TRACKING THESE FOUR-LEGGED TACTICAL PREDATORS:

A SYNTHESIS

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Bobcat
Cougar
Coyote
Dingo
Domestic Dog
Eastern Wolf
Gray Fox
Gray Wolf
Red Fox
Red Wolf

INTRODUCTION

Designed for Delaware and the Mid-Atlantic region, this study focuses on addressing the ancestry of prehistoric Native American domestic dogs. For comparative examples and behavioral reference points, we broaden our focus to the following ten species of four-legged tactical predators: 1) Bobcat; 2) Cougar; 3) Coyote; 4) Dingo; 5) Domestic Dog; 6) Eastern Wolf; 7) Gray Fox; 8) Gray Wolf; 9) Red Fox; and 10) Red Wolf. In this synthesis, we did not investigate the opportunistic predators: the Raccoon, Opossum, Weasel, Skunk, River Otter, etc. We also chose not to include predators such as the Bear, Lynx, Ocelot, Badger, Wolverine, various Ferrets, etc. even though potential systems of prehistoric trade and exchange may have provided opportunities for bones, teeth, or claws, etc., of these animals to be present within our study area.

A pragmatic way to track these four-legged tactical predators through time and space is in charting their DNA. Throughout the time that Native Americans occupied North America, cultural selection shaped the DNA in these predators to a greater extent than either natural selection or climate change. If we wish to view DNA sequences as artifacts, a new world of scientific description is being revealed. More accurate than seriating ceramics, less time consuming than sourcing lithic quarries, more reliable than typing projectile points, and less expensive than radiometric dating; sequencing the DNA of tactical predators focuses our lens on this RELATIVE artifact class (no pun intended).

We are now able to track these four-legged tactical predators through both time and space by identifying shared (or absent) segments of ancestry, as well as progeny. We need to excavate this new method, tracking and comparing these animals on these anthropogenic landscapes, as well as identifying where, when, and how specific breeds of the domestic dog participated in human migration, and systems of trade and exchange.

OUR RESEARCH QUESTION

How can archaeologists use the comprehensive DNA sequencing of these four-legged tactical predators to their benefit? We provide an example (see below) where recent DNA analysis of two small populations of living Native American domestic dog breeds, have had their DNA sequenced. These data are truly inspiring. Yet, this is only a beginning--just imagine how testing domestic dog burials, and the remains of other tactical predators across the landscape will provide new discoveries and opportunities for comparative analysis.

TWO DOMESTIC DOG DNA EXAMPLES

To date, the most far-reaching study on Native American domestic dogs is Barbara Van Asch et al. (2013) entitled, "Pre-columbian origins of Native American dog breeds, with only limited Replacement by European dogs, confirmed by mtDNA analysis." We have included their essay in our Appendix 5 (see appendix 5, pages 8-20). Their study was designed to take cheek swabs and blood samples from a variety of living dogs alleged to have pre-columbian, or Native American context(s) in the western hemisphere. The results of their DNA samples indicated there were no distinct haplogroups unique to American dogs (Appendix 5, p16). However, they did discover several genetic mutations that had occurred in the western hemisphere since the domestic dog's arrival (ca. 14,000 ybp). We will discuss these genetic mutations within their two sets of data: 1) the Carolina Dog breed, and 2) the Mexican Chihuahua breed.

Van Asch et al (2013) sequenced the DNA of nineteen living individuals of the Carolina Dog breed from South Carolina and Georgia. They discovered a mutation known as haplotype A184, unique to the Carolina Dog breed. No archaeological or ancient samples were tested for comparison. Additionally, in the same study, they sequenced the DNA of fourteen living individuals of the Chihuahua breed in Mexico. They discovered a mutation known as haplotype A185 in 5/14 of their living Chihuahua samples, and that mutation is evident in one pre-columbian, archaeological sample from Mexico (showing geographical continuity). Van Asch et al. registered their discoveries (A184 and A185) with GenBank under accession numbers HQ452424-HQ452430 and HQ452435-HQ452438 (see Appendix 5, page 10).

What does the recent discovery of these two genetic mutations mean? Given more samples, we will be able to track these mutations through various ancestral Native American domestic dogs, as well as identifying the Native American people who owned and bred them. Combining DNA sequencing with the metric data of archaeological examples would permit any number of new and interesting avenues of research. Our outline

for developing a five point DNA sequencing program for Delaware (and the wider Mid-Atlantic region) would look something like this:

FIVE POINT PROGRAM

1) DNA sequencing of archaeological examples of Native American dogs will promote the identification of currently unknown, individual domestic dog breeds.

2) The mapping of specific genetic mutations of Native American domestic dogs will allow for the geographic and temporal setting of the mutation (ie. identity of the common ancestor). Furthermore, the offspring of these domestic dogs carrying the mutation can be traced both across the landscape and through time (ie. progeny dispersal).

3) Given the available 14,000 year time span and the entire forty-eight continental states, surely there must have been more than the one domestic dog breed (the Carolina Dog). We could envision several breeds of domestic dogs, each with their own function in society, for each Native American culture region. And, when we look at that through the lens of deep-time, the possibility of successions of specialized domestic dog breeds seems both, diverse and limitless.

4) The astonishing thing about obtaining these DNA sequences for all of the four-legged tactical predators itemized in this synthesis is that we already have procured, cleaned, catalogued, and stored many of the samples, which are (for the most part) under the supervision of respective Offices of Historic Preservation. All we need now is the willingness and cooperation to get started! In Delaware, it would be beneficial for the Delaware Department of Transportation (DelDOT) to initiate an Alternative Mitigation Program for DNA sequencing on all four-legged tactical predators, and fund that program using **one half of one percent** of the projected funds for all future DelDOT supervised Cultural Resource Management contracts.

5) Each Office of Historic Preservation should mandate a spreadsheet listing all of the four-legged tactical predators currently in storage in their respective facilities that are discussed in this synthesis. Even though we are located in Delaware, we need to be sensitive to excavated dental, claw, and bone artifacts traded into our area, even where there are remote possibilities those animals actually lived here. These might include the Badger, Coyote, Gray Wolf, Grizzly Bear, Lynx, Wolverine, and so on.

RESEARCH

Each of the ten, four-legged tactical predators mentioned in this synthesis is worthy of comprehensive DNA sequencing. In Delaware, we are certain there are many archaeological examples (quantity currently unknown) of Native American Domestic Dog. There are also archaeological examples of alleged Fox (quantity and species unknown), and Wolf/Coyote (quantity and species unknown). Glen Mellin remembers excavating the hind claws of a Cougar (probably part of a Cougar skin robe) accompanying a Native American adolescent burial at the Island Field site (7K-F-17). To date, no comprehensive list of any of these archaeologically recovered tactical predators exists, and no comprehensive DNA sequencing has been performed.

DISCLAIMER

A background and profile of each of these ten, four-legged tactical predators accompanies this synthesis in appendicle form, each formatted in their respective "word" file (see Appendix 1 through 10). Throughout this synthesis and in each of the ten appendixes we collected recently produced data from the Internet. We reproduced some of that data (written by respective authors, some of it posted anonymously) in our appendixes. The important thing to remember is that our words are written in Cambria/10 font with 6.5 inch margins, and other author's words are written in Cambria/9 font with 5.5 inch margins (forming extensive block quotes). We have achieved due diligence in citing and referencing all copied work. This method of copying and re-formatting was done out of expedience. This is a research synthesis and should not be considered, nor does our work meet professional, publishable standards. We are independent, non-funded researchers. We offer this synthesis as a public contribution. We apologize in advance to anyone who is offended by our work, or presentation style. This synthesis and all accompanying ten appendixes are constructed in WORD 2008, printer coded for Black Ink, with the exception of two Color Figures, both appearing in APPENDIX 5: DOMESTIC DOG; see Color Figure 1 on page 11, and Color Figure 2 on page 14.

OUR TEN APPENDICES

The ten appendices (attachments) are assembled in alphabetical order: 1) Bobcat; 2) Cougar; 3) Coyote; 4) Dingo; 5) Domestic Dog; 6) Eastern Wolf; 7) Gray Wolf; 9) Red Fox; and 10) Red Wolf. We will briefly summarize the information in these appendices and what value comprehensive DNA sequencing of individual (archived) archaeological examples of these species may add to our understanding of ancestral Native American culture. Ten appendices (200+ pages) available upon request: glen.lenny1952@gmail.com.

APPENDIX 1: BOBCAT, pages 1-14. Schreber first identified the Bobcat as *Lynx rufus*, in 1777. Thirteen subspecies have been proposed, yet some of these distinctions have been challenged. Schreber defined the *L. rufus rufus* living in the eastern and Midwestern United States. Bangs defined the *L. rufus gigas* living in northern New York to Nova Scotia and New Brunswick. The Lynx, *Lynx lynx*, is a "cold weather" cousin of the Bobcat, generally found in Canada and the colder portions of the U.S. The Ocelot, *Leopardus pardalis*, is found in the southwestern parts of the U.S.

The Bobcat entered North America at least 1.8 million years ago and evolved into the modern Bobcat around 20,000 ybp. At a later date, the Lynx migrated to North America via the Bering Land Bridge and occupied niches deemed too cold for the Bobcat. Crossbreeding between the Bobcat and Lynx does occasionally occur.

Bobcats prefer to occupy wooded areas, but does well in semi-desert, urban edge, forest edge, and swampland landscapes. Weighing between 14 and 40 pounds, the crepuscular Bobcat prefers to hunt rabbits, but will eat insects, birds, rodents, even deer. The Bobcat is largely solitary within its established and defended hunting territory. The presence of efficient Canid populations may pressure the Bobcat's success. Healthy Bobcats are expected to live for about seven years, rarely ten years. The Bobcat is featured in Native American storytelling.

Archaeological remains of Bobcat, found in Delaware, have yet to be professionally identified (Mellin and Truitt, February 13, 2016).

APPENDIX 2: COUGAR, pages 1-19. The Cougar was identified as *Puma concolor* by Linnaeus in 1771. Six subspecies are widely recognized with one subspecies in North America, *P. concolor cougar*, identified by Kerr in 1792, and five subspecies in Latin America. Additionally, the validity of the Florida Panther, *P. concolor coryi*, described by Bangs in 1899, remains contested.

The Ice Age Cougar probably inhabited North America as early as 8 million ybp. Culver et al. (2000) suggest the original population of *P. concolor* was extirpated along with other large species at the end of the Ice Age. At the beginning of the Holocene, the Cougar known as *P. concolor cougar*, migrated northward and adapted to colder, northern ranges including Canada. Interestingly, it is possible the first Paleo Indians and the first modern Cougars (*P. concolor cougar*) arrived in the Mid-Atlantic region at, or about, the same time.

In the Mid-Atlantic region, modern Cougars are thought to have weighed between 115-220 lbs. for males, and 64-141 lbs. for females. Cougars appear to grow larger at higher latitudes and grow smaller in lower latitudes. Cougars are crepuscular ambush predators--they will eat whatever they can catch. Hunting is more successful in dense underbrush, but maximum adaptability allows smaller populations and individuals to survive in mountain and desert regions. Their principal diet consists of various deer and other mammals. For a generalized estimate; one ungulate is expected to be killed and consumed every two weeks by each adult Cougar. Life expectancy of the Cougar is 8 to 13 years. At two years old, young adults will leave their mother's supervision to establish their own territory. The relationship between Cougars and Wolves in the prehistoric Mid-Atlantic region is largely speculative. Some people of Algonquin lineage consider the Cougar to represent the underworld. Custer and Mellin reported one alleged archaeological Cougar find associated with a Native American burial (ca. 750--850ce) at the Island Field Site, 7K-F-17.

APPENDIX 3: COYOTE, pages 1-20. In 1819, Say identified Coyote as *Canis latrans*. An ancient derivative of the Eurasia wolf, the ancestral Coyote probably entered North America over one million years ago. Young and Jackson (1951) compiled a list of nineteen Coyote subspecies, descriptions developed during the nineteenth and twentieth centuries. Nowak (1978) states many of these individual descriptions are not defensible. The *Canis latrans thamnos* is said to occupy the Great Lakes region of the U.S. and Canada… and is the likely candidate for the presence of Coyotes in the Northeast and Mid-Atlantic regions (see the Red Wolf restocking program where Red Wolves from Texas were moved to North Carolina. These restocking wolves likely contained significant Coyote DNA admixtures, which originated in the American southwest). Furthermore, an analysis of 48,000 SNP genome chips suggests a period of Coyote DNA admixture to both Eastern Wolf populations in Canada and Red Wolf populations in North Carolina at about 600-900 ybp. Additionally, another admixture disruption is suggested for the time period 287-430 ybp. This latter admixture disruption may be due to European colonial expansion and alteration of established prehistoric natural and cultural processes (see Appendix 3, pages 6-7).

If the Coyote had prehistoric ancestry in Delaware and the Mid-Atlantic region, we think these tactical predators would have weighed between 18-44 lbs for the male and 15-40 lbs for the female. Colonial records indicate confusion in accurately describing the differences between the local Coyote and/or Wolf based on visual accounts and behavioral characteristics. Local courts supported the extirpation of whatever animal(s) was preying on livestock through the construction of private traps and bounty payments. Many authors suggest that Colonial extirpation programs "allowed/forced" various levels of genetic admixtures between available Coyotes, Wolves, Native American Domestic Dogs, and Domestic Dogs of European descent. For example, a population of non-albino, white Coyote currently located in Newfoundland owes its distinctive coloration to a genetic mutation inherited from the Domestic Golden Retriever (see Appendix 3, page 6).

Coyote pair bonding allows the Coyote to socialize and hunt within a nuclear family structure. Coyotes are not particularly aggressive in defending their territory. Primarily carnivorous, the Coyote derives about 90% of its diet from small rodents like mice, moles, and shrews, and ground-feeding animals like squirrels and rabbits. Insects like crickets, grasshoppers, and caterpillars, and fruits like persimmon, blackberries, apples, and prickly pears add to the diet, which requires about 600 grams of quality food per day. Ungulates may be hunted and killed opportunistically, and occasionally, an experienced and skilled adult Coyote may kill a porcupine. Coyote pups are easily tamed and are known to achieve tractable companion skills like pointing and retrieving.

There is one alleged archaeological example of Coyote in Delaware: according to faunal expert, Dr. Adam Heinrich (analyst for Hunter Research Inc.), the remains of a Coyote were recovered from archaeological excavations at the Cardon-Holton Site, 7NC-F-128 (occupation estimated to be from 1720 to 1740) (DelDOT Blog: US Route 301 Archaeology Update, March 25, 2014, at: http://blogs.deldot.gov/2014/03/, Internet Retrieval, January 3, 2016). Unfortunately, no DNA sequencing on this archaeological find was performed.

APPENDIX 4: DINGO, pages 1-34. The story of the Dingo is included in this essay for comparative purposes because of this dog's far-ranging dispersal as an element of human culture. Additionally, Domestic Dogs in the state of Hawaii and other U.S. Pacific territories were derived from Dingo lineage. To date, no known Dingo DNA is recorded in Domestic Dogs in the western hemisphere as a result of trans-Pacific contact.

In 1793, Meyer described the Dingo as *Canis lupus dingo*. Various individual as well as dispersed populations of the Dingo subspecies has been the subject of extensive DNA sequencing. It is now clear the ancestral Dingo originated in east and southeastern Asia, from a predecessor Domestic Dog lineage, about 10,000 ybp. Tracing the mtDNA mutation A29 in Dingoes, a 5,000 ybp arrival date is suggested for the Australian continent. Furthermore, the Dingo likely arrived in Australia as a Domestic Dog derived from a very small founding population, before individuals escaped to form seemingly wild populations. There are 18 mtDNA-types unique to the Dingo lineage.

The average Australian Dingo (19th century examples) weighed between 29-44 lbs. Rabbits and rodents form the principal diet with crepuscular, solitary, wandering hunting tactics. Dingo pack formed hunting behavior is suggested to be a relatively recent, successful adaptive hunting strategy for addressing larger animals.

APPENDIX 5: DOMESTIC DOG, pages 1-20. It is true the ancestors of the Domestic Dog, the Coyote, and various species of wolves migrated from Siberia to Alaska, but not all at the same time. In fact, unlike opening and closing a gated fence, the migration routes were open a various times in the past, and it is inconceivable to describe these routes as only a west to east movement. Further complicating these issues is the fact that all of these Canids are capable of cross-breeding, thus producing hybrid offspring (see Appendices 3, Coyote; 5, Domestic Dog; 6, Eastern Wolf; 8, Gray Wolf; and 10, Red Wolf).

The true story of Native American Domestic Dogs is largely incomplete. The over-arching question is this: what events transpired between the Domestic Dog's arrival in Alaska (ca. 14,000 ybp) and the Domestic Dog walking around in Delaware (ca. 400 ybp, the first European observations)? DNA sequencing of examples of Native American Domestic Dogs can help us answer this question, while offering crucial insight to the Native American people who owned and bred them.

Linnaeus is widely recognized as having described the Domestic Dog, *Canis lupus familiaris* in 1758. An untold number of breeds of the Domestic Dog are recognized by various groups of record keepers. Most of these recognized breeds were developed through cross-breeding and selecting desirable traits since 300 ybp. When we turn our attention to the western hemisphere before European exploration, a limited number of breeds are known. Nevertheless, European explorers discussed the presence of Native Americans and their dogs existing from the Arctic region of North America (including Greenland) to Patagonia in South America.

Today, the Carolina Dog, the Chihuahua, the Xoloitzcuintli, and the Perro Sin Pelo del Peru are the only extant Native American breeds, which were derived from Domestic Dogs of the early migrations. Within the past 300 years, the Tahltran Bear Dog, the Hare Indian Dog, the Salish Wool Dog, and the Innu Canoe Hunting Dog have been extirpated. All of these breeds are thought to have ancestry with the early migrations starting around 14,000 ybp.

The Thule working dogs, arriving around 4,000 ybp, represented by the Inuit sled dog, the Canadian Eskimo Dog, and the Greenland Dog, as well as modern variants are doing well in higher latitudes. Beginning around 3000 ybp, we see the Alaskan Malamute and the Siberian Husky belonging to the Spitz ancestral grouping are associated with the ancestral Mahlemuit, or today's Inupiat culture.

No one knows how many Native American Domestic Dogs have been excavated in Delaware. We do know that some of them are archived under DESHPO supervision. We can forecast a similar situation for all of the other states in the Mid-Atlantic region, and beyond. Collectively, we invested the time, spent the money, and made the effort to excavate and archive examples of Native American Domestic Dog burials, with the hope that these specimens would be available for future research. Have we been waiting for the future development of applicable research questions, and an inexpensive, pragmatic method to retrieve the data? We are at that point in time, we are there, the time is now.

Geneticists have arrived at the point where they can secure, process, and sequence the entire genome of any given sample. With the benefit of mtDNA sequencing, multiple samples can be compared for shared genetic relationships. Given sufficient samples, percentages of shared DNA allow for predictions of relationship and ancestry of the samples in both time and space. Even when a sample is thousands of years old, we can still track the ancestry of these Domestic Dogs, as well as the people who owned and bred them.

APPENDIX 6: EASTERN WOLF, pages 1-10. In 1775, Schreber first described the Eastern Wolf as *Canis lycaon*. Schreber did not suggest any subspecies of the Eastern Wolf, but he did provide an assumed range map of what has been referred to as the "cold weather species", as opposed to the Red Wolf, which has been referred to as the "temperate weather species". The eighteenth century range of the Eastern Wolf was roughly mapped with the Potomac River being at the southern limit, running north into the Northeast region and well into Canada. Today, the Eastern Wolf range is centered around a semi-protected habitat know as the Algonquin Provincial Park in south central Ontario and south central Quebec. Historically, the Eastern Wolf was found in the upper mid-west and even out to the eastern portion of the Great Plains. This data has caused concern for the U.S. Fish and Wildlife service in regards to protection of the species and its indigenous habitat.

Both Canada and the United States have funded genetic research in attempts to define the specific attributes and scientific descriptions of the species.

Thiel and Wydeven (2011:80-1) produced a document for the Wisconsin Department of Natural Resources under contract from the U.S. Fish and Wildlife Service. Their Summary / Recommendations highlights four points, which a listed below in block quote:

> Summary / Recommendations
> 1. A genetically and morphologically unique large Canis species occupied much of east-central North America during the final stages of the Pleistocene up to present times. Its present range is restricted to a swath of east-central Ontario and southwestern Quebec in Canada. Scientists are increasingly referring to this canid as the eastern wolf, Canis lycaon.
>
> 2. Recent carcass recoveries reveal that individual eastern wolves are at least occasionally present in the Northeastern United States, but there is no evidence that any breeding occurs at the present time.
>
> 3. Wolves in the Western Great Lakes states lie within a naturally occurring suture zone where gray wolf and eastern wolf populations collided during and following the retreat of the continental glaciers. The wolf population in this geographic region is taxonomically distinct, an admixture of Canis lupus X Canis lycaon. It displays genetic continuity and is representative of the gene pool present prior to anthropogenic influences. There is good agreement that wolf populations in this region have since functionally and numerically recovered.
>
> 4. Geneticists, especially, use peer-reviewed scientific journals to advance their position that this unique wolf type, labeled the eastern wolf, Canis lycaon, is a distinct species. This posture is presently subject to robust and healthy scientific debate. The fact remains these large canids presently lack official designations a species. We encourage those who promote eastern wolves as a distinct species petition an international authority such as the International Commission of Zoological Nomenclature, the American Society of Mammalogists, etc., to resolve this issue so that conservation efforts may proceed. (Thiel and Wydeven, 2011:80-1).

As we analyze these data, it becomes impossible to say with certainty whether the wolves that Native American and Colonial populations in Delaware encountered were examples of the Eastern Wolf, or the Red Wolf, or both. However, DNA descriptions of archaeological excavated wolf remains found in Delaware and the Mid-Atlantic region could contribute to these highly significant conversations. On the one hand, we could be witnessing a situation where two distinct species are converging and hybridizing into one species, with Delaware and the Mid-Atlantic region being the principal genome admixture area. On the other hand, we could be witnessing a situation where one distinct species is splitting into two distinct species, with Delaware and the Mid-Atlantic region, because of the range overlap, being the holdout for genome admixture. We also have to ask whether Native American cultural processes affected the natural limits of these wolves' ranges and behaviors, and ultimately, their genetic signatures?

Rutledge et al. (2015) found by using mtDNA and genome-wide data from 127,235 SNP, the Eastern Wolf population in the Algonquin Provincial Park are "a distinct remnant entity of a historical wolf and most likely existed throughout the eastern United States." NCBI/GenBank now lists the Eastern Wolf, *Canis lycaon* as a distinct species.

The Eastern Wolf, like the Red Wolf, targets small to medium sized prey. Comparative diet is constrained by habitat and available edible species. The Eastern Wolf is proficient in hunting and killing white-tailed deer and beaver. A wide variety of smaller mammals and birds are consumed. The average weight of the Eastern Wolf adult male is 67 lbs. and females average 53 lbs. Average life span is only 3-4 years.

APPENDIX 7: GRAY FOX, pages 1-7. In 1775, Schreber described the Gray Fox, Canidae *Urocyon cineroargenteus*. True foxes are listed under the Genus *Vulpes*, making the Gray Fox a very distant divergence, somewhere in the neighborhood of 12 million years ago. The Gray Fox appeared in the western hemisphere 3.6 million ybp, and currently is ONLY found in the western hemisphere. Fritzell and Haroldson (1982) list

sixteen subspecies, where; the *U .c. borealis* is currently found in New England and the *U. c. cinereoargenteus* is currently found in the eastern United States. These two subspecies are capable of producing hybrids.

Genetic studies on the Gray Fox indicate the historic distribution of the Gray Fox along the eastern seaboard was different, as Sillero-Zubiri et al. (2004:92-7) explain in the following block quote:

> *Historical distribution* In North America, the historical northernmost distribution of the gray fox probably was somewhat further south than its current northern limit (Fritzell and Haroldson 1982). Also, the range of the species probably did not extend significantly into the Great Plains because of the lack of brushy cover. Habitat modifications, such as fire suppression and tree planting, have facilitated occupation of this biome (Fritzell 1987). The species also was formerly found on Martha's Vineyard, a small offshore island in the state of Massachusetts (Waters 1964), see (Sillero-Zubiri et al, 2004:92-7).

Furthermore, as Bozarth et al. (2011) found that genetic analysis demonstrates the Gray Fox migrated into the northeastern United States during a significant warming period, ca. 950ce to 1250ce, also known by the "Eurocentric" label, the Medieval Climate Anomaly. Alternatively, we see dynamic changes in Native American populations during that time frame, with major events in human migration and significant changes in economic strategies and settlement pattern, with examples of the development of Chieftain level society based on Horticulture/Agricultural practices.

The Gray Fox weighs between 8 and 15 pounds. Easily distinguished from the Red Fox, the Gray Fox lacks the "black stockings" above the paws. The Gray Fox is an omnivorous, solitary hunter. Diet consists mainly of rabbits and various rodents--mice, voles, shrews, and birds. Fruits, berries, grapes, and insects are eaten when in season. The Gray Fox is noted for climbing trees as an escape tactic, and is known to jump from branch to branch while gathering fruit and berries (including fox grapes). The Gray Fox is also known to den in standing hollow trees. The Gray Fox prefers to live in deciduous forest, where the Red Fox prefers to live in boreal forests.

If we are to address possible cultural implications, where the Gray Fox migrated into the northeastern portion of the United States during a time great economic and cultural shifts forming the Late Woodland Cultural Period, we have the opportunity to view this Gray Fox migration as a possibly culturally related phenomenon, if not actually a culturally induced process. What were the relationships between Native American cultures and the Gray Fox? DNA analysis of archaeological remains of the Gray Fox could help explain these very intriguing questions.

APPENDIX 8: GRAY WOLF, pages 1-38. The majority of current hypotheses stipulate that Gray wolves were never active in Delaware and the Mid-Atlantic region. Yet, Gray Wolf genetic admixture is present in Eastern wolves, possibly a direct result of Gray Wolf, or a result of back-crossing from either, or both Domestic Dog and/or Coyote (see Appendix 8, pages 6-7 for a full explanation). The Gray Wolf needs to be discussed in this synthesis for two reasons; 1) Gray Wolf genetic admixture does appear in the Eastern Wolf lineage, and 2) pieces of the Gray Wolf carcass (teeth, claws, finished bone artifacts, etc.) could occur in Delaware as ceremonial objects as a result of trade and exchange.

Linnaeus first described the Gray Wolf, *Canis lupus*, in 1758. Nowak (1995) refines the diversity and ranges of the Gray Wolf with seven Eurasian and five North American subspecies. Genetic material from the Eurasian Wolf stock as well as the Taimyr Wolf stock shape the Gray Wolf's specialized characteristics; organized hunting in packs and capable of killing very large animals, like Caribou, Moose, and Elk. The male Gray wolves that were recently moved from Canada to restock Yellowstone National Park weighed between 95-99 lbs, and the females weighed between 79-85 lbs.

The true Gray Wolf appeared between 500,000 and 300,000 ybp. Today's subspecies seem to have developed within the last 40,000 years, with migration into Alaska between 20,000 and 10,000 years ago. Our understanding is that all extant Gray wolves in North America belong to haplogroup 1 (Gray wolves in North America belonging to haplogroup 2 are extirpated), and all Gray wolves elsewhere (Siberia, Asia, and eastern Europe) belong to either haplogroup 1 or 2. It has been suggested that Gray wolves in North America in

haplogroup 2 were specialized in hunting Pleistocene megafauna, and were either unable to survive the effects of Holocene climate change, or possible human cultural processes. On a species level, it is very interesting that Gray wolves belonging to haplogroup 2 became extinct only in North America.

APPENDIX 9: RED FOX, pages 1-23. Linnaeus first described the Red Fox, *Vulpes vulpes*, in 1758. Historically, forty-four subspecies of Red Fox are identified involving most of both hemispheres. The subspecies we are interested in for Delaware and the Mid-Atlantic region is *V. vulpes fulva*.

Red foxes appear to have colonized North America in two waves: first during the Illinoian glaciation, and later during the Wisconsinian glaciation. North American isolation appears to have existed for 400,000 years, which suggests the possibility for subspecies specialization. Even though European Red foxes were introduced since Colonial times, recent genetic mapping indicates an absence of European fox haplotypes in any North American Red Fox populations.

Contemporary Red foxes can weight between 5 and 30 pounds. Red foxes are crepuscular omnivores with a highly varied diet. Subsisting primarily on small rodents they can kill rabbits, porcupines raccoon, opossums, ground nesting birds, and reptiles. They also eat a wide variety of fruits, berries, grapes, and acorns, and insects seasonally. Occasionally, surplus kills are cached.

Gray foxes favor heavily wooded habitats while Red foxes favor more open, mesic habitats. Gray foxes will dominate Red foxes where their ranges meet. Red foxes generally avoid interacting with both wolves and coyotes.

APPENDIX 10: RED WOLF, pages 1-12. Audubon and Bachman first described the Red Wolf, *Canis rufus* in 1851. However, at various times in the nineteenth century, the Red Wolf was referred to as *Canis lupus rufus* (Red Wolf derived from Gray Wolf) as well as *Canis latrans rufus* (Red Wolf derived from Coyote). Today, with the benefit of DNA analysis, there is little support for using these nineteenth century derivatives. Three subspecies were proposed by Goldman (1937) forming *C. rufus gregoryi*, *C. rufus floridanus*, and *C. rufus rufus*. These three subspecies were supported by Paradiso and Nowak as late as 1972. However, *C. rufus flordanus*, and *C. rufus rufus* are thought to be extirpated at this time. This would leave *C. rufus gregoryi*, or perhaps we are simply back to the original *Canis rufus*.

Sillero-Zubiri et al. (2004:88) say, "As recently as 1979, the red wolf was believed to have a historical distribution limited to the south-eastern United States (Nowak 1979). However, Nowak (1995) later described the red wolf's historic range as extending northward into central Pennsylvania and more recently has redefined the red wolf's range as extending even further north into the north-eastern USA and extreme eastern Canada (Nowak 2002). Recent genetic evidence (see Taxonomy section above) supports a similar but even greater extension of historic range into Algonquin Provincial Park in southern Ontario, Canada."

Today, Red wolves (*Canis rufus*) probably exist as a re-introduced and stable population (containing *Canis rufus gregoryi* DNA admixture, which is known to contain Coyote (*Canis latrans*) DNA admixture) in eastern North Carolina on protected land between Albermarle and Pamilico Sounds (Sillero-Zubiri et al. (2004:88). What we are facing here is this: in order to save the remnant, endanged population in the east, wolves from the Texas and Mexican population (probably designated (*Canis rufus gregoryi*, which were likely contaminated with as much as 50% Coyote DNA in some samples) were introduced into the dwindling North Carolina population starting in 1987. The Coyote DNA found in the North Carolina DNA samples most probably originated in the American Southwest, represents a very recent admixture in the East. To fully grasp the range of these issues, researches should become fully versed in all three species: the Red Wolf (Appendix 10), the Eastern Wolf (Appendix 6), and the Coyote (Appendix 3). For comparison, it would be helpful to become fully versed in the Domestic Dog (Appendix 5) and the Gray Wolf (Appendix 8). GenBank currently recognizes the Red Wolf as *Canis rufus*. Of course, all elements of this conversation are subject to change, and if we can sequence the DNA of all archaeological examples that resemble a wolf or coyote, we can contribute to and hopefully refine these discussions.

The Red Wolf is said to weight between 50-85 pounds. See specific characteristics of Red Wolf and Eastern Wolf (Appendix 6) for discussion of habitat, diet, and range of the Red Wolf. Because there has likely been, and to unknown extents, admixtures of Coyote DNA in the Red Wolf, we continue to think that all visual and metric analysis and descriptions of skeletal remains should be considered unreliable for determining species within the overall *Canis* Genus. With that being said, it becomes even more crucial to secure the DNA sequences of all early historic and Native American archaeological remains of these predators.

We know of one Delaware archaeological example: according to faunal expert, Dr. Adam Heinrich (analyst for Richard Grubb Associates, Inc.), the remains of a wolf was recovered from archaeological excavations at the eighteenth century Rumsey/Polk site, 7NC-F-112. The blog says:

> The wolf bones include the right and left scapulae (shoulder blades), the right ulna and radius (forearm bones), and most of the right front foot. Even more intriguing, the bones were butchered. The wrist end of the radius and ulna contain cut marks made by a metal knife. The location of these marks near the animal's wrist indicates removal of the wolf's pelt after it was killed. The wolf found in Feature 5 may have been shot. An oval shaped pit with crushed bone within it is located on the animal's elbow, consistent with being shot with the lead balls from a musket or comparable firearm. It is uncertain if being shot in the elbow had killed the wolf, but it may have injured it enough to be finished off more easily. (DelDOT Blog: US Route 301 Archaeology Update, March 25, 2014, at: http://blogs.deldot.gov/2014/03/).

INTERPRETATION

During the winter of 2015-2016, Lenny and I researched our topic, included various introductory documents collected from the Internet, wrote the ten summaries introducing each appendix, and assembled this synthesis. Without further summary, we present our interpretations, and hopefully what we think the reader and/or researcher will find important. There is no doubt that over the past 14,000 years the characteristics of human cultures changed, the attributes of the physical landscape changed, and the traits of the four-legged tactical predators changed. We should not discuss these three themes in isolation of each other, they are inextricably linked, and they need to be addressed in unison. The only pragmatic way to track these four-legged tactical predators through time and space is in charting their DNA. We are now able to track these four-legged tactical predators through both time and space by identifying shared (and absent) segments of ancestry, as well as progenitors. We need to excavate this new method, tracking and comparing these animals on these anthropogenic landscapes, as well as identifying where, when, and how specific breeds of tactical predators (the domestic dog(s), for example) participated in human migration, hunting tactics, diet, ceremonialism, and systems of trade and exchange. Our professional pursuits need to be more pragmatic--we need to track the DNA of all of these four-legged tactical predators following these two suggestions:

1) Programmatic consultation with Genetic Lab(s): SHPOs need to identify, locate, and organize all of their archived four-legged tactical predators into a comprehensive, compatible, and comparable spreadsheet database. Ask good research questions--select samples to test. NPS and academic guidance would be helpful.

2) Testing: initially, we need to have the relevant DNA strings (adenine (A), cytosine (C), guanine (G), thymine (T), and uracil (U) DNA and RNA) diagnosed for each sample tested. This product will be digitally recorded on CD with identification number. The Sequencing Lab's software will establish species, specific haplogroups, as well as genetic mutations within haplotypes. Sample comparison testing is used to develop temporal and geographical ancestry. Comparison testing is also necessary to identify genetic anomalies, the building blocks needed to segregate and describe genetic mutations. These anomalies and mutations may be tracked to address how Native Americans developed their various breeds of Domestic Dogs, as well as the other four-legged tactical predators discussed in this synthesis.

Final thoughts: We are distributing our synthesis: "Tracking These Four-Legged Tactical Predators", by email. We can email the ten appendices (200+ pages), with bibliographies and references cited upon request, send request to: glen.lenny1952@gmail.com.

RITUAL LANDSCAPES: A JOURNAL SYNTHESIS

Glen Mellin and Lenny Truitt
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July 2017

PREFACE

Ritual Landscapes is a collective term that addresses processes ascribed to Native American ecological manipulation in the Eastern Woodlands of the United States. We found that archaeological and cultural landscape evidence of management processes is robust during the second half of the Holocene (ca. 6,000ybp to 400ybp). Environmental management processes are much less visible during the first half of the Holocene where we assume economic processes between culture and the environment were based on ideas of kinship rather than outright possession.

This compilation of twenty-nine chapters is organized chronologically as a journal synthesis. In doing so, we offer unique insights into how our independent research project developed through time with the challenging twists and turns inherent in creative thinking, while continuously being guided by our basic research question: To what extent did Native Americans in the Eastern Woodlands manipulate the environments in which they lived?

Our project began with Chapter One in January 2013 and concluded with Chapter Twenty-nine in July 2017. We began by mapping clusters of rare plants that we found growing outside their natural range and ended with the identification of very large areas of the Eastern Woodlands that had been transformed into cultural landscapes, or ritual landscapes, through continuous landscape burning, agroforestry programs, and other creative agencies.

To fully appreciate this research and the thought processes involved, it is best to think about the dramatic differences between managing perennial plant species as opposed to annual plant species. Perennials are managed on a diversified/decentralized basis, while annuals are managed on a specialized/centralized basis. Thus, the remains of formerly elusive agroforestry economic systems need to be investigated on project scales approaching one hundred square miles, while most archaeologists typically speak about annual, or corn--bean--squash economic systems on project scales somewhat less than ten square miles. Our research shows that the remnants of agroforestry catchment areas are typically identified in the range of fifty-to-seventy square miles.

We restored the one-hectare remnants of a likely Native American Mockley age (ca. 200bce--500ce) Chinquapin (Dwarf Chestnut) nut grove. While we regularly eat the nuts from this descendent, artifact plant cluster, we are the contemporary beneficiaries of these ancient Native American agroforestry efforts. To put this in perspective, we envisioned the anachronism, PLACES in Spacetime, where Public Landscaping, Agroforestry, and Creating Economic Strategies shaped these ritual landscapes, which are still evident today. The components of these ritual landscapes are easy to find, easy to restore, and best of all, these botanical artifacts are still productive and edible--talk about sustainability! Some private interests, such as ourselves, are identifying, restoring, and preserving various components of these ancient Native American ritual landscapes, but this remaining question needs to be asked: does the general public have any interest in doing likewise?

Thank you for your interest, Glen and Lenny in Delaware.

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Chapter 2, June 2013.
Interesting Botanicals on a Historic Site in Delaware: Recognition, Significance, and Meaning. (Text file, PDF, B&W, 2.9MB).

Chapter 3, July 2013.
Prickly Pear and American Chestnut Clusters Identified in the Lower Nanticoke River Basin. (Text file, PDF, B&W, 6.6MB).

Chapter 4, August 2013a.
A Botanical Survey in Trap Pond State Park Identifies Three Chinquapin Clusters. (Text file, PDF, B&W, 250KB).

Chapter 5, August 2013b.
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Chapter 6, August 2013c.
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Transformation of Native American and Historic Botanicals.
Transformation of Native American and Historic Botanicals. (Text file, PDF, B&W, 1.3MB).
Appendix 1 (Text file, PDF, B&W, 268KB).
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2014

Chapter 13 February 2014a. (File Folder).
McAvoy x Moerman. An Excel Spreadsheet cross-reference of McAvoy's Plants of Delaware with Moerman's medicinal plants of North America. (Excel spreadsheet, unprotected, B&W, 542KB, DO NOT PRINT--THIS FILE IS HUNDREDS OF PAGES).
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Tracking These Four-Legged Tactical Predators: A Synthesis. (Text file, PDF, B&W, 172KB).
A1.Bobcat. (Text file, PDF, B&W, 240KB).
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A10. Red Wolf. (Text file, PDF, B&W, 210KB).

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An Agroforestry Sampler. (Power Point slides, PPTX, contains color slides, 19MB).

Chapter 29, July 2017. Three Scaled Approaches for Modeling Native American Anthropogenic Landscapes. (Text file, PDF, Color, 3.8M).

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APPENDIX 1: BOBCAT

Glen Mellin
Lenny Truitt

March 2016

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OUR SUMMARY

This appendix identifies aspects of the Bobcat (*Lynx rufus*), which we feel are important to the discussion of the complex prehistoric and historic landscape interplay between humans and this four-legged tactical predator in Delaware and the Mid-Atlantic region. Schreber first described the Bobcat in 1777, as follows:

Kingdom: Animalia
Phylum: Chordata
Class: Mamalia
Order: Carnivora
Family: Felidae
Genus: *Lynx*
Species: *rufus*

Although thirteen subspecies of Bobcat have been described, the following subspecies division has been challenged, given a lack of clear geographic breaks in their ranges and the minor differences between subspecies (see citation number 10 in the Wikipedia list of citations: "Deletion of Bobcat (*Lynx rufus*) from Appendix II", 2004).

Subspecies
List of thirteen proposed bobcat subspecies:

- ***L. rufus rufus*** (Schreber) – eastern and midwestern United States
- ***L. r. gigas*** (Bangs) – northern New York to Nova Scotia and New Brunswick
- *L. r. floridanus* (Rafinesque) – southeastern United States and inland to the Mississippi valley, up to southwestern Missouri and southern Illinois
- *L. r. superiorensis* (Peterson & Downing) – western Great Lakes area, including upper Michigan, Wisconsin, southern Ontario, and most of Minnesota
- *L. r. baileyi* (Merriam) – southwestern United States and northwestern Mexico
- *L. r. californicus* (Mearns) – California west of the Sierra Nevada
- *L. r. mohavensis* (B.Anderson) – Mojave Desert of California
- *L. r. escuinapae* (J. A. Allen) – central Mexico, with a northern extension along the west coast to southern Sonora
- *L. r. fasciatus* (Rafinesque) – Oregon, Washington west of the Cascade Range, northwestern California, and southwestern British Columbia
- *L. r. oaxacensis* (Goodwin) – Oaxaca
- *L. r. pallescens* (Merriam) – northwestern United States and southern British Columbia, Alberta, and Saskatchewan
- *L. r. peninsularis* (Thomas) – Baja California
- *L. r. texensis* (Mearns) – western Louisiana, Texas, south central Oklahoma, and south into Tamaulipas, Nuevo León, and Coahuila (1), (9).

The subspecies division has been challenged, however: *L. rufus rufus* seems to be the dominant subspecies and *L. rufus gigas* seems to be challenged. Both subspecies should be considered within the broader Mid-Atlantic region until further clarification is achieved.

Finding evidence of Bobcat in archaeological contexts would have direct bearing on the landscape relationships between humans and these four-legged tactical predators in Delaware and the Mid-Atlantic region. In constructing this Appendix, we reviewed several dozen documents, (essays, books, contracted reports, professional papers, Internet sites, etc.) For the purpose of our essay, the "Hubpages" file and the Wikipedia file establishes a reasonable and sufficient background. We decided to include portions of both files in our essay. The Wikipedia file includes complete citations used for that file. We closely reviewed, edited, and re-formatted the contents of both files to make a good fit with our research topic.

Four members of the *Felis* lineage migrated to the western hemisphere via the Bering land bridge about eight million years ago. These lineages include the Puma (Cougar), the Bobcat, the Lynx, and the Ocelot. During the "American Interchange", with the closing of the Isthmus of Panama, all four of the *Felis* linages expanded into South America. We have separated and described Puma (Cougar) in our essay into its own Appendix (see Appendix 2). Nevertheless, we will describe Bobcat, and provide brief descriptions of the Lynx and Ocelot lineages below. Additionally, we provide the Wikipedia file on Bobcat (see below).

The following file, which discusses the Bobcat, Lynx, and Ocelot is derived from: http://hubpages.com/education/The-Four-Wildcats-of-North-America.

> **Bobcat- (*Lynx rufus*)**
> The Bobcat is the most commonly known wildcat in North America. He is also the only species of wildcat that is not currently on the endangered list. The Bobcat and the Canadian Lynx are sometimes though of as the same animal. They are both of the same family but different species. The Bobcat is about twice the size of the average house cat. They have long legs, large paws and tufted ears. They get their name from the short, black-tipped tail which appears to be "bobbed" or cut off. The "tufts" of their ears are actually used like hearing aids and they have excellent eyesight.
>
> With 12 subspecies, the bobcat ranges from southern Canada to northern Mexico. At one time the Bobcat's territory was wide spread over the US, however, their number have decreased over the years. Bobcats are nocturnal animals and are rarely seen by humans. They inhabit woodlands, forest areas, swamp lands as well as some semi-arid areas. The Bobcats diet consists of rabbits, mice, squirrels, reptiles and fowl, including the farmer's chickens. They are many times regarded as a nuisance and are shot by farmers. Many hunters will also kill a Bobcat as they eat the quail, pheasant and chukka that many hunters shoot for sport.
>
> **Lynx (*Lynx lynx*)**
> The lynx is actually the bobcats "cold weather" cousin. They are actually several species of lynx. The Asian and European lynx are larger that the North American species, the Canada lynx. The Canada lynx are generally found in Canada and the colder parts of the US. They inhabit mainly forest and tundra regions.
>
> The Canada lynx is about the same size as the bobcat and has tufted ears and a bobbed tail as well. The tail of the lynx however, is tipped in black. The lynx has more hair than the bobcat especially around the face and feet to keep them warmer in the colder climate. Their feet are used as "snow shoes" and are larger and have more hair for added insulation from the cold and snow.
>
> The Canada lynx diet consists mainly of snowshoe hares. There is a correlation between the number of snowshoe hares and the population of lynx. As the number of snowshoe hares decline, so do the number of lynx. The larger Eurasian lynx will hunt deer as well as smaller animals.
>
> **Ocelot- (*Leopardus pardalis*)**
> The ocelot is sometimes called the "Painted Leopard" or "Dwarf Leopard". At one time they could be found throughout the southwestern parts of the US. However due to their beautifully spotted fur, they have been illegally hung to the point that their numbers have been greatly reduced and has placed them on the endangered list. Occasionally you will see the ocelot in Arizona or extreme southern parts of Texas. They are most commonly seen in Mexico and northern parts of South America. They are primarily nocturnal, solitary animals.
>
> The ocelot has short tawny or reddish brown fur with black spots and rosette shaped markings. Their face has two black stripes down each side and their tail has black bands. They weight between 18 to 40 pounds and are 27 to 39 inches in length not including their tail which is between 10 to 18 inches in length. They can be found in the trees, stalking monkeys and birds. They also eat small mammals and rodents, frogs, fish and some reptiles. Unlike most other cats, they don't mind the water and can swim very well.

This concludes the "Hubpages" document on the *Felis* lineage in the western hemisphere found at: http://hubpages.com/education/The-Four-Wildcats-of-North-America.

The following document is a portion of the Bobcat Internet Wikipedia file together with the Wikipedia file references cited. We closely reviewed, edited, and re-formatted the contents of the open-source Wikipedia file to make a good fit with our research topic. The full Wikipedia document can be found and downloaded at: https://en.wikipedia.org/wiki/Bobcat.

Introduction

The **bobcat** (*Lynx rufus*) is a North American mammal of the cat family Felidae that appeared during the Irvingtonian stage of around 1.8 million years ago (AEO) (4). Containing 12 recognized subspecies, it ranges from southern Canada to central Mexico, including most of the continental United States. The bobcat is an adaptable predator that inhabits wooded areas, as well as semidesert, urban edge, forest edges, and swampland environments. It remains in some of its original range, but local populations are vulnerable to extirpation by coyotes and domestic animals. The bobcat is vital for controlling pest populations. With a gray to brown coat, whiskered face, and black-tufted ears, the bobcat resembles the other species of the mid-sized *Lynx* genus. It is smaller on average than the Canada lynx, with which it shares parts of its range, but is about twice as large as the domestic cat. It has distinctive black bars on its forelegs and a black-tipped, stubby tail, from which it derives its name.

Though the bobcat prefers rabbits and hares, it will hunt anything from insects, chickens, geese and other birds and small rodents to deer. Prey selection depends on location and habitat, season, and abundance. Like most cats, the bobcat is territorial and largely solitary, although with some overlap in home ranges. It uses several methods to mark its territorial boundaries, including claw marks and deposits of urine or feces. The bobcat breeds from winter into spring and has a gestation period of about two months.

Although bobcats have been hunted extensively by humans, both for sport and fur, their population has proven resilient though declining in some areas. The elusive predator features in Native American mythology and the folklore of European settlers.

Taxonomy

There had been debate over whether to classify this species as *Lynx rufus* or *Felis rufus* as part of a wider issue regarding whether the four species of *Lynx* should be given their own genus, or be placed as a subgenus of *Felis* (5), (6). The *Lynx* genus is now accepted, and the bobcat is listed as *Lynx rufus* in modern taxonomic sources.

Johnson et al. reported *Lynx* shared a clade with the puma, leopard cat (*Prionailurus*), and domestic cat (*Felis*) lineages, dated to 7.15 million years ago (mya); *Lynx* diverged first, approximately 3.24 million years ago (7). The bobcat is believed to have evolved from the Eurasian lynx, which crossed into North America by way of the Bering Land Bridge during the Pleistocene, with progenitors arriving as early as 2.6 million years ago (6). The first wave moved into the southern portion of North America, which was soon cut off from the north by glaciers. This population evolved into modern bobcats around 20,000 years ago. A second population arrived from Asia and settled in the north, developing into the modern Canada lynx (5). Hybridization between the bobcat and the Canada lynx may sometimes occur (8).

Subspecies

Thirteen bobcat subspecies are currently recognized:

- *L. rufus rufus* (Schreber) – eastern and midwestern United States
- *L. r. gigas* (Bangs) – northern New York to Nova Scotia and New Brunswick
- *L. r. floridanus* (Rafinesque) – southeastern United States and inland to the Mississippi valley, up to southwestern Missouri and southern Illinois
- *L. r. superiorensis* (Peterson & Downing) – western Great Lakes area, including upper Michigan, Wisconsin, southern Ontario, and most of Minnesota
- *L. r. baileyi* (Merriam) – southwestern United States and northwestern Mexico
- *L. r. californicus* (Mearns) – California west of the Sierra Nevada
- *L. r. mohavensis* (B.Anderson) – Mojave Desert of California
- *L. r. escuinapae* (J. A. Allen) – central Mexico, with a northern extension along the west coast to southern Sonora
- *L. r. fasciatus* (Rafinesque) – Oregon, Washington west of the Cascade Range, northwestern California, and southwestern British Columbia
- *L. r. oaxacensis* (Goodwin) – Oaxaca

- *L. r. pallescens* (Merriam) – northwestern United States and southern British Columbia, Alberta, and Saskatchewan
- *L. r. peninsularis* (Thomas) – Baja California
- *L. r. texensis* (Mearns) – western Louisiana, Texas, south central Oklahoma, and south into Tamaulipas, Nuevo León, and Coahuila (1), (9).

The subspecies division has been challenged, given a lack of clear geographic breaks in their ranges and the minor differences between subspecies (10).

Physical characteristics

The bobcat resembles other species of the *Lynx* genus, but is on average the smallest of the four. Its coat is variable, though generally tan to grayish-brown, with black streaks on the body and dark bars on the forelegs and tail. Its spotted patterning acts as camouflage. The ears are black-tipped and pointed, with short, black tufts. There is generally an off-white color on the lips, chin, and underparts. Bobcats in the desert regions of the southwest have the lightest-colored coats, while those in the northern, forested regions are darkest. Kittens are born well-furred and already have their spots (11). A few melanistic bobcats have been sighted and captured in Florida. They appear black, but may still exhibit a spot pattern (12).

The face appears wide due to ruffs of extended hair beneath the ears. Bobcat eyes are yellow with black pupils. The nose of the bobcat is pinkish-red, and it has a base color of gray or yellowish- or brownish-red on its face, sides, and back (13). The pupils are round, black circles and will widen during nocturnal activity to maximize light reception (14). The cat has sharp hearing and vision, and a good sense of smell. It is an excellent climber, and will swim when it needs to, but will normally avoid water (15). Though there have been recorded cases of bobcats swimming long distances across lakes (16).

The adult bobcat is 47.5 to 125 cm (18.7 to 49.2 in) long from the head to the base of the tail, averaging 82.7 cm (32.6 in); the stubby tail adds 9 to 20 cm (3.5 to 7.9 in) (13) and its "bobbed" appearance gives the species its name (17), (18), (19), (20). An adult stands about 30 to 60 cm (12 to 24 in) at the shoulders (11), (21). Adult males can range in weight from 6.4 to 18.3 kg (14 to 40 lb), with an average of 9.6 kg (21 lb); females at 4 to 15.3 kg (8.8 to 33.7 lb), with an average of 6.8 kg (15 lb) (22), (23). The largest bobcat accurately measured on record weighed 22.2 kg (49 lb), although unverified reports have them reaching 27 kg (60 lb) (24). Furthermore, a June 20, 2012 report of a New Hampshire roadkill specimen listed the animal's weight at 27 kg (60 lb) (25). The largest-bodied bobcats are from eastern Canada and northern New England of the subspecies (*L. r. gigas*), while the smallest are from the southeastern subspecies (*L. r. floridanus*), particularly those in the southern Appalachians (26). The bobcat is muscular, and its hind legs are longer than its front legs, giving it a bobbing gait. At birth, it weighs 0.6 to 0.75 lb (270 to 340 g) and is about 10 in (25 cm) in length. By its first birthday, it will reach about 10 lb (4.5 kg) (15).

The cat is larger in its northern range and in open habitats (27). A morphological size comparison study in the eastern United States found a divergence in the location of the largest male and female specimens, suggesting differing selection constraints for the sexes (28).

Behavior

The bobcat is crepuscular. It keeps on the move from three hours before sunset until about midnight, and then again from before dawn until three hours after sunrise. Each night it will move from 2 to 7 mi (3.2 to 11.3 km) along its habitual route (15). This behavior may vary seasonally, as bobcats become more diurnal during fall and winter in response to the activity of their prey, which are more active during the day in colder months (14).

Social structure and home range

Bobcat activities are confined to well-defined territories, which vary in size depending on gender and the distribution of prey. The home range is marked with feces, urine scent, and by clawing prominent trees in the area. In its territory, the bobcat will have numerous places of shelter, usually a main den, and several auxiliary shelters on the outer extent of its range, such as hollow logs, brush piles, thickets, or under rock ledges. Its den smells strongly of the bobcat (29).

The sizes of bobcats' home ranges vary significantly; a World Conservation Union (IUCN) summary of research suggests ranges from 0.02 to 126 sq mi (0.052 to 326.339 km^2) (27). One study in Kansas found resident males to have ranges of roughly 8 sq mi (21 km^2), and females less than half that area. Transient bobcats were found to have both larger (roughly 22 sq mi (57 km^2)) and less well-defined

home ranges. Kittens had the smallest range at about 3 sq mi (7.8 km^2) (30). Research has shown dispersal from the natal range is most pronounced with males (31).

Reports on seasonal variation in range size have been equivocal. One study found a large variation in male range sizes, from 16 sq mi (41 km^2) in summer up to 40 sq mi (100 km^2) in winter (29). Another found that female bobcats, especially those which were reproductively active, expanded their home range in winter, but that males merely shifted their range without expanding it, which was consistent with numerous earlier studies (32). Other research in various American states has shown little or no seasonal variation (30), (33), (34).

Like most felines, the bobcat is largely solitary, but ranges will often overlap. Unusual for cats, males are more tolerant of overlap, while females rarely wander into others' ranges (32). Given their smaller range sizes, two or more females may reside within a male's home range. When multiple male territories overlap, a dominance hierarchy is often established, resulting in the exclusion of some transients from favored areas.

In line with widely differing estimates of home range size, population density figures are divergent, from one to 38 bobcats per 10 sq mi (26 km^2) in one survey (27). The average is estimated at one bobcat per 5 square miles (13 km^2) (29). A link has been observed between population density and sex ratio. One study noted a dense, unhunted population in California had a sex ratio of 2.1 males per female. When the density decreased, the sex ratio skewed to 0.86 males per female. Another study observed a similar ratio, and suggested the males may be better able to cope with the increased competition, and this would help limit reproduction until various factors lowered the density (35).

Hunting and diet

The bobcat is able to survive for long periods without food, but will eat heavily when prey is abundant. During lean periods, it will often prey on larger animals it can kill and return to feed on later. The bobcat hunts by stalking its prey and then ambushing it with a short chase or pounce. Its preference is for mammals weighing about 1.5 to 12.5 lb (0.68 to 5.67 kg). Its main prey varies by region. In the eastern United States, it is the eastern cottontail species, and in the north it is the snowshoe hare. When these prey species exist together, as in New England, they are the primary food sources of the bobcat. In the far south, the rabbits and hare are sometimes replaced by cotton rats as the primary food source. Birds up to the size of a swan are also taken, along with their fledglings and eggs. The bobcat is an opportunistic predator that, unlike the more specialized Canada lynx, will readily vary its prey selection (27). Diet diversification positively correlates to a decline in numbers of the bobcat's principal prey; the abundance of its main prey species is the main determinant of overall diet (36).

The bobcat hunts animals of different sizes, and will adjust its hunting techniques accordingly. With small animals, such as rodents (including squirrels), birds, fish, including small sharks (37), and insects, it will hunt in areas known to be abundant in prey, and will lie, crouch, or stand, and wait for victims to wander close. It will then pounce, grabbing its prey with its sharp, retractable claws. For slightly larger animals, such as geese, rabbits and hares, it will stalk from cover and wait until they come within 20 to 35 ft (6.1 to 10.7 m) before rushing in to attack. Less commonly, it will feed on larger animals, such as young ungulates and other carnivores such as fishers (primarily female), foxes, minks, skunks, small dogs and domesticated cats (29), (38), (39). Bobcats are considered the major predatory threat to the endangered whooping crane (40). Bobcats are also occasional hunters of livestock and poultry. While larger species, such as cattle and horses, are not known to be attacked, bobcats do present a threat to smaller ruminants, such as sheep and goats. According to the National Agricultural Statistics Service, bobcats killed 11,100 sheep in 2004, comprising 4.9% of all sheep predator deaths (41). However, some amount of bobcat predation may be misidentified, as bobcats have been known to scavenge on the remains of livestock kills by other animals (42).

It has been known to kill deer, especially in winter when smaller prey is scarce, or when deer populations become more abundant. One study in the Everglades showed a large majority of kills (33 of 39) were fawns, but prey up to eight times the bobcat's weight could be successfully taken (43). It stalks the deer, often when the deer is lying down, then rushes in and grabs it by the neck before biting the throat, base of the skull, or chest. On the rare occasions a bobcat kills a deer, it eats its fill and then buries the carcass under snow or leaves, often returning to it several times to feed (29).

The bobcat prey base overlaps with that of other midsized predators of a similar ecological niche. Research in Maine has shown little evidence of competitive relationships between the bobcat and

coyote or red fox; separation distances and territory overlap appeared random among simultaneously monitored animals (44). However, other studies have found bobcat populations may decrease in areas with high coyote populations, with the more social inclination of the canid giving them a possible competitive advantage (45). With the Canada lynx, however, the interspecific relationship affects distribution patterns; competitive exclusion by the bobcat is likely to have prevented any further southward expansion of the range of its felid relative (6).

Reproduction and life cycle

The average Bobcat lifespan is 7 years long and rarely exceeds 10 years. The oldest wild Bobcat on record was 16 years old, and the oldest captive Bobcat lived to be 32 (35). Bobcats generally begin breeding by their second summer, though females may start as early as their first year. Sperm production begins each year by September or October, and the male will be fertile into the summer. A dominant male will travel with a female and mate with her several times, generally from winter until early spring; this varies by location, but most mating takes place during February and March. The pair may undertake a number of different behaviors, including bumping, chasing, and ambushing. Other males may be in attendance, but remain uninvolved. Once the male recognizes the female is receptive, he grasps her in the typical felid neck grip and mates with her. The female may later go on to mate with other males (29), and males will generally mate with several females (46). During courtship, the otherwise silent bobcat may let out loud screams, hisses, or other sounds (47). Research in Texas has suggested establishing a home range is necessary for breeding; studied animals with no set range had no identified offspring (32). The female has an estrous cycle of 44 days, with the estrus lasting five to ten days. Bobcats remain reproductively active throughout their lives (14), (46).

The female raises the young alone. One to six, but usually two to four, kittens are born in April or May, after roughly 60 to 70 days of gestation. Sometimes a second litter is born as late as September. The female generally gives birth in an enclosed space, usually a small cave or hollow log. The young open their eyes by the ninth or tenth day. They start exploring their surroundings at four weeks and are weaned at about two months. Within three to five months, they begin to travel with their mother (47). They will be hunting by themselves by fall of their first year, and usually disperse shortly thereafter (29). In Michigan, however, they have been observed staying with their mother as late as the next spring (46).

Tracks

Bobcat tracks show four toes without claw marks, due to their retractable claws. The tracks can range in size from 1 to 3 in (2.5 to 7.6 cm); the average is about 1.8 inches (48). When walking or trotting, the tracks are spaced roughly 8 to 18 in (20 to 46 cm) apart. The bobcat can make great strides when running, often from 4 to 8 ft (1.2 to 2.4 m) (49). Like all cats, the bobcat 'directly registers', meaning its hind prints usually fall exactly on top of its fore prints. Bobcat tracks can be generally distinguished from feral or house cat tracks by their larger size: about 2.0 in^2 (13 cm^2) versus 1.5 in^2 (10 cm^2) (50).

Ecology

The adult bobcat has few predators other than humans, although it may be killed in interspecific conflict. Cougars and gray wolves will kill adult bobcats, a behavior repeatedly observed in Yellowstone National Park (51). Coyotes have killed adult bobcats and kittens (52), (53), (54). There is at least one confirmed observation of a bobcat and an American black bear *(Ursus americanus)* fighting over a carcass (55). Bobcat remains have occasionally been found in the resting sites of male fishers (56).

Kittens may be taken by several predators, including owls, eagles, and foxes, as well as other adult male bobcats; when prey populations are not abundant, fewer kittens are likely to reach adulthood. Golden eagles (*Aquila chrysaetos*) have been reportedly observed preying on adult bobcats (57).

Diseases, accidents, hunters, automobiles, and starvation are the other leading causes of death. Juveniles show high mortality shortly after leaving their mothers, while still perfecting their hunting techniques. One study of 15 bobcats showed yearly survival rates for both sexes averaged 0.62, in line with other research suggesting rates of 0.56 to 0.67 (58). Cannibalism has been reported; kittens may be taken when prey levels are low, but this is very rare and does not much influence the population (35).

The bobcat may have external parasites, mostly ticks and fleas, and will often carry the parasites of its prey, especially those of rabbits and squirrels. Internal parasites (endoparasites) are especially

common in bobcats (59). One study found an average infection rate of 52% from *Toxoplasma gondii*, but with great regional variation (60). One mite in particular, *Lynxacarus morlani*, has to date been found only on the bobcat. Parasites' and diseases' role in the mortality of the bobcat is still unclear, but they may account for greater mortality than starvation, accidents, and predation (35).

Distribution and habitat

The species' range does not seem to be limited by human populations, as long as it can still find a suitable habitat. The bobcat is an adaptable animal. It prefers woodlands—deciduous, coniferous, or mixed—but unlike the other *Lynx* species, it does not depend exclusively on the deep forest. It ranges from the humid swamps of Florida to desert lands of Texas or rugged mountain areas. It will make its home near agricultural areas, if rocky ledges, swamps, or forested tracts are present; its spotted coat serves as camouflage (29). The population of the bobcat depends primarily on the population of its prey; other principal factors in the selection of habitat type include protection from severe weather, availability of resting and den sites, dense cover for hunting and escape, and freedom from disturbance (10).

The bobcat's range does not seem to be limited by human populations, as long as it can find a suitable habitat; only large, intensively cultivated tracts are unsuitable for the species (27). The animal may appear in back yards in "urban edge" environments, where human development intersects with natural habitats (61). If chased by a dog, it will usually climb up a tree (29).

The historical range of the bobcat was from southern Canada, throughout the United States, and as far south as the Mexican state of Oaxaca, and it still persists across much of this area. Range maps typically show a pocket of territory in the US Midwest and parts of the Northeast, where it is no longer thought to exist, including southern Minnesota, eastern South Dakota and much of Missouri, mostly due to habitat changes from modern agricultural practices (14), (27), (29). While thought to no longer exist in western New York and Pennsylvania, multiple confirmed sightings of bobcats (including dead specimens) have been recently reported in New York's Southern Tier and in central New York (62). In addition, bobcat sightings have been confirmed in northern Indiana, and one was recently killed near Albion, Michigan (63). In early March, 2010, a bobcat was sighted (and later captured by animal control authorities) in a parking garage in downtown Houston, TX (64). In August and September, 2010, a number of sightings were reported in the Houston suburbs of Pearland and Friendswood.

Its population in Canada is limited due to both snow depth and the presence of the Canadian lynx. The bobcat does not tolerate deep snow, and will wait out heavy storms in sheltered areas (65); it lacks the large, padded feet of the Canadian lynx and cannot support its weight on snow as efficiently. The bobcat is not entirely at a disadvantage where its range meets that of the larger felid: displacement of the Canadian lynx by the aggressive bobcat has been observed where they interact in Nova Scotia, while the clearing of coniferous forests for agriculture has led to a northward retreat of the Canadian lynx's range to the advantage of the bobcat (27). In northern and central Mexico, the cat is found in dry scrubland and forests of pine and oak; its range ends at the tropical southern portion of the country (27).

Conservation

The bobcat population has seen decline in the American Midwest, but is generally stable and healthy It is listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (66), which means it is not considered threatened with extinction, but hunting and trading must be closely monitored. The animal is regulated in all three of its range countries, and is found in a number of protected areas of the United States, its principal territory (27). Estimates from the US Fish and Wildlife Service placed bobcat numbers between 700,000 and 1,500,000 in the US in 1988, with increased range and population density suggesting even greater numbers in subsequent years; for these reasons, the U.S. has petitioned CITES to remove the cat from Appendix II (10). Populations in Canada and Mexico remain stable and healthy. The IUCN lists it as a species of "least concern", noting it is relatively widespread and abundant, but information from southern Mexico is poor (2). The species is considered endangered in Ohio, Indiana, and New Jersey. It was removed from the threatened list of Illinois in 1999 and of Iowa in 2003. In Pennsylvania, limited hunting and trapping are once again allowed, after having been banned from 1970 to 1999. The bobcat also suffered population decline in New Jersey at the turn of the 19th century, mainly because of commercial and agricultural developments causing habitat fragmentation; by 1972, the bobcat was given full legal protection, and was listed as endangered in the state in 1991 (14). *L. r. escuinipae*, the

subspecies found in Mexico, was for a time considered endangered by the US Fish and Wildlife Service, but was delisted in 2005 (67).

The bobcat has long been valued both for fur and sport; it has been hunted and trapped by humans, but has maintained a high population, even in the southern United States, where it is extensively hunted. In the 1970s and 1980s, an unprecedented rise in price for bobcat fur caused further interest in hunting, but by the early 1990s, prices had dropped significantly (68). Regulated hunting still continues, with half of mortality of some populations being attributed to this cause. As a result, the rate of bobcat deaths is skewed in winter, when hunting season is generally open (35).

Urbanization can result in the fragmentation of contiguous natural landscapes into patchy habitat within an urban area. Animals that live in these fragmented areas often have reduced movement between the habitat patches, which can lead to reduced gene flow and pathogen transmission between patches. Animals such as the bobcat are particularly sensitive to fragmentation because of their large home ranges (69). A study in coastal Southern California has shown bobcat populations are affected by urbanization, creation of roads, and other developments. The populations may not be declining as much as predicted, but instead the connectivity of different populations is affected. This leads to a decrease in natural genetic diversity among bobcat populations (70). For bobcats, preserving open space in sufficient quantities and quality is necessary for population viability. Educating local residents about the animals is critical, as well, for conservation in urban areas (71).

In mythology

In Native American mythology, the bobcat is often twinned with the figure of the coyote in a theme of duality (72). Lynx and coyote are associated with the fog and wind, respectively—two elements representing opposites in Amerindian folklore. This basic story, in many variations, is found in the native cultures of North America (with parallels in South America), but they diverge in the telling. One version, which appears in the Nez Perce folklore for instance, depicts lynx and coyote as opposed, antithetical beings (73). However, another version depicts them with equality and identicality. Claude Lévi-Strauss argues the former concept, that of twins representing opposites, is an inherent theme in New World mythologies, but they are not equally balanced figures, representing an open-ended dualism rather than the symmetric duality of Old World cultures. The latter notion then, Lévi-Strauss suggests, is the result of regular contact between Europeans and native cultures. Additionally, the version found in the Nez Perce story is of much greater complexity, while the version of equality seems to have lost the tale's original meaning (74).

In a Shawnee tale, the bobcat is outwitted by a rabbit, which gives rise to its spots. After trapping the rabbit in a tree, the bobcat is persuaded to build a fire, only to have the embers scattered on its fur, leaving it singed with dark brown spots (75). The Mohave believed dreaming habitually of beings or objects would afford them their characteristics as supernatural powers. Dreaming of two deities, cougar and lynx, they thought, would grant them the superior hunting skills of other tribes (76). European settlers to the Americas also admired the cat, both for its ferocity and its grace, and in the United States, it "rests prominently in the anthology of ... national folklore" (77).

BOBCAT
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This concludes the Wikipedia file, https://en.wikipedia.org/wiki/Bobcat.

APPENDIX 2: COUGAR

Glen Mellin
Lenny Truitt

March 2016

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OUR SUMMARY

This appendix identifies aspects of the Cougar (*Puma concolor*), which we feel are important to the discussion of the prehistoric and historic landscape interplay between humans and this four-legged tactical predator in Delaware and the Mid-Atlantic region. Linnaeus first described the Cougar in 1771, as follows:

Kingdom: Animalia
Phylum: Chordata
Class: Mamalia
Order: Carnivora
Family: Felidae
Genus: *Puma*
Species: *P. concolor*

Six subspecies of Cougar are widely recognized, one in North American and five in Latin America. Additionally, the Florida Panther (first described by Bangs in 1899) (*P. concolor coryi*) making a seventh subspecies, but the validity of that designation remains contested, see below:

- Argentine cougar (*Puma concolor cabrerae*) Pocock, 1940:
  includes the previous subspecies and synonyms *hudsonii* and *puma*
- Costa Rican cougar (*P. c. costaricensis*) Merriam, 1901
- Eastern South American cougar (*P. c. anthonyi*) Nelson and Goldman, 1931:
  includes the previous subspecies and synonyms *acrocodia*, *borbensis*, *capricornensis*, *concolor*, *greeni*, and *nigra*
- North American cougar (*P. c. couguar*) Kerr, 1792:
  includes the previous subspecies and synonyms *arundivaga*, *aztecus*, *browni*, *californica*, *floridana*, *hippolestes*, *improcera*, *kaibabensis*, *mayensis*, *missoulensis*, *olympus*, *oregonensis*, *schorgeri*, *stanleyana*, *vancouverensis*, and *youngi*
- Northern South American cougar (*P. c. concolor*) Linnaeus, 1771:
  includes the previous subspecies and synonyms *bangsi*, *incarum*, *osgoodi*, *soasoaranna, sussuarana*, *soderstromii*, *suçuaçuara*, and *wavula*
- Southern South American cougar (*P. c. puma*) Molina, 1782:
  includes the previous subspecies and synonyms *araucanus*, *concolor*, *patagonica*, *pearsoni*, and *puma*

Incerta sedis (uncertain placement)

- Florida panther (*P. c. coryi*)

We are confident to say, the Cougar, also known as *P. concolor couguar* (Kerr, 1792) is the only big cat that may have dwelled in Delaware and the Mid-Atlantic region during the last 10,000 years. See also the Bobcat (a much smaller cat) that dwelled in this region. Evidence of these large cats recovered in archaeological contexts would have direct bearing on the landscape relationships between humans and these four-legged tactical predators.

In constructing this Appendix, we reviewed several dozen documents, (essays, books, contracted reports, professional papers, Internet sites, etc.). For the purpose of our essay, the Cougar Wikipedia file establishes a reasonable and sufficient background. We decided to include a portion of the Cougar Wikipedia file with complete references cited. We closely reviewed, edited, and re-formatted the contents of the open-source Wikipedia file to make a good fit with our research topic.

The following document is a portion of Cougar Internet Wikipedia file together with the Wikipedia file references cited. We closely reviewed, edited, and re-formatted the contents of the open-source Wikipedia file to make a good fit with our research topic. The full Wikipedia document can be found and downloaded at https://en.wikipedia.org/wiki/Cougar.

Introduction

The **cougar** (*Puma concolor*), also commonly known as the **mountain lion**, **puma**, **panther**, or **catamount**, is a large felid of the subfamily Felinae native to the Americas. Its range, from the Canadian Yukon to the southern Andes of South America, is the greatest of any large wild terrestrial mammal in the Western Hemisphere (3). An adaptable, generalist species, the cougar is found in most American habitat types. It is the second-heaviest cat in the New World, after the jaguar. Secretive and largely solitary by nature, the cougar is properly considered both nocturnal and crepuscular, although sightings during daylight hours do occur (4), (5), (6), (7). The cougar is more closely related to smaller felines, including the domestic cat (subfamily Felinae), than to any species of subfamily Pantherinae (1), (8), (9), of which only the jaguar is native to the Americas.

The cougar is an ambush predator and pursues a wide variety of prey. Primary food sources are ungulates, particularly deer, but also livestock. It also hunts species as small as insects and rodents. This cat prefers habitats with dense underbrush and rocky areas for stalking, but can also live in open areas. The cougar is territorial and survives at low population densities. Individual territory sizes depend on terrain, vegetation, and abundance of prey. While large, it is not always the apex predator in its range, yielding to the jaguar, gray wolf, American black bear, and grizzly bear. It is reclusive and mostly avoids people. Fatal attacks on humans are rare, but in North America have been increasing in recent years as more people enter their territories (10).

Prolific hunting following European colonization of the Americas and the ongoing human development of cougar habitat has caused populations to drop in most parts of its historical range. In particular, the cougar was extirpated in eastern North America in the beginning of the 20th century, except for an isolated Florida panther subpopulation. Breeding populations have moved east into the far western parts of the Dakotas, Nebraska, and Oklahoma. Transient males have been verified in Minnesota (11), Missouri (12), Wisconsin (13), Iowa (14), (15), the Upper Peninsula of Michigan, and Illinois, where a cougar was shot in the city limits of Chicago (16), (17), (18) and, in at least one instance, observed as far east as coastal Connecticut (19), (20). Reports of eastern cougars *(P. c. cougar)* still surface, although it was declared extirpated in 2011 (21).

Naming and etymology

With its vast range across the length of the Americas, *P. concolor* has dozens of names and various references in the mythology of the indigenous Americans and in contemporary culture. Currently, it is referred to as "puma" by most scientists (22) and by the populations in 21 of the 23 countries in the Americas where "puma" is the common name in Spanish or Portuguese (23). The cat has many local or regional names in the United States and Canada, of which cougar, puma, mountain lion, and panther are popular (24). "Mountain lion" was a term first used in writing in 1858 from the diary of George A. Jackson of Colorado (25). Other names include catamount (probably a contraction from "cat of the mountain"), mountain screamer, and painter. Lexicographers regard painter as a primarily upper-Southern US regional variant on panther (26). The word panther is commonly used to specifically designate the black panther, a melanistic jaguar or leopard, and the Florida panther, a subspecies of cougar (*P. c. coryi*).

P. concolor holds the Guinness record for the animal with the greatest number of names, over 40 in English alone (27). "Cougar" may be borrowed from the archaic Portuguese *çuçuarana*; the term was originally derived from the Tupi language *susua'rana*, meaning "similar to deer (in hair color)". A current form in Brazil is *suçuarana*. It may also be borrowed from the Guaraní language term *guaçu ara* or *guazu ara*. Less common Portuguese terms are *onça-parda* (brown *onça*, in distinction of the black-spotted [yellow] one, *onça-pintada*, the jaguar) or *leão-baio* (lit. chestnut lion), or unusually non-native *puma* or *leão-da-montanha*, more common names for the animal when native to a region other than South America (especially for those who do not know that *suçuaranas* are found elsewhere but with a different name). People in rural regions often refer to both the cougar and the jaguar as simply *gata* (she-cat), and outside of the Amazon, both are colloquially referred to as simply *onça* by many people (that is also a name for the leopard in Angola).

In the 17th century, German naturalist Georg Marcgrave named the cat the *cuguacu ara*. Marcgrave's rendering was reproduced by his associate, Dutch naturalist Willem Piso, in 1648. *Cuguacu ara* was then adopted by English naturalist John Ray in 1693 (28). The French naturalist Georges-Louis Leclerc, Comte de Buffon in 1774 (probably influenced by the word "jaguar") converted the *cuguacu ara* to *cuguar*, which was later modified to "cougar" in English (29), (30), (31).

The first English record of "puma" was in 1777, where it had come from the Spanish, who in turn borrowed it from the Peruvian Quechua language in the 16th century, where it means "powerful" (32).

Taxonomy and evolution

Although large, the cougar is more closely related to smaller felines than to other big cats. Cougars are the largest of the small cats. They are placed in the subfamily Felinae, although their bulk characteristics are similar to those of the big cats in the subfamily Pantherinae (1). The family Felidae is believed to have originated in Asia about 11 million years ago. Taxonomic research on felids remains partial, and much of what is known about their evolutionary history is based on mitochondrial DNA analysis (33), as cats are poorly represented in the fossil record (34), and significant confidence intervals exist with suggested dates. In the latest genomic study of the Felidae, the common ancestor of today's *Leopardus*, *Lynx*, *Puma*, *Prionailurus*, and *Felis* lineages migrated across the Bering land bridge into the Americas 8.0 to 8.5 million years ago (Mya). The lineages subsequently diverged in that order (34). North American felids then invaded South America 3 Mya as part of the Great American Interchange, following formation of the Isthmus of Panama. The cougar was originally thought to belong in *Felis* (*Felis concolor*), the genus which includes the domestic cat. As of 1993, it is now placed in *Puma* along with the jaguarundi, a cat just a little more than a tenth its weight.

The cougar and jaguarundi are most closely related to the modern cheetah of Africa and western Asia (34), (35), but the relationship is unresolved. The cheetah lineage is suggested by some studies to have diverged from the *Puma* lineage in the Americas (see American cheetah) and migrated back to Asia and Africa (34), (35), while other research suggests the cheetah diverged in the Old World itself (36). The outline of small feline migration to the Americas is thus unclear.

A high level of genetic similarity has been found among North American cougar populations, suggesting they are all fairly recent descendants of a small ancestral group. Culver *et al.* propose the original North American population of *P. concolor* was extirpated during the Pleistocene extinctions some 10,000 years ago, when other large mammals, such as *Smilodon*, also disappeared. North America was then repopulated by a group of South American cougars (35).

Subspecies

Until the late 1980s, as many as 32 subspecies were recorded; genetic study of mitochondrial DNA (35) found many of these are too similar to be recognized as distinct at a molecular level. Following the research, the canonical *Mammal Species of the World* (3rd ed.) recognizes six subspecies, five of which are solely found in Latin America (1):

- Argentine cougar (*Puma concolor cabrerae*) Pocock, 1940:
  includes the previous subspecies and synonyms *hudsonii* and *puma*
- Costa Rican cougar (*P. c. costaricensis*) Merriam, 1901
- Eastern South American cougar (*P. c. anthonyi*) Nelson and Goldman, 1931:
  includes the previous subspecies and synonyms *acrocodia*, *borbensis*, *capricornensis*, *concolor*, *greeni*, and *nigra*
- North American cougar (*P. c. couguar*) Kerr, 1792:
  includes the previous subspecies and synonyms *arundivaga*, *aztecus*, *browni*, *californica*, *floridana*, *hippolestes*, *improcera*, *kaibabensis*, *mayensis*, *missoulensis*, *olympus*, *oregonensis*, *schorgeri*, *stanleyana*, *vancouverensis*, and *youngi*
- Northern South American cougar (*P. c. concolor*) Linnaeus, 1771:
  includes the previous subspecies and synonyms *bangsi*, *incarum*, *osgoodi*, *soasoaranna, sussuarana*, *soderstromii*, *suçuaçuara*, and *wavula*
- Southern South American cougar (*P. c. puma*) Molina, 1782:
  includes the previous subspecies and synonyms *araucanus*, *concolor*, *patagonica*, *pearsoni*, and *puma*
  Incerta sedis
- Florida panther (*P. c. coryi*)

The status of the Florida panther remains uncertain. It is still regularly listed as subspecies *P. c. coryi* in research works, including those directly concerned with its conservation (37). Culver et al. noted low microsatellite variation in the Florida panther, possibly due to inbreeding (35); responding to the research, one conservation team suggests, "the degree to which the scientific community has accepted the results of Culver et al. and the proposed change in taxonomy is not resolved at this time" (35).

Biology and behavior

Physical characteristics

Cougars are slender and agile members of the cat family. They are the fourth-largest cat (39); adults stand about 60 to 90 cm (24 to 35 in) tall at the shoulders (40). Adult males are around 2.4 m (7.9 ft) long nose-to-tail and females average 2.05 m (6.7 ft), with overall ranges between 1.5 to 2.75 m (4.9 to 9.0 ft) nose to tail suggested for the species in general (41), (42). Of this length, 63 to 95 cm (25 to 37 in) is comprised by the tail (43). Males typically weigh 53 to 100 kg (115 to 220 lb), averaging 62 kg (137 lb). Females typically weigh between 29 and 64 kg (64 and 141 lb), averaging 42 kg (93 lb) (43), (44), (45). Cougar size is smallest close to the equator, and larger towards the poles (3). The largest recorded cougar, shot in 1901, weighed 105.2 kg (232 lb); claims of 125.2 kg (276 lb) and 118 kg (260 lb) have been reported, though they were most likely exaggerated (46). On average, adult male cougars in British Columbia weigh 56.7 kg (125 lb) and adult females 45.4 kg (100 lb), though several male cougars in British Columbia weighed between 86.4 and 95.5 kg (190 to 210 lb) (47).

Although cougars somewhat resemble the domestic cat, they are about the same size as an adult human. The head of the cat is round and the ears are erect. Its powerful forequarters, neck, and jaw serve to grasp and hold large prey. It has five retractable claws on its forepaws (one a dewclaw) and four on its hind paws. The larger front feet and claws are adaptations to clutching prey (48).

Cougars can be almost as large as jaguars, but are less muscular and not as powerfully built; where their ranges overlap, the cougar tends to be smaller on average. Besides the jaguar, the cougar is on average larger than all felids apart from lions and tigers. Despite its size, it is not typically classified among the "big cats", as it cannot roar, lacking the specialized larynx and hyoid apparatus of *Panthera* (49). Compared to "big cats", cougars are often silent with minimal communication through vocalizations outside of the mother-offspring relationship (50). Cougars sometimes voice low-pitched hisses, growls, and purrs, as well as chirps and whistles, many of which are comparable to those of domestic cats. They are well known for their screams, as referenced in some of their common names, although these screams are often misinterpreted to be the calls of other animals (51).

Cougar coloring is plain (hence the Latin *concolor*) but can vary greatly between individuals and even between siblings. The coat is typically tawny, but ranges to silvery-grey or reddish, with lighter patches on the underbody, including the jaws, chin, and throat. Infants are spotted and born with blue eyes and rings on their tails (44); juveniles are pale, and dark spots remain on their flanks (42). Despite anecdotes to the contrary, all-black coloring (melanism) has never been documented in cougars (52). The term "black panther" is used colloquially to refer to melanistic individuals of other species, particularly jaguars and leopards (53).

Cougars have large paws and proportionally the largest hind legs in the cat family (44). This physique allows it great leaping and short-sprint ability. The cougar is able to leap as high as 5.5 m (18 ft) in one bound, and as far as 40 to 45 ft (12 to 13.5 m) horizontally (54), (55), (56), (57). The cougar's top running speed ranges between 64 and 80 km/h (40 and 50 mph) (58), (59), but is best adapted for short, powerful sprints rather than long chases. It is adept at climbing, which allows it to evade canine competitors. Although it is not strongly associated with water, it can swim (60).

Hunting and diet

A successful generalist predator, the cougar will eat any animal it can catch, from insects to large ungulates (over 500 kg). Like all cats, it is an obligate carnivore, meaning it needs to feed exclusively on meat to survive. The mean weight of vertebrate prey (MWVP) that pumas attack increases with the puma's body weight; in general, MWVP is lower in areas closer to the equator (3). Its most important prey species are various deer species, particularly in North America; mule deer, white-tailed deer, elk and even bull moose are taken. Other species such as the bighorn and Dall's sheep, horse, fallow deer, caribou, mountain goat, coyote, pronghorn, and domestic livestock such as cattle and sheep are also primary food bases in many areas (61). A survey of North America research found 68% of prey items were ungulates, especially deer. Only the Florida panther showed variation, often preferring feral hogs and armadillos (3).

Cougars are ambush predators, feeding mostly on deer and other mammals. Investigation in Yellowstone National Park showed that elk, followed by mule deer, were the cougar's primary targets; the prey base is shared with the park's gray wolves, with which the cougar competes for resources (62). Another study on winter kills (November–April) in Alberta showed that ungulates accounted for greater than 99% of the cougar diet. Learned, individual prey recognition was observed, as some cougars rarely killed bighorn sheep, while others relied heavily on the species (63).

In Pacific Rim National Park Reserve, scat samples showed raccoons to make up 28% of the cougar's diet, harbor seals and blacktail deer 24% each, North American river otters 10%, California sea lion 7%, and American mink 4%; the remaining 3% were unidentified (64).
In the Central and South American cougar range, the ratio of deer in the diet declines. Small to mid-sized mammals are preferred, including large rodents such as the capybara. Ungulates accounted for only 35% of prey items in one survey, about half that of North America. Competition with the larger jaguar has been suggested for the decline in the size of prey items (3). Other listed prey species of the cougar include mice, porcupines, beavers, raccoons, hares, guanaco, peccary, vicuna, rhea, and wild turkey (65). Birds and small reptiles are sometimes preyed upon in the south, but this is rarely recorded in North America (3). Not all of their prey is listed here due to their large range.

Though capable of sprinting, the cougar is typically an ambush predator. It stalks through brush and trees, across ledges, or other covered spots, before delivering a powerful leap onto the back of its prey and a suffocating neck bite. The cougar is capable of breaking the neck of some of its smaller prey with a strong bite and momentum bearing the animal to the ground (48).

Kills are generally estimated around one large ungulate every two weeks. The period shrinks for females raising young, and may be as short as one kill every three days when cubs are nearly mature around 15 months (44). The cat drags a kill to a preferred spot, covers it with brush, and returns to feed over a period of days. The cougar is generally reported to not be a scavenger, and rarely consumes prey it has not killed, but deer carcasses left exposed for study were scavenged by cougars in California, suggesting more opportunistic behavior (66).

Reproduction and life cycle
Females reach sexual maturity between one-and-a-half to three years of age. They typically average one litter every two to three years throughout their reproductive lives (67), though the period can be as short as one year (44). Females are in estrus for about 8 days of a 23-day cycle; the gestation period is approximately 91 days (44). Females are sometimes reported as monogamous (68), but this is uncertain and polygyny may be more common (69). Copulation is brief but frequent. Chronic stress can result in low reproductive rates when in captivity as well as in the field (70).

Only females are involved in parenting. Female cougars are fiercely protective of their cubs, and have been seen to successfully fight off animals as large as Grizzly bears in their defense. Litter size is between one and six cubs; typically two. Caves and other alcoves that offer protection are used as litter dens. Born blind, cubs are completely dependent on their mother at first, and begin to be weaned at around three months of age. As they grow, they begin to go out on forays with their mother, first visiting kill sites, and after six months beginning to hunt small prey on their own (67). Kitten survival rates are just over one per litter (44). When cougars are born, they have spots, but they lose them as they grow, and by the age of 2 1/2 years, they will completely be gone (71).

Young adults leave their mother to attempt to establish their own territory at around two years of age and sometimes earlier; males tend to leave sooner. One study has shown high mortality amongst cougars that travel farthest from the maternal range, often due to conflicts with other cougars (intraspecific competition) (67). Research in New Mexico has shown that "males dispersed significantly farther than females, were more likely to traverse large expanses of non-cougar habitat, and were probably most responsible for nuclear gene flow between habitat patches" (72).

Life expectancy in the wild is reported at eight to 13 years, and probably averages eight to 10; a female of at least 18 years was reported killed by hunters on Vancouver Island (44). Cougars may live as long as 20 years in captivity. One male North American cougar (*P. c. couguar*), named Scratch, was two months short of his 30th birthday when he died in 2007 (73). Causes of death in the wild include disability and disease, competition with other cougars, starvation, accidents, and, where allowed,

human hunting. Feline immunodeficiency virus, an endemic HIV-like virus in cats, is well-adapted to the cougar (74).

Social structure and home range

Like almost all cats, the cougar is a solitary animal. Only mothers and kittens live in groups, with adults meeting only to mate. It is secretive and crepuscular, being most active around dawn and dusk. Estimates of territory sizes vary greatly. *Canadian Geographic* reports large male territories of 150 to 1000 km² (58 to 386 sq mi) with female ranges half the size (68). Other research suggests a much smaller lower limit of 25 km² (10 sq mi), but an even greater upper limit of 1300 km² (500 sq mi) for males (67). In the United States, very large ranges have been reported in Texas and the Black Hills of the northern Great Plains, in excess of 775 km² (300 sq mi) (75). Male ranges may include or overlap with those of females but, at least where studied, not with those of other males, which serves to reduce conflict between cougars. Ranges of females may overlap slightly with each other. Scrape marks, urine, and feces are used to mark territory and attract mates. Males may scrape together a small pile of leaves and grasses and then urinate on it as a way of marking territory (60).

Home range sizes and overall cougar abundance depend on terrain, vegetation, and prey abundance (67). One female adjacent to the San Andres Mountains, for instance, was found with a large range of 215 km² (83 sq mi), necessitated by poor prey abundance (72). Research has shown cougar abundances from 0.5 animals to as much as 7 (in one study in South America) per 100 km² (38 sq mi) (44).

Because males disperse farther than females and compete more directly for mates and territory, they are most likely to be involved in conflict. Where a subadult fails to leave his maternal range, for example, he may be killed by his father (75). When males encounter each other, they hiss, spit, and may engage in violent conflict if neither backs down (69). Hunting or relocation of the cougar may increase aggressive encounters by disrupting territories and bringing young, transient animals into conflict with established individuals (76).

Ecology

Distribution and habitat

The cougar has the largest range of any wild land animal in the Americas. Its range spans 110 degrees of latitude, from northern Yukon in Canada to the southern Andes. Its wide distribution stems from its adaptability to virtually every habitat type: it is found in all forest types, as well as in lowland and mountainous deserts. The cougar prefers regions with dense underbrush, but can live with little vegetation in open areas (2). Its preferred habitats include precipitous canyons, escarpments, rim rocks, and dense brush (60).

The cougar was extirpated across much of its eastern North American range (with the exception of Florida) in the two centuries after European colonization, and faced grave threats in the remainder of its territory. Currently, it ranges across most western American states, the Canadian provinces of Alberta, Saskatchewan and British Columbia, and the Canadian territory of Yukon. There have been widely debated reports of possible recolonization of eastern North America (77). DNA evidence has suggested its presence in eastern North America (78), while a consolidated map of cougar sightings shows numerous reports, from the mid-western Great Plains through to eastern Canada (79). The Quebec wildlife services (known locally as MRNF) also considers cougar to be present in the province as a threatened species after multiple DNA tests confirmed cougar hair in lynx mating sites (80). The only unequivocally known eastern population is the Florida panther, which is critically endangered. There have been unconfirmed sightings in Elliotsville Plantation, Maine (north of Monson); and in New Hampshire, there have been unconfirmed sightings as early as 1997 (81). In 2009, the Michigan Department of Natural Resources confirmed a cougar sighting in Michigan's Upper Peninsula (82). Typically, extreme-range sightings of cougars involve young males, which can travel great distances to establish ranges away from established males; all four confirmed cougar kills in Iowa since 2000 involved males (83).

On April 14, 2008, police shot and killed a cougar on the north side of Chicago, Illinois. DNA tests were consistent with cougars from the Black Hills of South Dakota. Less than a year later, on March 5, 2009, a cougar was photographed and unsuccessfully tranquilized by state wildlife biologists in a tree near Spooner, Wisconsin, in the northwestern part of the state (84).

Other eastern sightings since 2010 have occurred in locations such as Greene County, Indiana (85), Greenwich (86) and Milford, Connecticut (87), Morgan County (88), Pike County (89), and Whiteside County, Illinois (90), and Bourbon County, Kentucky (91).

South of the Rio Grande, the International Union for the Conservation of Nature and Natural Resources (IUCN) lists the cat in every Central and South American country (2). While specific state and provincial statistics are often available in North America, much less is known about the cat in its southern range (92).

The cougar's total breeding population is estimated at less than 50,000 by the IUCN, with a declining trend (2). US state-level statistics are often more optimistic, suggesting cougar populations have rebounded. In Oregon, a healthy population of 5,000 was reported in 2006, exceeding a target of 3,000 (93). California has actively sought to protect the cat and a similar number of cougars has been suggested, between 4,000 and 6,000 (94).

In 2012 research in Río Los Cipreses National Reserve, Chile, based in 18 motion-sensitive cameras counted a population of two males and two females, one of them with at least two cubs, in an area of 600 km^2, that is 0.63 cougars every 100 km^2 (95).

Ecological role

An adult paw print is approximately 10 cm (4 inches) long (96). Aside from humans, no species preys upon mature cougars in the wild, although conflicts with other predators or scavengers occur. The Yellowstone National Park ecosystem provides a fruitful microcosm to study inter-predator interaction in North America. Of the three large predators, the massive grizzly bear appears dominant, often although not always able to drive both the gray wolf pack and the cougar off their kills. One study found that American black bears visited 24% of cougar kills in Yellowstone and Glacier National Parks, usurping 10% of carcasses. Bears gained up to 113%, and cougars lost up to 26%, of their respective daily energy requirements from these encounters (97). Accounts of cougars and black bears killing each other in fights to the death have been documented from the 19th century (98), (99). In spite of the size and power of the cougar, there have also been accounts of both brown and black bears killing cougars, either in disputes or in self-defense (100), (101).

The gray wolf and the cougar compete more directly for prey, especially in winter. Wolves can steal kills and occasionally kill the cat. One report describes a large pack of 7 to 11 wolves killing a female cougar and her kittens (102). Conversely, lone female or young wolves are vulnerable to predation, and have been reported ambushed and killed by cougars (103). Various accounts of cougars killing lone wolves, including a six-year-old female, have also been documented (104), (105), (106). Wolves more broadly affect cougar population dynamics and distribution by dominating territory and prey opportunities, and disrupting the feline's behavior. Preliminary research in Yellowstone, for instance, has shown displacement of the cougar by wolves (107). In nearby Sun Valley, Idaho, a cougar/wolf encounter that resulted in the death of the cougar was documented (108). One researcher in Oregon noted: "When there is a pack around, cougars are not comfortable around their kills or raising kittens ... A lot of times a big cougar will kill a wolf, but the pack phenomenon changes the table" (109). Both species, meanwhile, are capable of killing mid-sized predators, such as bobcats and coyotes, and tend to suppress their numbers (62). Although cougars can kill coyotes, the latter have been documented attempting to prey on cougar cubs (110).

In the southern portion of its range, the cougar and jaguar share overlapping territory (111). The jaguar tends to take larger prey and the cougar smaller where they overlap, reducing the cougar's size and also further reducing the likelihood of direct competition (3). Of the two felines, the cougar appears best able to exploit a broader prey niche and smaller prey (112).

As with any predator at or near the top of its food chain, the cougar impacts the population of prey species. Predation by cougars has been linked to changes in the species mix of deer in a region. For example, a study in British Columbia observed that the population of mule deer, a favored cougar prey, was declining while the population of the less frequently preyed-upon white-tailed deer was increasing (113). The Vancouver Island marmot, an endangered species endemic to one region of dense cougar population, has seen decreased numbers due to cougar and gray wolf predation (114). Nevertheless, there is a measurable effect on the quality of deer populations by puma predation (115), (116). In the southern part of South America, the puma is a top level predator that has controlled the population of guanaco and other species since prehistoric times (117).

Pumapard hybrids
A pumapard is a hybrid animal resulting from a union between a cougar and a leopard. Three sets of these hybrids were bred in the late 1890s and early 1900s by Carl Hagenbeck at his animal park in Hamburg, Germany. Most did not reach adulthood. One of these was purchased in 1898 by Berlin Zoo. A similar hybrid in Berlin Zoo purchased from Hagenbeck was a cross between a male leopard and a female puma. Hamburg Zoo's specimen was the reverse pairing, the one in the black-and-white photo, fathered by a puma bred to an Indian leopardess.

Whether born to a female puma mated to a male leopard, or to a male puma mated to a female leopard, pumapards inherit a form of dwarfism. Those reported grew to only half the size of the parents. They have a puma-like long body (proportional to the limbs, but nevertheless shorter than either parent), but short legs. The coat is variously described as sandy, tawny or greyish with brown, chestnut or "faded" rosettes (118).

Conservation status
The World Conservation Union (IUCN) currently lists the cougar as a "least concern" species. The cougar is regulated under Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (119), rendering illegal international trade in specimens or parts.

Cougar conservation depends on preservation of its habitat. In the United States east of the Mississippi River, the only unequivocally known cougar population is the Florida panther. Until 2011, the United States Fish and Wildlife Service (USFWS) recognized both an Eastern cougar (claimed to be a subspecies by some, denied by others) (120), (121) and the Florida panther, affording protection under the Endangered Species Act (122), (123). Certain taxonomic authorities have collapsed both designations into the North American cougar, with Eastern or Florida subspecies not recognized (1), while a subspecies designation remains recognized by some conservation scientists (37). In 2003 the documented count for the Florida sub-population was 87 individuals (124). In March 2011, the USFWS declared the Eastern cougar extinct. With the taxonomic uncertainty about its existence as a subspecies as well as the possibility of eastward migration of cougars from the western range, the subject remains open (125).

This uncertainty has been recognized by Canadian authorities. The Canadian federal agency called Committee on the Status of Endangered Wildlife in Canada rates its current data as "insufficient" to draw conclusions regarding the eastern cougar's survival, and says on its Web site "Despite many sightings in the past two decades from eastern Canada, there are insufficient data to evaluate the taxonomy or assign a status to this cougar." Notwithstanding numerous reported sightings in Ontario, Quebec, New Brunswick and Nova Scotia, it has been said that the evidence is inconclusive: ". . . there may not be a distinct 'eastern' subspecies, and some sightings may be of escaped pets" (126), (127).

The cougar is also protected across much of the rest of its range. As of 1996, cougar hunting was prohibited in Argentina, Brazil, Bolivia, Chile, Colombia, Costa Rica, French Guiana, Guatemala, Honduras, Nicaragua, Panama, Paraguay, Suriname, Venezuela, and Uruguay. The cat had no reported legal protection in Ecuador, El Salvador, and Guyana (44). Regulated cougar hunting is still common in the United States and Canada, although they are protected from all hunting in the Yukon; it is permitted in every U.S. state from the Rocky Mountains to the Pacific Ocean, with the exception of California. Texas is the only state in the United States with a viable population of cougars that does not protect that population in some way. In Texas, cougars are listed as nuisance wildlife and any person holding a hunting or a trapping permit can kill a cougar regardless of the season, number killed, sex or age of the animal (128). Killed animals are not required to be reported to Texas Parks and Wildlife Department. Conservation work in Texas is the effort of a non-profit organization, Balanced Ecology Inc (BEI), as part of their Texas Mountain Lion Conservation Project (129). Cougars are generally hunted with packs of dogs, until the animal is 'treed'. When the hunter arrives on the scene, he shoots the cat from the tree at close range. The cougar cannot be legally killed without a permit in California except under very specific circumstances, such as when a cougar is in act of pursuing livestock or domestic animals, or is declared a threat to public safety (94). Permits are issued when owners can prove property damage on their livestock or pets. For example, multiple dogs have been attacked and killed, sometimes while with the owner. Many attribute this to the protection cougars have from being hunted and are now becoming desensitized to humans; most are removed from the population after the attacks have already occurred. Statistics from the Department of Fish and Game indicate that cougar killings in California have been on the rise since the 1970s with an average of over 112 cats killed per year from

2000 to 2006 compared to six per year in the 1970s. They also state on their website that there is a healthy number of cougars in California. The Bay Area Puma Project aims to obtain information on cougar populations in the San Francisco Bay area and the animals' interactions with habitat, prey, humans, and residential communities (130).

Conservation threats to the species include persecution as a pest animal, environmental degradation and habitat fragmentation, and depletion of their prey base. Wildlife corridors and sufficient range areas are critical to the sustainability of cougar populations. Research simulations have shown that the animal faces a low extinction risk in areas of 2200 km^2 (850 sq mi) or more. As few as one to four new animals entering a population per decade markedly increases persistence, foregrounding the importance of habitat corridors (131). On March 2, 2011, the United States Fish and Wildlife Service declared the Eastern cougar (*Puma concolor couguar*) officially extinct (132).

Relationships with humans

In mythology

The grace and power of the cougar have been widely admired in the cultures of the indigenous peoples of the Americas. The Inca city of Cusco is reported to have been designed in the shape of a cougar, and the animal also gave its name to both Inca regions and people. The Moche people represented the puma often in their ceramics (133). The sky and thunder god of the Inca, Viracocha, has been associated with the animal (134).

In North America, mythological descriptions of the cougar have appeared in the stories of the Hocąk language ("Ho-Chunk" or "Winnebago") of Wisconsin and Illinois (135) and the Cheyenne, amongst others. To the Apache and Walapai of Arizona, the wail of the cougar was a harbinger of death (136). The Algonquins and Ojibwe believe that the cougar lived in the underworld and was wicked, whereas it was a sacred animal among the Cherokee (137).

Livestock predation

During the early years of ranching, cougars were considered on par with wolves in destructiveness. According to figures in Texas in 1990, 86 calves (0.0006% of a total of 13.4 million cattle & calves in Texas), 253 Mohair goats, 302 Mohair kids, 445 sheep (0.02% of a total of 2.0 million sheep & lambs in Texas) and 562 lambs (0.04% of 1.2 million lambs in Texas) were confirmed to have been killed by cougars that year (138), (139). In Nevada in 1992, cougars were confirmed to have killed 9 calves, 1 horse, 4 foals, 5 goats, 318 sheep and 400 lambs. In both cases, sheep were the most frequently attacked. Some instances of surplus killing have resulted in the deaths of 20 sheep in one attack (140). A cougar's killing bite is applied to the back of the neck, head, or throat and they inflict puncture marks with their claws usually seen on the sides and underside of the prey, sometimes also shredding the prey as they hold on. Coyotes also typically bite the throat region but do not inflict the claw marks and farmers will normally see the signature zig-zag pattern that coyotes create as they feed on the prey whereas cougars typically drag in a straight line. The work of a cougar is generally clean, differing greatly from the indiscriminate mutilation by coyotes and feral dogs. The size of the tooth puncture marks also helps distinguish kills made by cougars from those made by smaller predators (141).

Remedial hunting appears to have the paradoxical effect of increased livestock predation and complaints of human-puma conflicts. In a 2013 study the most important predictor of puma problems were remedial hunting of puma the previous year. Each additional puma on the landscape increased predation and human-puma complaints by 5% but each additional animal killed on the landscape the previous year increased complaints by 50%, an order of magnitude higher. The effect had a dose-response relationship with very heavy (100% removal of adult puma) remedial hunting leading to a 150% – 340% increase in livestock and human conflicts (142). This effect is attributed to the fact that inexperienced younger male pumas are most likely to approach human developments, whereas remedial hunting removes older pumas who have learned to avoid people in their established territories. Remedial hunting enables younger males to enter the former territories of the older animals (143), (144).

Attacks on humans

North American subspecies

See also: List of fatal cougar attacks in North America. The pertinent North American subspecies is *P. concolor couguar*. Due to the expanding human population, cougar ranges increasingly overlap with areas inhabited by humans. Attacks on humans are very rare, as cougar prey recognition is a learned behavior and they do not generally recognize humans as prey (10). Attacks on people, livestock, and pets may occur when

a puma habituates to humans or is in a condition of severe starvation. Attacks are most frequent during late spring and summer, when juvenile cougars leave their mothers and search for new territory (96).

Between 1890 and 1990, in North America there were 53 reported, confirmed attacks on humans, resulting in 48 nonfatal injuries and 10 deaths of humans (the total is greater than 53 because some attacks had more than one victim) (145). By 2004, the count had climbed to 88 attacks and 20 deaths (146).

Within North America, the distribution of attacks is not uniform. The heavily populated state of California has seen a dozen attacks since 1986 (after just three from 1890 to 1985), including three fatalities (94). Lightly populated New Mexico reported an attack in 2008, the first there since 1974 (147).

As with many predators, a cougar may attack if cornered, if a fleeing human stimulates their instinct to chase, or if a person "plays dead". Standing still may cause the cougar to consider a person easy prey (148). Exaggerating the threat to the animal through intense eye contact, loud shouting, and any other action to appear larger and more menacing, may make the animal retreat. Fighting back with sticks and rocks, or even bare hands, is often effective in persuading an attacking cougar to disengage (10), (96).

When cougars do attack, they usually employ their characteristic neck bite, attempting to position their teeth between the vertebrae and into the spinal cord. Neck, head, and spinal injuries are common and sometimes fatal (10). Children are at greatest risk of attack, and least likely to survive an encounter. Detailed research into attacks prior to 1991 showed that 64% of all victims – and almost all fatalities – were children. The same study showed the highest proportion of attacks to have occurred in British Columbia, particularly on Vancouver Island where cougar populations are especially dense (145). Preceding attacks on humans, cougars display aberrant behavior, such as activity during daylight hours, a lack of fear of humans, and stalking humans. There have sometimes been incidents of pet cougars mauling people (149), (150).

Research on new wildlife collars may be able to reduce human-animal conflicts by predicting when and where predatory animals hunt. This can not only save human lives and the lives of their pets and livestock but also save these large predatory mammals that are important to the balance of ecosystems (151).

Other subspecies

The puma of the plains of South America (*P. concolor cabrerae* (152), called the Argentine cougar by North Americans) is noted for its extreme unwillingness to attack humans. According to the Anglo-Argentine naturalist William Henry Hudson (153) "It does not attack man, and Azara is perfectly correct when he affirms that it never hurts, or threatens to hurt, man or child, even when it finds them sleeping. This, however, is not a full statement of the facts; the puma will not even defend itself against man". And: "All who have killed or witnessed the killing of the puma--and I have questioned scores of hunters on this point--agree that it resigns itself in this unresisting, pathetic manner to death at the hands of man. Claudio Gay, in his Natural History of Chili, says, "When attacked by man its energy and daring at once forsake it, and it becomes a weak, inoffensive animal, and trembling, and uttering piteous moans, and shedding abundant tears, it seems to implore compassion from a generous enemy". Hudson adds that, except in relation to man, the puma is a ferocious animal, attacking even the much stronger jaguar (153).

PUMA

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APPENDIX 3: COYOTE

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March 2016

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OUR SUMMARY

This appendix identifies aspects of the Coyote (*Canis latrans*), which we feel are important to the discussion of the complex prehistoric and historic landscape interplay between humans and this four-legged tactical predator in Delaware and the Mid-Atlantic region. Say first described the Coyote in 1819, as follows:

Kingdom: Animalia
Phylum: Chordata
Class: Mamalia
Order: Carnivora
Family: Canidae
Genus: *Canis*
Species: *latrans*

Young and Jackson (1951) listed the names of nineteen Coyote subspecies that had been suggested and debated during the nineteenth and twentieth centuries. However, as Nowak (1978) suggests, the taxonomic validity of individual subspecies remains questionable. We cannot predict which subspecie(s) are likely to be found in Delaware and the Mid-Atlantic region. Nevertheless, DNA sequencing from archaeological finds in Delaware and the Mid-Atlantic region may help resolve these issues. (see also, the twentieth century introduction of Coyote DNA admixture in Red wolves in North Carolina through restocking, as well as introduction of Coyote DNA to Eastern wolves in the Algonquin Provincial Park program).

List of nineteen Coyote subspecies discussed:
C. l. latrans (Great Plains region of the U.S. and southern Canada)
C. l. ochropus (west coast of the U.S.)
C. l. cagottis (south-eastern Mexico)
C. l. frustror (parts of Oklahoma, Texas, Missouri, Kansas in the U.S.)
C. l. lestes (intermountain and north-west U.S., south-west Canada)
C. l. mearnsi (south-western U.S., north-western Mexico)
C. l. microdon (north-eastern Mexico, southern Texas in the U.S.)
C. l. peninsulae (Baja California of Mexico)
C. l. vigilis (south-western Mexico)
C. l. clepticus (Baja California of Mexico)
C. l. impavidus (western Mexico)
C. l. goldmani (southern Mexico, Belize, Guatemala)
C. l. texensis (Texas and New Mexico in the U.S.)
C. l. jamesi (Tiburon Island, Baja California of Mexico)
C. l. dickeyi (El Salvador, Honduras, Nicaragua, Costa Rica)
C. l. incolatus (Alaska in the U.S., north-western Canada)
C. l. hondurensis (Honduras)
C. l. thamnos (Great Lakes region of the U.S. and Canada, north central Canada)
C. l. umpquensis (west coast of north-western U.S.)

The Coyote (*Canis latrans*) likely a split-off of the Eurasian Wolf that happen over one million years ago and entered North America during the Pleistocene. Our fundamental understanding is that the Coyote is native to North and Meso- America. Say (1819) did not identify the existence of any subspecies of Coyote in Delaware or the Mid-Atlantic region (in the eastern U.S.) and Coyote was also absent south of Panama (the former northern portion of Columbia). Twentieth century observations include Coyote in the eastern U.S. as well as south of the Panama Canal. The Coyote is an adaptable and opportunistic animal.

The Coyote's appearance is a slender *Canis*, with "a long, narrow, pointed nose; small rounded nose pads; large pointed ears; slender legs; small feet; and a bushy tail..." (Young and Jackson, 1951). Size varies geographically (Young and Jackson, 1951). The Coyote dental formula is 3/ 3-1/1-4/4-2/3=42. The Coyote can mate with various dogs and wolves, but surviving offspring are not naturally ascendant (except in captivity) withstanding the so-called Coywolf, where free-ranging populations are noted. For pre-European

settlement contexts in the Mid-Atlantic Region, some people continue to operate under the assumption there was no native Coyote ranges east of the Appalachian Plateau. Nevertheless, *C. latrans thamnos* is suggested to have opportunistically expanded into Pennsylvania and New York (and further east and south) as a result of European settlement. There were likely many unintended consequences of settler and government programs orchestrated to reduce or extirpate the wolf (and wolf-like predator) population beginning in the late 17th century.

In a synthesis by Vonholdt et al. (2011), an anonymous author (see following block quote) discusses some of the issues we face with the analyzing the actual genomes from individuals and species that are already hybridized through crossbreeding (https://en.wikipedia.org/wiki/Coyote). It is important to note, however, that various levels of genetic mixing "apparently" occurred relatively recently; first, a period of genetic mixing occurred around 1,000 ybp, and second, a period of genetic mixing is associated with European settlement.

> In 2011, an analysis of 48,000 SNP chips in the genomes of various wolf and coyote populations revealed that the eastern wolf (native to Algonquin Provincial Park) and the red wolf (native to North Carolina), both previously labeled as species distinct from the gray wolf, are in fact products of varying degrees of wolf-coyote hybridization. The wolf-coyote admixture resulting in the development of the eastern wolf may have occurred on the order of 600–900 years ago between gray wolves and a now extinct pre-Columbian coyote population. The eastern wolf has since backcrossed extensively with parent gray wolf populations. The red wolf may have originated later, approximately 287–430 years ago, when much of the southeastern U.S. was being converted to agriculture and predators were targeted for extermination. During this period, declining local wolf populations would have been forced to mate with coyotes, with the resulting hybrids backcrossing to coyotes as the wolves disappeared, to the extent that ~75–80% of the modern red wolf's genome is of coyote derivation.

See also: Sillero-Zubiri et al., (2004:81-7)

Sillero-Zubiri, Claudio., Michael Hoffmann, and David W. Macdonald, Eds.
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The above explanation presents LARGE opportunities in developing research questions concerning the history of Native American culture in Delaware and the Mid-Atlantic region. If in fact, there is significant genome mixture in the period 600-900 ybp concerning Coyote and the Eastern Wolf, this adds to the very interesting movement of Gray Fox sweeping into the Mid-Atlantic region and New England in the same (or very similar) time frame (see our appendix on Gray Fox). With the above explanation citing genome mixture in the Red Wolf (ca. 287 to 430 ybp), another opportunity is presented. Does this time frame illustrate Native American change, Spanish exploration, or early European colonization? For addressing this research question, it should be crystal clear that DNA sequencing of pre-contact archaeological remains of these four-legged tactical predators is essential to figure out these very interesting problems.

Finding evidence of Coyote (or any one of the three: Coyote, Eastern Wolf, and Red Wolf) in archaeological contexts would have direct bearing on the landscape relationships between humans and these four-legged tactical predators in Delaware and the Mid-Atlantic region. In constructing this Appendix, we reviewed several dozen documents, (essays, books, contracted reports, professional papers, Internet sites, etc.) For the purpose of our essay we found the Wikipedia file establishes a reasonable and sufficient background. We decided to include portions of the Wikipedia file including complete citations used for that file. We closely reviewed, edited, and re-formatted the contents to make a good fit with our research topic.

The following document is a portion of the Coyote Internet Wikipedia file together with the Wikipedia file references cited. We closely reviewed, edited, and re-formatted the contents of the open-source Wikipedia file to make a good fit with our research topic. The full Wikipedia document can be found and downloaded at: https://en.wikipedia.org/wiki/Coyote.

Introduction

The **coyote** (US /kaɪˈoʊtiː/ or /ˈkaɪ.oʊt/, UK /kɔɪˈjoʊteɪ/, or /kɔɪˈjoʊt/; *Canis latrans*) is a canid native to North America. It is a smaller, more basal animal than its close relative, the gray wolf (2), being roughly the North American equivalent to the Old World golden jackal, though it is larger and more predatory in nature (3). It is listed as "least concern" by the IUCN, on account of its wide distribution and abundance throughout North America, even southwards through Mexico and Central America. It is a highly versatile species, whose range has expanded amidst human environmental modification (1). This expansion is ongoing, and it may one day reach South America, as shown by the animal's presence beyond the Panama Canal in 2013 (4). As of 2005, 19 subspecies are recognized (5).

The ancestors of the coyote diverged from those of the gray wolf, 1–2 million years ago (6), with the modern species arising in North America during the Middle Pleistocene (2). It is highly flexible in social organization, living either in nuclear families or in loosely knit packs of unrelated individuals. It has a varied diet consisting primarily of animal matter, including ungulates, lagomorphs, rodents, birds, reptiles, amphibians, fish, and invertebrates, though it may also eat fruit and vegetable matter on occasion (7). It is a very vocal animal, whose most iconic sound consists of a howl emitted by solitary individuals (8). Humans aside, cougars (9) and gray wolves (10) are the coyote's only serious enemies. Nevertheless, coyotes have on occasion mated with the latter species, producing hybrids colloquially called "coywolves".

The coyote is a prominent character in Native American folklore (Southwestern United States and Mexico), usually depicted as a trickster that alternately assumes the form of an actual coyote or a man. As with other trickster figures, the coyote acts as a picaresque hero which rebels against social convention through deception and humor (11). The animal was especially respected in Mesoamerican cosmology as a symbol of military might (12), with some scholars having traced the origin of the Aztec god Quetzalcoatl to a pre-Aztec coyote deity (13). After the European colonization of the Americas, it was reviled in Anglo-American culture as a cowardly and untrustworthy animal. Unlike the gray wolf, which has undergone a radical improvement of its public image, cultural attitudes towards the coyote remain largely negative (14), (15).

Description

Coyote males average 8–20 kg (18–44 lb) in weight, while females average 7–18 kg (15–40 lb), though size varies geographically. Northern subspecies, which average 18 kg (40 lb), tend to grow larger than the southern subspecies of Mexico, which average 11.5 kg (25 lb). Body length ranges on average from 1.0 to 1.35 m (3 ft 3.37 in to 4 ft 5.15 in), and tail length 40 cm (16 in), with females being shorter in both body length and height (16). The largest coyote on record was a male killed near Afton, Wyoming on November 19, 1937, which measured 1.6 m (5 ft 3 in) from nose to tail, and weighed 33.9 kg (75 lb) (17). Scent glands are located at the upper side of the base of the tail and are a bluish-black color (18).

The color and texture of the coyote's fur varies somewhat geographically (16). The hair's predominant color is light gray and red or fulvous, interspersed around the body with black and white. Coyotes living at high elevations tend to have more black and gray shades than their desert-dwelling counterparts, which are more fulvous or whitish-gray (19). The coyote's fur consists of short, soft underfur and long, coarse guard hairs. The fur of northern subspecies is longer and denser than in southern forms, with the fur of some Mexican and Central American forms being almost hispid (bristly) (20). Albinism is extremely rare in coyotes; out of a total of 750,000 coyotes harvested by federal and cooperative hunters between March 22, 1938, and June 30, 1945, only two were albinos (19).

The coyote is typically smaller than the gray wolf, but has longer ears and a larger braincase (16), as well as a thinner frame, face, and muzzle. The coyote also carries its tail downwards when running or walking, rather than horizontally as the wolf does (21). Coyote tracks can be distinguished from those of dogs by their more elongated, less rounded shape (22). Scent glands are smaller than the gray wolf's, but the same color (18). Its fur color variation is much less varied than that of a wolf.

History
By the time of the European colonization of the Americas, coyotes were largely confined to open plains and arid regions of the western half of the continent (23). It is often difficult in early post-Columbian historical records to distinguish between coyotes and wolves. One record from 1750 in Kaskaskia, Illinois, written by a local priest, noted that the "wolves" encountered there were smaller and less daring than European wolves. Another account from the early 1800s in Edwards County mentioned wolves howling at night, though these were likely coyotes (24). The species was encountered several times during the Lewis and Clark Expedition (1804–1806), though it was already well known to European traders on the upper Missouri. Lewis, writing on May 5, 1805, in northeastern Montana, described the coyote as (25): the small woolf or burrowing dog of the prairies are the inhabitants almost invariably of the open plains; they usually ascociate in bands of ten or twelve sometimes more and burrow near some pass or place much frequented by game; not being able alone to take deer or goat they are rarely ever found alone but hunt in bands; they frequently watch and seize their prey near their burrows; in these burrows they raise their young and to them they also resort when pursued; when a person approaches them they frequently bark, their note being precisely that of the small dog. They are of an intermediate size between that of the fox and dog, very active fleet and delicately formed; the ears large erect and pointed the head long and pointed more like that of the fox; tale long; . . . the hair and fur also resembles the fox tho' is much coarser and inferior. they are of a pale redish brown colour. the eye of a deep sea green colour small and piercing. their tallons [claws] are reather longer than those of the ordinary wolf or that common to the atlantic states, none of which are to be found in this quarter, nor I believe above the river Plat.

The coyote was first scientifically described by Thomas Say in September 1819 on the site of Lewis and Clark's Council Bluffs, 15 miles up the Missouri River from the mouth of the Platte during a government-sponsored expedition with Major Stephen Long. He had the first edition of the Lewis and Clark journals in hand, which contained Biddle's edited version of Lewis's observations dated May 5, 1805 (26), (27).

Naming and etymology
The earliest written reference to the species comes from Francisco Hernández's *Plantas y Animales de la Nueva España* (1651), where it is described as a "Spanish fox" or "jackal". The first published usage of the word "coyote" (the root word of which is the Nahuatl *coyotl* meaning "barking dog") comes from Francisco Javier Clavijero's *Historia de México* in 1780 (28). The first time it was used in English occurred in William Bullock's *Six months' residence and travels in Mexico* (1824), where it is variously transcribed as *cayjotte* and *cocyotie*. The word's spelling was standardized as "coyote" by the 1880s (25), (29). Alternative English names for the coyote include "prairie wolf", "brush wolf", "cased wolf" (30), "little wolf" (7) and "American jackal" (31).

Taxonomy and evolution
The earliest fossil carnivores that can be linked with some certainty to canids are the Eocene miacids, which lived some 38 to 56 million years ago. The miacids later diverged into caniforms and feliforms, with the former line leading to such genera as the coyote-sized *Mesocyon* of the Oligocene (38 to 24 million years ago), the fox-like *Leptocyon*, and the wolf-like *Tomarctus* which inhabited North America some 10 million years ago (47). The coyote represents a more primitive form of *Canis* than the gray wolf, as shown by its relatively small size and its comparatively narrow skull and jaws, which lack the grasping power necessary to hold the large prey in which wolves specialize. This is further corroborated by the coyote's sagittal crest, which is low or totally flattened, thus indicating a weaker bite than the wolf's. The coyote is not a specialized carnivore as the wolf is, as shown by the larger chewing surfaces on the molars, reflecting the species' relative dependence on vegetable matter. In these respects, the coyote resembles the fox-like progenitors of the genus more so than the wolf (2). Modern phylogenetics places the coyote between the gray wolf and golden jackal (48).

The evolution of the coyote is remarkably well documented, and can be traced back in an unbroken line to the Hemphillian *Eucyon davisi* (49). The coyote likely arose from a certain population of the Blancan species *C. lepophagus* which, although similar in weight to modern coyotes, had shorter limb bones, thus indicating a less cursorial lifestyle. Modern coyotes arose during the Middle Pleistocene, and showed much more variation than they do today (2). Compared to their modern Holocene counterparts, Pleistocene coyotes (*C. l. orcutti*) were larger and more robust, likely in response to larger competitors and prey (50). Pleistocene coyotes were likely more specialized carnivores than their descendants, as their teeth were more adapted to shearing meat, showing fewer grinding surfaces

suited for processing vegetation (51). Their reduction in size occurred within 1000 years of the Quaternary extinction event, when their large prey died out (50). Furthermore, Pleistocene coyotes were unable to exploit the big-game hunting niche left vacant after the extinction of the dire wolf, as it was rapidly filled by gray wolves, which likely actively killed off the large coyotes, with natural selection favoring the modern gracile morph (51).

Subspecies

As of 2005 (5), 19 subspecies are recognized. Geographic variation in coyotes is not great, though taken as a whole, the eastern subspecies (*C. l. thamnos* and *C. l. frustor*) are large, dark colored animals, with a gradual paling in color and reduction in size westward and northward (*C. l. texensis*, *C. l. latrans*, *C. l. lestes*, and *C. l. incolatus*), a brightening of ochraceous tones towards the Pacific coast (*C. l. ochropus*, *C. l. umpquensis*), a reduction in size in the southwestern United States (*C. l. microdon*, *C. l. mearnsi*) and a general trend towards dark reddish colors and short muzzles in Mexican and Central American populations (52).

Hybridization

Coyotes have occasionally mated with dogs, sometimes producing crosses capable of work (62). Such matings are rare in the wild, as the mating cycles of dogs and coyotes do not coincide, and coyotes are usually antagonistic towards dogs, with even captive specimens having shown reluctance to mate with them. Hybridization usually only occurs when coyotes are expanding into areas where conspecifics are few, and dogs are the only alternatives. Even then, pup survival rates are lower than normal, as dogs do not form pair bonds with coyotes, thus making the rearing of pups more difficult (63). In captivity, F_1 hybrids tend to be more mischievous and less manageable as pups than dogs, and are less trustworthy on maturity than wolf-dog hybrids (62). Hybrids vary in appearance, but generally retain the coyote's adult sable coat color, dark neonatal coat color, bushy tail with an active supracaudal gland, and white facial mask. F_1 hybrids tend to be intermediate in form between dogs and coyotes, while F_2 hybrids are more varied. Both F_1 and F_2 hybrids resemble their coyote parents in terms of shyness and intrasexual aggression (64). Hybrid play behavior includes the coyote "hip-slam" (65). Hybrids of both sexes are fertile, and can be successfully bred through four generations (62). Melanistic coyotes owe their black pelts to a mutation that first arose in domestic dogs (66). A population of nonalbino white coyotes in Newfoundland owe their coloration to a melanocortin 1 receptor mutation inherited from Golden Retrievers (67).

Coyotes have hybridized with wolves to varying degrees, particularly in the Eastern United States and Canada. The so-called "eastern coyote" of northeastern North America has been confirmed to be of mixed wolf-coyote parentage, and probably originated in the aftermath of the extermination of wolves in the northeast, thus allowing coyotes to colonize former wolf ranges and mix with remnant wolf populations. This hybrid is smaller than the wolf, and holds smaller territories, but is in turn larger and holds more extensive home ranges than the typical western coyote. As of 2010, the eastern coyote's genetic makeup is fairly uniform, with minimal influence from eastern wolves or western coyotes (68). Adult eastern coyotes are larger than western coyotes, weighing an average of 30–40 lb, with female eastern coyotes weighing 21% more than male western coyotes (68), (69). Eastern coyotes also weigh more at birth; while newborn western coyotes weigh 250–300 g, eastern coyotes weigh 349–360 g. By the age of 35 days, eastern coyote pups average 1590 g, 200 g more than western coyotes of similar age. By this time, physical differences become more apparent, with eastern coyote pups having longer legs than their western counterparts. Differences in dental development also occur, with tooth eruption being later, and in a different order in the eastern coyote (70). Aside from its size, the eastern coyote is physically not unlike the western coyote; both have erect ears, a straight and bushy tail, a conspicuous supracaudal gland, and a narrow chest. The four color phases range from dark brown to blond or reddish blond, though the most common phase is gray-brown, with reddish legs, ears, and flanks (71). No significant differences are seen between eastern and western coyotes in expressing aggression and fighting, though eastern coyotes tend to fight less, and are more playful. Unlike western coyote pups, in which fighting precedes play behavior, fighting among eastern coyote pups occurs after the onset of play (70). Eastern coyotes tend to reach sexual maturity at two years of age, much later than in western coyotes (68). In 2011, an analysis of 48,000 single-nucleotide polymorphism chips in the genomes of various wolf and coyote populations revealed that the eastern wolf (native to Algonquin Provincial Park) and the red wolf (native to North Carolina), both previously labeled as species distinct from the gray wolf, are in fact products of varying degrees of wolf-coyote hybridization. The wolf-coyote admixture resulting in the development of the eastern wolf may have occurred on the order of 600–900 years ago between gray wolves and a now-extinct pre-Columbian coyote population. The eastern wolf has since backcrossed extensively with parent gray wolf populations. The red wolf

may have originated later, about 287–430 years ago, when much of the southeastern U.S. was being converted to agriculture and predators were targeted for extermination. During this period, declining local wolf populations would have been forced to mate with coyotes, with the resulting hybrids backcrossing to coyotes as the wolves disappeared, to the extent that about 75–80% of the modern red wolf's genome is of coyote derivation (72).

Behavior

Social and reproductive behaviors

Like the golden jackal, the coyote is gregarious, but not as dependent on conspecifics as more social canid species like wolves are. This is likely because the coyote is not a specialized hunter of large prey as the latter species is (73). The basic social unit of a coyote pack is a nuclear family centered on a reproductive female. However, unrelated coyotes may join forces for companionship, or to bring down prey too large to attack singly. Such "nonfamily" packs are only temporary, and may consist of bachelor males, nonreproductive females and subadult young. Families are formed in midwinter, when females enter estrus (7). Pair bonding can occur 2–3 months before actual copulation takes place (74). A female entering estrus attracts males by scent marking and howling with increasing frequency (31). A single female in heat can attract up to seven reproductive males, which can follow her for as long as a month. Although some squabbling may occur among the males, once the female has selected a mate and copulates, the rejected males do not intervene, and move on once they detect other estrous females (7). Unlike the wolf, which has been known to practice both monogamous and bigamous matings (75), the coyote is strictly monogamous, even in areas with high coyote densities and abundant food (76). Females that fail to mate sometimes assist their sisters or mothers in raising their pups, or join their siblings until the next time they can mate. The newly mated pair then establishes a territory and either constructs their own den or cleans out abandoned badger, marmot, or skunk earths. During the pregnancy, the male frequently hunts alone and brings back food for the female. The female may line the den with dried grass or with fur pulled from her belly (7). The gestation period is 63 days, with an average litter size of six, though the number fluctuates depending on coyote population density and the abundance of food (31).

Coyote pups are born in dens, hollow trees, or under ledges, and weigh 200-500 g at birth. They are altricial, and are completely dependent on milk for their first 10 days. The incisors erupt at about 12 days, the canines at 16, and the second premolars at 21. Their eyes open after 10 days, by which point the pups become increasingly more mobile, walking by 20 days, and running at the age of six weeks. The parents begin supplementing the pup's diet with regurgitated solid food after 12–15 days. By the age of 4–6 weeks, when their milk teeth are fully functional, the pups are given small food items such as mice, rabbits, or pieces of ungulate carcasses, with lactation steadily decreasing after two months (7). Unlike wolf pups, coyote pups begin seriously fighting prior to engaging in play behavior. By 3 weeks of age, coyote pups bite each other with less inhibition than wolf pups. By the age of 4–5 weeks, pups have established dominance hierarchies, and are by then more likely to play rather than fight (77). The male plays an active role in feeding, grooming, and guarding the pups, but abandons them if the female goes missing before the pups are completely weaned. The den is abandoned by June–July, and the pups follow their parents in patrolling their territory and hunting. Pups may leave their families in August, though can remain for much longer. The pups attain adult dimensions at eight months, and gain adult weight a month later (7).

Territorial and sheltering behaviors

Individual feeding territories vary in size from 0.38 to 62 km^2 (0.15 to 23.94 sq mi), with the general concentration of coyotes in a given area depending on food abundance, adequate denning sites, and competition with conspecifics and other predators. The coyote generally does not defend its territory outside of the denning season (7), and is much less aggressive towards intruders than the wolf is, typically chasing and sparring with them, but rarely killing them (78). Conflicts between coyotes can arise during times of food shortage (7).

Like wolves, coyotes use a den (usually the deserted holes of other species) when gestating and rearing young, though they may occasionally give birth under sagebrushes in the open. Coyote dens can be located in canyons, washouts, coulees, banks, rock bluffs, or level ground. Some dens have been found under abandoned homestead shacks, grain bins, drainage pipes, railroad tracks, hollow logs, thickets, and thistles. The den is continuously dug and cleaned out by the female until the pups are born. Should the den be disturbed or infested with fleas, the pups are moved into another den. A coyote den can have several entrances and passages branching out from the main chamber (79). A single den can be used year after year (31).

Hunting and feeding behaviors
While the popular consensus is that olfaction is very important for hunting (80), two studies that experimentally investigated the role of olfactory, auditory, and visual cues found that visual cues are the most important ones for hunting in red foxes (81) and coyotes (82), (83).

When hunting large prey, the coyote often works in pairs or small groups (16). Success in killing large ungulates depends on factors such as snow depth and crust density. Younger animals usually avoid participating in such hunts, with the breeding pair typically doing most of the work (31). Unlike the wolf, which attacks large prey from the rear, the coyote approaches from the front, lacerating its prey's head and throat. Like other canids, the coyote caches excess food (84). Coyotes catch mouse-like rodents by pouncing, whereas ground squirrels are chased. Although coyotes can live in large groups, small prey is typically caught singly (31). Coyotes have been observed to kill porcupines in pairs, using their paws to flip the rodents on their backs, then attacking the soft underbelly. Only old and experienced coyotes can successfully prey on porcupines, with many predation attempts by young coyotes resulting in them being injured by their prey's quills (85). Coyotes sometimes urinate on their food, possibly to claim ownership over it (86).

Coyotes may occasionally form mutualistic relationships with American badgers, assisting each other in digging up rodent prey. The relationship between the two species may occasionally border on apparent friendship, as some coyotes have been observed laying their heads on their badger companions or licking their faces without protest. The amicable interactions between coyotes and badgers were known to pre-Columbian civilizations, as shown on a Mexican jar dated to 1250–1300 AD depicting the relationship between the two (87).

Ecology
Habitat
Prior to the near extermination of wolves and cougars, the coyote was most numerous in grasslands inhabited by bison, antelope, elk, and other deer, doing particularly well in short-grass areas with prairie dogs, though it was just as much at home in semiarid areas with sagebrush and jackrabbits or in deserts inhabited by cactus, kangaroo rats, and rattlesnakes. As long as it was not in direct competition with the wolf, the coyote ranged from the Sonoran Desert to the alpine regions of adjoining mountains or the plains and mountainous areas of Alberta. With the extermination of the wolf, the coyote's range expanded to encompass broken forests from the tropics of Guatemala and the northern slope of Alaska (7).

Diet
The coyote is highly versatile in its choice of food, but is primarily carnivorous, with 90% of its diet consisting of animal matter. Prey species include bison, deer, sheep, rabbits, rodents, birds, amphibians (except toads), lizards, snakes, fish, crustaceans, and insects. Coyotes may be picky over the prey they target, as animals such as shrews, moles, and brown rats do not occur in their diet in proportion to their numbers (7). More unusual prey include fishers (88), young black bears (89), harp seals (90), and rattlesnakes. Coyotes kill rattlesnakes mostly for food (but also to protect their pups at their dens) by teasing the snakes until they stretch out and then biting their heads and snapping and shaking the snakes (91). In Death Valley, coyotes may consume great quantities of hawkmoth caterpillars or beetles in the spring flowering months (92), (93). Although coyotes prefer fresh meat, they will scavenge when the opportunity presents itself. Excluding the insects, fruit, and grass eaten, the coyote requires an estimated 600 g of food daily, or 250 kg annually (7). The coyote readily cannibalizes the carcasses of conspecifics, with coyote fat having been successfully used by coyote hunters as a lure or poisoned bait (18). The coyote's winter diet consists mainly of large ungulate carcasses, with very little vegetable matter. Rodent prey increases in importance during the spring, summer, and fall (16).

The coyote feeds on a variety of different fruits, including blackberries, blueberries, peaches, pears, apples, prickly pears, chapotes, persimmons, and peanuts. Other vegetable foods include watermelon, cantaloupe, and carrots. During the winter and early spring, the coyote eats large quantities of grass, such as green wheat blades. It sometimes eats unusual items such as cotton cake, soybean meal, domestic animal droppings, and cultivated grain such as corn, wheat, and sorghum, and beans (7).

Enemies and competitors
In areas where the ranges of coyotes and gray wolves overlap, interference competition and predation by wolves has been hypothesized to limit local coyote densities. Coyote ranges expanded during the 19th and 20th centuries following the extirpation of wolves, while coyotes were driven to extinction on Isle Royale after wolves colonized the island in the 1940s. One study conducted in Yellowstone National Park, where both species coexist, concluded that the coyote population in the Lamar River Valley declined by 39% following the reintroduction of wolves in the 1990s, while coyote populations in wolf inhabited areas of the Grand Teton National Park are 33% lower than in areas where they are absent (10). Wolves have been observed to not tolerate coyotes in their vicinity, though coyotes have been known to trail wolves to feed on their kills (87).

Coyotes rarely kill healthy adult red foxes, and have been observed to feed or den alongside them, though they often kill foxes caught in traps. Coyotes may kill fox kits, but this is not a major source of mortality (94). In southern California, coyotes frequently kill gray foxes, and these smaller canids tend to avoid areas with high coyote densities (95).

Coyotes may compete with cougars in some areas. In eastern Sierra Nevada, coyotes compete with cougars over mule deer. Cougars usually outcompete coyotes, and may kill them occasionally, thus reducing coyote predation pressure on smaller carnivores such as foxes and bobcats (9).

In some areas, coyotes share their ranges with bobcats. These two similarly sized species rarely physically confront one another, though bobcat populations tend to diminish in areas with high coyote densities (96). However, several studies have demonstrated interference competition between coyotes and bobcats, and in all cases coyotes dominated the interaction (97). Multiple researchers (98), (99), (100), (101), (102) reported instances of coyotes killing bobcats, whereas bobcats killing coyotes is more rare (97). Coyotes attack bobcats using a bite-and-shake method similar to that used on medium-sized prey. Coyotes (both single individuals and groups) have been known to occasionally kill bobcats – in most cases, the bobcats were relatively small specimens, such as adult females and juveniles (101). However, coyote attacks (by an unknown number of coyotes) on adult male bobcats have occurred. In California, coyote and bobcat populations are not negatively correlated across different habitat types, but predation by coyotes is an important source of mortality in bobcats (95). Biologist Stanley Paul Young noted that in his entire trapping career, he had never successfully saved a captured bobcat from being killed by coyotes, and wrote of two incidences wherein coyotes chased bobcats up trees (87). Coyotes have been documented to directly kill Canadian lynx on occasion (103), (104), (105), and compete with them for prey, especially snowshoe hares (103). In some areas, including central Alberta, lynx are more abundant where coyotes are few, thus interactions with coyotes appears to influence lynx populations more than the availability of snowshoe hares (106).

Communication
Body language
Being both a gregarious and solitary animal, the variability of the coyote's visual and vocal repertoire is intermediate between that of the solitary foxes and the highly social wolf (73). The aggressive behavior of the coyote bears more similarities to that of foxes than it does that of wolves and dogs. An aggressive coyote arches its back and lowers its tail (107). Unlike dogs, which solicit playful behavior by performing a "play-bow" followed by a "play-leap", play in coyotes consists of a bow, followed by side-to-side head flexions and a series of "spins" and "dives". Although coyotes will sometimes bite their playmates' scruff as dogs do, they typically approach low, and make upward-directed bites (108). Pups fight each other regardless of sex, while among adults aggression is typically reserved for members of the same sex. Combatants approach each other waving their tails and snarling with their jaws open, though fights are typically silent. Males tend to fight in a vertical stance, while females fight on all four paws. Fights among females tend to be more serious than ones among males, as females seize their opponents' forelegs, throat, and shoulders (107).

Vocalizations
The coyote has been described as "the most vocal of North American wild mammals...", whose vocal proclivity led to its being given the binomial name *Canis latrans*, meaning "barking dog". At least 11 different vocalizations are known in adult coyotes. These sounds are divided into three categories: agonistic and alarm, greeting, and contact. Vocalizations of the first category include woofs, growls, huffs, barks, bark howls, yelps, and high-frequency whines. Woofs are used as low-intensity threats or

alarms, and are usually heard near den sites, prompting the pups to immediately retreat into their burrows. Growls are used as threats at short distances, but have also been heard among pups playing and copulating males. Huffs are high-intensity threat vocalizations produced by rapid expiration of air. Barks can be classed as both long-distance threat vocalizations and as alarm calls. Bark howls may serve similar functions. Yelps are emitted as a sign of submission, while high-frequency whines are produced by dominant animals acknowledging the submission of subordinates. Greeting vocalizations include low-frequency whines, 'wow-oo-wows', and group yip howls. Low-frequency whines are emitted by submissive animals, and are usually accompanied by tail wagging and muzzle nibbling. The sound known as 'wow-oo-wow' has been described as a "greeting song". The group yip howl is emitted when two or more pack members reunite, and may be the final act of a complex greeting ceremony. Contact calls include lone howls and group howls, as well as the previously mentioned group yip howls. The lone howl is the most iconic sound of the coyote, and may serve the purpose of announcing the presence of a lone individual separated from its pack. Group howls are used as both substitute group yip howls and as responses to either lone howls, group howls, or group yip howls (8).

Range

The coyote's pre-Columbian range was limited to the Southwest and Plains regions of the U.S. and Canada, and northern and central Mexico. By the 19th century, the species expanded north and west, expanding further after 1900, coinciding with land conversion and the extirpation of wolves. By this time, its range encompassed all of the U.S. and Mexico, southward into Central America, and northward into most of Canada and Alaska. This expansion is ongoing, and the species now occupies the majority of areas between 8°N (Panama) and 70°N (northern Alaska) (1).

In Mexico and Central America

Although it was once widely believed that coyotes are recent immigrants to southern Mexico and Central America, aided in their expansion by deforestation, Pleistocene-Early Holocene records, as well as records from the pre-Columbian period and early European colonization show that the animal was present in the area long before modern times. Nevertheless, range expansion did occur south of Costa Rica during the late 1970s and northern Panama in the early 1980s, following the expansion of cattle-grazing lands into tropical rainforests. The coyote is predicted to appear in northern Belize in the near future, as the habitat there is favorable to the species (109). Concerns have been raised of a possible expansion into South America through the Panamanian Isthmus, should the Darién Gap ever be closed by the Pan-American Highway (110). This fear was partially confirmed in January 2013, when the species was recorded in eastern Panama's Chepo District, beyond the Panama Canal (4).

Diseases and parasites

Among large North American carnivores, the coyote probably carries the largest number of diseases and parasites, likely due to its wide range and varied diet (111). Viral diseases known to infect coyotes include rabies, canine distemper, infectious canine hepatitis, four strains of equine encephalitis, and oral papillomatosis. By the late 1970s, serious rabies outbreaks in coyotes had ceased to be a problem for over 60 years, though sporadic cases every 1–5 years did occur. Distemper causes the deaths of many pups in the wild, though some specimens can survive infection. Tularemia, a bacterial disease, infects coyotes through their rodent and lagomorph prey, and can be deadly for pups (112).

Coyotes can be infected by both demodectic and sarcoptic mange, the latter being the most common. Mite infestations are rare and incidental in coyotes, while tick infestations are more common, with seasonal peaks depending on locality (May–August in the Northwest, March–November in Arkansas). Coyotes are only rarely infested with lice, while fleas infest coyotes from puphood, though they may be more a source of irritation than serious illness. *Pulex simulans* is the most common species to infest coyotes, while *Ctenocephalides canis* tends to occur only in areas where coyotes and dogs (its primary host) inhabit the same area. Although coyotes are rarely host to flukes, they can nevertheless have serious effects on coyotes, particularly *Nanophyetus salmincola*, which can infect them with salmon poisoning disease, a disease with a 90% mortality rate. Trematode *Metorchis conjunctus* can also infect coyotes (113). Tapeworms have been recorded to infest 60–95% of all coyotes examined. The most common species to infest coyotes is *Taenia pisiformis* and *T. crassiceps*, which uses cottontail rabbits as intermediate hosts. The largest species known in coyotes is *T. hydatigena*, which enters coyotes through infected ungulates, and can grow to lengths of 80–400 cm. Though once largely limited to wolves, *Echinococcus granulosus* has expanded to coyotes since the latter began colonizing former wolf ranges. The most frequent ascaroid roundworm in coyotes is *Toxascaris leonina*, which dwells in the coyote's short intestine and has no ill effects, save for causing the host to eat more frequently. Hookworms of the genus *Ancylostoma* infest coyotes throughout their range, being particularly

prevalent in humid areas. In areas of high moisture, such as coastal Texas, coyotes can carry up to 250 hookworms each. The blood-drinking *A. caninum* is particularly dangerous, as it damages the coyote through blood loss and lung congestion. A 10-day-old pup can die from being host to as few as 25 *A. caninum* worms (112).

Relationships with humans

In folklore and mythology

The coyote features prominently as a trickster figure in the folktales of America's indigenous peoples, alternately assuming the form of an actual coyote or a man. As with other trickster figures, the coyote acts as a picaresque hero which rebels against social convention through deception and humor (11). The coyote was likely given its trickster role in light of the actual animal's intelligence and adaptability; pre-Columbian American people observed its behavior, and their folkloric representations reflected its attributes (114). It is variously credited for having brought fire to humanity, releasing the bison into the world, and of having slain monsters by petrifying them. The Maidu creation myth has the coyote introducing work, suffering, and death to the world. Zuni folklore has the coyote bringing winter into the world by stealing light from the kachinas. Some tribes, such as the Chinook, Maidu, Paiute, Pawnee, Tohono O'odham, and Ute portray the coyote as the companion of the creator. In the Paiute creation myth, the coyote was created by the wolf as a companion, and the two created land by piling soil on the water-covered world. A Tohono O'odham flood myth has the coyote helping Montezuma survive a global deluge that destroys humanity. After the Great Mystery creates humanity, the coyote and Montezuma teach people how to live. The Crow creation myth portrays Old Man Coyote as the creator. In Navajo mythology, the coyote was present in the First World with First Man and First Woman, though a different version has it being created in the Fourth World. The Navajo coyote brings death into the world, explaining that without death, too many people would exist, thus no room to plant corn (115).

Prior to the Spanish conquest of the Aztec Empire, the coyote played a significant role in Mesoamerican cosmology. The coyote symbolized military might in pre-Aztec Teotihuacan, with warriors dressing up in coyote costumes to call upon its predatory power. The species continued to be linked to Central Mexican warrior cults in the centuries leading up to Aztec rule (12). In Aztec mythology, Huehuecóyotl (meaning "old coyote"), the god of dance, music and carnality, is depicted in several codices as a man with a coyote's head (116). He is sometimes depicted as a womanizer, responsible for bringing war into the world by seducing Xochiquetzal, the goddess of love (117). Epigrapher David H. Kelley argued that the god Quetzalcoatl owed its origins to pre-Aztec Uto-Aztecan mythological depictions of the coyote, which is portrayed as mankind's "Elder Brother", a creator, seducer, trickster, and culture hero linked to the morning star (13).

Attacks on humans

Coyote attacks on humans are uncommon and rarely cause serious injuries, due to the relatively small size of the coyote, but have been increasingly frequent, especially in California. In the 30 years leading up to March 2006, at least 160 attacks occurred in the United States, mostly in the Los Angeles County area (118). Data from USDA Wildlife Services, the California Department of Fish and Game, and other sources show that while 41 attacks occurred during the period of 1988–1997, 48 attacks were verified from 1998 through 2003. The majority of these incidents occurred in Southern California near the suburban-wildland interface (119).

In the absence of the harassment of coyotes practiced by rural people, urban coyotes are losing their fear of humans, which is further worsened by people intentionally or unintentionally feeding coyotes. In such situations, some coyotes have begun to act aggressively toward humans, chasing joggers and bicyclists, confronting people walking their dogs, and stalking small children (119). Nonrabid coyotes in these areas sometimes target small children, mostly under the age of 10, though some adults have been bitten.

Although media reports of such attacks generally identify the animals in question as simply "coyotes", research into the genetics of the eastern coyote indicates those involved in attacks in northeast North America, including Pennsylvania, New York, New England, and eastern Canada, may have actually been coywolves, hybrids of *Canis latrans* and *C. lupus,* not fully coyotes (120).

Livestock and pet predation

Coyotes are presently the most abundant livestock predators in western North America, causing the majority of sheep, goat, and cattle losses (121). For example, according to the National Agricultural Statistics Service, coyotes were responsible for 60.5% of the 224,000 sheep deaths attributed to predation in 2004 (122). The total number of sheep deaths in 2004 comprised 2.22% of the total sheep and lamb population in the United States (123). According to the National Agricultural Statistics Service USDA report, "All sheep and lamb inventory in the United States on July 1, 2005, totaled 7.80 million head, 2% above July 1, 2004. Breeding sheep inventory at 4.66 million head on July 1, 2005 was 2% above July 1, 2004" (124). Because coyote populations are typically many times greater and more widely distributed than those of wolves, coyotes cause more overall predation losses. However, an Idaho census taken in 2005 showed that individual coyotes were 5% as likely to attack livestock than individual wolves (125).

Livestock guardian dogs are commonly used to aggressively repel predators and have worked well in both fenced pasture and range operations. A 1986 survey of sheep producers in the USA found that 82% reported the use of dogs represented an economic asset (126), (127).

Coyotes typically bite the throat just behind the jaw and below the ear when attacking adult sheep or goats, with death commonly resulting from suffocation. Blood loss is usually a secondary cause of death. Calves and heavily fleeced sheep are killed by attacking the flanks or hindquarters, causing shock and blood loss. When attacking smaller prey, such as young lambs, the kill is made by biting the skull and spinal regions, causing massive tissue and bone damage. Small or young prey may be completely carried off, leaving only blood as evidence of a kill. Coyotes usually leave the hide and most of the skeleton of larger animals relatively intact, unless food is scarce, in which case they may leave only the largest bones. Scattered bits of wool, skin, and other parts are characteristic where coyotes feed extensively on larger carcasses (121).

Coyote predation can usually be distinguished from dog or coydog predation because coyotes partially consume their victims. Tracks are also an important factor in distinguishing coyote from dog predation. Coyote tracks tend to be more oval-shaped and compact than those of domestic dogs, and their claw marks are less prominent and the tracks tend to follow a straight line more closely than those of dogs. With the exception of sighthounds, most dogs of similar weight to coyotes have a slightly shorter stride (121). Coyote kills can be distinguished from wolf kills by less damage to the underlying tissues in the former. Also, coyote scat tends to be smaller than wolf scat (128).

The U.S. government agents routinely shoot, poison, trap, and kill about 90,000 coyotes each year to protect livestock (129). Coyotes are often attracted to dog food and animals that are small enough to appear as prey. Items such as garbage, pet food, and sometimes feeding stations for birds and squirrels attract coyotes into backyards. About three to five pets attacked by coyotes are brought into the Animal Urgent Care hospital of south Orange County (California) each week, the majority of which are dogs, since cats typically do not survive the attacks (130). Scat analysis collected near Claremont, California, revealed that coyotes relied heavily on pets as a food source in winter and spring (119). At one location in Southern California, coyotes began relying on a colony of feral cats as a food source. Over time, the coyotes killed most of the cats, and then continued to eat the cat food placed daily at the colony site by people who were maintaining the cat colony (119). Coyotes usually attack smaller-sized dogs, but they have been known to attack even large, powerful breeds such as the Rottweiler in exceptional cases (131). Dogs larger than coyotes are generally able to drive them off, and have been known to kill coyotes. Smaller breeds are more likely to suffer injury or death.

Uses

Prior to the mid-1800s, coyote fur was considered worthless. This changed with the diminution of beavers, and by 1860, the hunting of coyotes for their fur became a great source of income (75 cents to $1.50 per skin) for wolfers in the Great Plains. Coyote pelts were of significant economic importance during the early 1950s, ranging in price from $5 to $25 per pelt, depending on locality (132). The coyote's fur is not durable enough to make rugs (133), but can be used for coats and jackets, scarves, or muffs. The majority of pelts are used for making trimmings, such as coat collars and sleeves for women's clothing. Coyote fur is sometimes dyed black as imitation silver fox (132).

Coyotes were occasionally eaten by trappers and mountain men during the western expansion. Coyotes sometimes featured in the feasts of the Plains Indians, and coyote pups were eaten by the indigenous people of San Gabriel, California. The taste of coyote meat has been likened to that of the

wolf, and is more tender than pork when boiled. Coyote fat, when taken in the fall, has been used on occasion to grease leather or eaten as a spread (134).

Tameability

Coyotes were probably semidomesticated by various pre-Columbian cultures. Some 19th-century writers wrote of coyotes being kept in native villages in the Great Plains. The coyote is easily tamed as a pup, but can become destructive as an adult (135). Both full-blooded and hybrid coyotes can be playful and confiding with their owners, but are suspicious and shy of strangers (62), though coyotes being tractable enough to be used for practical purposes like retrieving (136) and pointing have been recorded (137). A tame coyote named "Butch", caught in the summer of 1945, had a short-lived career in cinema, appearing in *Smoky* and *Ramrod* before being shot while raiding a henhouse (135).

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This concludes the Wikipedia file, https://en.wikipedia.org/wiki/Coyote.

APPENDIX 4: DINGO

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March 2016

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OUR SUMMARY

This appendix identifies aspects of the Dingo (*Canis lupus dingo*), which we feel are important to the discussion of the complex prehistoric and historic landscape interplay between humans and this four-legged tactical predator in Hawaii and Pacific Island territories. If Dingo-specific DNA were to be identified in South American dogs, a case could be made for trans-Pacific cultural contact. Meyer first described the Dingo in 1793, as follows:

Kingdom: Animalia
Phylum: Chordata
Class: Mamalia
Order: Carnivora
Family: Canidae
Genus: *Canis*
Species: *C. lupus*
Subspecies: *C. l. dingo*

The following block quote is an extracted explanation from Wikipedia, https://en.wikipedia.org/wiki/Dingo.

> The DNA of the Dingo demonstrates the breed was derived from east Asian and southeast Asian ancestry. The Dingo is more closely related to the domestic dog than it is to the Gray Wolf or the Coyote. To determine the origin and time of arrival of Australian dingoes, mitochondrial DNA (mtDNA) sequences of 211 dingoes and 19 archaeological samples from pre-European Polynesia were compared with mtDNA samples of 676 domestic dogs and 38 grey wolves in 2004. The domestic dog samples came from China, Africa, Southwest Asia, India, Siberia, the arctic America, Europe, Mongolia, Korea, Japan, Vietnam, Cambodia, Thailand, Indonesia, the Philippines, Malaysia, New Zealand, Hawaii and the highlands of New Guinea. The dingo samples came from zoos, wildlife parks, dingo conservation groups, dingo lovers and 192 wild living specimens from 27 areas in Australia, mainly located in the Pilbara region, New South Wales and northeastern Victoria. The wild specimens had been selected based on similarities of external appearance to exclude the influence of dingo-hybrids and domestic dogs as far as possible.
>
> Compared to wolves and domestic dogs, the variation of mtDNA sequences was very limited. Among dingoes, only 20 mtDNA sequences differing in two point mutations at most could be found. In comparison, 114 mtDNA-sequences with a maximal difference of 16 point mutations between the DNA-types could be found among domestic dogs. Two of the dingo mtDNA-types were similar to that of domestic dogs (A9, A29), while the other 18 types were unique to dingoes.
>
> In a phylogenetic tree of wolves and domestic dogs, dingoes were included in the main clade (A), which contained 70% of all domestic dog types. Within this clade, the dingo-types

formed a group around the type A29, which was surrounded by 12 less frequent dingo-types, as well as a set of other domestic dog types. This mtDNA-type was found in 53% of the dingoes and was also found among some domestic dogs from East Asia, New Guinea and the American Arctic. Based on these findings, it was reasoned that all dingo-mtDNA-types originated in A29. A9 was only found in one individual, and it was regarded as possible that this type is the result of a parallel mutation.

Based on a mutation rate of mtDNA with A29 being the only founder type, it was considered that dingoes probably arrived in Australia between 4,600 and 5,400 years ago, which was consistent with archaeological findings. However, it was also considered that dingoes might have arrived from an even earlier date of up to 10,800 years ago in the event of the mtDNA-mutation rate being slower than assumed. It was further reasoned that these findings strongly indicate a descent of dingoes from East Asian domestic dogs and not from Indian domestic dogs or from wolves. In addition these findings indicated two possibilities of descent: all Australian dingoes are descended from a few domestic dogs, theoretically one pregnant female; and all Australian dingoes are descended from a group of domestic dogs, who radically lost their genetic diversity through one or several severe genetic bottlenecks on their way from the Asian continent over South East Asia.

The Dingo is the basic genetic stock of prehistoric dogs found in archaeological contexts in Hawaii. The Dingo dog breed was a domesticated breed before it reached Australia. After the breed reached Australia, a variety of degrees of tameness and wildness have transpired. Although some Dingoes are currently mixed with European breeds, no realistic data exists where individual breeds of Dingoes have developed.

We do not expect to find evidence of Dingo in Delaware or the Mid-Atlantic region. Nevertheless, we decided to include portions of the Dingo Wikipedia file including complete citations used for that file. We closely reviewed, edited, and re-formatted the contents to make a good fit with our research topic. The data on the Dingo may be used as an example of what is relevant to human and four-legged tactical predators. This data may be compared to Native American dog breeds in the western hemisphere. This Dingo data may be used to speculate about the origin of the Yellow or Carolina Dog as a Native American breed in the Mid-Atlantic region.

The following document is a portion of the Dingo Internet Wikipedia file together with the Wikipedia file's references cited. We closely reviewed, edited, and re-formatted the contents of the open-source Wikipedia file to make a good fit with our research topic. There are sections of this file that are vague and lack acceptable citations or proper references. The full Wikipedia document can be found and downloaded at: https://en.wikipedia.org/wiki/Dingo.

Introduction

The **dingo** (*Canis lupus dingo*) is a free-ranging dog found in Australia. Its exact ancestry is debated, but dingoes are generally believed to be descended from semi-domesticated dogs from East or South Asia, which returned to a wild lifestyle when introduced to Australia. It and the dog are classified as a subspecies of *Canis lupus* in Mammal Species of the World (5), (6).

The dingo's habitat ranges from deserts to grasslands and the edges of forests. Dingoes will normally make their dens in deserted rabbit holes and hollow logs close to an essential supply of water.

The dingo is the largest terrestrial predator in Australia, and plays an important role as an apex predator. However, the dingo is seen as a pest by livestock farmers due to attacks on animals. Conversely, their predation on rabbits, kangaroos and rats may be of benefit to graziers.

For many Australians, the dingo is a cultural icon. The dingo is seen by many as being responsible for thylacine extinction on the Australian mainland about two thousand years ago (7), although a recent study challenges this view (8). Dingoes have a prominent role in the culture of Aboriginal Australians as a feature of stories and ceremonies, and they are depicted on rock carvings and cave paintings (9).

Despite being an efficient hunter, it is listed as vulnerable to extinction. It is proposed that this is due to susceptibility to genetic pollution: a controversial concept according to which interbreeding with domestic dogs may dilute the dingo's unique adaptations to the Australian environment.

Etymology

The most commonly used name is **dingo**, which has its origins in the early European colonisation in New South Wales and is most likely derived from the word *tingo*, used by the Aboriginal people of Port Jackson for their camp dogs (10). Depending on where they live, local dingoes can be called "alpine dingoes," "desert dingoes," "northern dingoes," "Cape York dingoes," or "tropical dingoes". More recently, people have begun to call dingoes "Australian native dogs" or, by reasoning that they are a subspecies of *Canis lupus*, "Australian wolves" (11) [unreliable source?]. In Australia, the term "wild dog" is also widely used, but generally includes dingoes as well as dingo-hybrids and other feral dogs (12).

The dingo has been given different names in the Indigenous Australian languages, including *joogong*, *mirigung*, *noggum*, *boolomo*, *papa-inura*, *wantibirri*, *maliki*, *kal*, *dwer-da*, *kurpany*, *aringka*, *palangamwari*, *repeti* and *warrigal* (12). Some languages have different names for the dingoes depending on where they live; the Yarralin, for instance, call the dingoes that live with them *walaku* and those in the wilderness *ngurakin* (9).

Taxonomy

Since its first official nomenclature in 1792 (*Canis antarcticus*), the scientific name of the dingo has changed several times (13). Current taxonomy classifies the Australian dingo, together with its closest relatives outside of Australia, as a subspecies of *Canis lupus* as *Canis lupus dingo*, separate from the dog, *Canis lupus familiaris* (13). An older taxonomy, used throughout most of the 20th century, applied the epithet *Canis familiaris dingo*. This taxonomy assumed that domestic dogs are a distinct species from *Canis lupus*, with the dingo classified as a subspecies of domestic dog. However, the term *Canis dingo* (14), (15), which classifies the dingo as a separate species from both dogs and wolves, has gained support in 2014 in a study that established a reference description of the dingo based on pre-20th century specimens that are unlikely to have been influenced by hybridization (16), (17). The dingo differs from the domestic dog by relatively larger palatal width, relatively longer rostrum, relatively shorter skull height and relatively wider top ridge of skull (16). A sample of 19th century dingo skins the study examined suggests that there was considerable variability in the colour of dingoes and included various combinations of yellow, white, ginger and darker variations from tan to black (16). Although it remained difficult to provide consistent and clear diagnostic features, the study placed morphological limits on what can be considered a dingo (16).

Description
Domestic and pariah dogs in southern Asia share so many characteristics with Australian dingoes that they are now considered (source needed) to be members of the same taxon *Canis lupus dingo*, a particular subspecies of *Canis lupus*. While the relationship with humans varies widely among these animals, they are all quite similar in terms of physical features (12). As is typical in domestic dogs, the dingo's relative brain size is smaller than that of all non-domesticated subspecies of *Canis lupus*, being almost identical in size to that of dogs considered *Canis lupus familiaris* (18).

A dingo has a relatively broad head, a pointed muzzle and erect ears. Eye colour varies from yellow over orange to brown (19). Compared to other similarly sized *familiaris* dogs, dingoes have longer muzzles, larger carnassials (large teeth found in many carnivorous mammals), longer canine teeth, and flatter skulls with larger nuchal lines (10).

Size
The average Australian dingo is 52 to 60 cm (20 to 24 in) tall at the shoulders and measures 117 to 154 cm (46 to 61 in) from nose to tail tip. The average weight is 13 to 20 kg (29 to 44 lb); however, there are a few records of outsized dingoes weighing up to 27 to 35 kg (60 to 77 lb) (20), (21). Males are typically larger and heavier than females of the same age. Dingoes from northern and northwestern Australia are larger than central and southern populations. Australian dingoes are invariably heavier than Asian ones (12). The legs are about half the length of the body and the head put together. The hind feet make up a third of the hind legs and have no dewclaws (12). Dingoes can have sabre-form tails (typically carried erect with a curve towards the back) or tails carried directly on the back (19).

Fur
Fur of an adult dingo is short and soft, bushy on the tail, and varies in thickness and length depending on the climate. The fur colour is mostly sandy to reddish brown, but can include tan patterns and sometimes be black, light brown, or white. Completely black dingoes might have been more prevalent in Australia in the past, but have only been rarely sighted in recent times. They are now more common in Asia (10).

Most dingoes are at least bi-coloured, with small, white markings on the chest, muzzle, tag, legs and paws being the most common feature. "Pure" dingoes are also found in white or cream (not albinism). They are also found in black and tan colourations. In the case of reddish individuals, there can be small, distinctive, dark stripes on the shoulders (12).

Origin and genetic status
Since dingoes were the largest wild placental mammals in Australia at the time of colonisation and looked similar to domestic dogs, their origin has always been questioned and much debated. Archaeological and morphological studies indicated a relatively late introduction and a close relationship to other domestic dogs. Their exact descent, place of origin and date of arrival in Australia were not identified, nor whether they had once been domesticated or half-domesticated and had gone feral, or whether they had already existed as truly wild animals (22).

It is widely held that dingoes have evolved or were bred from the Indian wolf or Arabian wolf around 6,000 to 10,000 years ago, as was assumed for all domestic dogs (23). This theory was based on the morphological similarities of dingo skulls and the skulls of these subspecies of wolves. However, genetic analyses indicated a much earlier domestication. New studies suggest dingoes may have originated in southern China, travelling to Australia anywhere between 4600 and 18,300 years ago (24).

DNA analysis
Analyses of amino acid sequences of the haemoglobin from a "pure" dingo in the 1970s supported the theory that dingoes are more closely related to domestic dogs than they are to grey wolves or coyotes. As a result, it was assumed that dingoes and other similar Asian dogs belong to a group of domestic dogs that went feral at a very early time. DNA studies on Australian dingoes and domestic dogs were also undertaken in an effort to reliably differentiate between both populations and to try to determine the extent of interbreeding.

The first two examinations looked firstly at 14 loci (the specific locations of the DNA-sequence of a chromosome), with five of these being more closely examined. No genetic difference could be found. The analyses were then extended to cover 16 loci, comparing dingoes from Central Australia, dingoes from the Eastern Highlands, dingo-hybrids and domestic dogs of other origin. Again, no differences could be found, regardless of the type of examination used. It was reasoned that dingoes and domestic dogs must have a very similar gene pool. However, since only a few differences in the enzymes of different species of the genus *Canis* could be found, it was assumed that a lack of differences might not indicate a close taxonomic relationship. It was also reasoned that the degree of interbreeding in the wild would be hard to determine (25). During further analyses in the late 1990s, researchers examined 14 loci and detected a significantly lower genetic variability among Australian dingoes than among domestic dogs, leading to consideration of the possibility of a small founding population. There was one locus found that might have been suitable for differentiation, but not in the case of interbreeding of a dingo-hybrid with a "pure" dingo. Additionally, it was suspected that findings of other suitable loci might be used to determine whether there are clearly separate sub-populations of the "pure" dingoes (26).

More recent studies have concluded that the previous assumptions about the origins of the dingo are incorrect, with the dingo appearing to have no ancestral relationship with the wolf. Dr Mathew Crowther of Sydney University says they based their research using specimens collected in the 19th century, and the dingo should be described as *Canis dingo* rather than *Canis lupus dingo* (27). Steven Strong in his piece for Wake up World adds to the knowledge by highlighting that the dingo is a common element in indigenous dream time stories and that rock art dated at over 20,000 years includes images of dingoes (28).

Mitochondrial DNA sequences

This section needs additional citations for verification.

To determine the origin and time of arrival of Australian dingoes, mitochondrial DNA (mtDNA) sequences of 211 dingoes and 19 archaeological samples from pre-European Polynesia were compared with mtDNA samples of 676 domestic dogs and 38 grey wolves in 2004. The domestic dog samples came from China, Africa, Southwest Asia, India, Siberia, the arctic America, Europe, Mongolia, Korea, Japan, Vietnam, Cambodia, Thailand, Indonesia, the Philippines, Malaysia, New Zealand, Hawaii and the highlands of New Guinea. The dingo samples came from zoos, wildlife parks, dingo conservation groups, dingo lovers and 192 wild living specimens from 27 areas in Australia, mainly located in the Pilbara region, New South Wales and northeastern Victoria. The wild specimens had been selected based on similarities of external appearance to exclude the influence of dingo-hybrids and domestic dogs as far as possible.

Compared to wolves and domestic dogs, the variation of mtDNA sequences was very limited. Among dingoes, only 20 mtDNA sequences differing in two point mutations at most could be found. In comparison, 114 mtDNA-sequences with a maximal difference of 16 point mutations between the DNA-types could be found among domestic dogs. Two of the dingo mtDNA-types were similar to that of domestic dogs (A9, A29), while the other 18 types were unique to dingoes.

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Based on a mutation rate of mtDNA with A29 being the only founder type, it was considered that dingoes probably arrived in Australia between 4,600 and 5,400 years ago, which was consistent with archaeological findings. However, it was also considered that dingoes might have arrived from an even earlier date of up to 10,800 years ago in the event of the mtDNA-mutation rate being slower than assumed. It was further reasoned that these findings strongly indicate a descent of dingoes from East Asian domestic dogs and not from Indian domestic dogs or from wolves. In addition these findings indicated two possibilities of descent: all Australian dingoes are descended from a few domestic dogs, theoretically one pregnant female; and all Australian dingoes are descended from a group of domestic

dogs, who radically lost their genetic diversity through one or several severe genetic bottlenecks on their way from the Asian continent over South East Asia.

Other types
Nonetheless, the existence of other mtDNA-types on the islands surrounding Australia indicate there have been other types (needs further explanation) apart from A29 and only one single founding event. These results also indicated that there hasn't been any significant introduction of other domestic dog on the Australian continent prior to the arrival of the Europeans. Also, a shared origin and some sort of genetic exchange between Australian dingoes and the New Guinea singing dogs was regarded as possible. The current state of the Australian dingoes was ascribed to the long wild existence of these dogs and assumed that they are an isolated example of early domestic dogs.

Despite accordant claims (29), (30), these findings did not show that only dingo females mate with non-dingo males and not vice versa. The findings would not allow such a conclusion, since the mating of a dingo female with a non-dingo male could not be detected via analyses of mtDNA. Furthermore, the researchers made sure from the start that dingo-hybrids were excluded as far as possible (22).

Communication
Like all domestic dogs, dingoes tend towards phonetic communication. However, in contrast to domestic dogs, dingoes howl and whimper more, and bark less. Eight sound classes with 19 sound types have been identified (31).

Barking
Compared to most domestic dogs, the bark of a dingo is short and monosyllabic, and is rarely used. Barking was observed to make up only 5% of vocalisations. Dog barking has always been distinct from wolf barking (32). Australian dingoes bark mainly in swooshing noises or in a mixture of atonal and tonal sounds. In addition, barking is almost exclusively used for giving warnings. Warn-barking in a homotypical sequence and a kind of "warn-howling" in a heterotypical sequence have also been observed. The bark-howling starts with several barks and then fades into a rising and ebbing howl and is probably (similar to coughing) used to warn the puppies and members of the pack. Additionally, dingoes emit a sort of "wailing" sound, which they mostly use when approaching a wateringhole, probably to warn already present dingoes (12).

According to the present state of knowledge, it is not possible to get Australian dingoes to bark more frequently by putting them in contact with other domestic dogs. However, German zoologist Alfred Brehm reported a dingo that learned the more "typical" form of barking and how to use it, while its brother did not (33). Whether dingoes bark or bark-howl less frequently in general is not certain (31).

Howling
Dingoes have three basic forms of howling (moans, bark-howls and snuffs) with at least 10 variations. Usually, three kinds of howls are distinguished: long and persistent, rising and ebbing, and short and abrupt.

Observations have shown that each kind of howling has several variations, though their purpose is unknown. The frequency of howling varies with the season and time of day, and is also influenced by breeding, migration, lactation, social stability and dispersal behaviour. Howling can be more frequent in times of food shortage, because the dogs become more widely distributed within their home range (12).

Additionally, howling seems to have a group function, and is sometimes an expression of joy (for example, greeting-howls). Overall howling was observed less frequently in dingoes than among grey wolves. It may happen that one dog will begin to howl, and several or all other dogs will howl back and bark from time to time. In the wilderness, dingoes howl over long distances to attract other members of the pack, to find other dogs, or to keep intruders at bay. Dingoes howl in chorus with significant pitches, and with increasing number of pack-members, the variability of pitches also increases (34). Therefore, it is suspected that dingoes can measure the size of a pack without visual contact (10). Moreover, it has been proposed that their highly variable chorus howls may generate a confounding effect in the receivers by making pack size appear larger (35).

Other forms of communication

Growling, making up approximately 65% of the vocalisations, is used in an agonistic context for dominance, and as a defensive sound. Similar to many domestic dogs, a reactive usage of defensive growling is only rarely observed. Growling very often occurs in combination with other sounds, and has been observed almost exclusively in swooshing noises (similar to barking) (31).

During observations in Germany, dingoes were heard to produce a sound that observers have called *Schrappen*. It was only observed in an agonistic context, mostly as a defence against obtrusive pups or for defending resources. It was described as a bite intention, during which the receiver is never touched or hurt. Only a clashing of the teeth could be heard (31).

Aside from vocal communication, dingoes communicate, like all domestic dogs, via scent marking specific objects (for example, *Spinifex*) or places (such as waters, trails and hunting grounds) using chemical signals from their urine, feces and scent glands. Males scent-mark more frequently than females, especially during the mating season. They also scent-rub, whereby a dog rolls its neck, shoulders, or back on something that is usually associated with food or the scent markings of other dogs (12). Unlike wolves, dingoes can react to social cues and gestures from humans (36).

Behaviour

Dingoes tend to be nocturnal in warmer regions, but less so in cooler areas. Their main period of activity is around dusk and dawn. The periods of activity are short (often less than one hour) with short times of resting. Dingoes have two kinds of movement: a searching movement (apparently associated with hunting) and an exploratory movement (probably for contact and communication with other dogs) (37), (38).

In general, dingoes are shy towards humans. However, there are reports of dingoes that were agitated by the presence of humans, such as around camps in national parks, near streets or suburbs (20), (39). According to studies in Queensland, the wild dogs (dingo hybrids) there, move freely at night through urban areas and cross streets and seem to get along quite well (40).

Dietary habits

About 170 species (from insects to buffalo) have been identified as part of the dingo's diet. In general, livestock seems to make up only a small proportion of their diet (12). In continent-wide examinations, 80% of the diet of wild dogs consisted of 10 species: red kangaroo, swamp wallaby, cattle, dusky rat, magpie goose, common brushtail possum, long-haired rat, agile wallaby, European rabbit and the common wombat. This narrow range of major prey indicates these wild dogs are rather specialized (10), but in the tropical rainforests of northeastern Australia, dingoes are supposed to be opportunistic hunters of a wide range of mammals (41). In certain areas, they tend to specialise on the most common prey, with a preference for medium- to large-sized mammals. Their consumption of domestic cats has also been proven (42). Non-mammalian prey is irregularly eaten and makes up only 10% of the dingo's diet. Big reptiles are only rarely captured, at least in eastern Australia, although they are widespread. It is possible that especially large monitor lizards are too defensive and well-armed, or they are simply able to flee fast enough into dens or climb trees (10).

Dietary composition varies from region to region. In the gulf region of Queensland, feral pigs and agile wallabies are the dingo's main prey. In the rainforests of the north, the main prey consists of magpie geese, rodents and agile wallabies. In the southern regions of the Northern Territory, the dogs mainly eat European rabbits, rodents, lizards and red kangaroo; in arid Central Australia, rabbits, rodents, lizards, red kangaroo and cattle carcasses; and in the dry northwest, eastern wallaroos and red kangaroo. In the deserts of the southwest, they primarily eat rabbits, and in the eastern and southeastern highlands, they eat wallabies, possums and wombats.

To what extent the availability of rabbits influences the composition of the diet cannot be clarified. However, because rabbit haemorrhagic disease killed a large part of the Australian rabbit population at the end of the 20th century, it is suspected that the primary prey of the dogs has changed in the affected areas. Also, on Fraser Island, fish have been proven to be a part of the dingo diet. The main prey species, though, are bandicoots and several rodents. Dingoes also eat a lot of echidnas, crabs, small skinks, fruits and other plants, as well as insects (mostly beetles). During these observations, only 10% of the examined feces-samples contained human garbage (in earlier studies 50% were reported) (10).

When scavenging for food, wild dogs (presumably, all dogs free to roam, not just dingoes) primarily eat cattle and kangaroo carcasses. Dingoes in coastal regions regularly patrol the coast for dead fish, seals, penguins and other washed-up birds (10).

Dingoes in general drink one litre of water a day in the summer and about half a litre a day in winter. During the winter in arid regions, dingoes could potentially live from the liquid in the bodies of their prey, as long as the number of prey is sufficient. Similarly, weaned pups in Central Australia are able to draw their necessary requirements of liquid from their food. There, regurgitation of water by the females for the pups was observed. During lactation, females have no higher need of water than usual, since they consume the urine and feces of the pups and therefore recycle the water and keep the den clean (10). Seventeen tracked dingoes have survived 22 days without water in the winter (43).

Hunting behaviour

Dingoes often kill by biting the throat, and they adjust their hunting strategies to suit circumstances. For larger prey, due to strength and potential danger, two or more individuals are needed to bring down the prey. Such group formations are unnecessary when hunting rabbits or other small prey (10).

Kangaroo hunts are probably more successful in open areas than in places with high densities of vegetation, and juvenile kangaroos are killed more often than adults. Dingoes typically hunt large kangaroos by having lead dingoes chase the quarry toward their waiting packmates, which are skilled at cutting corners in chases. In one area of Central Australia, dingoes hunt kangaroos by chasing them toward a wire fence that hindered their escape (44).

Birds can be captured when they do not fly or fail to take off fast enough. Dingoes also steal the prey of eagles and the coordinated attack of three dingoes for killing a large monitor lizard has been observed (45).

Reports state that some dingoes live almost entirely on human food through stealing, scavenging, or begging. In fact, dingoes are well known for such behaviour in some parts of Australia. It is suspected that this might cause the loss of hunting strategies or a change in the social structures (46).

During studies at the Fortescue River in the mid-1970s, observation showed that most of the studied dingoes learned to hunt and kill sheep very quickly, even without prior contact with sheep. Although the dingoes killed many sheep at that time, they still killed and ate kangaroos.

During the early 1990s, wild dogs were observed to have an extraordinarily high success rate when killing sheep, and did not have to hunt in a coordinated manner to achieve success. Often, a dog may chase and outrun a single sheep, only to turn away suddenly and chase another. Therefore, only a small proportion of the injured or killed sheep and goats are eaten, which seems to be the rule and not the exception. The dog probably falls into some kind of "killing spree," due to the rather panicked and uncontrolled flight behaviour of the sheep, which run in front of the dingoes time and again and, therefore, cause one attack after another. Dingoes often attack sheep from behind during the sheep's flight, which causes injuries to the sheep's hind legs. Rams are normally attacked from the side – probably in order to avoid the horns – or sometimes on the testicles. Inexperienced dingoes, or those that kill "for fun," sometimes cause significant damage to the sheep's hind legs, which often causes death (47), (48).

Nearly all dingo attacks on cattle and water buffalo are directed against calves. Hunting success depends on the health and condition of the adult bovines and on their ability to defend their calves. The defence behaviour of the mother can be sufficient to fend off an attack. Therefore, the basic dingo tactics of attack are distracting the mother, rousing the herd/group and waiting (sometimes for hours), and testing of the herd to find the weakest members.

While locating a cattle herd, dingoes have been observed to make several feint attacks, during which they concentrate on the calves at first then, later on, attack the mothers to distract them. Thereupon, the dingoes retreat and wait at a distance from the herd until the rest of the cows have gathered their calves and move on.

During another observed attack, "subgroups" of a dingo pack took turns in attacking and resting, until the mother was too tired to effectively defend her calf. Dingoes have been observed hunting a water

buffalo with an estimated weight of 200 kg, and taking turns biting the buffalo's legs during the chase (10), (49).

Social behaviour

The dingo's social behaviour is about as flexible as that of a coyote or gray wolf, which is perhaps one of the reasons it was initially believed that the dingo was descended from the Indian wolf (50). While young males are often solitary and nomadic in nature, breeding adults will often form a settled pack (51). However, in areas of the dingo's habitat with a widely spaced population, breeding pairs remain together, apart from others (51).

Where conditions are favourable among dingo packs, the pack is stable with a distinct territory and little overlap between neighbors (52). The size of packs often appears to correspond to the size of prey that appears in the pack's territory (52). Desert areas have smaller groups of dingoes with a more loose territorial behaviour and sharing of the water sites (53). It has been noted that the average monthly pack size was between three and twelve members (54).

Similar to other canids, a dingo pack largely consists of a mated pair, their current year's offspring, and occasionally a previous year's offspring (52). There are dominance hierarchies both between and within males and females, with males usually being more dominant than females (52). However, a few exceptions have been noted in captive packs (52). During travel, while eating prey, or when approaching a water source for the first time, the breeding male will be seen as the leader, or alpha (55). Subordinate dingoes will approach a more dominant dog in a slightly crouched posture, ears flat and tail down, to ensure peace in the pack (52). Establishment of artificial packs in captive dingoes have failed (52).

Reproduction

See also: Canine reproduction

Dingoes breed once annually, depending on the estrus cycle of the females which, according to most sources, only come in heat once per year. Dingo females can come in heat twice per year, but can only be pregnant once a year, with the second time only seeming to be pregnant (56), (57).

Males are virile throughout the year in most regions, but have a lower sperm production during the summer in most cases. During studies on dingoes from the Eastern Highlands and Central Australia in captivity, no specific breeding cycle could be observed. All were potent throughout the year. The breeding was only regulated by the heat of the females. A rise in testosterone was observed in the males during the breeding season, but this was attributed to the heat of the females and copulation. In contrast to the captive dingoes, captured dingo males from Central Australia did show evidence of a male breeding cycle. Those dingoes showed no interest in females in heat (this time other domestic dogs) outside of the mating season (January to July) and did not breed with them (58).

The mating season usually occurs in Australia between March and May (according to other sources between April and June). In South East Asia, mating occurs between August and September. During this time, dingoes may actively defend their territories using vocalisations, dominance behaviour, growling and barking (10).

Most females in the wild start breeding at the age of two years. Within packs, the alpha female tends to go into heat before subordinates and actively suppresses mating attempts by other females. Males become sexually mature between the ages of one and three years. The precise start of breeding varies depending on age, social status, geographic range and seasonal conditions. Among dingoes in captivity, the pre-estrus was observed to last 10–12 days. However, it is suspected that the pre-estrus may last as long as 60 days in the wild (12).

In general, the only dingoes in a pack that successfully breed are the alpha pair, and the other pack members help with raising the pups. Subordinates are actively prevented from breeding by the alpha pair and some subordinate females have a false pregnancy. Low-ranking or solitary dingoes can successfully breed if the pack structure breaks up (59).

The gestation period lasts for 61–69 days and the size of the litter can range from one to 10 (usually five) pups, with the number of males born tending to be higher than that of females. Pups of subordinate females usually get killed by the alpha female, which causes the population increase to be low even in good times. This behaviour possibly developed as an adaptation to the fluctuating

environmental conditions in Australia. Pups are usually born between May and August (the winter period), but in tropical regions, breeding can occur at any time of the year (12).

At the age of three weeks, the pups leave the den for the first time, and leave it completely at eight weeks. In Australia, dens are mostly underground. There are reports of dens in abandoned rabbit burrows, rock formations, under boulders in dry creeks, under large spinifex, in hollow logs, in augmented burrows of monitor lizards and wombat burrows. The pups usually stray around the den within a radius of 3 km, and are accompanied by older dogs during longer travels. The transition to consuming solid food is normally accompanied by all members of the pack during the age of 9 to 12 weeks. Apart from their own experiences, pups also learn through observation.[60] Young dingoes usually become independent at the age of three to six months or they disperse at the age of 10 months when the next mating season starts.

Migration

Dingoes usually remain in one area and do not undergo seasonal migrations. However, during times of famine, even in normally "safe" areas, dingoes travel into pastoral areas, where intensive, human-induced control measures are undertaken. It was noted in Western Australia in the 1970s that young dogs can travel for long distances when necessary. About 10% of the dogs captured—all younger than 12 months—were later recaptured far away from their first location. Among these, 10% of the travelled distance for males was 21.7 km and for females 11 km (61). Therefore, travelling dingoes had lower chances of survival in foreign territories, and it was apparently unlikely that they would survive long migrations through occupied territories. The rarity of long migration routes seemed to confirm this. During investigations in the Nullarbor Plain, even longer migration routes were recorded. The longest recorded migration route of a radio-collared dingo was about 250 km.

Mortality and health

Documented evidence shows that dingoes in captivity have survived for up to 24 years (19). The main cause of death for dingoes is being killed by humans, crocodiles and dogs, including other dingoes. Other causes of death include starvation and dehydration during times of drought or after strong bush fires, infanticide, snake bites, killing of pups by wedge-tailed eagles, and injuries caused by cattle and buffalo.

Dingoes are susceptible to the same diseases as domestic dogs. At present, 38 species of parasites and pathogens have been detected in Australian dingoes. The bulk of these diseases have a minimal influence on their survival. The exceptions include canine distemper, hookworms and heart worms in North Australia and southeastern Queensland. Dingo pups can also be killed by lungworms, whipworms, hepatitis, coccidiosis, lice and ticks. Sarcoptic mange is a widespread parasitic disease among the dingoes of Australia, but is seldom debilitating. Free-roaming dogs are the primary host of Echinococcosis (tapeworms) and have an infection rate of 70 to 90%.

Distribution

It is only possible to give a crude description of the dingo's distribution area and the accordant population density. Giving an exact assessment of the distribution of dingoes and other domestic dogs is difficult since the exact extent of interbreeding between the two is not known. The following information on the distribution of the dingo applies to dogs classified as dingoes based on fur colour, body form and breeding cycle. Therefore, the maps illustrating their distribution might be conflicting.

Distribution in the past

This section needs additional citations for verification.

Based on fossil, molecular and anthropogenic evidence, dingoes might have once had a widespread distribution (citation needed). These early dingoes would have associated with nomadic hunter-gatherer societies and later with the rising agricultural centres. It is further assumed that they would have been tamed there and then transported to various places in the world. Findings of dingo habitation in Thailand and Vietnam, regarded as the oldest findings, have been estimated at 5,000 to 5,500 years old. The age of similar findings from the highlands of Indonesia vary from 2,500 to 5,000 years. Originally, the dingo was suspected to have been introduced to Australia in the Pleistocene by Aborigines, which led to confusion concerning the dingo's nomenclature. Today, the most common theory is that the dingo arrived in Australia about 4,000 years ago. In 1979, an eroding dingo skeleton was excavated by Brown and Gollan (ANU) on the mid-coast of southern New South Wales (63), dated to 6,000 years of age. More recent mitochondrial DNA research estimates the arrival of dingoes to be

between 4,600 and 18,300 years (64). Evidence of dingoes appears to be absent from Tasmania, which was separated from the main Australian landmass around 12,000 years ago due to a rise in sea level, which led to the theory that dingoes have not been in Australia longer than this time. To reach Australia from Asia, there would have been at least 50 km of open sea to be crossed, even at the lowest sea level. Since there are few, if any, cases of a large land animal making such a journey by itself (the Falkland Islands wolf being a possible exception), the ancestors of modern dingoes most likely were brought to Australia on boats by Asian seafarers (22). A dance of the Aborigines in the coastal regions of the Kimberley, during which they depict dogs running excitedly up and down a boat and finally jumping into the water, is seen as further evidence for the introduction of dingoes by seafarers (65). These dogs possibly were used as food or eventually guard dogs. Potentially, the dingo came to Australia and the islands of South East Asia and the Pacific during the course of expansion of the Austronesian culture.

The two main theories concerning the geographical origin and travel routes of the modern dingo's ancestors and their arrival in Australia are (66):

- The dingoes originated in East Asia and took a travel route over the South East Asian islands due to their close proximity to Australia, and the relatively easy accessibility over the islands of the South East Asian archipelago. This theory is supported by examination of the mtDNA of Australian dingoes (22).
- Sheepdogs were introduced from the Indus Valley in Asia, over Timor by Indian seafarers, based on similarities in skeletal anatomy of Indian pariah dogs and Iranian wolves. This theory implies that the oldest-known fossils are 4,000 years old and were found on Timor, where the dogs coexisted for a time with pigs and sheep. This theory would be supported by the assumption that the simultaneous appearance of certain stone tools was caused by Indian influence, but other authorities dispute this. Recent genetic research on aboriginal DNA seems to support this conclusion, that Indian seafarers brought their dogs and other tools with them to Australia 4,000 years ago (67), (68), (69).

Whether there were several introductions of dingoes to Australia or just one is not yet known. The first official report of a "wild dog" in Australia comes from Captain William Dampier in 1699 (70). At the time, dingoes were probably (citation needed) widespread over the main part of the continent and lived in the wild, as well as alongside the Aboriginals. They were mostly tolerated by the European settlers and sometimes kept as pets. The number of dingoes was probably (citation needed) low in those times and increased since then in some parts of Australia. Their numbers probably (citation needed) increased strongly around the 1880s due to the establishment of the pastoral economy and artesian watering places, and probably (citation needed) peaked in the 1930s and 1950s. Afterwards, the numbers remained high, but the percentage of dingo-hybrids has significantly increased since then (citation needed).

Present distribution

This section needs additional citations for verification.

Today, dingoes live in many diverse habitats, including the snow-covered mountain forests of eastern Australia, the deserts of Central Australia, and Northern Australia's tropical forest wetlands. The absence of dingoes in many parts of the Australian grasslands is probably due to human persecution. Based on skull characteristics, size, fur colour and breeding cycles, distinct regional populations could be seen to exist between Australia and Asia, but not within Australia (12), (10).

The wild dog population of Australia now includes dingoes and a wide panoply of feral domestic dogs (mostly mixed-breeds and dingo-hybrids) having an enormous variety of colours. Due to the increased availability of water, native and introduced prey, livestock and human-provided food, this population is on the increase. Reports from some parts of Australia indicate that wild dogs now hunt in packs there, where they had previously been solitary hunters (71). Dingo densities have been measured at up to 0.3 per square kilometre in both the Guy Fawkes River region of New South Wales and in South Australia at the height of a rabbit plague (10).

"Pure" (72) dingoes are regarded as widespread in Northern, North West and Central Australia; rare in Southern and Northeast Australia; and possibly extinct in the Southeastern and Southwestern areas. The establishment of agriculture caused a significant decrease in dingo numbers, and dingoes were practically expelled from the territories occupied by the sheep industry, primarily affecting large parts of southern Queensland, New South Wales, Victoria and South Australia. This situation was maintained by the construction of the Dingo Fence. Although dingoes were eradicated from most areas south of the Dingo Fence, they still exist in an area of about 58,000 km^2 in the dry northern areas north of the Dingo Fence and, therefore, on about 60% of the entire area (clarification needed).

In Victoria, wild dog populations are currently concentrated on the densely forested areas of the Eastern Highlands, from the border to New South Wales, south to Healesville and Gembrook. They also exist in the large desert in the northwest of the state. Wild dog populations in New South Wales primarily exist along the Great Dividing Range and the hinterlands on the coast, as well as in the Sturt National Park in the northwest of the state.

In the rest of the continent, dingoes are regarded as widespread, with the exception of the arid eastern half of Western Australia. In the bordering areas of South Australia and the Northern Territory, they are regarded as naturally scarce. Wild dogs are widespread in the Northern Territory, with the exception of the Tanami and Simpson Deserts, where they are rare due to the lack of watering holes. However, local concentrations exist there near artificial water sources. According to DNA examinations from 2004, the dingoes of Fraser Island are "pure" (73). However, skull measurements from the mid-1990s had a different result (74). A 2013 study showed that dingoes living in the Tanami Desert are among the "purest" in Australia (75).

Outside Australia, dingoes were proven to exist in Thailand, based on comparisons between the skulls of Thai dogs and those of fossil and present-day dingoes. The population there probably has the largest proportion of "pure" dingoes. They are widespread in northern and central Thailand and rare in the southern regions. They may also exist in Burma (Myanmar), China, India, Indonesia, Laos, Malaysia, Papua New Guinea, the Philippines and Vietnam, but if they exist there, their distribution is unknown. Dingoes are regarded as widespread in Sulawesi, but their distribution in the rest of Indonesia is unknown. They are regarded as rare in the Philippines and are probably extinct on many islands. In Korea, Japan and Oceania, a few local dog breeds with dingo-like features exist, but dingoes are considered extinct there (12).

Ecological impact of the dingo after its arrival in mainland Australia

See also: Extinction of the thylacine in mainland Australia

The dingo is suspected to have caused the extinction of the thylacine, the Tasmanian devil and the Tasmanian nativehen from mainland Australia, since a correlation in space and time is found between the arrival of the dingo and the extinctions of these species. Recent studies have questioned this theory, suggesting that climate change and increasing human populations may have been the cause (76). Dingoes do not seem to have had the same ecological impact that the red fox had in later times. This might be connected to the dingo's way of hunting and the size of their favoured prey, as well as to the low number of dingoes in the time before European colonization (77).

The assumption that dingoes and thylacines were competitors for the same prey stems from their external similarities; the thylacine had a stronger and more efficient bite, but was probably dependent on relatively small prey, while the dingo's stronger skull and neck would have allowed it to bring down bigger prey (78). The dingo was probably a superior hunter, as it hunted cooperatively in packs and could better defend resources, while the thylacine was probably more solitary. Also, wild dingo populations might have had demographic support from conspecific living with humans and may have introduced new diseases that affected the thylacine more severely (citation needed).

The extinction of the thylacine on the continent around 2,000 years ago has also been linked to changes in climate and land use by the Aborigines. It is plausible to name the dingo as the cause of the extinction, but significant morphological differences between the two suggest that the ecological overlapping of both species might be exaggerated. The dingo has the dentition of a generalist, while the thylacine had the dentition of a specialist carnivore without any signs of consumption of carrion or bones. It is also argued that the thylacine was a flexible predator that should have withstood the competition by the dingo, but was instead wiped out due to human persecution (citation needed).

This theory does not explain how the Tasmanian devil and the dingo coexisted on the same continent until about 430 years ago, when the dingo supposedly caused the Tasmanian devil's demise. The group dynamics of dingoes should have successfully kept devils away from carrion, and since dingoes are able to break bones, little would have been left for the devils to scavenge. Additionally, devils are successful hunters of small- to medium-sized prey, so there should have been an overlapping of the species in this area, too. Furthermore, the arguments that the dingo caused the extinction of the thylacine, the devil and the hen are in direct conflict with each other. If the dingo were really so similar to the thylacine and the Tasmanian devil in its ecological role and suppressed both, then coexisting with both for such an extended time is strange. Although this is a possible result of the dingo's introduction, critics regard the evidence for this as insubstantial (79).

Impact
Reliable information about the exact ecological, cultural and economic impact of wild dogs does not yet exist. Furthermore, the impact of wild dogs depends on several factors, and a distinction between dingoes and other domestic dogs is not necessarily made.

The appearance of a wild dog is sometimes very important when it comes to the cultural and economical impact. Here, it is often desired that the wild dog's appearance complies to what is demanded, that it is a "pure" dingo or at least looks like one (80). In the case of their economic impact, their appearance only seems to be important when "pure" dingoes are used as a tourist attraction. Where wild dogs are regarded as pests, their appearance is only of minor importance, if at all. The impact wild dogs have in urban areas and whether they are a danger to humans (such as direct attacks or diseases) is currently unknown.

Ecological impact
The dingo is regarded as part of the native Australian fauna by many environmentalists and biologists, as these dogs existed on the continent before the arrival of the Europeans and a mutual adaptation of the dingoes and their surrounding ecosystems had occurred. However, the contrary view has dingoes as just another introduced predator that are only native to Thailand (81).

Much of the present place of wild dogs in the Australian ecosystem, especially in the urban areas, remains unknown. Although the ecological role of dingoes in Northern and Central Australia is well understood, the same does not apply to the role of wild dogs in the east of the continent. In contrast to some claims (82), dingoes are assumed to have a positive impact on biodiversity in areas where feral foxes are present (83).

Dingoes are regarded as apex predators and possibly perform an ecological key function. It is likely (with increasing evidence from scientific research) that they control the diversity of the ecosystem by limiting the number of prey and keeping the competition in check. Wild dogs hunt feral livestock such as goats and pigs, as well as native prey and introduced animals. The low number of feral goats in Northern Australia is possibly caused by the presence of the dingoes, but whether they control the goats' numbers or not is still disputable. Studies from 1995 in the northern wet forests of Australia found the dingoes there did not reduce the number of feral pigs, but their predation only has an impact on the pig population together with the presence of water buffalos (which hinder the pigs' access to food) (84).

Observations concerning the mutual impact of dingoes and red fox and cat populations suggest dingoes limit the access of foxes and cats to certain resources. As a result, it is assumed that a disappearance of the dingoes may cause an increase of red fox and feral cat numbers and, therefore, a higher pressure on native animals. These studies found the presence of dingoes is one of the factors that keep fox numbers in an area low, and therefore reduces pressure on native animals, which then do not disappear from the area. The countrywide numbers of red foxes are especially high where dingo numbers are low, but other factors might responsible for this, depending on the area (42). Evidence was found for a competition between wild dogs and red foxes in the Blue Mountains of New South Wales, since there were many overlaps in the spectrum of preferred prey, but there was only evidence for local competition, not on a grand scale (85).

It is also possible that dingoes can live with red foxes and feral cats without reducing their numbers in areas with sufficient food resources (for example, high rabbit numbers) and hiding places. Nearly nothing is known about the relationship of wild dogs and feral cats, except both mostly live in the same areas. Although wild dogs also eat cats, it is not known whether this has an impact on the cat populations (42). At the moment, the Invasive Animals Cooperative Research Centre is investigating the exact effects of dingoes on the fox and cat populations to determine the benefits of keeping the dog in certain areas of Australia (86). In many areas, wild dogs live together with the most species of quolls (citation needed), except for the eastern quoll, which is probably extinct on the mainland, so wild dogs are not regarded as a threat to them.

Additionally, the disappearance of dingoes might increase the prevalence of kangaroo, rabbit and turkey (clarification needed) numbers. In the areas outside the Dingo Fence, the number of dingoes and emus is lower than in the areas inside. However, the numbers changed depending on the habitat. Since the environment is the same on both sides of the fence, the dingo was assumed to be a strong factor for the regulation of these species (clarification needed) (87). Therefore, some people demand that dingo

numbers should be allowed to increase or dingoes should be reintroduced in areas with low dingo populations to lower the pressure on endangered populations of native species and to reintroduce them in certain areas. In addition, the presence of the Australian brushturkey in Queensland increased significantly after dingo baiting was conducted (88).

Cultural impact

The neutrality of this section is disputed.

Cultural opinions about the dingo are often based on its perceived "cunning", and the idea that it is an intermediate between civilisation and wildness (89). Some of the early European settlers looked on dingoes as domestic dogs, while others thought they were more like wolves. Over the years, dingoes began to attack sheep, and their relationship to the Europeans changed very quickly: they were regarded as devious and cowardly, since they did not fight bravely in the eyes of the Europeans, and vanished into the bush (90). Dingoes were seen as predators that killed wantonly, rather than out of hunger (similar claims are made today concerning dingo-hybrids) (91). Additionally, they were seen as promiscuous or as devils with a venomous bite or saliva, and so they could be killed unreservedly. Over the years, dingo trappers gained some prestige for their work, especially when they managed to kill hard to catch dingoes. Dingoes were associated with thieves, vagabonds, bushrangers and parliamentary opponents. From the 1960s, politicians began calling their opponents "dingo," meaning they were cowardly and treacherous, and it has become a popular form of attack since then (65). Today, the word "dingo" still stands for "coward" and "cheat," with verb and adjective forms used, as well (89).

The image of the dingo now ranges from the romantic to the demonic (92), (93). While some Australians see the dingo as a wild dog, others see them as slightly tame wolves, and cultural biases about each of these animals affect general perceptions about dingoes. Some Australians believe the dingo which should be preserved (at least in its "pure" form), and its possible "extinction" is compared to that of the thylacine (7).

Traditionally, dogs have a privileged position in the Aboriginal cultures of Australia (clarification needed) (which the dingo may have adopted from the thylacine), and the dingo is a well-known part of rock carvings and cave paintings (9). Ceremonies (like a keen at the Cape York Peninsula in the form of howling (60)) and dreamtime stories are connected to the dingo, which were passed down through the generations.

Similar to how Europeans acquired dingoes, the Aboriginal people of Australia acquired dogs from the immigrants very quickly. This process was so fast that Francis Barrallier (the first European to explore the Outback) discovered in 1802 that five dogs of European origin were there before him (65). One theory holds that other domestic dogs will adopt the role of the "pure" dingo (92). In fact, the majority of the myths about dingoes simply call them "dogs" (whether that role was adopted, or whether there was no difference for the storyteller, is unknown) (9), and other introduced animals, such as the water buffalo and the domestic cat, have been adopted into the indigenous Aboriginal culture in the forms of rituals, traditional paintings and dreamtime stories (89).

The dingo is connected to holy places, totems, rituals and dreamtime characters. There are stories that dogs can see the supernatural, serve as guard dogs, and warn against evil powers. There is evidence that dogs have been buried with their owners to protect them against evil even after death (94). Most of the published myths originate from the Western Desert and show a remarkable complexity. In some stories, dingoes are the central characters, while in others, they are only minor ones. One time, it is an ancestor from the dreamtime who created humans and dingoes or gave them their current shape. There are stories about creation, socially acceptable behaviour, and explanations why some things are the way they are. There are myths about shapeshifters (human to dingo or vice versa), "dingo-people," and the creation of certain landscapes or elements of those landscapes, like waterholes or mountains.

In other stories, the dingo is responsible for death. In some myths, advice and warnings are given to those who do not want to follow the social rules. Stories can show the borders of one's territory or the dingo in it might stand for certain members of the community; for example, rebellious dingoes stand for "wild" members of the tribe. The dingo has a wild and uncontrollable face in other stories, and there are many tales about dingoes that kill and eat humans (for example, the Mamu, which catches and devours the spirit of every child who roams too far from the campfire) (9). Other stories tell of a giant devil dingo, from which ordinary dingoes originate.

The dog is thereby depicted as a homicidal, malicious creature that—apart from the lack of a subtle mind—is similar to a trickster, since it plays the role of a mischievous adversary for other mythological beings. Many of them fall victim to blood-thirsty dogs or escape them. Here, individual beings have a significant meaning or sometimes become part of the landscape. The actions of these dogs result, for instance, in the creation of stones and trees from flying bones and meat or ochre from the spilled blood (94).

Economic impact

Wild dogs are responsible for a wide range of negative and undesired impacts on the livestock industry of Australia, and they have been regarded as pests since the start of the European livestock industry. Sheep are the most frequent prey, followed by cattle and goats. Research on the real extent of the damage, though, and the reason for this problem, only started recently. Livestock can die from many causes and, when the carcass is found, it is often difficult to determine with certainty the cause of death. Since the outcome of an attack on livestock depends to a high degree on the behaviour and experience of the predator and the prey, only direct observation is certain to determine whether an attack was by dingoes or another domestic dog. Even the existence of remnants of the prey in the scat of wild dogs do not prove they are pests, since wild dogs also eat carrion. Exact numbers or reliable estimates of the damage caused by wild dogs are, therefore, hard to obtain and are seldom reliable. Even if livestock is not a big part of the dingo's diet, the extent of damage dingoes could potentially cause to the livestock industry could be much larger because of wanton killing.

The significance of dingoes as a pest is based primarily on the predation of sheep and, to a lesser extent, on cattle, and is not connected only to the direct loss of livestock. Harassment of sheep can cause a less optimal use of grassland and miscarriages.

The cattle industry can tolerate low to moderate, and sometimes high, grades (clarification needed) of wild dogs (therefore dingoes are not so easily regarded as pests in these areas). In the case of sheep and goats, a zero-tolerance attitude is common. The biggest threats are dogs that live inside or near the paddock areas. The extent of sheep loss is hard to determine, due to the wide pasture lands in some parts of Australia. The numbers of cattle losses is much more variable and less well-documented. Although the loss of cattle can rise up to 30% (59), the normal loss rate is about 0–10% (95).

Therefore, factors such as availability of native prey, as well as the defending behaviour and health of the cattle, play an important role in the number of losses. A study in Central Australia in 2003 confirmed that dingoes only have a low impact on cattle numbers when a sufficient supply of other prey (such as kangaroos and rabbits) is available. In some parts of Australia, it is assumed that the loss of calves can be minimised if horned cattle are used instead of polled (10). The precise economic impact is not known in this (clarification needed) case, and it is unlikely that the rescue of some calves compensates for the necessary costs of control measures. Calves usually suffer less lethal wounds than sheep due to their size and the protection by the adult cattle, and therefore have a higher chance of surviving an attack. As a result, the evidence of a dog attack may only be discovered after the cattle have been herded back into the enclosure (clarification needed), and signs such as bitten ears, tails and other wounds are discovered.

The opinions of cattle owners regarding dingoes are more variable than the those of sheep owners. Some cattle owners believe that it is better that the weakened mother loses her calf in times of drought so that she does not have to care for her calf, too. Therefore, these owners are more hesitant to kill dingoes (60). The cattle industry may benefit from the predation of dingoes on rabbits, kangaroos and rats. Furthermore, the mortality rate of calves has many possible causes, and it is difficult to discriminate between them. The only reliable method to document the damage would be to document all pregnant cows, then observe their development and that of their calves (59). The loss of calves in observed areas where dingoes were controlled was higher than in other areas. Loss of livestock is, therefore, not necessarily caused by the occurrence of dingoes and is independent from wild dogs (96). One researcher has stated that for cattle stations where dingoes were controlled, kangaroos were abundant, and this affects the availability of grass (97).

Domestic dogs are the only terrestrial predators in Australia that are big enough to kill fully-grown sheep, and only a few sheep manage to recover from the severe injuries. In the case of lambs, death can have many causes apart from attacks by predators, which are blamed for the deaths because they eat from the carcasses. Although attacks by red foxes are possible, such attacks are more rare than previously thought (96). The fact that the sheep and goat industry is much more susceptible to damage

caused by wild dogs than the cattle industry is mostly due to two factors: the flight behaviour of the sheep and their tendency to flock together in the face of danger, and the hunting methods of wild dogs, along with their efficient way of handling goat and sheep.

Therefore, the damage to the livestock industry does not correlate to the numbers of wild dogs in an area (except that there is no damage where no wild dogs occur (96)). Even if there are only a few wild dogs in an area, the damage to the sheep industry can be very high, since surplus killing can occur. Sometimes, extreme losses of livestock are reported (once reportedly 2,000 sheep in one night (81)) and are supposed (clarification needed) to be increasing.

According to a report from the government of Queensland, wild dogs cost the state about $30 million annually due to livestock losses, the spread of diseases and control measures. Losses for the livestock industry alone were estimated to be as high as $18 million (59). In Barcaldine, Queensland, up to one-fifth of all sheep are killed by dingoes annually, a situation which has been described as an "epidemic" (98). According to a survey among cattle owners in 1995, performed by the Park and Wildlife Service, owners estimated their annual losses due to wild dogs (depending on the district) to be from 1.6% to 7.1% (99).

Despite the variety of estimates, there is little doubt that predation by dingoes can cause enormous economic damage, especially in times of drought when natural prey is sparse and the number of dingoes is still relatively high. Furthermore, wild dogs are involved in the spread of echinococcosis among cattle and sheep. An infection with echinococcosis can lead to confiscation of 90% of the intestines (clarification needed), which further leads to a value decrease of the meat and high economical damage.

Among the indigenous Australians, dingoes were also used as hunting aids, living hot water bottles and camp dogs. Their scalps were used as a kind of currency, their teeth were traditionally used for decorative purposes, and their fur for traditional costumes. In some parts of Australia, premiums are paid for dingo fur and scalps. The fur of dingoes generally has only a low value, and export of this fur is forbidden in states where they are protected. There is no widespread commercial catching and killing of dingoes for the purposes of obtaining their fur.

Sometimes "pure" dingoes are important for tourism, when they are used to attract visitors. However, this seems to be common only on Fraser Island, where the dingoes are extensively used as a symbol to enhance the attraction of the island. Tourists are drawn to the experience of personally interacting with dingoes. Pictures of dingoes appear on brochures, many websites and postcards advertising the island (46). The use of dingo-urine as a repellent against dingoes and wallabies has been considered, but has not yet been economically implemented (100).

Legal status

Until 2004, the dingo was categorised as of "least concern" on the Red List of Threatened Species. However, it has since been recategorised as "vulnerable," following the decline in numbers to around 30% of "pure" dingoes, due to crossbreeding with domestic dogs (1). The dingo is regarded as a regulated, but not threatened, native species under the *Environment Protection and Biodiversity Conservation Act 1999* in the Commonwealth of Nations and is, therefore, protected in the national parks of the Commonwealth, as well as in World Heritage Sites and other conservation areas. However, this law also allows that dingoes can be controlled in areas where they have a proven impact on the environment. The law forbids the export of dingoes or their body parts from Australia, except for cases where it is regulated by the law. The legal status of the dingo and other wild dogs varies across the Australian federal states and territories (59).

- Northern Territory: The dingo is regarded as protected, not threatened, and native (due to its ecological impact) under the *Territory Parks and Wildlife Conservation Act (2000)*. Dingoes in the Northern Territory are regarded as having an important conservational value, since interbreeding of dingoes and other domestic dogs is low in the area. However, dingoes can be legally killed when they are a danger to the livestock industry.
- Western Australia: Dingoes and their hybrids are regarded as declared animals under the *Agriculture and Related Resources Protection Act (1976)*. Populations must be controlled, and dingoes can be kept as pets under certain conditions. Control measures are strictly confined to livestock areas, and other domestic dogs are controlled in general. Dingoes are also regarded as unprotected native fauna under the *Western Australian Wildlife Conservation Act*. Although not protected, dingoes are normally not hunted without permission in conservation areas.

- South Australia: Dingoes and their hybrids are considered pests in the sheep areas inside (south) of the Dingo Fence under the *Animal and Plant Control Board (Agricultural Protection and Other Purposes) Act (1986)*. There, they must be controlled and can only be kept in captivity by authorised zoos and wildlife parks. Outside (north) of the Dingo Fence, dingoes are regarded as legitimate wildlife and, although not protected, control is not mandatory and certain control methods (such as aerial baiting) are not permitted. A 35 km wide buffer zone exists immediately outside (north) of the Dingo Fence, where dingo numbers are controlled to very low levels to reduce incursion through the fence.
- Queensland: Dingoes and their hybrids are regarded as pests under the *Land Protection (Pest and Stock Route Management) Act 2002*. All landowners are legally committed to reduce the number of all wild dogs on their lands. The dingo is regarded as wildlife and native wildlife under the *Nature Conservation Act 1992* and is a natural resource (therefore protected) in conservation areas. Outside of these areas, dingoes are not regarded as native Australian and are not protected. Dingoes and their hybrids can only be kept in wildlife parks and zoos with ministerial agreement.
- New South Wales: *The Rural Lands Protection Act (1998)* allocates wild dogs the status of pests, and demands from landowners that dingoes shall be decimated or eradicated (citation needed). Although dingoes are not regarded as protected under the *National Parks and Wildlife Act 1974*, they are granted full protection in national parks. The dingo is regarded as a native species under the *Threatened Species Conservation Act (1995)*, since these dogs had established populations before the European colonisation. The *Wild Dog Destruction Act (1921)* includes dingoes in its definition of "wild dogs". This law only affects the western part of the state, where landowners are committed to control wild dogs. The law forbids the ownership of dingoes in that region, except with legal permission. In other parts of the federal state, dingoes can be kept as pets under the *Companion Animals Act (1998)*.
- Australian Capital Territory: Dingoes are regarded as protected under the *Nature Conservation Act (1980)*. On private land, the killing of wild dogs is allowed when with permission from the territory.
- Victoria: Wild dogs are regarded as established pests under the *Catchment and Land Protection Act (1994)*, and landowners (except from the Commonwealth) have the legal duty to hinder the spreading of wild dogs on their lands and eradicate them as much as possible. The term "wild dogs" here includes all dingoes, feral domestic dogs, dogs who became wild and crossbreeds (except for recognised breeds such as the Australian Cattle Dog) (101). The *Domestic (Feral and Nuisance) Animal Act (1994)* requires every dog owner to have their dogs under control at all times. The dingoes are granted a certain protection in areas that are managed by the *National Parks Act (1975)*. Since 1998, it is possible to own dingoes as pets (65). There is the possibility that "pure" dingoes may become officially classified as a protected species, according to official statements, and would not stand in conflict with control measures against wild dogs (102). Update: In 2008, dingoes were officially declared a threatened species (in danger of extinction) and are now protected (citation needed).
- Tasmania: The import of dingoes to Tasmania is forbidden under the *National Parks and Wildlife Act (1970)*. The control of dogs that attack livestock is managed under the *Dog Control Act (1987)*.

Control measures

This section needs additional citations for verification.

Dingo attacks on livestock led to widescale efforts to repel them from areas with intensive agricultural usage, and all states and territories have enacted laws for the control of dingoes (10). In the early 20th century, fences were erected to keep dingoes away from areas frequented by sheep, and a tendency to routinely eradicate dingoes developed among some livestock owners. Established methods for the control of dingoes in sheep areas entailed the employment of specific workers on every property. The job of these people (who were nicknamed "doggers") was to reduce the number of dingoes by using steel traps, baits, firearms and other methods. The responsibility for the control of wild dogs lay solely in the hands of the landowners. At the same time, the government was forced to control the number of dingoes. As a result, a number of measures for the control of dingoes developed over time. It was also considered that dingoes travel over long distances to reach areas with richer prey populations, and the control methods were often concentrated along "paths" or "trails" and in areas that were far away from sheep areas. All dingoes were regarded as a potential danger and were hunted.

Apart from the introduction of 1080 (extensively used for 40 years and nicknamed "doggone"), the methods and strategies for controlling wild dogs have changed little over time. Information concerning cultural importance to indigenous people and the importance of dingoes and the impact of control measures on other species is also lacking in some areas. Historically, the attitudes and needs of indigenous people were not taken into account when dingoes were controlled. Other factors that might be taken into account are the genetic status (degree of interbreeding) of dingoes in these areas, ownership and land usage, as well as a reduction of killing measures to areas outside of the zones.

However, most control measures and the appropriate studies are there to minimise the loss of livestock and not to protect dingoes.

Increasing pressure from environmentalists against the random killing of dingoes, as well as the impact on other animals, demanded that more information needed to be gathered to prove the necessity of control measures and to disprove the claim of unnecessary killings.Today, permanent population control is regarded as necessary to reduce the impact of all wild dogs and to ensure the survival of the "pure" dingo in the wild (59).

Deterrence
One method that does not have any proven effect is to hang dead dogs along the borders of the property in the belief that this would repel wild dogs (10).

Guardian animals
To protect livestock, livestock guardian dogs (for example, Maremmas), donkeys, alpacas and llamas are used (103), (104). To keep wild dogs away from certain areas, efforts are taken to make these areas unattractive for them (for example, by getting rid of food waste) and therefore forcing them to move elsewhere. Control through deliberately spreading disease is normally not considered. Such attempts probably would not be successful, because typical dog diseases are already present in the population. Additionally, dogs under human care would also be susceptible. Other biological control methods are not regarded as achievable, since there would be a high risk of decimating dogs under human care.

Dingo Fence
In the 1920s, the Dingo Fence was erected on the basis of the *Wild Dog Act (1921)* and, until 1931, thousands of miles of Dingo Fences had been erected in several areas of South Australia. In the year 1946, these efforts were directed to a single goal, and the Dingo Fence was finally completed. The fence connected with other fences in New South Wales and Queensland. The main responsibilities in maintaining the Dingo Fence still lies with the landowners, whose properties border on the fence and receive financial support from the government.

Reward system
A reward system (local, as well from the government) was active from 1846 to the end of the 20th century, but there is no evidence that – despite the billions of dollars spent – it was ever an efficient control method. Therefore, its importance declined over time (12).

Poisoning
Baits with the poison 1080 are regarded as the fastest and safest method for dog control, since they are extremely susceptible. Even small amounts of poison per dog are sufficient (0.3 mg per kg) (59). The application of aerial baiting is regulated in the Commonwealth by the *Civil Aviation Regulations (1988)*. The assumption that the tiger quoll might be damaged by the poison led to the dwindling of areas where aerial baiting could be performed. In areas where aerial baiting is no longer possible, it is necessary to put down baits.

Over the last years, cyanide-ejectors and protection collars (filled with 1080 on certain spots) have been tested (105), (106). The eradication of dingoes due to livestock damage decreased along with the importance of the sheep industry and the usage of strychnine (which beforehand had been used for 100 years) in the 1970s. The number of doggers also decreased and the frequency of government-approved aerial baiting increased. During this period, many farmers in Western Australia switched to the cattle industry, and findings in the area of biology led to a significant change in control measures and techniques in association with reduced costs and increased efficiency. At the same time, the importance of 1080 increased.

Neutering
Owners of dingoes and other domestic dogs are sometimes asked to neuter their pets and keep them under observation to reduce the number of stray/feral dogs and prevent interbreeding with dingoes (for instance under the *Territory Parks and Wildlife Conservation Act (2000)*) (59).

Efficiency of measures
The efficiency of control measures was questioned in the past and is often questioned today, as well as whether they stand in a good cost-benefit ratio. The premium system proved to be susceptible to

deception and to be useless on a large scale, and can therefore only be used for getting rid of "problem-dogs" (10), (107). Animal traps are considered inhumane and inefficient on a large scale, due to the limited efficacy of baits. Based on studies, it is assumed that only young dogs that would have died anyway can be captured (61). Furthermore, wild dogs are capable of learning and sometimes are able to detect and avoid traps quite efficiently. In one case, a dingo bitch followed a dogger and triggered his traps one after another by carefully pushing her paw through the sand that covered the trap (90).

Poisonous baits can be very effective when they are of good meat quality; however, they do not last long (108) and are occasionally taken by red foxes, quolls, ants and birds. Aerial baiting can nearly eliminate whole dingo populations (61). Livestock guardian dogs can effectively minimise livestock losses, but are less effective on wide open areas with widely distributed livestock. Furthermore, they can be a danger to the livestock or be killed by control measures themselves when they are not sufficiently supervised by their owners (106). Fences are reliable in keeping wild dogs from entering certain areas, but they are expensive to build, need permanent maintenance, and only cause the problem to be relocated.

According to studies, control measures can eliminate 66% to 84% of a wild dog population, but the population can reach its old numbers very quickly over the course of a year, depending on the season, such as by immigration of young dogs from other areas. Only a cohesive coordinated control in all areas could be efficient in the long run, if at all (80). Control measures mostly result in smaller packs and a disruption of pack structure. The measures seem (clarification needed) to be rather detrimental to the livestock industry because the empty territories are taken over by young dogs and the predation then increases. Nonetheless, it is regarded as unlikely that the control measures could completely eradicate the dingo in Central Australia, and the elimination of all wild dogs is not considered a realistic option.

It has been shown that culling a small percentage of immature dingoes on Fraser Island have little significant negative impact on the overall island population, though this is being disputed (109).

Conservation

Dingoes are reasonably abundant in large parts of Australia, but there is some argument that they are endangered due to interbreeding with other dogs in many parts of their range (1). Dingoes are not a protected species, but they are regulated under federal law and, thus, their status varies in different states and territories. Dingoes receive varying levels of protection in conservation areas such as national parks and natural reserves in New South Wales, the Northern Territory and Victoria, Arnhem Land and other Aboriginal lands, UNESCO World Heritage Sites, and the whole of the Australian Capital Territory. In some states, dingoes are regarded as declared pests and landowners are allowed to control the local populations. Throughout Australia, all other wild dogs are considered pests.

The dingoes of Fraser Island are considered to be of significant conservational value. Due to their geographic and genetic isolation, they are considered to be the most similar to the original dingoes, and they are seen as the most pure dingo population. The dingoes there are not "threatened" by interbreeding with other domestic dogs. Because of their conservational value, outrage was sparked in January 2013 when two six-month-old dingo pups were found dead, believed to have been run over near Lake McKenzie (110). The couple who found the dingoes were outraged at the reaction of the rangers, and Fraser Coast area manager Ross Belcher said that there will be serious penalties for those who kill or injure Fraser Island dingoes (111).

In February 2013, a report on Fraser Island dingo management strategies was released, with options including ending the intimidation of dingoes, tagging practice changes and regular veterinarian checkups, as well as a permanent dingo sanctuary on the island (112).
Groups that have devoted themselves to the conservation of the "pure" dingo by using breeding programs include the *Australian Native Dog Conservation Society* and the *Australian Dingo Conservation Association*. Presently, the efforts of the dingo conservation groups are considered to be ineffective because most of their dogs are untested or are known to be hybrids (12).

Dingo conservation efforts focus primarily on preventing interbreeding between dingoes and other domestic dogs in order to conserve the population of pure dingoes. This is extremely difficult and costly. Conservation efforts are hampered by the fact that it is not known how many pure dingoes still exist in Australia. Steps to conserve the pure dingo can only be effective when the identification of

dingoes and other domestic dogs is absolutely reliable, especially in the case of living specimens. Additionally, conservation efforts are in conflict with control measures.

Conservation of pure and survivable dingo populations is promising in remote areas, where contact with humans and other domestic dogs is rare. Under New South Wales state policy in parks, reserves and other areas not used by agriculture, these populations are only to be controlled when they pose a threat to the survival of other native species. The introduction of "dog-free" buffer zones around areas with pure dingoes is regarded as a realistic method to stop interbreeding. This is enforced in the way that all wild dogs can be killed outside of the conservation areas. However, studies from the year 2007 indicate that even an intensive control of core areas is probably not able to stop the process of interbreeding (113).

There is presently no information regarding what opinions the public has regarding the conservation of dingoes. There is no unity on the definition of "pure" dingoes and to what extent they should be controlled (114).

As a pet and working dog

This article contains vague phrasing that often accompanies biased or unverifiable information.

Opinion is divided about the keeping of dingoes as pets or as working dogs. Some consider the dingo unsuitable for domestication, while others see a domesticated dingo as no different from any other domesticated dog (115). In this vein, dingoes would have the right to be recognised as a dog breed, and domestication would be the only reliable way of ensuring the survival of the "pure" dingo (116). Some disagree that the dingo should be labeled a dog breed, as they believe "true" dingoes can be tamed but not truly domesticated (147).

Dingoes are sometimes kept as pets, although their tendencies as wild animals are difficult to suppress. Dingoes can be very tame when they come in frequent contact with humans (31). Furthermore, some dingoes live with humans (due to practical, as well as emotional reasons). Many indigenous Australians and early European settlers lived alongside dingoes. Indigenous Australians would take dingo pups from the den and tame them until sexual maturity and the dogs would leave (117). Alfred Brehm reported cases where dingoes that were completely tame and, in some cases, behaved exactly like other domestic dogs (one was used for shepherding heavy livestock), as well as specimens that remained wild and shy. He also reported about dingoes that were aggressive and completely uncontrollable, but he was of the opinion that these reports "should not get more attention than they deserve," since the behaviour depends on how the dingo was raised since early puppyhood. He believed that these dogs could become very decent pets (33).

According to Eberhard Trumler (clarification needed), dingoes are very smart and affectionate. To would-be owners, he recommended the provision of a large escape-proof enclosure and a partner of the opposite sex. During heat, dingoes are harder to manage than other domestic dogs which, combined with their attachment to their owners, can lead to problems, since they want to follow their owners and never miss the opportunity to feed. Dingoes are supposed (clarification needed) to find every weak spot of an enclosure or residence, escape for a while and stray through towns and villages. Their intellectual ability is supposedly (clarification needed) connected to an enormous ability to learn and a lightning perception. Dingoes have a reputation for not handling pressure, but this conflicts with their record as working dogs. They are suitable as shepherd dogs, appearing to see a purpose in it (keeping together a familiar group is in their nature) and, even today, some dingoes are employed as shepherd dogs. In addition, dingoes have strong toileting instincts and can easily be housebroken.

In 1976, the Australian Native Dog Training Society of NSW Ltd. was founded. Until this time, the ownership of dingoes was illegal (clarification needed). In mid-1994, the Australian National Kennel Council (ANKC) officially recognised the dingo as Australia's national dog breed, and a breed standard was published some years later. The dingo is listed in Group 4 (hound) of the ANKC (118). However, it is still illegal in some states to own, breed or sell dingoes, as it is in some countries (19).

In South Australia, dingoes can only be kept in specially licensed zoos, circuses and authorised research institutions. South Australia is a particularly sensitive region, due to extensive sheep farming conflicting with large populations of wild dingoes in the north of the state. Dingoes are bred by certain clubs and private individuals in Australia and the United States. The dingo is not regarded as a dog

breed by the Fédération Cynologique Internationale. However, the American Rare Breed Association (ARBA) regards the dingo as a breed belonging to the Spitz and Primitive Group.

Goals

In 1998 in New South Wales, the dingo was reclassified as a pet in order to save the species from extinction. Breeding programs were introduced, which were considered to be the best option available for safeguarding the continuation of the species, with the goal of returning them to the wild at a later date (115).

Dingoes have also been bred for sale or use as working dogs. The use of dingoes at customs (clarification needed) was first attempted in 1976 in Victoria. However, some people (clarification needed) speculated that these dogs were cross-breeds of dingoes and shepherd dogs (19).

Criticism

The ownership of dingoes as pets and their breeding is widely criticised. The main criticism is that the activities and the resulting consequences of the dingo conservation groups, "dingo farms" and legislation for legal ownership of dingoes for people in public, is seen to be an additional threat to the survival of the pure dingoes. This fear exists because the majority of these breeding activities effectively expedite the interbreeding of dingoes and other domestic dogs, when the identification of a pure dingo is not absolutely correct respectively when hybrids are sold as "pure" dingoes (12) (clarification needed).

Supporters of breeding programmes are only mildly optimistic about a successful outcome. Success in the form of a population viable for future re-wilding cannot be easily accomplished (119). According to David Jenkins (clarification needed), the breeding and reintroduction of pure dingoes is no easy option and, at the time (clarification needed), there were no studies that seriously dealt with this topic, especially in areas where dingo populations are already present (120).

An additional threat is that breeders may unconsciously select tamer dingoes by breeding individuals who are easier to manage. Therefore, it may happen that, over the years, the tame populations may become less suitable for living in the wild than their ancestors. In addition, a loss of genetic diversity (thus resulting in a higher susceptibility to diseases) might occur due to a small founding population, and negative changes could occur simply because the dogs were captive-bred. Furthermore, some features that are necessary for survival in the wild might "fade" under the conditions of domestication (for example, hunting techniques) because they are no longer needed.

Another criticism is that adult dingoes are viewed by some (clarification needed) to be unsuitable as pets in the same ways as other domestic dogs. Dingoes are regarded (clarification needed) as more independent-minded than other domestic dogs, making domestication reportedly (clarification needed) difficult. As dingoes age, they succumb (clarification needed) to their natural instincts and become more likely to escape into the wild (115). Furthermore, most people are unable to provide a dingo with what it needs, and dingoes may not react positively to domestication and training. Supposedly, only few dingoes and dingo-hybrids would reach an old age, since the owners would not know how to handle them. When a dingo is not socialised, it would be hard to control and develop behavioural problems from aspects of domestic life more easily tolerated by other dog breeds. To make dingoes more suitable as lapdogs, breeders would need to cross them with other domestic dogs (121).

Interbreeding with domestic dogs

Main article: Interbreeding of dingoes with other domestic dogs

European domestic dogs first arrived in Australia during the European colonisation. These dogs reverted to the wild (both unintentionally and intentionally), produced feral populations and interbred with the existing dingoes. Hybrids of dingoes and domestic dogs exist today in all wild dog populations of Australia, with their numbers having increased to such a degree that any completely "pure" populations may no longer exist (65). The degree of interbreeding is locally so high, for instance in urban and rural areas, that there are big populations consisting purely of hybrids. Estimates from the 1990s assumed a proportion of dingo-hybrids of about 78% in the wild (122). It is not clear how large the current population of hybrids is today.

Dingo-like domestic dogs and dingo-hybrids can be generally distinguished from "pure" dingoes by their fur colour, since there is a wider range of colours and patterns among them than among dingoes.

In addition, the more dog-typical kind of barking exists among the hybrids, and differences in the breeding cycle (123), certain skull characteristics (124), and genetic analyses (125) can be used for differentiation. Despite all the characteristics that can be used for distinguishing between dingoes and other domestic dogs, there are two problems that should not be underestimated. First, there is no real clarity regarding at what point a dog is regarded as a "pure" dingo (114), and, secondly, no distinguishing feature is completely reliable—it is not known which characteristics permanently remain under the conditions of natural selection.
In science, there are two main opinions regarding this process of interbreeding. The first, and likely most common, position states that the "pure" dingo should be preserved via strong controls of the wild dog populations, and only "pure" or nearly "pure" dingoes should be protected (126). The second position is relatively new and is of the opinion that people must accept that the dingo has changed and that it is impossible to bring the "pure" dingo back. Conservation of these dogs should therefore be based on where and how they live, as well as their cultural and ecological role, instead of concentrating on precise definitions or concerns about "genetic purity" (127). Both positions are controversially discussed.

There is a wider range of fur colours, skull shapes and body size in the modern-day wild dog population than in the time before the arrival of the Europeans. Over the course of the last 40 years (clarification needed), there has been an increase of about 20% in the average wild dog body size (128). It is currently unknown whether, in the case of the disappearance of "pure" dingoes, remaining hybrids would alter the predation pressure on other animals. It is also unclear what kind of role these hybrids would play in the Australian ecosystems. However, it likely that the dynamics of the various ecosystems will not be disturbed by this process (10).

Attacks on humans
Main article: Dingo attack
Although dingoes are large enough to be dangerous, they generally avoid conflict with humans. Apart from the well-known case in which an infant was taken from a campsite (see below), there have been numerous confirmed dingo attacks, often involving people feeding wild dingoes, particularly on Fraser Island, a special center of dingo-related tourism (see main article). Most dingo attacks are minor in nature, but some can be major, and a few can be fatal. Many Australian national parks have signs advising visitors not to feed wildlife, partly because this practice is not healthy for the animals, and partly because it may encourage undesirable behaviour, such as snatching or biting by dingoes, kangaroos, goannas and some birds.

Azaria Chamberlain dingo attack
Main article: Death of Azaria Chamberlain
On 17 August 1980, a nine-week-old girl named Azaria Chamberlain was taken by a dingo near Uluru (then known as Ayers Rock) and killed (39). Her mother, Lindy Chamberlain, was suspected and wrongly convicted of murder, and her father, Michael Chamberlain, with being an accessory after the fact, as the court did not believe that an animal generally shy of humans would be capable of such an act. After serving more than three years of her sentence, Lindy was released from prison when the jacket of the baby was found in a dingo den. The parents were thereafter found innocent, but the cause of death was not officially listed as a dingo attack until 12 June 2012 (129), (130), (131), (132).

Fraser Island attacks
- In April 1998, a 3-year-old Norwegian girl was bitten and scratched by a dingo (133).
- On 30 April 2001, nine-year-old Clinton Gage was attacked and killed by two dingoes near Waddy Point on Fraser Island. The incident and the resultant culling of 31 dingoes caused a large outcry among the residents. There were many protests and the suggestion was made to erect fences (134), (135).
- On 26 April 2011, a three-year-old girl was attacked on Fraser Island by two dingoes. She suffered serious puncture wounds to her leg (136).
- In November 2012, a six-month-old dingo was killed by rangers on Fraser Island after continued aggressive and dangerous behaviour towards people. The dangerous behaviour included "lunging" at a family, coming out of the bushland at high speed towards volleyball players, and grabbing two tourists on separate occasions with his mouth, not breaking the skin on either occasion (137). Rangers attempted to trap the dangerous dingo for a month before they were successful. The captured animal was then euthanized (138). One dingo advocacy group argued that, as a juvenile, the dingo's aggressive behaviours would be considered normal for his young age (137). Soon after the dingo's brother was

killed by rangers, although documented incidents for this dog never reached the serious Code E level his brother's had (139).

Dingo conservation groups on Fraser Island have become frustrated with the killing of dingoes that attack humans (citation needed). It has been proposed (clarification needed) that problem dingoes be relocated to a wildlife sanctuary (140). Queensland Environment Minister Andrew Powell said that the Fraser Island government should work to better educate people about dingoes to help stop attacks (141).

Conclusions

Articles published about dingo attacks blame them on habituation, especially through the intentional and unintentional feeding of dingoes (citation needed). The more frequently these animals are fed or allowed to scavenge on waste food, the more likely they are to react aggressively towards humans when they no longer receive or find food. It is further thought (clarification needed) that dingoes might have started to regard the food sources found (garbage cans, leftovers and handouts) as part of their territory. Attacks then occur with humans seen as competition, and dingoes simply reacting to protect their food supply.

Even when habituation to humans seems to be the general cause for attacks, it is not absolutely clear, and therefore the overall threat towards people is not known for sure. Some attacks might result from the "play" of young pups, especially with children. Attacks can also be caused by mistaken reactions of humans to aggressive and dominant behaviour of dingoes. That some dingoes might regard humans as prey is a possibility, as children or incapacitated adults could be theoretically overpowered (46), (135). Dr. Bradley Smith (clarification needed) said that Fraser Island has a problem with humans and not with the dingoes, that dogs who were labelled "aggressive" were simply behaving naturally (142).

The behaviour of humans might undermine efforts to guard against dingo attacks. Therefore, the change in human behaviour is at the centre of attention (clarification needed). Warning signs like "Beware of Dingoes" seem to have lost their effect on Fraser Island, despite the high number of such signs (citation needed). Furthermore, some humans (clarification needed) do not realise how adaptive and quick dingoes are. Therefore, humans do not remain attentive enough (citation needed). They (clarification needed) do not consider, for instance, that dingoes steal food like fruits and vegetables. In addition, some tourists seemed to be confused by the high number of rules in some parks, and they have been prompted in some cases to actively feed the wild animals (46), (59), (134), (135).

Problems in classification

There is no general agreement (scientific or otherwise) regarding what the dingo is, in a biological sense, since it has been called "wolf," "dingo," "dog," and "wild dog" (93). Even within the scientific community, the dingo is given several names. There is no consensus regarding whether the dingo is a feral or native animal, or what kinds of dogs should be classed as "dingoes". Thus, one writer considered the New Guinea singing dog, the Basenji, the Carolina Dog (65) and certain other dog populations (citation needed) to be dingoes. Evidence indicates a discord concerning the status of these dogs, as well.

Dingoes have been variously considered to be wild dogs (39), the progenitor of domestic dogs (65), the ancestor of modern dog breeds, a separate species (143), a link between wolf and domestic dog (65), a primitive canine species (144) or primitive domestic dog (12), a "dog-like" relative of wolves (145) or a subspecies of the domestic dog (146). Others consider them to be native dogs of Asia (147), a relatively unchanged form of early domestic dog (10), part wolf and part dog (148), or to have been selectively bred from wolves (103). Then again, some do not consider dingoes feral any more but completely wild, since they have been living under natural selection for a very long time (149). According to present scientific consensus and knowledge, dingoes are domestic dogs that arrived at their present distribution with humans, adapted to the respective conditions and are no more "primitive" or "primordial" than other domestic dogs (150). The Australian dingo has never been subject to the artificial selection that produced modern dog breeds (92), and it may be an undomesticated descendant of an extinct Asian wolf (151). However, compared to the European grey wolf, dingoes have an approximately 30% lower relative brain size (152), reduced facial expressions (153), reduced impressive behaviour (31), curled tails that can be carried over the back, and generally a permanent fertility in males—features that all known domestic dogs share and are considered to be caused by domestication (23), (31). It might happen that one and the same source names the dingo as a subspecies of the grey wolf, but lists all other domestic dogs as separate species (154) (clarification

needed). Likewise, the scientific name of the dingo might be *Canis lupus dingo*, but the dingo is regarded as a separate species, nonetheless (155). Alfred Brehm originally considered the dingo to be a separate species but, after examining several different specimens, he came to the conclusion that they could only be domestic dogs (33). In contrast, William Jardine considered the dingo to be an entirely separate species, while contemporary French naturalists regarded them as feral dogs (156). Even among modern-day scientists, dingoes and other domestic dogs are sometimes considered two separate species, despite small genetic, morphological and behavioural differences.

The phenomenon of interbreeding between both is then attributed to the statement that all wolf-like species can interbreed and produce fertile offspring (26). However, breeding experiments in Germany could only prove an unrestricted fertility in the offspring of domestic dogs and grey wolves. Hybrids between domestic dogs and coyotes, and domestic dogs and golden jackals, had communication problems (clarification needed) among each other, as well to the parent species. From the third hybrid generation on, a decrease in fertility and an increase in genetic damage (clarification needed) was observed among the coyote-hybrids and jackal-hybrids (150). Observations of this kind have never been made for hybrids of dingoes and other domestic dogs, only that dingoes and other domestic dogs can freely interbreed with each other (157).

The choice of classification can have a direct impact on the dingo. Dingoes officially cease to exist outside of national parks and become unprotected wild dogs (93). The term "wild dog," itself, sometimes only includes dingoes and their hybrids (158) or respectively excludes dingoes (159). Another view is that dingoes are "only" feral outside of national parks, with this term having a more negative meaning than the term "wild".

On the other hand, dingoes have been "rehabilitated" in some way, by changing their status from pests to "Australia's native dog" or, more subtly, from a subspecies of the domestic dog to that of the grey wolf. The undertone in the Australian press seemed to be that being a grey wolf or an Asian wolf means that the dingo is more "wild" and, therefore, more desirable than a companion animal (domestic dog). It is possible that the habit of calling the dingo only "dog" (not "wild dog") in colloquial language indicates a form of familiarity or debasing. In the last case, it might be morally easier to kill a dog when it causes problems because it would not have the "high status" of a wolf or dingo (93). Sometimes, it is considered bad that dingoes are domestic dogs, that they are descended from them and not "directly" from the grey wolf (160). In short, if the dingo is regarded as native, then it is worthy of protection. But if it is considered to be "just" a variant of the domestic dog, it is regarded as a pest and should be eradicated (36), (81).

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APPENDIX 5: DOMESTIC DOG

Glen Mellin
Lenny Truitt

March 2016

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This appendix addresses Native American Domestic Dog breeds. To date, we have no comprehensive DNA sequencing of any archaeologically recovered dog remains in the Mid-Atlantic region. This present lack of data presents huge opportunities, going forward. Our best guess is that groups of people in each Native American cultural region would have bred and maintained their breed(s) of dogs. Through collecting and comparing comprehensive DNA sequences, we should be able to piece together which breeds of dogs were present at specific locations together with the cultural contexts they lived in, as well as where their ancestors came from.

Occasionally, dog remains are briefly discussed in archaeology reports. Visual and metric data may indicate these finds are actually dogs, and not raccoons, or foxes. We searched archaeological and records management literature for dog burial data bases in the Mid-Atlantic region, but found none. It seems that no state in the Mid-Atlantic region maintains a comprehensive dog burial list, or any other list(s) documenting any of the four-legged tactical predators identified in this essay (Bobcat, Cougar, Coyote, Domestic Dog, Eastern Wolf, Gray Fox, Red Fox, and Red Wolf).

The history of Native American dogs in the western hemisphere is sure to be complex. We are less concerned with the origin of the dog(s) in eastern Asia and Siberia than we are with the contexts of how, and when the true dog (*Canis lupus familiaris*) spread across the landscape of the western hemisphere.

Kingdom: Animalia
Phylum: Chordata
Class: Mamalia
Order: Carnivora
Family: Canidae
Genus: *Canis*
Species: *C. lupus*
Subspecies: familiaris
Breed: (various)

Linnaeus is widely recognized as having described the domestic dog in 1758. All true dogs in the prehistoric western hemisphere were of the subspecies *familiaris*. The implication is that these dogs and their human owners had co-dependent relationships. There are no known wild dogs independently migrating to the western hemisphere. With that being said, results of current, but limited, DNA analysis of living dogs strongly suggest there were at least three separate migrations, resulting in at least three strains of DNA groupings coming to America, at three different times. The window of migration is suggested to be no older than 14,000 ypb for the first migration, and no younger than 3,000 ybp on the most recent migration.

The first grouping (the older grouping) seems to be the smaller dog, weighing less than twenty pounds, who's progeny spread throughout North, Central, and South America, Cuba, Hispaniola, Jamaica, Puerto Rico, Virgin Islands, etc. During the Holocene, this early arrival dog was bred into various breeds at the whim of their owners. Living breeds in this grouping include the Carolina Dog ("Ol' Yeller"), Chihuahua, Xoloitzcuintli, Perro Sin Pelo del Peru, etc. Extirpated breeds include the Tahltran Bear Dog, Hare Indian Dog, Salish Wool Dog, and the Innu Canoe Hunting Dog, etc.

The second grouping probably arrived as Thule working dogs. These large dogs were bred for hunting, protection, and transportation, well suited for the arctic conditions. This group seems to have some Siberian Taimyr wolf ancestry. Starting around 4,000 ybp, this group evolved into the Inuit sled dog, the Canadian Eskimo Dog, and the Greenland Dog, as well as modern variants.

The third grouping probably arrived as Mahlemuit, or Inupiat, working dogs. These large dogs were bred for hunting, protection, and transportation, well suited for the arctic conditions. Starting around 3,000 ybp, this grouping seems to be variants of the Spitz grouping, where we have the Alaskan Malamute, and the Siberian Husky, and modern variants.

Ironically, the North American Reservation Dog ("Rez"), a popular Native American breed in the Midwest and western states, is almost entirely of European descent. Prehistoric dogs in Hawaii and the inhabited Pacific Islands have varying degrees of Dingo and ancestral Southeast Asian ancestry (ca. 6,000 to 8,000 ybp).

One of the issues we have here in the lower forty-eight states is that we have identified only one ancestral Native American dog breed, the Carolina Dog. Examples of this breed can be found roaming wild in portions of South Carolina and Georgia. Some living examples of these Carolina dogs have had their DNA sequenced. The following quote from Wikipedia illustrates the genetic make-up of Carolina Dog blood samples (citations 15 through 18 follow the block quote):

> "In 2013, a study looked at the mDNA haplotypes associated with samples of the Carolina dog. The study showed that 58% of the dogs carried universal haplotypes that could be found around the world (haplotypes A16, A18, A19, and B1), 5% carried haplotypes associated with Korea and Japan (A39), and 37% carried a unique haplotype that was not recorded before (A184) and that relates to the a5 mDNA sub-haplogroup that originated in East Asia (14). As the dingo and the New Guinea singing dog belong to haplotype A29 (15), (16) that relates to the a2 sub-haplogroup (17), (18), there is no genetic relationship." (Carolina dog, https://en.wikipedia.org/wiki/Carolina_Dog.)
>
> (14) *Van Asch, B.; Zhang, A.-b.; Oskarsson, M. C. R.; Klutsch, C. F. C.; Amorim, A.; Savolainen, P. (2013). "Pre-Columbian origins of Native American dog breeds, with only limited replacement by European dogs, confirmed by mtDNA analysis". Proceedings of the Royal Society B: Biological Sciences* ***280*** *(1766): 20131142. doi:10.1098/rspb.2013.1142.* Table 1
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> (16) *Oskarsson, M. C. R.; Klutsch, C. F. C.; Boonyaprakob, U.; Wilton, A.; Tanabe, Y.; Savolainen, P. (2011). "Mitochondrial DNA data indicate an introduction through Mainland Southeast Asia for Australian dingoes and Polynesian domestic dogs". Proceedings of the Royal Society B: Biological Sciences* ***279*** *(1730): 967. doi:10.1098/rspb.2011.1395.*
> (17) *Pang, J.-F.; Kluetsch, C.; Zou, X.-J.; Zhang, A.-b.; Luo, L.-Y.; Angleby, H.; Ardalan, A.; Ekstrom, C.; Skollermo, A.; Lundeberg, J.; Matsumura, S.; Leitner, T.; Zhang, Y.-P.; Savolainen, P. (2009). "MtDNA Data Indicate a Single Origin for Dogs South of Yangtze River, Less Than 16,300 Years Ago, from Numerous Wolves". Molecular Biology and Evolution* ***26*** *(12): 2849. doi:10.1093/molbev/msp195. PMID 19723671.*
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What Van Asch and her colleagues (2013) actually said concerning the Carolina Dog haplotype A184, is summed up in the following two quotes: 1) "Among the 'free-ranging' Carolina dogs of southern USA, the most frequent haplotype was A184, which was unique to these dogs (it is a novel halpotype not previously reported in GenBank) and belongs to the East Asian-specific phylogenetic subclade a5 (figure 1). One individual had haplotype A39, otherwise found only among Chinese non-breed dogs and the Japanese breed shiba inu. The remaining dogs had universal haplotypes. This gives a strong support to the hypothesis that the Carolina Dog has indeed originated from pre-Columbian dogs." (See below, the Van Asch et al. essay, page 16), and 2) "The most frequent haplotype (A184) is unique to Carolina dogs and belongs to an East Asian-specific phylogenetic subclade, offering a clear indication of an East Asian origin for these dogs." (See below, the Van Asch et al. essay, page 17) (Figure 1 is found on page 11).

So, some of the Carolina dogs tested exhibit haplotype A184, arranged on the East Asian phylogenetic subclade a5. No other living examples of ancestral American dogs, for examples; the Chihuahua, the Xoloitzcuintli, and the Perro Sin Pelo del Peru, exhibit haplotype A184. This information may support our theory that haplotype A184 is an American genetic mutation and not a mutation that occurred in Asia. If the A184 mutation occurred here in North America, we have a wonderful opportunity to trace geographical and temporal pathways of progeny of that mutation. What other mutations besides A184 are out there? We would

like to know how many breeds of dogs Native Americans created? But of course, we cannot address these research questions because we do not have the necessary DNA sequencing of archaeological dog remains.

We already have a substantial number of dog burials from all around the United States--cleaned, catalogued, and currently sitting is storage, ready to have their DNA sequenced. What is lacking is the will to test the sample. The Koster site, in Indiana, is a perfect example, the samples have been in storage since 1973, waiting for someone to process them. We have found no indication the samples have been processed. Here is a brief quote from the Department of Natural Resources in Indiana where they compare dogs from the Koster site to other sites, but apparently do not feel the need for DNA analysis:

> At the Koster site, in Illinois, the remains of four domesticated dogs were buried by Native Americans over 8,000 years ago. Each dog was laid on its side in a shallow grave. The dogs were buried in an area of the village where residents also buried the remains of adults and children (15). Ancient dog burials, dating to the Middle Archaic period, were also uncovered at the Bluegrass site in Warrick County, Indiana. Based on the skeletons, these dogs are thought to have been light-limbed and about the size of a terrier (16). Other studies suggest most prehistoric American dogs were about the size of a modern dalmation (17). (Prehistoric American Dogs.)
>
> (15) Illinois State Museum: http://www.museum.state.il.us.
> (16) Stafford, C.R. Prehistoric People of Indiana: http://baby.indstate.edu/geo/anthro/prehist.html.
> (17) Crockford, S.J. (2005). Native Dog Types in North America before Arrival of European Dogs: http://www.vin.com/proceedings/Proceedings
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It is interesting to see some dog burials at the Koster site yielding Archaic dates of 8,000 ybp. It is also interesting to see how some adult dogs are estimated to weigh twelve to fifteen pounds, while other adult dogs are estimated to weigh between thirty to forty pounds. Are we looking at evidence that describes differences in Native American domestic dog breeds? Why would Native American people need different breeds of dogs--what functions would these different breeds perform on a day-to-day basis? And, when considering the 14,000 years or so that these human/dog relationships transpired and evolved, a great many research questions may be applied to the Native American cultures involved.

We may forecast master dog breeds created in New England, Mid-Atlantic, Southeast, Florida, Central River Basin, North and Central Plains, Southwest, Mountain, Pacific southwest, and the Pacific Northwest. Additional minor dog breeds and/or special purpose dog attributes may have been bred within these geographic areas. Furthermore, 14,000 years is a pretty long time, and although the above geographical regions are generalized, culture zones within them were dynamic, not static. As populations and economies changed, surely the expectations of their dogs changed as well.

Pick a number--any number! Are we going to be able to identify between 10 and 20 breeds, 20 and 30 breeds? We don't know for sure. But one thing is for sure, and that is if we continue to ignore the collection and analysis of Domestic Dog DNA sequencing data, we will never know any more about "our best friend" than we already know. Let's be pragmatic, why do we continue to incarcerate our archaeological Domestic dogs without offering them a fair trial?

In this appendix, we include portions of two documents retrieved from the Internet. The first document is a brief essay written by a woman who lives in Alaska and is of Native American descent. We found her Native point of view fascinating and her comments and interpretations add substantially to our understanding of Native Americans and their dogs. This documents is called "Precolumbian Tribal Dogs in the Americas and was authored by Stephanie Little Wolf. We retrieved the document from the Internet on January 28, 2016 on her website at: http://www.native-languages.org/dogs.htm. We contacted Ms. Little Wolf and asked her for permission to re-print her work. She was enthusiastic, even inspired, but would neither agree nor disagree. So, we chose to re-print her work here offering as much respect as possible.

The second entry, "Pre-Columbian origins of Native American dog breeds, with only limited replacement by European dogs, confirmed by mtDNA analysis." is a professional document written by, Barbara van Asch; Ai-bing Zhang; C. R. Mattias Oskarsson; C. F. C. Klütsch; António Amorim; and Peter Savolainen and was published by the Royal Society in 2013. We retrieved the document from the Internet, and re-formatted it to fit our purposes on January 28, 2016. We included the van Asch et al. two color Figures and one Table just as they appear on Internet site: http://rspb.royalsocietypublishing.org/content/280/1766/20131142. We did not contact the Royal Society and we are offering as much respect as possible.

The following essay, "Precolumbian Tribal Dogs in the Americas." is the work of Stephanie Little Wolf. Her essay is dated February 15, 2015 and may be accessed at http://www.native-languages.org/dogs.htm. We have reduced the margins to separate her work from ours (see below):

Precolumbian Tribal Dogs In The Americas
by Stephanie Little Wolf

The dog who first entered North America with paleoindians was a well established inhabitant along with his human counterpart as early as fourteen thousand years ago. DNA studies on the genetic structure of paleoamerican dogs show that this was a fully domesticated animal at the time of entry into the North American continant, suggesting that the domestication of dogs occurred at an earlier time than has been previously suggested, (the archaeological record suggests canid domestication events around fourteen thousand years ago)- about the same time that humans walked over from Eurasia to the new world. This would indicate that the dog was actually domesticated at an earlier time than that.

The DNA Factor
Indeed, the Mtdna (mitochondrial) studies strongly support the hypothesis that paleoamerican and eurasian domestic dogs share a common origin, both evolving from the Eurasian gray Wolf. No evidence of a separate domestication of dogs from North American Grey Wolves was discovered. Although the haplotypes found in paleoamerican dogs were closely related to Eurasian dogs, some of them formed a unique clade within the main genetic group, (clad 1), which is found **only** in paleoamerican dogs. This indicates that dogs were present and isolated in the new world for a considerable amount of time. This long period of isolation led to the appearance of a group of genetic sequences (haplotypes) that are similar but very easily distinguishable from dogs from other parts of the world, or from any modern dog population in America today. Indeed, no surveyed modern population of dogs in the united states carries these unique genetic markers in their DNA. American Indian Dogs were extinct early on by the inbreeding and replacemnt by European dogs. Only the Eskimo dog has survived. Dna evidence links the Eskimo Dog with the Australian Dingo, the New Guinea Singing dog, and the Shiba Inu. The Mexican Hairless or Xoloitzcuintle was present in the Americas long before Europeans arrived, but the genetic lineage shows extreme mixing with European dogs and may not genetically resemble its precolumbian ancestors anymore, although reduced dentition and hairlessness are extremely dominant traits, so the dogs strongly resemble their forbears in appearance.

Dogs, Wolves, and Coyotes
At the time of European contact, American Indians were groups of diverse and widely dispersed nations. It is common yet inaccurate these days for them to be discussed as one single population, and their dogs do not escape this inaccuracy. In fact, there were many different types of Indian dogs and they were used for a variety of reasons that were as diverse and unique as the people they inhabited the land with. It is also common for modern researchers to site early explorers from the late 1600's to

the late 1800's and their anecdotal interpretations of Indian dogs as being almost impossible to distinguish from the wolf. This is also a common mistake and misinterpretation today. Countless times I have heard children, and adults refer to my Alaskan Village dogs as wolves. In fact, Eskimo dogs, huskies and other sled dogs may have fur and vocalizations that resemble their wolf ancestors, but that is about it. Dogs have a shorter stockier build, wider chests and shorter faces and muzzles, with short steep "stops" or angle from forehead to the bridge of the nose. In all, many dogs filled rolls within Indian cultures. Some tribes had rather loose associations with their dogs, some were extremely attached and involved with dogs as pets and or using them for various tasks. Dogs probably tracked game, and packed meat after a hunt. Dogs were eaten by some groups as a food source and some were only consumed ceremonially. Dogs were the playmates of young children and companions to the elders.

Four distinct types of tribal dog are presented here, although many more existed at one time. I encourage one to carefully review the list of resources presented at the end of this article.

Great Plains Dogs

Dogs were an intregal and important aspect of the tribes they were a part of. It is logical to discuss "dog culture" as the time period before the acquisition of the horse, and the time after this acquisition as "horse culture" by nations of the great plains. Some dogs were used for hauling and packing, pulling the famous travious across the plains. They packed meat or belongings, children and the elderly. They were pets, a food source, and possible trackers of game. They were numerous, partly fended for themselves, and bred freely with little input or selectiveness from tribal people. Selective breeding most likely did not occur among plains tribes, the only intervention in this respect was the culling of small or sickly pups or those that were snappish or surly with small children. Culling was also practiced to reduce the load of pups on the mother so she retained her health during the nursing period, and to select for large heavily boned individuals. Dogs served the important function of barking to alarm the tribe of the approach of enemies or visitors. Large and medium sized dogs coexisted and are sometimes vicariously referred to as Plains Indian Dogs and Sioux Dogs. These dogs according to some descriptions were either Dingo tawny colored and short or smooth coated, or grayish and somewhat longer coated. Many other color combinations existed, however, such as white, black, spotted and mottled. In reading many of the descriptions, what comes across is an animal somewhat like a dingo and somewhat like a husky. Tails were either short, broom or half tails, or sickle shaped with the typical curve of many a pariah dog throughout the world today. Photographs that exist of plains Indians and dogs show extremely mixed individuals, in recreated scenes that tried to depict a lifestyle well after cultural demise. The dogs bear the mark of European breeds, in color, coat texture, many possessing the typical heavier flopped over ears.

The Tahl Tan Bear Dog

This little bear dog was from 12 to 18 inches tall and weighed from 10- to 18lbs. Amazingly, It survived into the late 1960's or early 70's. This dog of the Tlingits, Tahltans, Kaska, and Sekani was used for hunting bears in British Columbia, Canada. The hunters carried the dog inside a pouch until bear tracks were discovered, where upon the dogs tracked the bear. These small dogs could run on top of crusty snow and bark and worry the bear until hunters arrived. These little dogs were black with white markings, or white with black markings, not much bigger that today's Schipperke. On examining a photograph from Atlin, B.C., of a bear dog, I noticed its resemblance to the New Guinea Singing Dog, an extremely rare dingo type dog from Papua New Guinea. In another photograph, the dog resembled a Papillon.

The Eskimo, or Inuit Dog of Canada, Alaska, and Greenland: The Qimmiq

Today, the Eskimo dog thankfully is alive and well. It originally occupied the coastal and archipelago areas of Greenland, Alaska, and Canada. Once upon a time, today's Malamute fell into the Eskimo dog category, the indigenous dog of the Mahlemuit Eskimos from the Kotzebue sound area in Alaska. The Eskimo Dog was a puller of sleds, used for hauling heaving loads of fish, whale, and seal or walrus from the hunt to the village or camp. In the summer, backpacking was the traditional use of the dog. The dogs are bigger and more heavily boned than Siberian Huskies, which are not native to North America. They could and can work in the most hostile of environments with little food or care. They are friendly for the most part but fight with each other to establish the ritual pecking order. They are primitive compared to most modern breeds, as they don't bark as much and howl often. They have heavy winter coats and range from as small as 45 lbs for females to as large as 85lbs for males, sexual dimorphism being related to more primitive qualities. An Eskimo dog's fur or pelage takes many colors, but the eyes should not be blue and there is some controversy here. These dogs are challenging to work with and

are strong beyond belief with incredible stamina. They are known in modern times as The Canadian Inuit Dog, The Inuit sled dog, and the Greenlander or Greenland dog. Clubs and organizations today are strong enthusiasts for the Eskimo dog, getting together and employing the old style fan hitch to go dog sledding or the modern tandem hitch for those of us who have narrow forest trails.

The West Coast Salish, Little woolly Dog or Clallam Indian Dog

These dogs were restricted to a fairly distinct area of northern British Columbia, where they were kept on islands to keep them from breeding with other types of dogs. The responsibility of woman, they were small, somewhat larger than todays Pomeranian. They had had a long thick mostly white pelage which was harvested by the Salish Indians to make clothing and blankets from. The dogs were numerous and highly utilized. Vancouver recorded that the dogs were shorn to the skin like sheep, and that the shorn wool of the dogs was so thick, that large mats of it could be lifted without being pulled apart. The wool of these dogs was dyed red or blue and striped blankets of cedar strips and dog wool were hardy and warm. The Artist Paul Kane gives us a wonderful and lengthy description of how the dog wool was made into blankets using cedar and white earth, apparently twisted together a beaten mixture of these, then rolling them down the leg as if twisting twine or yarn, then sewing the strips together.

Other Native American Dogs

There were many other dogs of North and South America. The Peruvian Pug-nosed dog, the Feugian dog, the Inca dogs, the Xoloytzecuintli, or Mexican hairless dog, the Hare Indian dog of the north, the Short Nosed dogs of the southwest, to name just a few. It is sad that most of these dogs are gone, with the exception of the Xolo, and Mexican Hairless. I have acquired photographs of Mayan dogs and they may resemble original Mayan dogs somewhat in their similarity to pariah type or aboriginal dogs from other parts of the world.

The Archaeological record tells us that native precolumbian dogs were often buried with their owners, and at other times, given their own intricate burials. They disappeared rapidly, and with good cause, unable as their owners were to withstand European dog diseases, and probably shot as a matter of course for their attention to European livestock. On the east coast among the original colonies of America, Indian dogs were outlawed and it was a crime for villages to possess them, as it was firearms. One needs only compare the demise of the pure Australian Dingo as a model for how fast native dogs disappeared from north, central, and South America. In Australia, only small pockets of genetically pure Dingoes remain, and they are threatened. One can openly imagine how fast North American dogs became amalgamated from their pure forms, and then disappeared entirely from the lives of a people whose own lives became increasingly difficult. It was all tribal nations could do to manage their own fates in the face of rapid decimation. Unlike the Dingo, dogs of the Americas had no wild populations from which to replenish their numbers. In their absence, we must turn to scientific research and learn what we can about this fascinating subject.

Resources on Native American Dogs

Studying modern aboriginal dogs such as the Dingo, the Santal Hound, and the New Guinea Singing dogs may shed some light on the relationship between native tribal peoples and their dogs. Following, is a list of resources which reveals a wonderful and interesting topic of study. In addition to these sources, I encourage one to study the works of R.K. Wayne, Jennifer Leonard, Susan Crockford, I. Lehr Brisbin, Janice Koler -Matznik, and Bulu Imam.

1) Dogs of the American Aborigines- Allen, Glover Bulletin of the Museum of Comparative Zoology, Harvard College Vol. 43, #9 Cambridge, Mass, 1920.
2) Dogs of the Northeastern Indians, Butler and Hancock Mass. Archaeological Society Bulletin vol. 10, #2 pages 17-35, 1949.
3) From Dogs to Horses among the Western Indian Tribes, F. G. Roe, Transactions, royal Society of Canada, third series, Volume xxx111 1939.
4) A History of Dogs of the Early Americas, By M.Schwartz Yale University Press 1979.
5) Lost History of the Canine Race M.E. Thurston, chapter 7 "The Other Americans" (page 146) Andrews and McMeel, 1996.
6) First Nations, First Dogs B.D. Cummins, Canadian Ethnocynolgy Destilig Enterprises, Alberta Canada, 2002.

This concludes the file, http://www.native-languages.org/dogs.htm.

The following essay, "Pre-Columbian origins of Native American dog breeds, with only limited replacement by European dogs, confirmed by mtDNA analysis." is the work of Barbara van Asch et al. Their essay is dated July 10, 2013 and may be accessed at: http://rspb.royalsocietypublishing.org/content/280/1766/20131142 . We have reduced the margins to separate their work from ours (see below):

Pre-Columbian origins of Native American dog breeds, with only limited Replacement by European dogs, confirmed by mtDNA analysis.

Barbara van Asch; Ai-bing Zhang; C. R. Mattias Oskarsson; C. F. C. Klütsch; António Amorim; and Peter Savolainen. Published 10 July 2013.DOI: 10.1098/rspb.2013.1142.

Abstract
Dogs were present in pre-Columbian America, presumably brought by early human migrants from Asia. Studies of free-ranging village/street dogs have indicated almost total replacement of these original dogs by European dogs, but the extent to which Arctic, North and South American breeds are descendants of the original population remains to be assessed. Using a comprehensive phylogeographic analysis, we traced the origin of the mitochondrial DNA lineages for Inuit, Eskimo and Greenland dogs, Alaskan Malamute, Chihuahua, xoloitzcuintli and perro sín pelo del Peru, by comparing to extensive samples of East Asian (n = 984) and European dogs (n = 639), and previously published pre-Columbian sequences. Evidence for a pre-Columbian origin was found for all these breeds, except Alaskan Malamute for which results were ambigous. No European influence was indicated for the Arctic breeds Inuit, Eskimo and Greenland dog, and North/South American breeds had at most 30% European female lineages, suggesting marginal replacement by European dogs. Genetic continuity through time was shown by the sharing of a unique haplotype between the Mexican breed Chihuahua and ancient Mexican samples. We also analysed free-ranging dogs, confirming limited pre-Columbian ancestry overall, but also identifying pockets of remaining populations with high proportion of indigenous ancestry, and we provide the first DNA-based evidence that the Carolina dog, a free-ranging population in the USA, may have an ancient Asian origin.

1. Introduction
The dog is now well established as the most ancient domestic animal and is unique as the only domesticate present in human societies on every continent in ancient times [1]. Previous studies of mitochondrial (mt) DNA have indicated southern East Asia as the geographical centre for the origin of dogs [2–5]. This has been largely supported by analyses of Y-chromosomal DNA [5,6], while a recent single nucleotide polymorphism (SNP)-based study argued that Middle Eastern wolves primarily contributed to the extant dog gene pool [7]. Regardless of the exact geographical origin of domestic dogs, it seems clear that American dogs originate from the Old World since analysis of ancient samples from several pre-Columbian archaeological sites were shown to have the same mtDNA haplogroups as Old World dogs [8].

A remaining question is if today's American dogs trace their origin to the dogs originally introduced from Asia via the Bering Straits in pre-Columbian time, or if this ancestry has been diluted or even completely erased by European dogs brought across the Atlantic following the arrival of Europeans in America. Several studies of mtDNA have attempted to elucidate this question, but did not include comprehensive samples across American breeds and/or of reference samples from the Old World, necessary for a comprehensive analysis [8–11]. Importantly, with the detailed knowledge of the worldwide dog mtDNA diversity presented recently [4], an opportunity has opened up to identify whether mtDNA haplotypes carried by American dogs originate from East Asia in ancient times or from Europe in the post-Columbian era.

Archaeological data and historic records have provided abundant evidence that dogs in pre-Columbian times were part of native cultures in the American continent long before the dawn of transoceanic travel in the fifteenth century [12]. Dogs were used for a large number of different purposes, for example, for hunting, sledging, freighting, protection and company, for religious and medicinal purposes and as a food resource. The earliest archaeological evidence for presence of dogs in the Americas has been dated to 10 000–8500 years ago, the dog thus being the sole domesticate in America during several thousand years [13,14]. According to current hypotheses, the Americas started

to be colonized by south Siberian peoples at least 15 000 years ago immediately after deglaciation of the Pacific coastal corridor [15]. Thus, pre-Columbian dogs must have been brought along by Paleo-Indians of Asian origin in their expansions throughout the American continent, although not necessarily in connection with the first waves of humans.

A small number of extant breeds in the American continent, for example, the Mexican Chihuahua, the xoloitzcuintli (Mexican hairless dog) and the Peruvian perro sín pelo (Peruvian hairless dog) have been claimed to descend from pre-Columbian populations. Archaeological findings in South America are abundant in evidence of dogs increasingly entwined in human societies [16]. In the Arctic region, the presence of well-adapted dogs and their use by Native American peoples prior to 1492 is also well recorded [17]. Many of those dogs, such as the hare Indian dog and the Tahltan bear dog have disappeared as the aboriginal hunting methods declined. Modern Arctic breeds thought to be indigenous include the Inuit sled dog, the Canadian Eskimo dog and the Greenland dog (all three thought to share the same origin) and the Alaskan Malamute. Some modern American breeds such as the dogo Argentino, the fox Paulistinha, the fila brasileiro and the cimarrón Uruguayo have historical origins in European dogs and are not putatively indigenous. Similarly, the Alaskan husky and the American Eskimo dog have a known origin from Siberian spitzes and European dogs.

Besides breed dogs, free-ranging dogs are abundantly found across the American continent. These dogs commonly have heterogeneous morphologies suggesting an origin predominantly from a mix of European breeds. However, in remote areas of southeastern USA (South Carolina and Georgia) there is a group of free-ranging dogs (called the Carolina dog) which morphologically resemble the Australian dingo and South Asian pariah dogs. Based on this resemblance to 'primitive' dogs, an origin from indigenous pre-Columbian dogs rather than from run-away breed dogs of European origin has been suggested [18].

The strong impact of the introduction of domestic species by European settlers and explorers, and its deleterious effects on Native American cultures, is indisputable. The replacement or dilution of Native American dog populations with European dogs is thought to have been severe, with consequent loss of historic Native breeds [19]. However, the extent of this replacement or admixture remains largely undisclosed. Did the ancient migrants leave descendants in the modern American gene pool or were they completely erased by European dogs brought across the Atlantic in the post-Columbian era, and are extant dog populations direct descendents of the ancient populations in the same geographical region?

A very recent study of mtDNA in pre-Columbian dogs from Alaska and Greenland [9] showed that the ancient population and the modern Inuit sled dog population in Greenland carry predominantly the unique haplotype A31, strongly indicating local ancestry for this group of Arctic dogs. By contrast, a study of mtDNA among village dogs and street dogs from across America indicated that the maternal lineages of the indigenous American dog population have been almost completely replaced with European dogs [10]. However, this study did not include American breed dogs. Furthermore, the results were based on comparisons with a restricted source of information, that is, with the haplotypes found among 19 ancient American dog samples analysed in one previous study [8].

Another approach, possibly allowing for a more comprehensive picture of the geographical ancestry of mtDNA lineages among American dogs, is to compare extant American dogs with European and East Asian dogs, assuming that today's populations are good approximations for the ancient ones. The possibility of tracing the geographical origin of mtDNA lineages has opened up with the comprehensive picture of the worldwide dog mtDNA diversity presented recently [4]. This study showed distinct differences between the European and East Asian mtDNA gene pools, offering the possibility to trace whether mtDNA haplotypes among American dogs may have originated from Europe or East Asia. All populations across the Old World share a common gene pool of three major phylogenetic groups called clades A, B and C. In East Asia, the full diversity of these genetic groups is represented, but European dogs (together with all other populations west of the Himalayas and the Urals) have a limited diversity. Out of totally 206 mtDNA haplotypes identified globally [3], there are 15 haplotypes which are represented in virtually every dog population across the Old World, called universal types (UTs). In Europe, 76.7% of the dogs carry one of these 15 haplotypes and totally 92.6% carry a haplotype which is a UT or differs by a single substitution from one of the UTs. In addition, haplogroup D (which is absent in East Asia) has been found in Europe, in 5.9% of the dogs. Thus, totally 98.5% of European dogs carry an mtDNA which is a UT, differs by one substitution from a UT or belongs to haplogroup D. Consequently, if an American dog carries a haplotype which does not belong to this group of

haplotypes, it is unlikely that its mtDNA lineage derives from Europe. In East Asia and Siberia, only 54.9% and 50% of the dogs, respectively, carry a UT; instead, there is a large number of unique haplotypes distinct from those in Europe. Therefore, it may be assumed that approximately 50% of the dogs that entered America via Bering Strait in pre-Columbian time carried a haplotype which was not a UT or belonged to haplogroup D and is therefore potentially informative for excluding a European origin.

Importantly, the high frequency of the 15 UTs and haplotypes differing by a single substitution from the UTs is a universal phenomenon west of the Himalayas, with for example 94.5% of dogs in southwest Asia and 93.1% in Africa, carrying such haplotypes [3,4]. Therefore, the high proportion of these haplotypes in today's European population most probably reflects the genetic make-up across western Eurasia in ancient times, and thus also in Europe at the time of European colonization of America. The assumption that today's European population can be used to represent the situation 500 years ago therefore seems justified, offering a firm basis for the analyses in this study.

In this study, the origins of American dogs were addressed by comparison of mtDNA sequences from American, European and East Asian dogs. This dataset includes new samples for several American breeds and free-ranging dog populations and an extensive collection of European dogs. Together with previous data for extant dogs across the world [4] and sequences derived from ancient American samples [8], we obtained a comprehensive picture of the mtDNA gene pools in America, Europe and East Asia. Based on this, we identified the sharing of haplotypes and haplogroups among these regions and between ancient and modern samples. Through this analysis, we traced the maternal ancestry of the modern New World dog populations, assessing for the first time the extent to which American dog breeds descend from the original pre-Columbian population, and reanalysing the ancestry of free-ranging populations in greater phylogeographical detail.

2. Material and methods

(a) Samples, PCR amplification and sequencing

A sample of American dogs, of supposedly indigenous breeds as well as street dogs from both North and South America, was analysed by comparison with a comprehensive sample of European and East Asian dogs (see the electronic supplementary material, table S1). The Old World samples (total, n = 1872) were from Europe (n = 639), East Asia excluding Siberia (n = 889), Siberia (n = 95), Africa (n = 57), southwest Asia (n = 133) and India (n = 59). The New World samples (total, n = 347) included the Arctic breeds Alaskan Malamute (n = 9), Canadian Eskimo dog (n = 9), Greenland dog (n = 11) and Inuit sled dog (n = 18), the North American breeds Chihuahua (n = 14) and xoloitzcuintli (n = 43), and the South American breed perro sín pelo (Peru, n = 53). The American breeds were sampled from pure-bred dogs avoiding known common female ancestry among individuals. Sampling was obtained from European as well as American lineages of the breeds, and for the perro sín pelo, 19 samples were obtained directly from the Peruvian stock. Two American breeds of known Old World origin were also studied: fox Paulistinha (Brazil, n = 16) and dogo Argentino (Argentina, n = 40). In addition, free-ranging dogs were studied: from North America (USA), the pariah-like Carolina dog [20] (n = 19; captive dogs descending from free-ranging dogs); from South America, dogs collected at rural locations (total, n = 108); Argentina (Cordova and Buenos Aires regions, n = 54; Brazil (Rio de Janeiro and Rio Grande do Norte regions), n = 19; Colombia (Bucaramanga region), n = 35).

The samples were collected in the form of buccal cells or total blood. Buccal cells were collected by swabbing the inside of the cheek using sponge swabs, and applied to Whatman FTA cards (Whatman International Ltd., Maidstone, UK), according to the manufacturer's instructions. Total blood was also sampled on Whatman FTA cards. DNA extractions, PCR amplifications and sequence analysis were performed as previously described [2]. A 582 base-pair fragment of the mt control region (CR) was surveyed using previously published and newly sequenced samples (see the electronic supplementary material, table S1). All novel haplotypes identified in this study have been deposited in GenBank under accession numbers HQ452424–HQ452430 and HQ452435–HQ452438. In a previous study [4], complete mt genomes of 169 individuals representing almost all parts of the CR networks resulted in the identification of subclades within the original clades A, B and C, which are informative since some of them have not been found in European dogs (figure 1). Individuals sequenced only for the CR can be assigned to subclades by mutations within the CR which are diagnostic for each subclade [4].

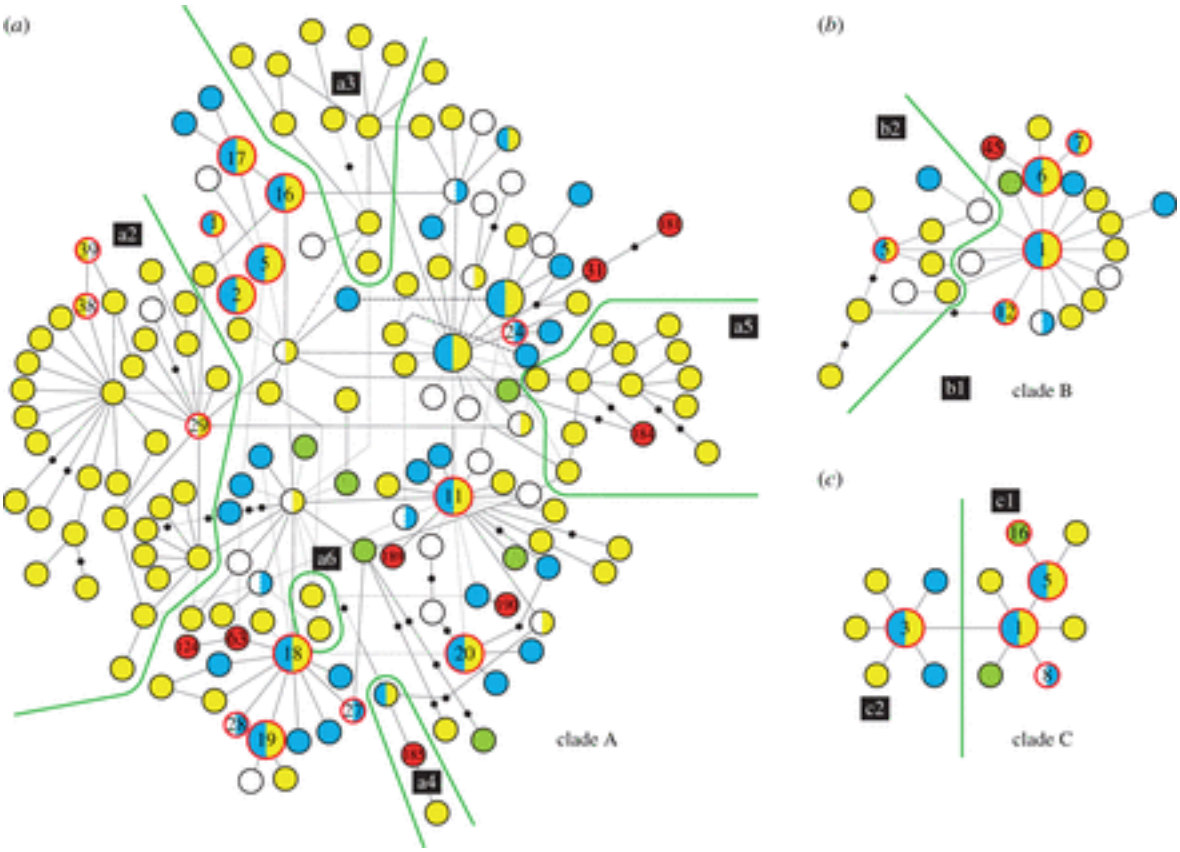

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Figure 1 (Copyright © 2016 The Royal Society)

Minimum-spanning network of dog mtDNA control region (582 bp) haplotypes for phylogenetic clades A, B and C. Haplotypes (circles) and empty nodes (solid dots) are separated by one substitutional step (indels are ignored). Phylogenetic subclades were defined based on sequences of mt genomes [4] and are indicated by green lines. Haplotypes found among American dogs are indicated by red colour, haplotypes unique to America by solid red and haplotypes shared with other regions by red outline, and their haplotype names are indicated. Representation of the haplotypes in other regions is indicated as follows. By solid circles: yellow, unique to East Asia (including Siberia) not counting America; green, unique to Siberia not counting America; blue, unique to Europe not counting America. By half circles (indicating sharing of haplotypes): yellow/blue, present in both East Asia and Europe; yellow/white, present in East Asia but absent in Europe; blue/white, present in Europe but absent in East Asia. Solid white, all other geographical representations. Larger sized circles indicate the 15 universal haplotypes (UTs).

We also compared our dataset with published data from ancient American dog samples [8] and modern American non-breed dogs [10]. Since the sequences of these two datasets overlapped only partly with our sequences, comparisons were performed separately from the main analysis. Thus, our modern sequences were compared with 19 ancient DNA sequences obtained from dog remains from South America (Bolivia, Peru and Mexico) and Alaska (Fairbanks area) [8]. These sequences overlap by 244 bp with our modern sequence data. We also compared our samples with sequences from Castroviejo-Fisher *et al*. [10] which consisted of mtDNA sequences from '400 dogs from rural and isolated areas as well as street dogs' from all across America. These sequence overlap by 342 bp with our sequences.

(b) Phylogenetic analysis

Sequences were aligned with the MUSCLE tool implemented in Geneious v. 5.5.3 Pro [21]. Comparisons of sequences and identification of haplotypes were performed with DnaSp v. 5 [22]. Minimum-spanning networks and trees were constructed manually based on the minimum distances between haplotypes calculated with Arlequin v. 3.5 software [23] ignoring indels. Unique and shared haplotypes among dog populations or breeds from different geographical regions were identified using the program UPST.EXE (available by request to zhangab2008@mail.cnu.edu.cn).

3. Results

Among the American samples, all haplotypes belonged to the universally occurring clades A, B and C, indicating an Old World origin for all maternal lineages. Among the Old World samples, 38 haplotypes were unique to Europe, 121 unique to East Asia (excluding Siberia) and 12 unique to Siberia (figure 1). This dataset included 302 new European samples relative to a previous study [4], but the large difference between European and East Asian samples observed previously did not alter. Thus, the diversity among European dogs was very limited, with practically all haplotypes centred around the 15 UTs (figure 1). By contrast, approximately 50% of East Asian dogs carried haplotypes on large distance from those found in Europe, many of which belonging to sub-haplogroups not detected in Europe, implying the possibility of tracing the geographical origins of a large proportion of the American maternal lineages.

(a) Breed dogs

(i) Arctic America

Inuit sled dogs, Canadian Eskimo dogs and Greenland dogs had similar mtDNA gene pools, in that the most frequent haplotype for all three breeds was A31, unique to this group of breeds (table 1 and figure 1). The Inuit sled dog and the Greenland dog also shared a haplotype unique to the two breeds (A124). In addition, the Inuit sled dog and the Eskimo dog had one unique haplotype each (A181 and A63, respectively). Three of these four private haplotypes differ by at least two substitutions from any of the European haplotypes. In total, 30/38 individuals in this group of dogs had haplotypes unique to the group, and the remaining eight dogs had universally occurring haplotypes, present in both Europe and East Asia. Importantly, a very recent article [9] showed that pre-Columbian samples from Greenland had a high frequency of A31, strongly suggesting ancestry from the pre-Columbian population for this group of dogs.

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breed (code)	*n*	haplotype (subclade)	frequency (*n*)	geographical distribution
		A181	6% (1)	PT
Inuit sled dog (ISD)	18	A124	6% (1)	PT in Arctic America (ISD, GD)
		A31	78% (14)	PT in Arctic America (ED, GD, ISD)
		A20	11% (2)	UT
		A31	67% (6)	PT in Arctic America (ED, GD, ISD)
Eskimo dog (ED)	9	A63	11% (1)	PT
		A18	22% (2)	UT
		A31	55% (6)	PT in Arctic America (ED, GD, ISD)
Greenland dog (GD)	11	A124	9% (1)	PT in Arctic America (ISD, GD)
		A11; A17; A20	36% (4)	UT
Alaskan Malamute (AM)	9	A29 (a2)	78% (7)	Siberia, Japan, China, Indonesia
		A11; A17	22% (2)	UT
		A185 (a4)	36% (5)	PT
Chihuahua (CH)	14	C16	7% (1)	South America (CH and PSP), Siberia
		A11; A17; B1	57% (8)	UT
		A24	2% (1)	Europe, Colombia
xoloitzcuintle (Xo)	43	B12	2% (1)	Europe, Japan
		A2; A16; A17; B1; C1; C2; C3	95% (41)	UT
		A184 (a5)	37% (7)	PT
Carolina dog (CD)	19	A39 (a2)	5% (1)	Japan, China
		A16; A18; A19; B1	58% (11)	UT
		C16	62% (33)	Siberia, South America (CH, PSP)
		A1	2% (1)	Europe , China, Korea, Brazil
perro sin pelo Del Peru (PSP)	53	B8	2% (1)	Europe
		C8	2% (1)	Europe
		A2; A11; A17; A18; A19; B1	32% (17)	UT

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Table 1 (Copyright © 2016 The Royal Society)

mtDNA control region haplotypes found among American breed dogs and Carolina dog, and their geographical distribution in both the Old World and the New World. Subclade refers to the 10 subclades of clades A, B and C; only haplotypes belonging to subclades other than the four universal subclades a1, b1, c1 and c2 are indicated. UT, universal types of DNA haplotype found worldwide [4]; PT, private types found only in a specific breed, population and/or region.

Among the Alaskan Malamute, 7/9 individuals had haplotype A29, which belongs to subclade a2 (not represented in Europe) and otherwise found only in East Asia (including Siberia) and island Southeast Asia. The two other individuals had universally occurring haplotypes. Haplotype A29 was also found in pre-Columbian samples from Alaska [8,9]. This suggests ancestry of modern Alaskan Malamute from the pre-European Alaskan population (figure 2) but, since A29 is also commonly found among Siberian husky with which Alaskan huskys were interbred in the early 1900s, the evidence for this is not clear cut. The Alaskan Malamute and the Eskimo/Greenland/Inuit group had almost totally different mtDNA gene pools, only 2/9 and 2/38 individuals, respectively, sharing haplotypes between the groups.

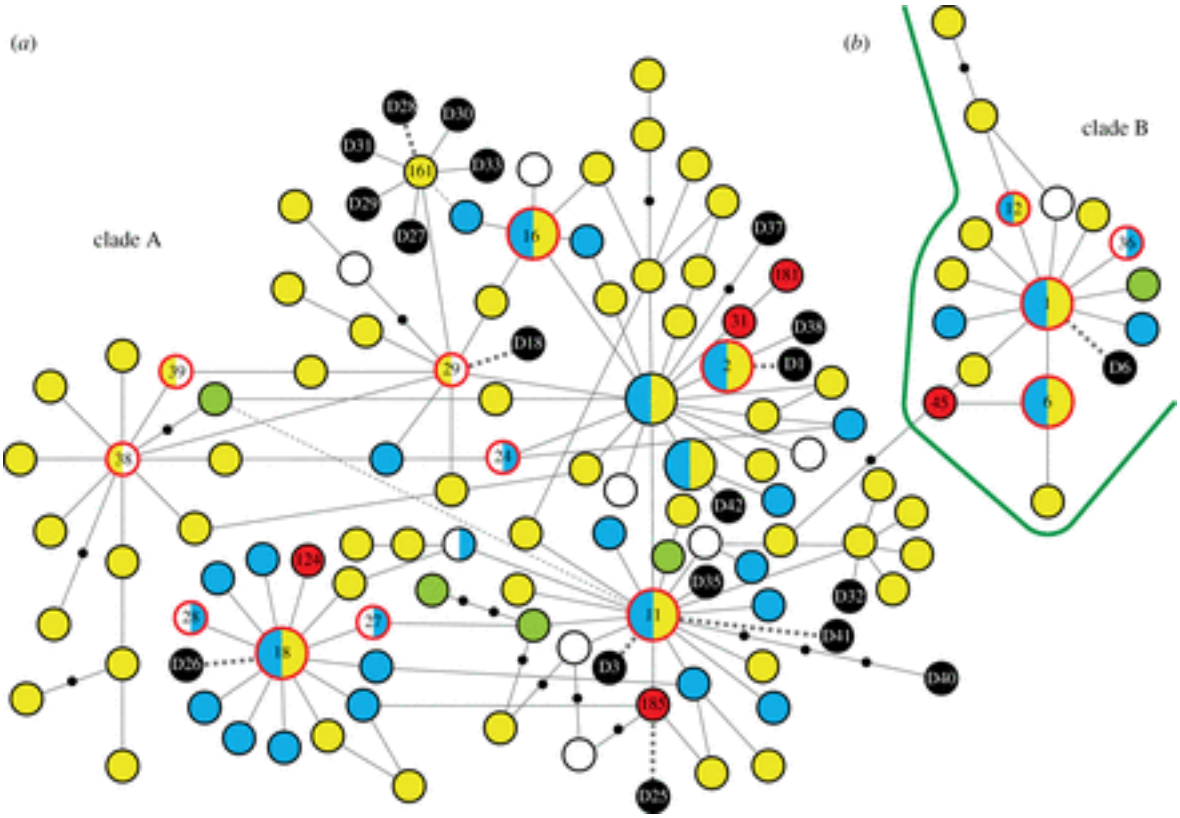

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Figure 2 (Copyright © 2016 The Royal Society)

Minimum-spanning network of dog mtDNA control region (244 bp) haplotypes for clades (A and B), comparing the modern samples with ancient American sequences from Leonard *et al.* [8]. Haplotypes (circles) and empty nodes (solid dots) are separated by one substitutional step (indels are ignored). The colours of the circles represent the geographical distribution of haplotypes as described in the legend to figure 1. Black solid circles indicate the ancient sequences, the numbering indicating the haplotype names used in Leonard *et al*. Dashed lines indicate that the ancient sequence is identical to the connected modern haplotype. The haplotypes of the modern samples sometimes correspond to several different full-length haplotypes (based on 582 bp); the name of one among these is indicated for haplotypes found among American samples. Larger sized circles represent universal haplotypes (UTs).

(ii) North America

For the Mexican breed Chihuahua, the most frequent haplotype (carried by 5/14 individuals) was A185, which was unique to this breed among the modern dogs. Importantly, this haplotype was also found in one pre-Columbian sample from Mexico (figure 2), suggesting direct ancestry of Chihuahua from ancient Mexican dogs. One individual had haplotype C16, the most common type among the South American breed perro sín pelo del Peru. C16 was also reported for xolo at a frequency of 16% in a previous study [24]. Among the Old World samples, C16 was found only among Siberian dogs. The remaining Chihuahua had universally occurring haplotypes. The Mexican 'naked breed' xoloitzcuintle (xolo) had only haplotypes occurring universally and two haplotypes found in Europe. However, as noted above, C16 was found in a previous study of xolo, at a frequency of 16% [24]. Notably, 79% of the xolo carried haplotypes shared with perro sín pelo del Peru, the South American 'naked breed'.

(iii) South America

For the Peruvian 'naked breed' perro sín pelo del Peru, the majority of dogs (33/53) had haplotype C16, absent among the European samples and shared only with the other 'naked breed' xolo, and with Chihuahua and Siberian dogs. Two individuals had haplotypes otherwise unique to Europe, and the remaining individuals had universally occurring haplotypes. Eighty-one per cent of the individuals shared a haplotype with xolo.

In conclusion, all investigated breeds of presumed indigenous origin across America carried haplotypes indicating pre-European origin, except for Alaskan Malamute for which the results were ambigous. All these breeds except xolo had a high frequency of haplotypes absent in Europe: 79% of the Arctic Inuit, Eskimo and Greenland dogs, and a total of 35% of dogs belonging to the Meso/South American breeds Chihuahua, xolo and perro sín pelo del Peru. Only half of the lineages introduced to America from Asia are expected to differ from European sequences, since the frequency of UTs is approximately 50% in Siberia and East Asia. Therefore, even if 100% of the lineages would have an ancient origin from Asia, only 50% of the individuals would be expected to carry haplotypes absent in Europe. Hence, our data indicates that the Arctic breeds Inuit, Eskimo and Greenland dog (having a frequency above 50% of haplotypes absent in Europe) have remained practically uninfluenced by European lineages, and that among the Meso/South American breeds (35% of the dogs carrying haplotypes distinct from European haplotypes), 70% of the maternal lineages originate from the pre-Columbian population. Thus, replacement of indigenous American breeds by European dogs seems to have been relatively limited.

We also analysed dogs belonging to the fox Paulistinha and dogo Argentino breeds. These breeds originate from dogs of known European ancestry. In accordance, these dogs carried only haplotypes that are frequently found in Europe, five universal haplotypes and one other haplotype frequent in Europe (see the electronic supplementary material, table S2).

(b) Comparison of pre-Columbian sequences with a comprehensive modern sample

We compared our dataset with ancient American mtDNA sequences from Mexico, Peru, Bolivia and Alaska reported in an earlier study ([8]; figure 2). This analysis is the first comparison of these ancient American sequences with a comprehensive collection of sequences from modern East Asian dogs and American breed dogs, instead of predominantly European breeds as in earlier studies. This allowed us to investigate possible geographical continuity over time among American breed dogs and to explore the possibility of an East Asian origin of the ancient American dog mtDNA lineages.

We found two cases where ancient and modern samples from the same geographical region had the same non-universal haplotype, suggesting continuity since pre-European time for these populations. In one case, haplotype A185 was found exclusively in ancient Mexican samples (D25) and in modern samples of the Mexican Chihuahua, strongly indicating direct ancestry of Chihuahua from Mexican pre-Columbian dogs. Furthermore, a haplotype corresponding to A29 (D18), otherwise found only in Siberia, East Asia and Oceania, was identified in ancient Alaskan samples as well as in the modern Arctic breed Alaskan Malamute but, as related above, the presence of A29 also among Siberian husky offers an alternative to genetic continuity in Alaska. Notably, a very recent study of pre-Columbian dogs from Alaska and Greenland [9] showed that, in Greenland, both the ancient population and the modern Inuit sled dog population carry predominantly the unique haplotype A31, strongly indicating ancient local ancestry for this group of Arctic dogs.

Importantly, Leonard *et al*. reported one phylogenetic group of haplotypes (containing haplotypes D27, D28, D29, D30, D31 and D33) to be unique for the ancient South/Meso American samples (figure 2). However, we found the central haplotype D28 in East Asia (in Korea, haplotype A161), thus placing the origins of these sequences in East Asia. Eight of the 19 ancient haplotypes correspond to haplotypes found in the modern samples, all of which, except the American specific A185, found in East Asia. The remaining haplotypes were unique to the ancient samples, but differ by one or two substitutions from extant haplotypes found in East Asia, except one ancient haplotype (D40). D40 is separated by at least four substitutions from any other dog haplotype and seemingly represents a separate phylogenetic clade (figure 2). Therefore, D40 is possibly the result of a crossbreeding between a dog and a female wolf in America.

In conclusion, we find a strong indication that the Mexican breed Chihuahua has a direct ancestry from Mexican pre-Columbian dogs, and a similar link was recently shown for Inuit dogs and pre-Columbian

samples in Greenland [9]. Importantly, except D40, all ancient American samples can be linked to haplotypes found among East Asian dogs.

(c) Free-ranging dogs

Among the 'free-ranging' Carolina dogs of southern USA, the most frequent haplotype was A184, which was unique to these dogs (it is a novel halpotype not previously reported in GenBank) and belongs to the East Asian-specific phylogenetic subclade a5 (figure 1). One individual had haplotype A39, otherwise found only among Chinese non-breed dogs and the Japanese breed shiba inu. The remaining dogs had universal haplotypes. This gives a strong support to the hypothesis that the Carolina dog has indeed originated from pre-Columbian dogs.

By contrast, South American free-ranging dogs from Argentina, Brazil and Colombia had mainly universally occurring haplotypes (83.3% carrying UTs) and several European specific haplotypes (see the electronic supplementary material, table S2). There were also three unique haplotypes (A189, A190, B45), a single step from haplotypes found also in Europe, and three haplotypes (A38, B2 and B5) absent from Europe but present in East and West Asian breeds (e.g. chow chow, Afghan hound and akita) and rural non-breed dogs. Thus, South American free-ranging dogs in our sample seem to originate mainly from European dogs, although traces of native dogs cannot be totally excluded.

This is in good agreement with a previous study by Castroviejo-Fisher *et al*. [10] of 400 dogs from rural and isolated areas, as well as street dogs from across America. This study reported that a very low proportion of the mtDNA lineages among these modern American non-breed dogs (less than 10%) derive from the pre-European dog population, based on a comparison with the 19 ancient American dog samples reported by Leonard *et al.* [8]. This indicated that almost all indigenous dogs were replaced by European dogs. However, comparing the dataset in Castroviejo-Fisher *et al*. with our comprehensive sample of modern dogs, we found that these dogs carry several potentially indigenous mtDNA haplotypes which are unique to America or otherwise found exclusively in East Asia (see the electronic supplementary material, figure S1 and table S3). These haplotypes were carried by 7.8% of all dogs, which indicates that approximately 15% of the lineages have pre-European ancestry, considering that at least 50% of indigenous American dogs are expected to carry non-informative haplotypes (UTs) also found in Europe. More importantly, in a detailed analysis of the different subpopulations, we also noted that the putatively indigenous haplotypes were not evenly distributed. Thus, 9.8% of the Mexican dogs and 14.8% of the Bolivian dogs carry these haplotypes (indicating 20–30% Asian ancestry), but only 2.3% of the dogs from Argentina. This agrees with our findings that a large proportion of Carolina dogs carry seemingly indigenous American haplotypes, whereas our sample of free-ranging Argentinan dogs has almost exclusively European haplotypes. Therefore, it seems that while free-ranging American dogs generally derive from European dogs, there are pockets of rural populations, for example, the Carolina dog and populations in Mexico and Bolivia, with a high proportion of pre-Columbian ancestry. Importantly, comparing with a dataset from Europe [25], only two of 94 dogs of European origin (2.1%) carried a unique haplotype, confirming that the majority of the unique American haplotypes have an indigenous origin and are not merely European haplotypes not yet sampled.

Castroviejo-Fisher *et al.* [10] also reported that a large proportion of haplotypes found in the dataset (23 out of 40) were unique to the American dogs compared with dogs of the Old world. However, the comparison was performed against a limited dataset of non-American dogs [26], and comparing instead to our more comprehensive dataset of dogs from across the Old World, we identified the majority of these 23 haplotypes. For the 342 bp region overlapping with our dataset, there were 34 haplotypes in the dataset of Castroviejo-Fisher *et al*. Of these, 27 were shared with dogs in Eurasia, leaving only seven haplotypes unique to America.

4. Discussion

This study provides clear evidence for the ancient Asian ancestry of extant American dog breeds. All breeds of presumed indigenous American origin carried haplotypes absent in a comprehensive sample of European dogs, and our data indicates that only 30% or less of the female lineages in indigenous American breeds have a European origin. Importantly, the Mexican breed Chihuahua shared a haplotype uniquely with Mexican pre-Columbian samples, showing genetic continuity over time and geographical region and corroborating the Mexican origins of the Chihuahua. The data also once more confirmed that American dogs have a common origin with Old World dogs, since no distinct haplogroups unique to American dogs were found and all haplotypes fell into the previously described universal phylogenetic clades A, B and C. However, we note that one pre-European Alaskan dog

reported by Leonard *et al*. [8] had a haplotype (D40) separated by four substitutions from the closest modern dog haplotype, which we believe may derive from a dog–wolf hybridization.

An important finding is that not only American breed dogs but also some populations of free-ranging dogs seem to stem from indigenous American dogs. Thus, we here give genetic evidence that feral dogs from the USA, the so-called Carolina dog, may have an indigenous American origin and are not just 'run-away' dogs of European descent. The dingo-like appearance of the Carolina dogs may therefore be a remnant of their ancient past. The most frequent haplotype (A184) is unique to Carolina dogs and belongs to an East Asian-specific phylogenetic subclade, offering a clear indication of an East Asian origin for these dogs. Also haplotype A39, otherwise found only among East Asian dogs including the shiba inu, may have an ancient East Asian origin, but the possibility remains that this haplotype derives from abandoned shiba. The South American free-ranging dogs carried mainly universal or typically European haplotypes, but a few individuals had haplotypes carried by East Asian dogs and absent among European breeds. However, all these haplotypes are also carried by East Asian breeds present in the Western world dog population and could have resulted from integration of abandoned Asian breed dogs. We conclude that the South American free-ranging dogs mainly originate from dogs brought by the Europeans, although traces of native dog cannot be totally excluded.

In general agreement with our data, the study by Castroviejo-Fisher *et al.* [10] reported that at most 10% of the mtDNA lineages among American rural and street dogs have indigenous American origin. However, in a more detailed phylogeographical analysis of these samples, we note that in the subsamples from Mexico and Bolivia approximately 25% of the lineages seem to retain mtDNA haplotypes with an Asian origin. Therefore, pockets of remaining populations with high proportion of indigenous pre-European origin seem to persist among American non-breed dogs, as well as among the indigenous American breeds.

We conclude that the ancestry of the American dog population is complex. There are several different types of populations of American dogs of possibly pre-Columbian origin, and these populations retain different proportions of pre-Columbian ancestry. The dog breeds of supposedly indigenous American origin carry predominantly mtDNA haplotypes of pre-Columbian origin. By contrast, free-ranging dogs, including dogs from rural areas as well as street dogs, generally show no or very little pre-Columbian ancestry, but also among these dogs there remain populations with considerable proportions of indigenous American ancestry.

The studied Arctic American dogs seem to consist of two separate populations. The Alaskan Malamute is thought to descend from dogs bred by the Mahlemut people of the upper-western Alaska. A majority of these dogs carried haplotype A29, which seemingly presents both spacial and temporal clues to the origins of the breed. A29 (absent in Europe) is found among East Asian dogs and, significantly, among Siberian husky, a sled dog originally bred by the Chukchi people on the northeastern tip of Siberia. This indicates genetic links between East Asia, Siberia and Arctic America. A29 was also found in ancient samples from Alaska, indicating the presence of the Alaskan Malamute ancestors in the pre-Columbian era. However, a complicating factor is that Alaskan Malamutes were interbred with Siberian husky in the gold rush era; analyses of additional markers will be necessary to establish how the modern Alaskan Malamutes relates to the dogs of the Mahlemut people. The other modern Arctic breeds (Inuit, Eskimo and Greenland dogs) seem to constitute a separate genetic group, as only 2/38 individuals shared haplotypes with Alaskan Malamutes. The three breeds share a common gene pool including a unique haplotype (A31) found in the majority of individuals. These three breeds, in accordance with the mtDNA data, are often considered a single breed and are thought to descend from sled dogs bred by Thule people, the ancestors of the modern Inuits. This culture developed in coastal Alaska by 1000 years ago and rapidly reached Greenland a few centuries later, having presented the first evidence of consistent use of sled dogs in the Arctic [27]. Importantly, a very recent study of pre-Columbian arctic dogs [9] showed that the related ancient dog population in Greenland carried almost exclusively A31. Thus, the ancient and modern populations share the unique haplotype A31 at high frequency, confirming the ancestry of modern Inuit, Eskimo and Greenland dogs from the local ancient population. The almost total lack of shared haplotypes between these breeds and the Alaskan Malamute possibly reflects sequential arrival to America of the related human populations [15].

Overlap was also minimal between the Arctic breeds and other dogs across America. By contrast, North American (excluding the Arctic) and South American breeds showed genetic links. Chihuahua shared one haplotype (C16) exclusively with perro sín pelo and Siberian dogs. This haplotype was absent from our xolo sample but was found in this breed in a previous study [24]. Furthermore, around 80% of the

individuals of the Mexican 'naked breed' xolo and the Peruvian 'naked dogs' shared haplotypes, indicating a geographical link connected with the shared morphology, in agreement with all naked breeds carrying the same causative mutation [28]. It is notable that genetic data for both dogs and humans indicate an initial migration forming the North and South American populations, followed by subsequent waves into the Arctics [15].

Comparison of the modern data with ancient sequences suggested genetic continuity from pre-Columbian into modern times in Mexico and, possibly, Alaska, adding to the evidence for genetic continuity in Greenland presented very recently by Brown *et al.* [9]. Modern Chihuahua and ancient Mexico had the same unique haplotype (A185 and D25, respectively), and ancient Alaska and modern Alaskan Malamute shared a non-European haplotype (D18 and A29, respectively). Interestingly, A185 and A29 have been reported also for modern Puerto Rican 'street dogs' [29], but the possible link to ancient American samples was not noted in that study. This suggests that A185 and A29 may have been widespread across ancient America but, since the two haplotypes are found among modern Chihuahua and Siberian husky, there remains the possibility that A185 and A29 in Puerto Rico originate from abandoned dogs of these breeds. An important finding when comparing the new modern sequences presented in this study with the ancient DNA samples was that the central haplotype (D28) in a formerly 'ancient America-specific' clade [8,10] was found among East Asian dogs (haplotype A161). This implies that all ancient American sequences except one (D40; possibly the result of dog–wolf crossbreeding) can now be linked to haplotypes present in East Asia or Siberia. We also note a large proportion of unique haplotypes among the ancient samples. However, the ancient sequences harbour an unusual amount of transversions, suggesting that these may be single base substitution artefacts, a known problem in the sequencing of ancient samples. For example, the five unique haplotypes surrounding D28 (D27, D29, D30, D31 and D33) are defined by three transversions (in previously non-variable positions) and two transitions, compared with six transversions and 50 transitions found among the 1555 modern samples in clade A. It is therefore possible that several of the haplotypes surrounding D28 are in reality D28 (modern A161), and thus identical to modern East Asian samples.

In the modern sample, we identified nine haplotypes, five in the Arctic and four in North and South America, which were distinct from haplotypes found among European dogs. Only 50% of the pre-European dogs are expected to have carried haplotypes absent in Europe, implying that several more of the American lineages probably have an Asian origin. There were also at least four additional haplotypes found in the ancient American samples. Thus, it seems that the American dog population was not formed through a severe genetic bottleneck, but that several lineages were brought to America from Asia in the pre-Columbian era, probably in several waves of migration. The analyses in this study are based on mtDNA, which is a single genetic marker inherited maternally, putting obvious limitations to the inferences. To assess fully the pre- and post-Columbian contribution of genetic material to the American breeds, as well as the possibility of hybridization between American dogs and wolves, studies based on additional markers, suggestively the Y-chromosome as well as autosomal markers will be necessary. Possibly, improved phylogeographic fine mapping of both American humans and dogs may show whether the genetic diversity of domestic dogs mirrors that of humans and provide clues for understanding the colonization of the New World.

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APPENDIX 6: EASTERN WOLF

Glen Mellin
Lenny Truitt

March 2016

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OUR SUMMARY

This appendix identifies aspects of the Eastern Wolf (*Canis lycaon*), which we feel are important to the discussion of the complex prehistoric and historic landscape interplay between humans and this four-legged tactical predator in Delaware and the Mid-Atlantic region. Schreber first described the Eastern Wolf, in 1775, as follows:

Kingdom: Animalia
Phylum: Chordata
Class: Mamalia
Order: Carnivora
Family: Canidae
Genus: *Canis*
Species: *C. lycaon*

Schreber did not identify any subspecies in his Eastern Wolf definition. He did, however, produce a map (see Wikipedia, Eastern Wolf) of eastern North America, which shows assumed range limits of the Eastern Wolf and the (yet to be scientifically described) Red Wolf. That map depicts the range of the Eastern Wolf (a cold weather species) having a southern limit near the Potomac River and a northern limit well into Canada. Schreber indicated the Eastern Wolf species was in the process of being displaced with population in decline. It should be noted the Red Wolf (a temperate weather species) was historically recorded as having a northern range limit of near the Potomac River and a southern range limit west of the Mississippi River. The Red Wolf species (first described by Audubon and Bachman in 1851) was also in the process of being displaced with population in decline.

Today, the species' definition separating the Eastern Wolf from the Red Wolf continues to be debated in the biological and ecological disciplines. These difficulties have direct bearing on how State, interstate, and cross border identification, conservation, and protection efforts are shaped. To date, Thiel and Wydeven's (2011) report on the status of the Eastern Wolf continues to be used by the U. S. Fish and Wildlife Service to shape policy. Of course, these issues would have direct bearing on any wolf remains archaeologically recovered in Delaware and the broader Mid-Atlantic region. We strongly recommend that all archaeologically recovered wolf remains excavated in Delaware, as well as the Mid-Atlantic region, have their complete, individual DNA profile established. These sets of DNA data would meaningfully contribute to the landscape relationships between humans and these four-legged tactical predators.

In constructing this Appendix, we reviewed over one hundred documents (essays, books, contracted reports, professional papers, internet sites, etc.). For the purpose of our essay, we selected two documents that review both the history and current status of the Eastern Wolf, as it would be applicable to Delaware and Mid-Atlantic archaeology. From the first document, Thiel and Wydeven (2011), we use block quotes to show how they identified competing interpretations, identified their research questions, and presented their summary with recommendations. The second document is a portion of the Internet Wikipedia file on Eastern wolves together with the Wikipedia file references cited. We closely reviewed, edited, and re-formatted the contents of the open-source Wikipedia file to make a good fit with our research topic.

Eastern Wolf Status Assessment 2

Eastern Wolf (Canis lycaon) Status Assessment Report: Covering East-Central North America.

In 2011, Richard Thiel and Adrian P. Wydeven produced a research document for the Wisconsin Department of Natural Resource as part of a contract for the U.S. Fish and Wildlife Service. The report was entitled: Eastern Wolf (*Canis lycaon*) Status Assessment Report: Covering East-Central North America, which is also known as the Eastern Wolf Status Assessment 2. We consider the Thiel and Wydeven document (delivered to the USFWS in 2011) to be a very sound argument, as they evaluated a range of realistic natural and cultural factors as can be seen below. This document may be found at http://www.fws.gov/midwest/wolf/aboutwolves/pdf/thielwydeveneasternwolfstatusreview8august12.pdf.

DISCLAIMER:
This document is a compilation of biological data and a description of past, present, and likely future threats to the eastern wolf, Canis lycaon. It does not represent a decision by the U.S. Fish and Wildlife Service (Service) on whether this taxon should be designated as a candidate species for listing as threatened or endangered under the Federal Endangered Species Act. That decision will be made by the Service after reviewing this document; other relevant biological and threat data not included herein; and all relevant laws, regulations, and policies. (Page 2)

Current Competing Genetic Hypotheses: Considerable controversy surrounds the placement of eastern wolves, Canis lycaon, within the suite of North American Canis species. Some of this controversy involves poor understanding of Canis species distribution over the geological time scale being represented (prehistoric, post European contact period through settlement at roughly 1900, and contemporary). Also contributing to this quandary are anthropogenic-caused shifts in habitat, prey diversity and population sizes, intense control campaigns causing severe reductions or annihilation of Canis populations over much of the area prior to or concomitant with the era of scientific inquiry, and invasion of Canis latrans over most of the eastern portion of North America in the 20th century. (Page 10).

These competing interpretations include:
(1) Considered eastern wolves to be a full species (Wilson et al. 2000, 2009, Baker et al. 2003, Grewal et al. 2004, Fain et al. 2010, Chambers et al. submitted, Wheeldon and White 2009, Wheeldon et al. 2010a, Rutledge et al. 2010a,b);

(2) a gray wolf subspecies, Canis lupus lycaon (Nowak 1979, 1983, 1995, 2002, 2003, 2009; Koblmüller et al. 2009, Leonard and Wayne 2009; vonHoldt et al. 2011);

(3) the same species as the red wolf, C. rufus (Wilson et al. 2000, Kyle et al. 2006, 2008; and

(4) a result of hybridization between C. rufus and C. lupus (Nowak 2002, 2003, 2009). (Page 11).

Summary / Recommendations
1. A genetically and morphologically unique large Canis species occupied much of east-central North America during the final stages of the Pleistocene up to present times. Its present range is restricted to a swath of east-central Ontario and southwestern Quebec in Canada. Scientists are increasingly referring to this canid as the eastern wolf, Canis lycaon.

2. Recent carcass recoveries reveal that individual eastern wolves are at least occasionally present in the Northeastern United States, but there is no evidence that any breeding occurs at the present time.

3. Wolves in the Western Great Lakes states lie within a naturally occurring suture zone where gray wolf and eastern wolf populations collided during and following the retreat of the continental glaciers. The wolf population in this geographic region is taxonomically distinct, an admixture of Canis lupus X Canis lycaon. It displays genetic continuity and is representative of the gene pool present prior to anthropogenic influences. There is good agreement that wolf populations in this region have since functionally and numerically recovered.

4. Geneticists, especially, use peer-reviewed scientific journals to advance their position that this unique wolf type, labeled the eastern wolf, Canis lycaon, is a distinct species. This posture is presently subject to robust and healthy scientific debate. The fact remains these large canids presently lack official designations a species. We encourage those who promote eastern wolves as a distinct species petition an international authority such as the International Commission of Zoological Nomenclature, the American Society of Mammalogists, etc., to resolve this issue so that conservation efforts may proceed. (Pages 80-1).

REFERENCE:

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This concludes the Thiel and Wydeven document file, which may be found in its entirety at: http://www.fws.gov/midwest/wolf/aboutwolves/pdf/thielwydeveneasternwolfstatusreview8august12.pdf.

The following document is a portion of the Eastern Wolves Internet Wikipedia file together with the Wikipedia file's references cited. We closely reviewed, edited, and re-formatted the contents of the open-source Wikipedia file to make a good fit with our research topic. The full Wikipedia document can be found and downloaded at https://en.wikipedia.org/wiki/Eastern_wolf.

Introduction

The **eastern wolf** (*Canis lycaon* or *Canis lupus lycaon*), also known as the **eastern timber wolf**, **Algonquin wolf** or **deer wolf** (3), (4) is a canid native to the northeastern side of North America's Great Lakes region (5). It is a medium-sized canid which, like the red wolf, is intermediate in size between the coyote and Northwestern wolf. It primarily preys on white-tailed deer, but may occasionally attack moose and beaver (6), (7).

The eastern wolf's taxonomic classification has been under review beginning c. 2000, with various suggestions having been presented as to its derivation, including its being a subspecies of gray wolf (2), its being conspecific with the red wolf (8), (9), gray wolf-coyote hybridization (10), and classification as a separate species within *Canis* (8), (11). The eastern wolf is still recognized as a gray wolf subspecies by MSW3 (as of 2005) (2), but in 2013, following a comprehensive review of several genetic studies, it has been classed as a distinct species by United States Fish and Wildlife Service.

The eastern wolf is currently listed as a ***Threatened Species*** under COSEWIC and with the Committee on the Status of Species at Risk in Ontario (COSSARO), because "new genetic analyses indicate that the eastern wolf is not a subspecies of grey wolf" versus earlier theories that it was a result of hybridization with both gray wolves and coyotes (3). The eastern wolf is particularly susceptible to hybridization, due to its close relationship to the coyote and its ability to bridge gene flow between both coyotes and gray wolves. Furthermore, human persecution over a period of 400 years caused a population decline which reduced the number of suitable mates, thus facilitating coyote gene swamping into the eastern wolf population. Aside from posing a threat to a unique species, the resulting eastern wolf-coyote hybrids are too small in size to substitute pure eastern wolves as apex predators of moose and deer. The main nucleus of pure eastern wolves is currently concentrated within Algonquin Provincial Park, south central Ontario and south central Quebec (1).

Taxonomic history and evolution

Genetic studies have indicated that the eastern wolf evolved in North America, unlike the gray wolf, which originated in Eurasia, and diverged from a common ancestor with the coyote and red wolf 150,000–300,000 years ago (11). However, in 2014, the research of Chambers et al. (2012) about the eastern wolf's status as a species became controversial, forcing the USF&WS to commission a peer review of it, known as NCAES (2014). This peer review concluded unanimously that the Chambers review "is not accepted as consensus scientific opinion or best available science" and "the issue is not yet settled" (12), (13). Two subsequent reviews of updated research in 2013 and 2014, one commissioned to the Wildlife Management Institute by the USFWS, and one journal review, concluded that historically there were four unique canine species in North America, gray wolf, eastern wolf, coyote and dog, and that "the red wolf may be conspecific with the eastern wolf" (14), (15). This view consistent with the idea that the coyote and gray wolf did not historically range into the eastern United States (14). These reviews and a 2015 genetics study, the most comprehensive to date (16), led the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in May, 2015 to change the designation of the eastern wolf to a distinct species, *Canis lycaon*. However, the previous assertion that gray wolves did not occur in the eastern third of the United States is still ill-founded by the newer genetic study's lead author Dr. Linda Y. Rutledge who noted in the conclusions that "the recognition of the eastern wolf as a separate species does not exclude the possibility that a grey wolf × eastern wolf hybrid animal (previously identified as Canis lupus lycaon, boreal/Ontario-type), similar to a Great Lakes boreal wolf currently located in the Great Lakes states and across Manitoba, northern Ontario, and northern Quebec, historically inhabited the northeastern United States alongside eastern wolves, and there is some evidence to support the historical presence of both Canis types."

The eastern wolf was first recognized as a distinct species in 1775 by German naturalist Johann Schreber, who termed it *loup noir* (black wolf). His depiction of the animal however showed it with a black coat, an atypical coloration in eastern wolves. It was later reclassified as a subspecies of gray wolf by Edward Nelson and Goldman (11). In 2000, the taxonomic status of the eastern wolf was once again brought into question when a genetic study on canids from Algonquin Provincial Park undertaken in Trent University showed that the local wolves bore similarities to red wolves, based on DNA profiles at

eight microsatellite loci. Furthermore, sequences were found in both eastern and red wolves that diverged from those of coyotes by 150,000-300,000 years, and no specimens of either species from the 1960s bore any gray wolf mtDNA. The scientists involved in this study proposed that the eastern and red wolf were the same species, and that the two be combined under the earlier binomial name of *C. lycaon* (8). However, this conclusion was disputed, with one study indicating that the eastern wolf is a gray wolf-coyote hybrid (10) and MSW3 (2) listed it in 2005 as a subspecies of gray wolf.

In May 2011, an analysis of eastern wolf, red wolf, gray wolf, and dog genomes suggested that the wolves of Algonquin Provincial Park are 58% gray wolf and 42% coyote, suggesting that the eastern wolf is a coywolf with more gray wolf content than the red wolf. This study analyzed 48,000 SNP and found no evidence for a unique eastern wolf species (17). In 2012, re-analysis of the 2011 SNP study argued that the original SNP study suffered from insufficient sampling and noted that gray wolves do not mate with coyotes (1). Another Y-chromosome genetic study in 2012 also argued that the eastern wolf and red wolf are not hybrids but rather are a distinct species from the gray wolf, although eastern and red wolves do intermix with coyotes (18). The same authors have argued that the 2011 SNP study finding that eastern wolves are not an independent species is flawed and that historical hunting and culling of wolves, leading to invasion of coyotes into eastern North America, has led to introgression of coyote mitochondrial and nuclear DNA into fragmented, decimated eastern wolf packs (1). They and other authors have postulated that large populations of eastern and red wolves with intact social/pack structures are less likely to interbreed with coyotes (19). The controversy over the eastern wolf's species status was the subject of a comprehensive review of the 2011 and 2012 genetics studies, which concluded that there are four separate species of *Canis* in North America, the eastern wolf, red wolf, gray wolf and coyote (11).

As of February 2014, an experiment which produced hybrids of coyotes and northwestern gray wolves in captivity using artificial insemination contributed more information to the controversy surrounding the eastern wolf. The six hybrids produced were weighed shortly after birth and were shown to be larger than western coyote pups born around the same time, despite being delivered by a female coyote. However, at six months of age they were weighed again with the two females weighing 17.6 and 21.8 kilograms respectively while the four males were varied between 20.1 to 26.0 kilograms which is close to the average weigh of adult eastern wolves who in turn are around 25 to 30 kilograms (20). This research suggests that while the eastern wolves are not coywolves, they are still physically similar to such hybrids. Moreover, the FWS review became controversial, forcing the USF&WS to commission a peer review of it, known as NCAES (2014) (21). This peer review concluded unanimously that the review "is not accepted as consensus scientific opinion or best available science".

In 2015, the most comprehensive genetics study, using comprehensive mitochondrial DNA data, Y-chromosome data and genome-wide data from 127,235 SNP, concluded that "the most parsimonious explanation" is that eastern wolves in Algonquin Provincial Park are "a distinct remnant entity of a historical wolf that most likely existed throughout the eastern United States" (16). The taxonomic reference Mammal Species of the World (2005) does not recognize *Canis lycaon*, however NCBI/Genbank does list it (22).

Physical description and behavior

Charles Darwin described the eastern wolf as being a lightly-built, greyhound-like animal that pursued deer, as opposed to the bulkier, shorter-legged gray wolf (23). The eastern wolf's fur is typically of a grizzled grayish-brown coloration mixed with cinnamon. The flanks and chest are rufous or creamy, while the nape, shoulder and tail region are a mix of black and gray. Unlike gray wolves, eastern wolves rarely produce melanistic individuals (4). The first documentend all-black eastern wolf was found to have been an eastern wolf-gray wolf hybrid (7). Like the red wolf, the eastern wolf is intermediate in size between the coyote and gray wolf, with females weighing 23.9 kilograms (53 lb) on average and males 30.3 kilograms (67 lb). Like the gray wolf, its average lifespan is 3–4 years, with a maximum of 15 years (6). Their physical sizes that sets them intermediate between gray wolves and coyotes are actually believed to be more related to their adaptations to an environment with predominately medium-sized prey similar to the case with the Mexican wolves in the southern USA rather than their close relationship to red wolves and coyotes (24).

The eastern wolf primarily targets small to medium-sized prey items like white-tailed deer and beaver, unlike the gray wolf which can effectively hunt large ungulates like caribou, elk, moose and bison (7). The average territory ranges between 110–185 km^2 (6), and the earliest age of dispersal for young eastern wolves is 15 weeks, much earlier than gray wolves (7).

History, hybridization and conservation

Before the arrival of Europeans, eastern wolves may have numbered at 64,500–90,200 individuals (1). The species ranged throughout the wooded and open areas of eastern North America, from the Maritime provinces and southern Quebec to approximately the southern United States and westward to the Great Plains. The region's indigenous human populations didn't fear eastern wolves, though they did occasionally catch them in traps, and their bones occur in native shell heaps (25). The earliest written records of the eastern wolf were in the writings of Jacques Cartier in 1535 and in Marc Lescarbot's *Histoire de la Nouvelle-France* (1609), where he wrote that the animal was common in Acadia (26).

Early European settlers often kept their livestock on eastern wolf-free outer islands, though animals kept in pasture on the mainland were vulnerable, to the point that a campaign against eastern wolves was launched in the early years of the Plymouth and Massachusetts Bay Colonies, in which both settlers and natives participated. A bounty system was put into effect, offering higher rewards for adult wolves, with their heads exposed on hooks in meetinghouses. Nevertheless, eastern wolves were still plentiful enough by the early 18th century to warrant the settlers of Cape Cod discussing the building of a high fence between Sandwich and Wareham to keep eastern wolves out of grazing lands. The scheme failed, though the settlers continued to utilize wolf pits, a wolf trapping technique learned from the region's indigenous peoples. Eastern wolf numbers declined noticeably shortly before and after the American Revolution, particularly in Connecticut, where the wolf bounty was repealed in 1774. Eastern wolf numbers however were still high enough to cause concern in the more sparsely populated areas of southern New Hampshire and Maine, with wolf hunting becoming a regular occupation among settlers and natives alike. By the early 19th century, few eastern wolves remained in southern New Hampshire and Vermont (25).

Prior to the establishment of Algonquin Provincial Park in 1893, the eastern wolf was common in central Ontario and the Algonquin Highlands. It continued to persist throughout the late 1800s, despite extensive logging and efforts by park rangers to eliminate it, largely due to the sustaining influence of plentiful prey items like deer and beaver. By the mid-1900s, there were as many as 55 eastern wolf packs in the Park (27), with an average of 49 wolves being killed annually between 1909–1958, until they were given official protection by the Ontario government in 1959, by which time the eastern wolf population in and around the Park had been reduced to 500–1000 individuals (1), (27). Nevertheless, between 1964–1965, 36% of the Park's wolf population was culled by researchers trying to understand the reproduction and age structure of the population. This cull coincided with the expansion of coyotes into the park, and lead to an increase in eastern wolf-coyote hybridization (1). Introgression of gray wolf genes into the eastern wolf population also occurred across northern Ontario, into Manitoba and Quebec, as well as into the western Great Lakes states of Minnesota, Wisconsin, and Michigan (7). Despite protection within the Park boundaries, there was a population decline in the east side of the Park between 1987–1999, with an estimated number of 30 packs by 2000. This decline exceeded annual recruitment, and was attributed to human-caused mortality, which mostly occurred when dispersing animals left the Park in search of deer during the winter months, and when pack ranges overlapped with Park boundaries (27). By 2001, protection was extended to eastern wolves occurring in the outskirts of the Park. By 2012, the genetic composition of the Park's eastern wolves was roughly restored to what it was in the mid-1960s than in the 1980s-1990s, when the majority of wolves had large amounts of coyote DNA (1).

Relationships with humans

In Algonquin folklore

The eastern wolf is prominently portrayed in Algonquin mythology, where it is referred to as *ma-hei-gan* or *nah-poo-tee* in the Algonquian languages. It is the spirit brother of the Algonquian folkhero Nanabozho, and assisted him in several of his adventures, including thwarting the plots of the malicious anamakqui spirits and assisting him in recreating the world after a worldwide flood (28).

Howling

Since the discovery in 1963 that eastern wolves answered human imitations of their howls, Algonquin Provincial Park began its Public Wolf Howls attraction, where as many as 2,500 visitors are led on expeditions into areas where eastern wolves were sighted the night before and listen to them answering the Park staff's imitation howls. By 2000, 85 Public Wolf Howls had been held, with over 110,000 people having participated. The Park considers the attraction as the cornerstone of its wolf education program, and credits it with changing public attitudes towards wolves in Ontario (27).

Attacks on humans
Since the early 1970s, there have been several incidents of bold or aggressive behavior towards humans in Algonquin Provincial Park. Between 1987-1996, there were four instances of wolves biting people. The most serious case occurred in 1998, when a male wolf that had been long noted to be unafraid of humans stalked a couple walking their four-year-old daughter in September that year, losing interest when the family took refuge in a trailer. Two days later, the wolf attacked a 19-month-old boy, causing several puncture wounds on his chest and back before being driven off by campers. After the animal was killed later that day, it was found to be non-rabid, and had a DNA profile typical of wolves of the area, thus indicating it was not a hybrid (29).

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APPENDIX 7: GRAY FOX

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March 2016

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OUR SUMMARY

This appendix identifies aspects of the Gray Fox (*Urocyon cinereoargenteus*), which we feel are important to the discussion of the complex prehistoric and historic landscape interplay between humans and this four-legged tactical predator in Delaware and the Mid-Atlantic region. Schreber first described the Gray Fox in 1775, as follows:

Kingdom: Animalia
Phylum: Chordata
Class: Mamalia
Order: Carnivora
Family: Canidae
Genus: *Urocyon*
Species: *U. cinereoargenteus*

Historically, sixteen subspecies of Gray Fox are identified, living in the western hemisphere only. Fritzell and Haroldson (1982) list the following subspecies:

U. c. borealis (New England)
U. c. californicus (southern California)
U. c. cinereoargenteus (eastern United States)
U. c. costaricensis (Costa Rica)
U. c. floridanus (Gulf states)
U. c. fraterculus (Yucatan)
U. c. furvus (Panama)
U. c. guatemalae (southernmost Mexico south to Nicaragua)
U. c. madrensis (southern Sonora, south-west Chihuahua, and north-west Durango)
U. c. nigrirostris (south-west Mexico)
U. c. ocythous (Central Plains states)
U. c. orinomus (southern Mexico, Isthmus of Tehuantepec)
U. c. peninsularis (Baja California)
U. c. scottii (south-western United States and northern Mexico)
U. c. townsendi (California and Oregon)
U. c. venezuelae (Colombia and Venezuela)

The subspecies *U. c. cinereoargenteus* and *U. c. borealis* are the subspecies that may be found archaeologically in Delaware and the Mid-Atlantic region. Overall, the Gray Fox is medium sized with a stocky body, moderately short legs and medium-sized ears. The coat is grizzled grey on the back and sides with a dark longitudinal stripe on top of a black-tipped tail, dark and white markings on its face, and a conspicuous cinnamon- rusty color on its neck, sides and limbs. There is also white on its ears, throat, chest, belly and hind limbs, while the undercoat is mostly buff and grey. The tail is thick and bushy, and the fur is coarse-appearing. The dental formula is 3/3-1/1-4/4-2/3=42 (Sillero-Zubiri et al, 2004:92-7). Genetic studies indicate the historic distribution of the Gray Fox along the eastern seaboard was different, as Sillero-Zubiri et al explain:

> *Historical distribution* In North America, the historical northernmost distribution of the gray fox probably was somewhat further south than its current northern limit (Fritzell and Haroldson 1982). Also, the range of the species probably did not extend significantly into the Great Plains because of the lack of brushy cover. Habitat modifications, such as fire suppression and tree planting, have facilitated occupation of this biome (Fritzell 1987). The species also was formerly found on Martha's Vineyard, a small offshore island in the state of Massachusetts (Waters 1964), see (Sillero-Zubiri et al, 2004:92-7).

Furthermore, Bozarth et al. (2011) found that genetic analysis has shown that the gray fox migrated into the northeastern United States during a significant warming period, ca. 950ce to 1250ce, or the Medieval Climate Anomaly, (a Eurocentric view) as some refer to this period. This significant warming trend is not to be confused with a later significant cooling trend, ca. 1400ce to 1700ce, known as the Little Ice Age. In the Mid-Atlantic region, this warming period, ca. 950ce to 1250ce, exhibits 1) major events in human migration, 2) changes in economic strategies and settlement patterns, and examples of the rise of Chieftain level society benefiting from various forms of what may be referred to as the eastern agricultural complex. This three hundred year time span in Delaware and the Mid-Atlantic region seems to be very dynamic, with not only people and plants moving across the landscape, but now we realize the probably that animals were moving too, all adjusting to dramatic upheavals in anthropogenic landscape formation and alteration. Additionally, the volcano, Baitoushan, violently erupted in 1000ce (+/- 40 years) as a category 7 on the Volcano Explosivity Index (VEI), the maximum size for Holocene eruptions.

See also:
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Finding evidence of Gray Fox in archaeological contexts would have direct bearing on the landscape relationships between humans and these four-legged tactical predators in Delaware and the Mid-Atlantic region. In constructing this Appendix, we reviewed several dozen documents, (essays, books, contracted reports, professional papers, Internet sites, etc.). For the purpose of our essay, the Gray Fox Wikipedia file establishes a reasonable and sufficient background. We decided to include a portion of the Gray Fox Wikipedia file with complete references cited. We closely reviewed, edited, and re-formatted the contents of the open-source Wikipedia file to make a good fit with our research topic.

The following document is a portion of the Gray Fox Internet Wikipedia file together with the Wikipedia file references cited. We closely reviewed, edited, and re-formatted the contents of the open-source Wikipedia file to make a good fit with our research topic. The full Wikipedia document can be found and downloaded at https://en.wikipedia.org/wiki/Gray_fox.

Introduction

The **gray fox** (*Urocyon cinereoargenteus*) is a carnivorous mammal of the family Canidae ranging throughout most of (3) the southern half of North America from southern Canada to the northern part of South America (Venezuela and Colombia) (1). No other canid's natural range spans both North and South America and it is the only American canid that can climb trees (4). This species and its only congener, the diminutive Channel Island fox (*Urocyon littoralis*), are the only living members of the genus *Urocyon*, which is considered to be the most basal of the living canids (5). Though it was once the most common fox in the eastern United States, and still is found there (3), (6), (7), human advancement and deforestation allowed the red fox to become more dominant. The Pacific States still have the gray fox as a dominant. Its specific epithet *cinereoargenteus* means 'ashen silver'.

Origin and Genetics

The gray fox appeared in North America during the mid-Pliocene epoch 3.6 million years ago (AEO) with the first fossil evidence found at the lower 111 Ranch site, Graham County, Arizona with contemporary mammals like the giant sloth, the elephant-like *Cuvieronius*, the large-headed llama, and the early small horses of *Nannippus* and *Equus* (8). Genetic analyses of the fox-like canids confirmed that the gray fox is a distinct genus from the red foxes (*Vulpes* spp.). Genetically, the grey fox often clusters with two other ancient lineages, the east Asian raccoon dog (*Nyctereutes procyonoides*) and the African bat-eared fox (*Otocyon megalotis*) (9). Chromosome number is 2n=66 (10). Faunal remains at two northern California cave sites confirm the presence of the gray fox during the late Pleistocene (11). Genetic analysis has shown that the gray fox migrated into the northeastern United States post-Pleistocene in association with the Medieval Climate Anomaly warming trend (12). Recent mitochondrial genetic studies suggests divergence of North American eastern and western gray foxes in the Irvingtonian mid-Pleistocene into separate sister taxa (13).

The gray fox's dwarf relative, the Channel Island fox, is likely descended from mainland gray foxes (14). These foxes apparently were transported by humans to the islands and from island to island, and are descended from a minimum of 3-4 matrilineal founders (13).

Description and behavior

The grey fox is mainly distinguished from most other canids by its grizzled upper parts, black-tipped tail and strong neck, while the skull can be easily distinguished from all other North American canids by its widely separated temporal ridges that form a U-shape. There is little sexual dimorphism, save for the females being slightly smaller than males. The grey fox ranges from 76 to 112.5 cm (29.9 to 44.3 in) in total length. The tail measures 27.5 to 44.3 cm (10.8 to 17.4 in) of that length and its hind feet measure 100 to 150 mm (3.9 to 5.9 in). The grey fox typically weighs 3.6 to 7 kg (7.9 to 15.4 lb), though exceptionally can weigh as much as 9 kg (20 lb) (15), (16), (17). It is readily differentiated from the red fox by the lack of "black stockings" that stand out on the latter and the stripe of black hair that runs along the middle of the tail. In contrast to all *Vulpes* and related (Arctic and fennec) foxes, the gray fox has oval (instead of slit-like) pupils (18).

The gray fox's ability to climb trees is shared only with the Asian raccoon dog among canids. Its strong, hooked claws allow it to scramble up trees to escape many predators, such as the domestic dog or the coyote (19), or to reach tree-bound or arboreal food sources. It can climb branchless, vertical trunks to heights of 18 meters and jump from branch to branch (20). It descends primarily by jumping from branch to branch, or by descending slowly backwards as a domestic cat would do. The gray fox is nocturnal or crepuscular and makes its den in hollow trees, stumps or appropriated burrows during the day. Such gray fox tree dens may be located 30 ft above the ground (18). Prior to European colonization of North America, the red fox was found primarily in boreal forest and the gray fox in deciduous forest, but now the red fox is dominant in most of the eastern United States since they are the more adaptable species to development and urbanization (21). In areas where both red and gray foxes exist, the grey fox is dominant (22).

Reproduction
The gray fox is monogamous. The breeding season of the gray fox varies geographically; in Michigan, the gray fox mates in early March, in Alabama, breeding peaks occur in February (15). The gestation period lasts approximately 53 days. Litter size ranges from 1 to 7. Kits begin to hunt with their parents at the age of 3 months. By the time that they are four months old, the kits will have developed their permanent dentition and can now easily forage on their own. The family group remains together until the autumn, when the young reach sexual maturity, then they disperse.

Diet
The gray fox is an omnivorous, solitary hunter. It frequently preys on the eastern cottontail (*Sylvilagus floridanus*) in the eastern U.S., though it will readily catch voles, shrews, and birds. In California, the gray fox primarily eats rodents, followed by lagomorphs, e.g. jackrabbit, brush rabbit, etc. (19). In some parts of the Western United States (such as in the Zion National Park in Utah), the gray fox is primarily insectivorous and herbivorous (22). Fruit is an important component of the diet of the gray fox and they seek whatever fruits are readily available, generally eating more vegetable matter than does the red fox (*Vulpes vulpes*) (15).

Subspecies
There are 16 subspecies recognized for the gray fox (10).

- *Urocyon cinereoargenteus borealis* (New England)
- *Urocyon cinereoargenteus californicus* (southern California)
- *Urocyon cinereoargenteus cinereoargenteus* (eastern United States)
- *Urocyon cinereoargenteus costaricensis* (Costa Rica)
- *Urocyon cinereoargenteus floridanus* (Gulf states)
- *Urocyon cinereoargenteus fraterculus* (Yucatán)
- *Urocyon cinereoargenteus furvus* (Panama)
- *Urocyon cinereoargenteus guatemalae* (southernmost Mexico south to Nicaragua)
- *Urocyon cinereoargenteus madrensis* (southern Sonora, south-west Chihuahua, and north-west Durango)
- *Urocyon cinereoargenteus nigrirostris* (south-west Mexico)
- *Urocyon cinereoargenteus ocythous* (Central Plains states)
- *Urocyon cinereoargenteus orinomus* (southern Mexico, Isthmus of Tehuantepec)
- *Urocyon cinereoargenteus peninsularis* (Baja California)
- *Urocyon cinereoargenteus scottii* (south-western United States and northern Mexico)
- *Urocyon cinereoargenteus townsendi* (northern California and Oregon)
- *Urocyon cinereoargenteus venezuelae* (Colombia and Venezuela)

Parasites
Parasites of gray fox include trematode, (*Metorchis conjunctus*) (23).

See also the *Urocyon progressus*, also known as the progressive Gray Fox, extirpated at the end of the ice age.

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This concludes the Wikipedia file, https://en.wikipedia.org/wiki/Gray_fox.

APPENDIX 8: GRAY WOLF

Glen Mellin
Lenny Truitt

March 2016

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OUR SUMMARY

This appendix identifies aspects of the Gray Wolf (*Canis lupus*), which we feel are important to the discussion of the complex prehistoric and historic landscape interplay between humans and this four-legged tactical predator in Delaware and the Mid-Atlantic region. Linnaeus first described the Gray Wolf in 1758, as follows:

Kingdom: Animalia
Phylum: Chordata
Class: Mamalia
Order: Carnivora
Family: Canidae
Genus: *Canis*
Species: *lupus*

For the Gray Wolf, Nowak (1995) supplies maps and measurements for seven Eurasian and five North American subspecies. We do not expect the Gray Wolf species to be present in Delaware and the Mid-Atlantic region, however; some Gray Wolf genetic material may exist in archaeologically recovered examples of Coyote, Eastern Wolf, and Red Wolf. Furthermore, these three species and the Gray Wolf have common ancestors (some may currently be extirpated) in the Eurasia Wolf--Taimyr Wolf genetic stream, hence ancestry, which lived in east Asia and Siberia ca. 3,000,000 ybp to about 500,000 ybp.

C. l. albus (northern Russia)
C. l. arctos (Canadian High Arctic)
C. l. baileyi (Mexico, south-western USA)
C. l. communis (central Russia)
C. l. cubanensis (east central Asia)
C. l. hattai (Hokkaido, Japan)
C. l. hodophilax (Honshu, Japan)
C. l. lupus (Europe, Asia)
C. l. lycaon(south-eastern Canada, north-eastern USA)
C. l. nubilis (central USA, east-central Canada)
C. l. occidentalis (Alaska, north-western Canada)
C. l. pallipes (Middle East, south-western Asia)

The Gray Wolf is the largest wild Canid living in North America, weighing up to 135 pounds. General appearance and proportions are similar to a large German shepherd dog except legs longer, feet larger, ears shorter, eyes slanted, tail curled, and winter fur longer and bushier, and with chin tufts in winter. Fur is thick and usually mottled grey, but can vary from nearly pure white, red, or brown to black. Dental formula is: 3/3-1/1-4/4-2/3=42.

The following document is a portion of the Gray Wolf Internet Wikipedia file together with the Wikipedia file references cited. We closely reviewed, edited, and re-formatted the contents of the open-source Wikipedia file to make a good fit with our research topic. The full Wikipedia document can be found and downloaded at: https://en.wikipedia.org/wiki/Gray_wolf.

Introduction

The **gray wolf** or **grey wolf** (*Canis lupus*), also known as the **timber wolf** (3), (4) or **western wolf**, is a canid native to the wilderness and remote areas of North America and Eurasia. It is the largest extant member of its family, with males averaging 43–45 kg (95–99 lb), and females 36–38.5 kg (79–85 lb) (6). Like the red wolf, it is distinguished from other *Canis* species by its larger size and less pointed features, particularly on the ears and muzzle (7). Its winter fur is long and bushy, and predominantly a mottled gray in color, although nearly pure white, red, or brown to black also occur (4). As of 2005 (8), 37 subspecies of *C. lupus* are recognised by MSW3.

The gray wolf is the second most specialised member of the genus *Canis*, after the Ethiopian wolf, as demonstrated by its morphological adaptations to hunting large prey, its more gregarious nature (9), and its highly advanced expressive behavior (10), (11). It is nonetheless closely related enough to smaller *Canis* species, such as the eastern wolf (5), coyote (12) and golden jackal (13), (14) to produce fertile hybrids. Its closest relative is the domestic dog, with which it shared a common European ancestor which likely diverged 40,000 years ago (15). It is the only species of *Canis* to have a range encompassing both the Old and New Worlds (5), and originated in Eurasia during the Pleistocene, colonizing North America on at least three separate occasions during the Rancholabrean (5). It is a social animal, travelling in nuclear families consisting of a mated pair, accompanied by the pair's adult offspring (16). The gray wolf is typically an apex predator throughout its range, with only humans and tigers (9), (17), (18), (19) posing a serious threat to it. It feeds primarily on large ungulates, though it also eats smaller animals, livestock, carrion, and garbage (4).

The gray wolf is one of the world's best known and well researched animals, with probably more books written about it than any other wildlife species (20). It has a long history of association with humans, having been despised and hunted in most pastoral communities because of its attacks on livestock, while conversely being respected in some agrarian and hunter-gatherer societies (21). Although the fear of wolves is pervasive in many human societies, the majority of recorded attacks on people have been attributed to animals suffering from rabies. Non-rabid wolves have attacked and killed people, mainly children, but this is rare, as wolves are relatively few, live away from people, and have developed a fear of humans from hunters and shepherds (22).

Etymology

The Latin *lupus* is a Sabine loanword (21), while the English 'wolf' stems from the Old English *wulf*, which is itself thought to be derived from the Proto-Germanic **wulfaz*, from the Proto-Indo-European root **wlq^{w}os*/**luk^{w}os* (23). Old English literature contains several instances of Anglo-Saxon kings and warriors taking on *wulf* as a prefix or suffix in their names. Examples include Wulfhere, Cynewulf, Ceonwulf, Wulfheard, Earnwulf, Wulfmǣr, Wulfstān and Æthelwulf. Wolf-related names were also common among pre-Christian Germanic warriors: Wolfhroc (Wolf-Frock), Wolfhetan (Wolf Hide), Isangrim (Grey Mask), Scrutolf (Garb Wolf), Wolfgang (Wolf Gait) and Wolfdregil (Wolf Runner) (24).

Taxonomy

Canis lupus was recorded by Linaeus in his publication Systema Naturae in 1758 (2). The Latin classification translates into English as "Dog wolf". The subspecies of Canis lupus are listed in Mammal Species of the World (8), (25). The nominate subspecies is the Eurasian wolf (*Canis lupus lupus*) (25), also known as the common wolf (26). As of 2005 (8) 37 subspecies of *C. lupus* are recognised by MSW3, however the classification of several as either species or subspecies has recently been challenged.

Origins

Ancestry

Feliforms and caniforms emerged within the super-family Carnivoramorpha 43 million YBP (27). The caniforms included the fox-like *Leptocyon* genus whose various species existed from 34 million YBP before branching 11.9 million YBP into vulpes (foxes) and canini (canines). The *Eucyon* genus diverged 6.2 million YBP towards *Canis ferox*, which diverged 5 million YBP towards *Canis lepophagus*, which diverged 3.5 million YBP towards the wolf-like canids (28):174-5. If the geological attribution of the material is correct then the earliest identifiable *C. lupus* remains date 800,000 YBP (28):5 (Middle

Pleistocene) with wolves similar to the living species (28):150 occurring at both the Olyor fauna (Siberia) and in the Cripple Creek Sump fauna (Alaska), which points to an origin of these wolves in Beringia (28):181. In 2010, a study found that the diversity of the Canis group decreased by the end of the Early Pleistocene to Middle Pleistocene and was limited to the small wolves of the *Canis mosbachensis–Canis variabilis* group and the large hypercarnivorous *Canis (Xenocyon) lycaonoides* in Eurasia. The true gray wolves made their appearance at the end of the Middle Pleistocene at about 0.5–0.3 million YBP (29). Based on morphology, *Canis mosbachensis* has been proposed as the ancestor of the *Canis lupus* lineage (30):239-245. Based on genetics, *Canis variabilis* has been proposed as contributing to the wolf/dog lineage (31). The two small wolves, *Canis variabilis* and *Canis mosbachensis*, are contemporaries in mid-latitude Eurasia and are similar in morphology, with phylogenetic analysis showing them to group together in a common region on a cladogram and they could represent one geographically-widespread mid-Pleistocene wolf (28):181.

Divergence

As of May 2015, genetic analyses indicate that the Taymyr wolf diverged from the ancestor of the dog/modern gray wolf 40,000 years ago (15):3, with the Taymyr wolf being classified as *Canis lupus* because it was found to be substantially closer to modern gray wolves than it was to coyotes (15):Fig.S4. Shortly after, the dog/modern gray wolf ancestor diverged into two sister clades (15):1, (32):872, (33):7 formed by the ancestral dog and the ancestral modern gray wolf. There was admixture between the ancestral dog and the ancestral modern gray wolf (33):5 before the ancestral dog diverged into the dingo and the domestic dog lines, and the ancestral modern gray wolf diverged into the extant gray wolf subspecies (33):7:Fig4a. All extant gray wolf populations share a relatively recent origin, most likely sometime after the divergence of the Taimyr wolf lineage but prior to the inundation of the Bering Land Bridge and subsequent isolation of Eurasian and North American wolves (15):3. Dogs arrived with the first humans to the New World within this timeframe (32):872. Some Arctic dog breeds show a genetic relationship to the Taymyr wolf, indicating admixture before the Taymyr wolf became extinct (15):3.

Haplogroups

In 2010, a study compared the mDNA haplotypes of 947 modern gray wolves from across Europe with the published sequences of 24 Pleistocene wolves from western Europe dated between 1,200-44,000 years BP. The study found that phylogenetically the haplotypes represented two haplogroups and referred to these as haplogroup 1 and 2. The 947 European wolves revealed 27 different haplotypes with haplogroup 1 forming a monophyletic clade, and all other haplotypes forming haplogroup 2. Comparison with gray wolves from other regions revealed that haplogroups 1 and 2 could be found spread across Eurasia but only haplogroup 1 could be found in North America. The Pleistocene wolf samples from western Europe all belonged to haplogroup 2, which suggested a long-term predominance in this region. A comparison of current and past frequencies indicated that in Europe haplogroup 2 became outnumbered by haplogroup 1 but in North America haplogroup 2 became extinct and was replaced by haplogroup 1 after the Last Glacial Maximum (34). Access into North America was available between 20,000-11,000 years ago, after the Wisconsin glaciation had retreated but before the Bering land bridge became inundated by the sea (35). Therefore, haplogroup 1 was able to enter into North America during this period.

Analysis of stable isotopes, which offer conclusions about the diet and therefore the ecology of the extinct wolf populations suggest that the Pleistocene wolves from haplogroup 2 mainly preyed on Pleistocene megafaunal species (36), (37), which became rare at the beginning of the Holocene 12,000 years ago (38):2. "Thus, Pleistocene wolves across Northern Eurasia and America may actually have represented a continuous and almost panmictic population that was genetically and probably also ecologically distinct from the wolves living in this area today" (39):R610. "The Pleistocene Eurasian wolves are morphologically and genetically comparable to the Pleistocene eastern-Beringian wolves" (40):791. The specialized Pleistocene wolves, thus, did not contribute to the genetic diversity of modern wolves. Rather, modern wolf populations across the Holarctic are likely be the descendants of wolves from populations that came from more southern refuges as suggested previously (41) for the North American wolves (39):R611. These 2 haplogroups exclude the older-lineage Himalayan wolf and the Indian gray wolf. Some of the ancient European and Beringian wolves shared a common haplotype (a17) (34):8. See also: Beringian wolf.

Haplotypes

In 2010, a study found that there were 75 different gray wolf mDNA haplotypes that include 23 in Europe, 30 in Asia, 18 in North America, 3 in both Europe and Asia, and 1 in both Europe and North America (34):TableS1. The Himalayan wolf is formed by one haplotype (43):166 that currently falls within the Tibetan wolf (*Canis lupus chanco*) subspecies, but based on mDNA sequencing has be proposed as a separate species *Canis himalayensis* (43), (44). The Indian gray wolf is formed by two closely related haplotypes (43):116 that fall within the Indian wolf (*Canis lupus pallipes*) subspecies, but based on mDNA sequencing has be proposed as a separate species *Canis indica* (43), (44). Neither proposal has been endorsed because they relied on a limited number of museum and zoo samples that may not have be representative of the wild population, and a call for further fieldwork has been made (45):886. Based on a fossil record estimate that the divergence time between the coyote and the wolf lineages occurred one million years ago and with an assumed wolf mutation rate, one study estimated the time of divergence of the Himalayan wolf and the Indian gray from the wolf/dog ancestor to be 800,000 years and 400,000 years ago respectively (44):S2. Another study, which expressed some concerns with the earlier study, gave an estimate of 630,000 ago years and 270,000 ago years respectively (43):169.

In Europe, one haplotype (w22) was found to be unique to the Apennine Peninsula. Two haplotypes (w24, w25) were found to be unique to the Iberian Peninsula. One haplotype (w10) was found to be common to the Iberian peninsula and the Balkans. These three populations with geographic isolation exhibited a near lack of gene flow (34):5 and spatially correspond to three glacial refugia (46):437. Similarly for the three Southern Asian haplotypes, during Pleistocene glaciations these wolf lineages were isolated in refuges (44):S2.

Subspecies

Main article: Subspecies of Canis lupus.

Globally, *C. lupus* taxonomy has been subject to numerous revisions, particularly in North America. As of 2005 (8), 37 subspecies of *C. lupus* are recognised by MSW3. Its list includes the domestic dog, dingo, eastern wolf and red wolf, but lists *C. l. italicus* and *C. l. communis* as synonyms of *C. l. lupus* (47).

Old World gray wolf subspecies

In 1995, mammologist Robert Nowak recognized five subspecies from Eurasia based on skull morphology; *C. l. lupus*, *C. l. albus*, *C. l. pallipes*, *C. l. cubanensis* and *C. l. communis* (48). In 2003, Nowak also recognized the distinctiveness of *C. l. arabs*, *C. l. hattai*, *C. l. hodophilax* and *C. l. lupaster* (49). Furthermore, genetic studies on gray wolves in Italy revealed that, unlike several European gray wolf populations, Italian wolves do not share haplotypes with either other gray wolves or domestic dogs, and are morphologically distinct enough to be classed as a separate subspecies; *C. l. italicus* (50), (51), (52).

Rueness et al. (2014) showed that wolves in the Caucasus Mountains of the putative Caucasian subspecies, *C. l. cubanensis*, are not genetically distinct enough to be considered a subspecies, but may represent a local ecomorph of *C. l. lupus* (53). In 2015, a study of mitochondrial and nuclear genomes on putative wolves and golden jackals in Africa revealed that they both represented differing ecomorphs of the same species, *Canis anthus*, which distinct from the grey wolf (42).

New World gray wolf subspecies

C. lupus colonized North America during the late Rancholabrean era through the Bering land bridge in at least three separate invasions, with each wave being represented by one or more different Eurasian gray wolf clades (5). Among the first to enter was a broad-skulled, hypercarnivorous ecomorph which never expanded its range below the Wisconsin ice sheet, likely because of competitive exclusion by *C. dirus* populations in the south, with both dying out during the Quaternary extinction event without leaving any modern descendants (36). The first gray wolves to permanently enter North America were the ancestors of *C. l. baileyi*, though these were followed and displaced by *C. l. nubilus* and pushed southwards. *C. l. nubilus* was in turn displaced from its northern range by *C. l. occidentalis*, likely during the Holocene, a process which may have continued into historic times (5).

In 1944, American zoologist Edward Goldman recognized as many as 23 subspecies in North America, based on morphology alone (54). In 1995, mammologist Ronald Nowak disputed these classifications, based on his comparison of numerous wolf skulls from throughout the continent. He concluded that there are only five North American subspecies: *C. l. occidentalis*, *C. l. nubilus*, *C. l. arctos*, *C. l. baileyi* and

C. l. lycaon. Wilson et al. (2000), a genetic study of canids from Algonquin Provincial Park, indicated that *C. l. lycaon* was a separate species from *C. lupus*, more closely related to *C. rufus* (55).

In a monograph prepared within the United States Fish and Wildlife Service (USF&WS), Chambers *et al.* (2012) reviewed many genetic studies and concluded that the eastern wolf and red wolf are separate species from the gray wolf, having originated in North America 150,000–300,000 years ago from the same line as coyotes. The Chambers review concluded that the subspecific status of *C. l. arctos* is doubtful, as Arctic wolf populations do not possess unique haplotypes (5). However, the Chambers review became controversial, forcing the USF&WS to commission a peer review of it, known as NCAES (2014) (56). This peer review concluded unanimously that the Chambers review "is not accepted as consensus scientific opinion or best available science..." Director of RESOLVE's Science Program, Steven Courtney, who was in charge of the peer review, had also noted that the Chambers conclusion that the eastern wolf should be listed outside the species limits of the gray wolf was based primarily on two non-recombining markers – those being mtDNA and sex chromosome – which the other panelists agreed unanimously "is insufficient to determine the existence of a species and specifically is completely insufficient for ruling out the alternative hypothesis that the pattern is explained by ancient (and recent) hybridization between *C. lupus* and *C. latrans*". Evolutionary biologist Dr. Robert Wayne of the UCLA Department of Ecology and Evolutionary Biology further elaborated that the Chambers review on the taxonomy of the eastern wolf not only suffered from insufficient sampling but that it was also biased in terms of attributing the presences of the gray wolf Y chromosomes in the modern day eastern wolves to two unfounded hypotheses: that *C. lupus* was historically absent in the eastern USA by *C. lycaon* followed with the suggestion of the former's invasion into the eastern third of North America and later introgressing into the latter's gene pool, and that the gray wolf Y chromosomes discovered in the Algonquin Provincial Park's eastern wolf samples originated from domestic dogs. Two subsequent reviews of updated research based on the 2013 and 2014 reviews, one commissioned to the Wildlife Management Institute by the USFWS, and one journal review, concluded that historically there were four unique canid species in North America, gray wolf, eastern wolf, coyote, and dog, and that "the red wolf may be conspecific with the eastern wolf" (57), (58). This view consistent with the idea that the coyote and gray wolf did not historically range into the southeastern United States.[57] These reviews and a 2015 genetics study, the most comprehensive to date (59), led the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in May, 2015 to change the designation of the eastern wolf back into a distinct species, *Canis lycaon*. However, the previous assertion that gray wolves did not occur in the eastern third of the United States is still heavily ill-founded by the newer genetic study's lead authors, such as Dr. Linda Y. Rutledge, who noted in the conclusions that "the recognition of the eastern wolf as a separate species does not exclude the possibility that a grey wolf × eastern wolf hybrid animal (previously identified as *Canis lupus lycaon*, boreal/Ontario-type), similar to a Great Lakes boreal wolf currently located in the Great Lakes states and across Manitoba, northern Ontario, and northern Quebec, historically inhabited the northeastern United States alongside eastern wolves, and there is some evidence to support the historical presence of both Canis types." The study also suggests that the coyote markers present in the Canis lupus populations that currently occupy the western Great Lakes states and western Ontario may have been historically circuited into the population by the eastern wolves since pure gray wolves in the wild rarely hybridize with coyotes whereas eastern wolves have a history of hybridizing with both species.

The taxonomy of wolves in the coastal rainforests of British Columbia and southeastern Alaska has also followed a variable path, regarding the putative Vancouver Island wolf *(C. l. crassodon)* and Alexander Archipelago wolf *(C. l. ligoni)*, respectively. Based on skull morphometrics, *C. l. ligoni* was recognized by Goldman (1944), Hall (1981) and Pedersen (1982) as a distinct population possibly warranting subspecific classification; however, Nowak (1996) considered it to be an isolated population of *C. l. nubilis* (60). From 2005 to 2014 several studies and the NCAES (2014) peer review have found the pacific coastal wolves to have a phenotypically distinct genotype (61), (62), (63), (64), (65). The putative British Columbian Raincoast Island wolves became the central discussion in a 2015 National Geographic documentary that introduced them as sea wolves due in part to the morphologically distinct skeletal structures of these wolves compared to inland North American wolves, which gives them the ability to swim longer distances between the islands than those on the mainland continent (66). The Raincoast wolves are also known to have a unique dietary preference for fish, orcas, mollusks, seals, and various small prey endemic to the islands, as opposed to their inland cousins who subsist on medium-sized ungulates. In the 2014 NCAES peer review, Dr. Robert Wayne suggested that centuries of adaptation to these remote islands coupled with the unique dietary habits may have played a critical role in uniforming the modern day Raincoast wolves' genetic distinction from

Vancouver island wolves and inland wolves, thus warranting a new subspecific classification distinct from Nowak's previous *C. l. nubilus* classification.

Relationship to the dog

Within the species *Canis lupus*, phylogenetic analysis strongly supports the hypothesis that dogs and wolves are reciprocally monophylic taxa that form two sister clades (67), (68):4. In 1868, Charles Darwin proposed that domestic dogs were phenotypically so diverse that they likely had originated from 2 or more wild canine species (69). All species within the *Canis* genus, the wolf-like canids, are phylogenetically closely related with 78 chromosomes and can potentially interbreed (70). The wild ancestor of the domestic dog was variously claimed to have been the dhole (71) or golden jackal (72). Later, others thought that the wolf was the most probable ancestor and closest relative of the domestic dog (73).

In 1993, a study of the wolf-like canids found that there was a close kinship between domestic dogs, gray wolves, coyotes and Simien jackals but with a distance from the African wild dog and from the golden, side-striped and black-backed jackals. The domestic dog was an extremely close relative of the gray wolf, differing from it by at most 0.2% of the maternal mitochondrial Cytochrome b gene marker. In comparison, the gray wolf differs from its closest wild relative, the coyote, by about 4%. Therefore, the study concluded that the molecular genetic evidence did not support theories that dogs arose from jackal ancestors. The study proposed the hypothesis that because of the diversity of dog remains found in archaeological sites, that dogs may be derived from several different ancestral gray wolf populations (74). Later that year, the domestic dog *Canis familiaris* was reclassified as *Canis lupus familiaris*, a subspecies of *Canis lupus* in Mammal Species of the World (25), (75).

In 1999, a review of the scientific literature regarding the genetic origin of the dog proposed a number of hypotheses. The molecular data indicated that dogs have protein alleles in common with wolves, share highly polymorphic microsatellites, and have mitochondrial DNA sequences similar or identical to those found in gray wolves. The maternal mitochondrial control region sequences shows an average divergence between dogs and wolves at 1.5% compared to dogs and coyotes, their next-closest relative, at 7.5%. Therefore, this indicated the origin of the dog was from wolves. The archaeological record suggests that dogs were in Europe and the Middle East approximately 14,000 years ago but the genetic record shows 135,000 YBP, which indicated that the morphological change was associated with artificial selection as humans shifted from hunter-gatherer to agrarian societies. Alternately, dogs may have had a more recent origin but are descended from a now extinct species of canid whose closest living relative was the gray wolf (70).

In 2013, a study on the mitochondrial genomes of both extant and fossil canids (dating back 1,000–36,000 years BP) indicated that modern dogs were closer genetically to extinct European canids than they were with modern gray wolves, therefore they formed a sister clade with a European origin dating back 18,800–32,100 years ago. The data also indicated that some of the earliest putative dog remains, such as a 36,000-year-old skull from Goyet, Belgium, represent an ancient sister clade to dogs and wolves (76). The co-senior author of the study theorized that the domestication process may have occurred when megafaunal wolves gave up their territoriality in favor of trailing early nomadic human hunters and began reproducing amongst themselves rather than with resident wolf packs, thus initiating reproductive isolation (77).

In 2014, a study of the nuclear DNA of modern gray wolves and dogs indicated that dogs are not descended from any existing gray wolf subspecies, but share a recent common ancestor. Based on timing assumptions made, the study indicated that dogs diverged from the ancestor 14,900 years ago, and this was followed by the gray wolf samples taken from Croatia, Israel and China having diverged 13,400 years ago, thus showing that extant gray wolf subspecies are descended from a younger lineage of wolves than that of dogs. The dog's genetic closeness to the gray wolf was due to admixture post-divergence (68). The common ancestor to both animals has been theorized to have been a large wolf-like canid native to Europe, which lived between 9,000–34,000 years ago (78). In May 2015, a study was able to map the first whole genome of a 35,000-year-old Pleistocene wolf. The data indicated that the recently discovered, but extinct, northern Asian Taymyr wolf, gray wolves and dogs all diverged at around 40,000 years ago from a common ancestor, and form three sister clades. The timing is thought to be accurate because the radio-carbon dating of the Taymyr specimen was in agreement with its molecular clock and those of gray wolves and dogs, yielding for the first time the lupine/dog mutation rate. Moreover, the study indicated that most dog breeds' genetic closeness to the Gray wolf is due to admixture, with clear evidence being found of a close relationship between the Taymyr wolf with those

breeds that are associated with high latitudes–the Siberian husky and Greenland dog (both of which are associated with arctic human populations), and to a lesser extent the Shar Pei and Finnish spitz also due to admixture. These findings support the hypothesis that the wild ancestors of dogs were a genetically distinct wolf population that inhabited the Late Pleistocene steppe-tundra biome, and that this population was subsequently possibly replaced by a northward postglacial expansion of smaller-bodied wolves that gave rise to modern-day gray wolf diversity. The divergence of the dog would not necessarily have had to coincide with domestication in the sense of selective breeding by humans (15).

Hybridization with other *Canis*

Although dogs and gray wolves are genetically very close, and have shared vast portions of their ranges for millennia, the two generally do not voluntarily interbreed in the wild, though they can produce viable offspring, with all subsequent generations being fertile (79). In North America, black colored wolves acquired their coloration from wolf-dog hybridization, which occurred 10,000–15,000 years ago (80). Although wolf-dog hybridization in Europe has raised concern among conservation groups fearing for the gray wolf's purity, genetic tests show that introgression of dog genes into European gray wolf populations does not pose a significant threat. Also, as wolf and dog mating seasons do not fully coincide, the likelihood of wild wolves and dogs mating and producing surviving offspring is small (81). Like pure wolves, hybrids breed once annually, though their mating season occurs three months earlier, with pups mostly being born in the winter period, thus lessening their chances of survival (79). However, one genetic study undertaken in the Caucasus Mountains showed that as many as 10% of dogs in the area, including livestock guardian dogs, are first generation hybrids (53). The captive breeding of wolf-dog hybrids has proliferated in the USA, with 300,000 such animals being present there (79). Recognized wolfdog breeds by FCI are the Czechoslovakian Wolfdog and the Saarloos wolfdog.

The gray wolf has interbred extensively with the eastern wolf across northern Ontario, into Manitoba and Quebec, as well as into the western Great Lakes states of Minnesota, Wisconsin, and Michigan, producing a hybrid population termed Great Lakes boreal wolves (82). The boreal wolf is 25% larger than a pure eastern wolf, and typically has a similarly colored gray-fawn coat but, unlike the eastern wolf, can also be black, cream, or white. It also specializes on larger prey such as moose and caribou rather than white-tailed deer. Unlike pure eastern wolves, Great Lakes boreal wolves primarily inhabit boreal rather than deciduous forests (5).

Unlike the red and eastern wolf, the gray wolf does not readily interbreed with coyotes.[5] Nevertheless, coyote genetic markers have been found in some wild isolated gray wolf populations in the southern United States. Gray wolf Y-chromosomes have also been found in Texan coyote haplotypes (83). In tests performed on a putative chupacabra carcass, mtDNA analysis showed that it was a coyote, though subsequent tests revealed that it was a coyote–gray wolf hybrid sired by a male Mexican gray wolf (84). In 2013, a captive breeding experiment in Utah between gray wolves and western coyotes produced six hybrids through artificial insemination, making this the very first hybridization case between pure coyotes and northwestern gray wolves. At six months of age, the hybrids were closely monitored and were shown to display both physical and behavioral characteristics from both species (12).

Although hybridization between wolves and golden jackals has never been observed, evidence of such occurrences was discovered through mtDNA analysis on jackals in Senegal (13) and Bulgaria (14). Although there is no genetic evidence of gray wolf-jackal hybridization in the Caucasus Mountains, there have been cases where otherwise genetically pure golden jackals have displayed remarkably gray wolf-like phenotypes, to the point of being mistaken for wolves by trained biologists (53).

Physical description

Anatomy and dimensions

The gray wolf generally places its hind paws in the tracks made by the front paws (85). Compared to its closest wild cousins (the coyote and golden jackal), the gray wolf is larger and heavier, with a broader snout, shorter ears, a shorter torso and longer tail (9), (13), (86). It is a slender, powerfully built animal with a large, deeply descending ribcage, a sloping back and a heavily muscled neck (9). The wolf's legs are moderately longer than those of other canids, which enables the animal to move swiftly, and allows it to overcome the deep snow that covers most of its geographical range (85). Females tend to have narrower muzzles and foreheads, thinner necks, slightly shorter legs and less massive shoulders than males (87). The gray wolf's head is large and heavy, with a wide forehead, strong jaws and a long, blunt muzzle. The ears are relatively small and triangular (9). The teeth are heavy and large, being better

suited to crushing bone than those of other extant canids, though not as specialised as those found in hyenas (88), (89). Its molars have a flat chewing surface, but not to the same extent as the coyote, whose diet contains more vegetable matter (3). The gray wolf's jaws can exert a crushing pressure of perhaps 10,340 kPa (1,500 psi) compared to 5,200 kPa (750 psi) for a German shepherd. This force is sufficient to break open most bones (90). The gray wolf usually carries its head at the same level as the back, raising it only when alert (9). It usually travels at a loping pace, placing its paws one directly in front of the other. This gait can be maintained for hours at a rate of 8–9 km/h (91), and allows the wolf to cover great distances. On bare paths, a wolf can quickly achieve speeds of 50–60 km/h. The gray wolf has a running gait of 55 to 70 km/h, can leap 5 metres horizontally in a single bound, and can maintain rapid pursuit for at least 20 minutes (92).

The gray wolf is the largest extant member of the Canidae, excepting certain large breeds of domestic dog (86). Gray wolf weight and size can vary greatly worldwide, tending to increase proportionally with latitude as predicted by Bergmann's Rule (9), with the large wolves of Alaska and Canada sometimes weighing 3–6 times more than their Middle Eastern and South Asian cousins (93). On average, adult wolves measure 105–160 cm (41–63 in) in length and 80–85 cm (32–34 in) in shoulder height (9). The tail measures 29–50 cm (11–20 in) in length. The ears are 90–110 millimetres (3.5–4.3 in) in height, and the hind feet are 220–250 mm (9). The skull averages 9–11 inches in length, and 5–6 inches wide (94). Gray wolf weight varies geographically; on average, European wolves may weigh 38.5 kilograms (85 lb), North American wolves 36 kilograms (79 lb) and Indian and Arabian wolves 25 kilograms (55 lb) (95). Females in any given wolf population typically weigh 5–10 lbs less than males (96). Wolves weighing over 54 kg (120 lbs) are uncommon, though exceptionally large individuals have been recorded in Alaska, Canada (96), and the former Soviet Union (9), (97). The heaviest recorded gray wolf in North America was killed on 70 Mile River in east-central Alaska on July 12, 1939 and weighed 79.4 kilograms (175 lb) (98), while the heaviest recorded wolf in Eurasia was killed after World War II in Ukraine's Poltavskij Region, and weighed 86 kilograms (190 lb) (97).

Fur

The gray wolf has very dense and fluffy winter fur, with short underfur and long, coarse guard hairs (9). Most of the underfur and some of the guard hairs are shed in the spring and grow back in the autumn period (95). The longest hairs occur on the back, particularly on the front quarters and neck. Especially long hairs are found on the shoulders, and almost form a crest on the upper part of the neck. The hairs on the cheeks are elongated and form tufts. The ears are covered in short hairs, which strongly project from the fur. Short, elastic and closely adjacent hairs are present on the limbs from the elbows down to the calcaneal tendons (9). The winter fur is highly resistant to cold; wolves in northern climates can rest comfortably in open areas at −40° by placing their muzzles between the rear legs and covering their faces with their tail. Wolf fur provides better insulation than dog fur, and does not collect ice when warm breath is condensed against it (95). In warm climates, the fur is coarser and scarcer than in northern wolves (9). Female wolves tend to have smoother furred limbs than males, and generally develop the smoothest overall coats as they age. Older wolves generally have more white hairs in the tip of the tail, along the nose and on the forehead. The winter fur is retained longest in lactating females, though with some hair loss around their nipples (87). Hair length on the middle of the back is 60–70 mm. Hair length of the guard hairs on the shoulders generally does not exceed 90 mm, but can reach 110–130 mm (9).

Coat color ranges from almost pure white through various shades of blond, cream, and ochre to grays, browns, and blacks (99), with variation in fur color tending to increase in higher latitudes (100). Differences in coat color between sexes are largely absent (9), though females may have redder tones (101). Black colored wolves in North America inherited the K^b allele responsible for melanism from past interbreeding with dogs (80), while the mutation was found to be naturally occurring in wolves from Iran (102). Black specimens are more common in North America than in Eurasia, with about half the wolves in Yellowstone National Park being black (80).

Behavior

Social and territorial behaviors

The gray wolf is a social animal, whose basic social unit consists of a mated pair, accompanied by the pair's adult offspring. The average pack consists of a family of 5–11 animals (1–2 adults, 3–6 juveniles and 1–3 yearlings) (9), or sometimes two or three such families (3), with exceptionally large packs consisting of 42 wolves being known (104). In ideal conditions, the mated pair produces pups every year, with such offspring typically staying in the pack for 10–54 months before dispersing (16). Triggers for dispersal include the onset of sexual maturity and competition within the pack for food

(105). The distance travelled by dispersing wolves varies widely; some stay in the vicinity of the parental group, while other individuals may travel great distances of 390 km, 206 km, and 670 km from their natal packs (106). A new pack is usually founded by an unrelated dispersing male and female, travelling together in search of an area devoid of other hostile packs (107). Wolf packs rarely adopt other wolves into their fold, and typically kill them. In the rare cases where other wolves are adopted, the adoptee is almost invariably an immature animal (1–3 years of age) unlikely to compete for breeding rights with the mated pair. In some cases, a lone wolf is adopted into a pack to replace a deceased breeder (104). During times of ungulate abundance (migration, calving etc.), different wolf packs may temporarily join forces (9).

Wolves are highly territorial animals, and generally establish territories far larger than they require to survive in order to assure a steady supply of prey. Territory size depends largely on the amount of prey available and the age of the pack's pups, tending to increase in size in areas with low prey populations (108) or when the pups reach the age of 6 months, thus having the same nutritional needs as adults (109). Wolf packs travel constantly in search of prey, covering roughly 9% of their territory per day (average 25 km/d or 15 mi/d). The core of their territory is on average 35 km^2 (14 sq mi), in which they spend 50% of their time (108). Prey density tends to be much higher in the territory's surrounding areas, though wolves tend to avoid hunting in the fringes of their range unless desperate, because of the possibility of fatal encounters with neighboring packs (110). The smallest territory on record was held by a pack of six wolves in northeastern Minnesota, which occupied an estimated 33 km^2 (13 sq mi), while the largest was held by an Alaskan pack of ten wolves encompassing a 6,272 km^2 (2,422 sq mi) area (109). Wolf packs are typically settled, and usually only leave their accustomed ranges during severe food shortages (9).

Wolves defend their territories from other packs through a combination of scent marking, direct attacks and howling (see Communication). Scent marking is used for territorial advertisement, and involves urination, defecation and ground scratching (111), (112), (113), (114), (115). Scent marks are generally left every 240 metres throughout the territory on regular travelways and junctions. Such markers can last for 2–3 weeks (109), and are typically placed near rocks, boulders, trees or the skeletons of large animals (9). Territorial fights are among the principal causes of wolf mortality, with one study concluding that 14–65% of wolf deaths in Minnesota and the Denali National Park and Preserve were due to predation by other wolves (116).

Reproduction and development

The gray wolf is generally monogamous, with mated pairs usually remaining together for life, unless one of the pair dies. Upon the death of one mated wolf, pairs are quickly re-established. Since males often predominate in any given wolf population, unpaired females are a rarity (9). If a dispersing male gray wolf is unable to establish a territory or find a mate, he mates with the daughters of already established breeding pairs from other packs. Such gray wolves are termed "Casanova wolves" and, unlike males from established packs, they do not form pair bonds with the females they mate with. Some gray wolf packs may have multiple breeding females this way, as is the case in Yellowstone National Park (117). Gray wolves also practice alloparental care, in which a wolf pair may adopt the pup or pups of another. This might take place if the original parents die or are for some reason separated from them (118). In addition to heterosexual behavior, homosexual behavior has been observed in gray wolves (119). Male gray wolves often mount each other when the highest ranking female in the pack comes into heat (120).

The age of first breeding in gray wolves depends largely on environmental factors: when food is plentiful, or when wolf populations are heavily managed, wolves can rear pups at younger ages in order to better exploit abundant resources. This is further demonstrated by the fact that captive wolves have been known to breed as soon as they reach 9–10 months, while the youngest recorded breeding wolves in the wild were 2 years old. Females are capable of producing pups every year, with one litter annually being the average. Unlike the coyote, the gray wolf never reaches reproductive senescence (121). Estrus typically occurs in late winter, with older, multiparous females entering estrus 2–3 weeks earlier than younger females (9). During pregnancy, female wolves remain in a den located away from the peripheral zone of their territories, where violent encounters with other packs are more likely (122). Old females usually whelp in the den of their previous litter, while younger females typically den near their birthplace. The gestation period lasts 62–75 days, with pups usually being born in the summer period (9).

Wolves bear relatively large pups in small litters compared to other canid species (123). The average litter consists of 5–6 pups (124), with litter sizes tending to increase in areas where prey is abundant (124), though exceptionally large litters of 14–17 pups occur only 1% of the time (125). Pups are usually born in spring, coinciding with a corresponding increase in prey populations (122). Pups are born blind and deaf, and are covered in short soft grayish-brown fur. They weigh 300–500 grams at birth, and begin to see after 9–12 days. The milk canines erupt after one month. Pups first leave the den after 3 weeks. At 1.5 months of age, they are agile enough to flee from danger. Mother wolves do not leave the den for the first few weeks, relying on the fathers to provide food for them and their young. Pups begin to eat solid food at the age of 3–4 weeks. Pups have a fast growth rate during their first four months of life: during this period, a pup's weight can increase nearly 30 times (9), (123). Wolf pups begin play fighting at the age of 3 weeks, though unlike young foxes and coyotes, their bites are inhibited. Actual fights to establish hierarchy usually occur at 5–8 weeks of age. This is in contrast to young foxes and coyotes, which may begin fighting even before the onset of play behavior (10). By autumn, the pups are mature enough to accompany adults on hunts for large prey (122).

Hunting and feeding behaviors

Although social animals, single wolves or mated pairs typically have higher success rates in hunting than do large packs, with single wolves having occasionally been observed to kill large prey such as moose, bison and muskoxen unaided (126). The gray wolf's sense of smell is relatively weakly developed when compared to that of some hunting dog breeds, being able to detect carrion upwind no farther than 2–3 km. Because of this, it rarely manages to capture hidden hares or birds, though it can easily follow fresh tracks. Its auditory perception is acute enough to be able to hear up to a frequency of 26 kHz (127), which is sufficient to register the fall of leaves in the autumn period (9). A gray wolf hunt can be divided into five stages:

- **Locating prey:** The wolves travel in search of prey through their power of scent, chance encounter, and tracking. Wolves typically locate their prey by scent, though they must usually be directly downwind of it. When a breeze carrying the prey's scent is located, the wolves stand alert, and point their eyes, ears and nose towards their target. In open areas, wolves may precede the hunt with group ceremonies involving standing nose-to-nose and wagging their tails. Once concluded, the wolves head towards their prey (128).
- **The stalk:** The wolves attempt to conceal themselves as they approach (129). As the gap between the wolves and their prey closes, the wolves quicken their pace, wag their tails, and peer intently, getting as close to their quarry as possible without making it flee (130).
- **The encounter:** Once the prey detects the wolves, it can either approach the wolves, stand its ground, or flee. Large prey, such as moose, elk, and muskoxen, usually stand their ground. Should this occur, the wolves hold back, as they require the stimulus of a running animal to proceed with an attack (131). If the targeted animal stands its ground, the wolves either ignore it, or try to intimidate it into running (126).
- **The rush:** If the prey attempts to flee, the wolves immediately pursue it. This is the most critical stage of the hunt, as wolves may never catch up with prey running at top speed (132). If their prey is travelling in a group, the wolves either attempt to break up the herd, or isolate one or two animals from it (129).
- **The chase:** A continuation of the rush, the wolves attempt to catch up with their prey and kill it (133). When chasing small prey, wolves attempt to catch up with their prey as soon as possible, while with larger animals, the chase is prolonged, in order to wear the selected prey out. Wolves usually give up chases after 1–2 km (0.62–1.3 mi), though one wolf was recorded to chase a deer for 21 km (13 mi) (126). Both Russian and North American wolves have been observed to drive prey onto crusted ice, precipices, ravines, slopes and steep banks to slow them down (134).

The actual killing method varies according to prey species. With large prey, mature wolves usually avoid attacking frontally, instead focusing on the rear and sides of the animal. Large prey, such as moose, is killed by biting large chunks of flesh from the soft perineum area, causing massive blood loss. Such bites can cause wounds 10–15 cm in length, with three such bites to the perineum usually being sufficient to bring down a large deer in optimum health (134). With medium-sized prey such as roe deer or sheep, wolves kill by biting the throat, severing nerve tracks and the carotid artery, thus causing the animal to die within a few seconds to a minute. With small, mouse-like prey, wolves leap in a high arc and immobilize it with their forepaws (135). When prey is vulnerable and abundant, wolves may occasionally surplus kill. Such instances are common in domestic animals, but rare in the wild. In the wild, surplus killing primarily occurs during late winter or spring, when snow is unusually deep (thus impeding the movements of prey) (136) or during the denning period, when wolves require a ready supply of meat when denbound (137). Medium-sized prey are especially vulnerable to surplus

killing, as the swift throat-biting method by which they are killed allows wolves to quickly kill one animal and move on to another (135).

Once prey is brought down, wolves begin to feed excitedly, ripping and tugging at the carcass in all directions, and bolting down large chunks of it (138). The breeding pair typically monopolizes food in order to continue producing pups. When food is scarce, this is done at the expense of other family members, especially non-pups (139). The breeding pair typically eats first, though as it is they who usually work the hardest in killing prey, they may rest after a long hunt and allow the rest of the family to eat unmolested. Once the breeding pair has finished eating, the rest of the family tears off pieces of the carcass and transport them to secluded areas where they can eat in peace. Wolves typically commence feeding by consuming the larger internal organs of their prey, such as the heart, liver, lungs and stomach lining. The kidneys and spleen are eaten once they are exposed, followed by the muscles (140). A single wolf can eat 15–19% of its body weight in a single feeding (141).

Communication

Visual

The gray wolf's expressive behavior is more complex than that of the coyote and golden jackal, as necessitated by its group living and hunting habits. While less gregarious canids generally possess simple repertoires of visual signals, wolves have more varied signals that subtly inter grade in intensity (10), (11). When neutral, the legs are not stiffened, the tail hangs down loosely, the face is smooth, the lips untensed, and the ears point in no particular direction (142). Postural communication in wolves consists of a variety of facial expressions, tail positions and piloerection (127). Aggressive, or self-assertive wolves are characterized by their slow and deliberate movements, high body posture and raised hackles, while submissive ones carry their bodies low, sleeken their fur and lower their ears and tail (143). When a breeding male encounters a subordinate family member, it may stare at it, standing erect and still with the tails horizontal to its spine (144). Two forms of submissive behavior are recognized: passive and active. Passive submission usually occurs as a reaction to the approach of a dominant animal, and consists of the submissive wolf lying partly on its back and allowing the dominant wolf to sniff its anogenital area. Active submission occurs often as a form of greeting, and involves the submissive wolf approaching another in a low posture, and licking the other wolf's face (145). When wolves are together, they commonly indulge in behaviors such as nose pushing, jaw wrestling, cheek rubbing and facial licking. The mouthing of each other's muzzles is a friendly gesture, while clamping on the muzzle with bared teeth is a dominance display (146).

Similar to humans, gray wolves have facial color patterns in which the gaze direction can be easily identified, although this is often not the case in other canid species. In 2014, a study compared the facial color pattern across 25 canid species. The results suggested that that the facial color pattern of canid species is related to their gaze communication, and that especially gray wolves use the gaze signal in conspecific communication (147).

Auditory

Gray wolves howl to assemble the pack (usually before and after hunts), to pass on an alarm (particularly at a den site), to locate each other during a storm or unfamiliar territory and to communicate across great distances (148). Wolf howls can under certain conditions be heard over areas of up to 130 km^2 (50 sq mi) (3). Wolf howls are generally indistinguishable from those of large dogs (149). Male wolves give voice through an octave, passing to a deep bass with a stress on "*O*", while females produce a modulated nasal baritone with stress on "*U*". Pups almost never howl, while yearling wolves produce howls ending in a series of dog-like yelps (9). Howling consists of a fundamental frequency that may lie between 150 and 780 Hz, and consists of up to 12 harmonically related overtones. The pitch usually remains constant or varies smoothly, and may change direction as many as four or five times (86). Howls used for calling pack mates to a kill are long, smooth sounds similar to the beginning of the cry of a horned owl. When pursuing prey, they emit a higher pitched howl, vibrating on two notes. When closing in on their prey, they emit a combination of a short bark and a howl (149). When howling together, wolves harmonize rather than chorus on the same note, thus creating the illusion of there being more wolves than there actually are (148). Lone wolves typically avoid howling in areas where other packs are present (150). Wolves from different geographic locations may howl in different fashions: the howls of European wolves are much more protracted and melodious than those of North American wolves, whose howls are louder and have a stronger emphasis on the first syllable. The two are however mutually intelligible, as North American wolves have been recorded to respond to European-style howls made by biologists (151).

Other vocalisations of wolves are usually divided into three categories: growls, barks and whines (152). Barking has a fundamental frequency between 320–904 Hz (86), and is usually emitted by startled wolves. Wolves do not bark as loudly or continuously as dogs do, but bark a few times and retreat from perceived danger (152). Growling has a fundamental frequency of 380–450 Hz (86), and is usually emitted during food challenges. Pups commonly growl when playing. One variation of the howl is accompanied by a high pitched whine, which precedes a lunging attack (148). Whining is associated with situations of anxiety, curiosity, inquiry and intimacy such as greeting, feeding pups and playing (152).

Olfactory

Olfaction is probably the wolf's most acute sense, and plays a fundamental role in communication. The wolf has a large number of apocrine sweat glands on the face, lips, back, and between the toes. The odor produced by these glands varies according to the individual wolf's microflora and diet, giving each a distinct "odor fingerprint". A combination of apocrine and eccrine sweat glands on the feet allows the wolf to deposit its scent whilst scratching the ground, which usually occurs after urine marking and defecation during the breeding season. The follicles present on the guard hairs from the wolf's back have clusters of apocrine and sebaceous glands at their bases. As the skin on the back is usually folded, this provides a microclimate for bacterial propagation around the glands. During piloerection, the guard hairs on the back are raised and the skin folds spread, thus releasing scent (153). The pre-caudal scent glands may play a role in expressing aggression, as combative wolves raise the base of their tails whilst drooping the tip, thus positioning the scent glands at the highest point (149). The wolf possesses a pair of anal sacs beneath the rectum, which contain both apocrine and sebaceous glands. The components of anal sac secretions vary according to season and gender, thus indicating that the secretions provide information related to gender and reproductive state. The secretions of the preputial glands may advertise hormonal condition or social position, as dominant wolves have been observed to stand over subordinates, apparently presenting the genital area for investigation (153), which may include genital licking (154). During the breeding season, female wolves secrete substances from the vagina, which communicate the females' reproductive state, and can be detected by males from long distances. Urine marking is the best-studied means of olfactory communication in wolves. Its exact function is debated, though most researchers agree that its primary purpose is to establish boundaries. Wolves urine mark more frequently and vigorously in unfamiliar areas, or areas of intrusion, where the scent of other wolves or canids is present. So-called raised leg urination (RLU) is more common in male wolves than in females, and may serve the purpose of maximizing the possibility of detection by conspecifics, as well as reflect the height of the marking wolf. Only dominant wolves typically use RLU, with subordinate males continuing to use the juvenile standing posture throughout adulthood (153). RLU is considered to be one of the most important forms of scent communication in the wolf, making up 60–80% of all scent marks observed (155).

Ecology

Habitat

The gray wolf is a habitat generalist, and can occur in deserts, grasslands, forests and arctic tundras. Habitat use by gray wolves is strongly correlated with the abundance of prey, snow conditions, absence or low livestock densities, road densities, human presence and topography (3). In cold climates, the gray wolf can reduce the flow of blood near its skin to conserve body heat. The warmth of the footpads is regulated independently of the rest of the body, and is maintained at just above tissue-freezing point where the pads come in contact with ice and snow (156). Gray wolves use different places for their diurnal rest: places with cover are preferred during cold, damp and windy weather, while wolves in dry, calm and warm weather readily rest in the open. During the autumn-spring period, when wolves are more active, they willingly lie out in the open, whatever their location. Actual dens are usually constructed for pups during the summer period. When building dens, females make use of natural shelters such as fissures in rocks, cliffs overhanging riverbanks and holes thickly covered by vegetation. Sometimes, the den is the appropriated burrow of smaller animals such as foxes, badgers or marmots. An appropriated den is often widened and partly remade. On rare occasions, female wolves dig burrows themselves, which are usually small and short with 1–3 openings. The den is usually constructed not more than 500 metres away from a water source (9), and typically faces southwards, thus ensuring enough sunlight exposure, keeping the denning area relatively snow free (3). Resting places, play areas for the pups and food remains are commonly found around wolf dens. The odour of urine and rotting food emanating from the denning area often attracts scavenging birds such as magpies and ravens. As there are few convenient places for burrows, wolf dens are usually occupied by animals of the same family. Though they mostly avoid areas within human sight, wolves have been known to nest near domiciles, paved roads and railways (9).

Diet
The gray wolf generally specializes in vulnerable individuals of large prey (3). In Eurasia, many gray wolf populations are forced to subsist largely on livestock and garbage in areas with dense human activity, though wild ungulates such as moose, red deer, roe deer and wild boar are still the most important food sources in Russia and the more mountainous regions of Eastern Europe. Other prey species include reindeer, argali, mouflon, wisent, saiga, ibex, chamois, wild goats, fallow deer and musk deer (157). The prey animals of North American wolves have largely continued to occupy suitable habitats with low human density, and cases of wolves subsisting largely on garbage or livestock are exceptional. Animals preferred as prey by North American wolves include moose, white-tailed deer, elk, mule deer, bighorn sheep, Dall's sheep, American bison, muskox and caribou (158).

Although wolves primarily feed on medium to large sized ungulates, they are not fussy eaters. Smaller sized animals that may supplement the diet of wolves include marmots, hares, badgers, foxes, weasels, ground squirrels, mice, hamsters, voles and other rodents, as well as insectivores. They frequently eat waterfowl and their eggs. When such foods are insufficient, they prey on lizards, snakes, frogs, rarely toads and large insects as available. In times of scarcity, wolves readily eat carrion, visiting cattle burial grounds and slaughter houses (9). Cannibalism is not uncommon in wolves: during harsh winters, packs often attack weak or injured wolves, and may eat the bodies of dead pack members (9), (159), (160). Wolf packs in Astrakhan hunt Caspian seals on the Caspian Sea coastline (161) and some wolf packs in Alaska and Western Canada have been observed to feed on salmon (162). Humans are rarely, but occasionally preyed upon (9), (163). Other primates occasionally taken by wolves include grey langurs in Nepal (164) and hamadryas baboons in Saudi Arabia (165).

Wolves supplement their diet with fruit and vegetable matter. They willingly eat the berries of mountain ash, lily of the valley, bilberries, blueberries and cowberry. Other fruits include nightshade, apples and pears. They readily visit melon fields during the summer months (9). A well-fed wolf stores fat under the skin, around the heart, intestines, kidneys, and bone marrow, particularly during the autumn and winter (141). Digestion only takes a few hours, thus wolves can feed several times in one day, making quick use of large quantities of meat (166).

Enemies and competitors
Gray wolves typically dominate other canid species in areas where they both occur. In North America, incidents of gray wolves killing coyotes are common, particularly in winter, when coyotes feed on wolf kills. Wolves may attack coyote den sites, digging out and killing their pups, though rarely eating them. There are no records of coyotes killing wolves, though coyotes may chase wolves if they outnumber them (167), (168). Near identical interactions have been observed in Eurasia and Africa between gray wolves and golden jackals, with the latter's numbers being comparatively small in areas with high wolf densities (9), (167), (169). Gray wolves are the most important predator of raccoon dogs, killing large numbers of them in the spring and summer periods (9). Wolves also kill red, arctic and corsac foxes, usually in disputes over carcasses, sometimes eating them (9), (170). In Asia, they may compete with dholes (9), though there is at least one record of a lone wolf associating with a pair of dholes in Debrigarh Wildlife Sanctuary (171).

Brown bears typically dominate wolf packs in disputes over carcasses, while wolf packs mostly prevail against bears when defending their den sites. Both species kill each other's young. Wolves eat the brown bears they kill, while brown bears seem to only eat young wolves (172). Wolf interactions with American black bears are much rarer than with brown bears, because of differences in habitat preferences. The majority of black bear encounters with wolves occur in the species' northern range, with no interactions being recorded in Mexico. Wolves have been recorded on numerous occasions to actively seek out black bears in their dens and kill them without eating them. Unlike brown bears, black bears frequently lose against wolves in disputes over kills (173). While encounters with brown and black bears appear to be common, polar bears are rarely encountered by wolves, though there are two records of wolf packs killing polar bear cubs (174). Wolves also kill the cubs of Asian black bears (9).

Wolves may encounter striped hyenas in Israel, Central Asia and India, usually in disputes over carcasses. Striped hyenas feed extensively on wolf-killed carcasses in areas where the two species interact. One-to-one, hyenas dominate wolves, but wolf packs can drive off single or outnumbered hyenas (175), (176). However, there was a case of a female striped hyena dominating 12 Arabian wolves (177).

Large wolf populations limit the numbers of small to medium-sized felines. Wolves encounter cougars along portions of the Rocky Mountains and adjacent mountain ranges. Wolves and cougars typically avoid encountering each other by hunting on different elevations. In winter, however, when snow accumulation forces their prey into valleys, interactions between the two species become more likely. Wolves in packs usually dominate cougars and can steal kills. They have been reported killing mothers and their kittens (178), (179). Wolves hunt steppe cats, and may scavenge from snow leopard kills (180), (181). Wolves may also reduce Eurasian lynx populations. Wolves may kill lynxes by running them down, or killing them before they can escape into trees (182). Similar reports of encounters between wolves and bobcats have been documented (183).

Leftovers of wolf kills are sometimes scavenged by wolverines. Wolverines usually wait until the wolves are done feeding, but have been known to drive away wolves from kills. However, there have been confirmed reports of wolf packs killing wolverines (184).

Other than humans, tigers appear to be the only serious predators of wolves (9), (17), (18), (19), (180). Wolf and tiger interactions are well documented in Sikhote-Alin, where tigers depress wolf numbers, either to the point of localized extinction or to such low numbers as to make them a functionally insignificant component of the ecosystem. Wolves appear capable of escaping competitive exclusion from tigers only when human persecution decreases tiger numbers. Proven cases of tigers killing wolves are rare and attacks appear to be competitive rather than predatory in nature, with at least four proven records of tigers killing wolves without consuming them (185).

Range and conservation

The gray wolf was once one of the world's most widely distributed mammals, living throughout the northern hemisphere north of 15°N latitude in North America and 12°N in India. However, deliberate human persecution has reduced the species' range to about one third, because of livestock predation and fear over attacks on humans. The species is now extinct in much of Western Europe, in Mexico and much of the United States. In modern times, the gray wolf occurs mostly in wilderness and remote areas, particularly in Canada, Alaska and northern USA, Europe, and Asia from about 75°N to 12°N. Wolf population declines have been arrested since the 1970s, and have fostered recolonization and reintroduction in parts of its former range, due to legal protection, changes in land-use and rural human population shifts to cities. Competition with humans for livestock and game species, concerns over the danger posed by wolves to people, and habitat fragmentation pose a continued threat to the species. Despite these threats, because of the gray wolf's relatively widespread range and stable population, it is classified as least concern by the IUCN (1).

Europe

Decline

The extermination of Northern Europe's wolves first became an organized effort during the Middle Ages, and continued until the late 1800s. In England, wolf persecution was enforced by legislation, and the last wolf was killed in the early sixteenth century during the reign of Henry VII. Wolves lasted longer in Scotland, where they sheltered in vast tracts of forest, which were subsequently burned down. Wolves managed to survive in the forests of Braemar and Sutherland until 1684. The extirpation of wolves in Ireland followed a similar course, with the last wolf believed to have been killed in 1786 (186). A wolf bounty was introduced in Sweden in 1647, after the extermination of moose and reindeer forced wolves to feed on livestock. The Sami extirpated wolves in northern Sweden in organized drives. By 1960, few wolves remained in Sweden, because of the use of snowmobiles in hunting them, with the last specimen being killed in 1966. The gray wolf was exterminated in Denmark in 1772 and Norway's last wolf was killed in 1973. The species was decimated in 20th century Finland, despite regular dispersals from Russia. The gray wolf was only present in the eastern and northern parts of Finland by 1900, though its numbers increased after World War II (187).

In Central Europe, wolves were dramatically reduced in number during the early nineteenth century, because of organized hunts and reductions in ungulate populations. In Bavaria, the last wolf was killed in 1847, and had disappeared from the Rhine regions by 1899 (187) and largely disappeared in Switzerland before the end of the nineteenth century. In 1934, Nazi Germany became the first state in modern history to place the wolf under protection, though the species was already extirpated in Germany at this point (188). The last free-living wolf to be killed on the soil of present-day Germany before 1945 was the so-called "Tiger of Sabrodt", which was shot near Hoyerswerda, Lusatia (then Lower Silesia) in 1904. Today, wolves have returned to the area (189). Wolf hunting in France was first institutionalized by Charlemagne between 800–813, when he established the *louveterie*, a special corps

of wolf hunters. The *louveterie* was abolished after the French Revolution in 1789, but was re-established in 1814. In 1883, up to 1,386 wolves were killed, with many more by poison (187).

In Eastern Europe, wolves were never fully exterminated, because of the area's contiguity with Asia and its large forested areas. However, Eastern European wolf populations were reduced to very low numbers by the late nineteenth century. Wolves were extirpated in Slovakia during the first decade of the twentieth century and, by the mid-twentieth century, could only be found in a few forested areas in eastern Poland. Wolves in the eastern Balkans benefitted from the region's contiguity with the former Soviet Union and large areas of plains, mountains and farmlands. Wolves in Hungary occurred in only half the country around the start of the 20th century, and were largely restricted to the Carpathian Basin. Wolf populations in Romania remained largely substantial, with an average of 2,800 wolves being killed annually out of a population of 4,600 from 1955–1965. An all-time low was reached in 1967, when the population was reduced to 1,550 animals. The extermination of wolves in Bulgaria was relatively recent, as a previous population of about 1,000 animals in 1955 was reduced to about 100–200 in 1964. In Greece, the species disappeared from the southern Peloponnese in 1930. Despite periods of intense hunting during the eighteenth century, wolves never disappeared in the western Balkans, from Albania to the former Yugoslavia. Organized persecution of wolves began in Yugoslavia in 1923, with the setting up of the Wolf Extermination Committee (WEC) in Kocevje, Slovenia. The WEC was successful in reducing wolf numbers in the Dinaric Alps (187).

In Southern Europe, wolf extermination was not as complete as in Northern Europe, because of greater cultural tolerance of the species. Wolf populations only began declining in the Iberian Peninsula in the early 19th-century, and was reduced by a half of its original size by 1900. Wolf bounties were regularly paid in Italy as late as 1950. Wolves were exterminated in the alps by 1800, and numbered only 100 by 1973, inhabiting only 3–5% of their former Italian range (187).

Recovery

The recovery of European wolf populations began after the 1950s, when traditional pastoral and rural economies declined and thus removed the need to heavily persecute wolves. By the 1980s, small and isolated wolf populations expanded in the wake of decreased human density in rural areas and the recovery of wild prey populations (190).

The gray wolf has been fully protected in Italy since 1976, and now holds a population of 450–500 animals, which has an annual increase of about 60%. Italian wolves entered France's Mercantour National Park in 1993, and at least fifty wolves were discovered in the western Alps in 2000. By 2013 the 250 wolves in the Western Alps imposed a significant burden on traditional sheep and goat husbandry with a loss of over 5,000 animals in 2012 (191). There are approximately 2,000 wolves inhabiting the Iberian Peninsula, of which 150 reside in northeastern Portugal. In Spain, the species occurs in Galicia, Leon, and Asturias. Although hundreds of Iberian wolves are illegally killed annually, the population has expanded south across the river Duero and east to the Asturias and Pyrenees Mountains (190).

In 1978, wolves began recolonising central Sweden after a twelve-year absence, and have since expanded into southern Norway. As of 2005, the total number of Swedish and Norwegian wolves is estimated to be at least one hundred, including eleven breeding pairs. The gray wolf is fully protected in Sweden and partially controlled in Norway. The Scandinavian wolf populations owe their continued existence to neighbouring Finland's contiguity with the Republic of Karelia, which houses a large population of wolves. Wolves in Finland are protected only in the southern third of the country, and can be hunted in other areas during specific seasons (190), though poaching remains common, with 90% of young wolf deaths being due to human predation, and the number of wolves killed exceeds the number of hunting licenses, in some areas by a factor of two. Furthermore, the decline in the moose populations has reduced the wolf's food supply (192), (193). Since 2011, Netherlands, Belgium and Denmark have also reported wolf sightings presumably by natural migration from adjacent countries (194), (195).

Wolf populations in Poland have increased to about 800–900 individuals since being classified as a game species in 1976. Poland plays a fundamental role in providing routes of expansion into neighbouring Central European countries. In the east, its range overlaps with populations in Lithuania, Belorussia, Ukraine, and Slovakia. A population in western Poland expanded into eastern Germany and in 2000 the first pups were born on German territory (196). In 2012, an estimated 14 wolf packs were living in Germany (mostly in the east) and a pack with pups has been sighted within 15 miles of Berlin

(197). The gray wolf is protected in Slovakia, though an exception is made for wolves killing livestock. A few Slovakian wolves disperse into the Czech Republic, where they are afforded full protection. Wolves in Slovakia, Ukraine and Croatia may disperse into Hungary, where the lack of cover hinders the buildup of an autonomous population. Although wolves have special status in Hungary, they may be hunted with a year-round permit if they cause problems (190). Romania has a large population of wolves, numbering 2,500 animals. The wolf has been a protected animal in Romania since 1996, although the law is not enforced. The number of wolves in Albania and Macedonia is largely unknown, despite the importance the two countries have in linking wolf populations from Greece to those of Bosnia and Herzegovina and Croatia. Although protected, sometimes wolves are still illegally killed in Greece, and their future is uncertain. Wolf numbers have declined in Bosnia and Herzegovina since 1986, while the species is fully protected in neighbouring Croatia and Slovenia (190).

Asia

Historical range and decline

During the 19th century, gray wolves were widespread in many parts of the Holy Land east and west of the Jordan River. However, they decreased considerably in number between 1964 and 1980, largely because of persecution by farmers (198). The species was not considered common in northern and central Saudi Arabia during the 19th century, with most early publications involving animals either from southwestern Asir, northern rocky areas bordering Jordan, or areas surrounding Riyadh (199).

The gray wolf's range in the Soviet Union encompassed nearly the entire territory of the country, being absent only on the Solovetsky Islands, Franz-Josef Land, Severnaya Zemlya, and the Karagin, Commander and Shantar Islands. The species was exterminated twice in Crimea, once after the Russian Civil War, and again after World War II (9). Following the two world wars, Soviet wolf populations peaked twice. 30,000 wolves were harvested annually out of a population of 200,000 during the 1940s, with 40,000–50,000 harvested during peak years. Soviet wolf populations reached a low around 1970, disappearing over much of European Russia. The population increased again by 1980 to about 75,000, with 32,000 being killed in 1979 (200). Wolf populations in northern inner Mongolia declined during the 1940s, primarily because of poaching of gazelles, the wolf's main prey (201). In British-ruled India, wolves were heavily persecuted because of their attacks on sheep, goats and children. In 1876, 2,825 wolves were bountied in the North-Western Provinces (NWP) and Bihar. By the 1920s, wolf extermination remained a priority in the NWP and Awadh. Overall, over 100,000 wolves were killed for bounties in British India between 1871 and 1916 (202).

Wolves in Japan became extinct during the Meiji restoration period, an extermination known as *ōkami no kujo*. The wolf was deemed a threat to ranching, which the Meiji government promoted at the time, and targeted via a bounty system and a direct chemical extermination campaign inspired by the similar contemporary American campaign. The last Japanese wolf was a male killed on January 23, 1905 near Washikaguchi (now called Higashi Yoshiro) (203). The now extinct Japanese wolves were descended from large Siberian wolves, which colonized the Korean Peninsula and Japan, before it separated from mainland Asia, 20,000 years ago during the Pleistocene. During the Holocene, the Tsugaru Strait widened and isolated Honshu from Hokkaidō, thus causing climatic changes leading to the extinction of most large bodied ungulates inhabiting the archipelago. Japanese wolves likely underwent a process of island dwarfism 7,000–13,000 years ago in response to these climatological and ecological pressures. *C. l. hattai* (formerly native to Hokkaidō) was significantly larger than its southern cousin *C. l. hodophilax*, as it inhabited higher elevations and had access to larger prey, as well as a continuing genetic interaction with dispersing wolves from Siberia (204).

Modern range

Although Turkish wolves have no legal protection, they may number about 7000 individuals (205). There is little reliable data on the status of wolves in the Middle East, save for those in Israel and Saudi Arabia, though their numbers appear to be stable, and are likely to remain so. Israel's conservation policies and effective law enforcement maintain a moderately sized wolf population, which radiates into neighbouring countries, while Saudi Arabia has vast tracts of desert, where about 300–600 wolves live undisturbed (206). The wolf survives throughout most of its historical range in Saudi Arabia, probably because of a lack of pastoralism and abundant human waste (199). Turkey may play an important role in maintaining wolves in the region, because of its contiguity with Central Asia. The mountains of Turkey have served as a refuge for the few wolves remaining in Syria. A small wolf population occurs in the Golan Heights, and is well protected by the military activities there. Wolves living in the southern Negev desert are contiguous with populations living in the Egyptian Sinai and

Jordan. Throughout the Middle East, the species is only protected in Israel. Elsewhere, it can be hunted year-round by Bedouins (206).

Little is known of current wolf populations in Iran, which once occurred throughout the country in low densities during the mid-1970s. The northern regions of Afghanistan and Pakistan are important strongholds for the wolf. It has been estimated that there are about 300 wolves in approximately 60,000 km² (23,000 sq mi) of Jammu and Kashmir in northern India, and 50 more in Himachal Pradesh. Overall, India supports about 800-3,000 wolves, scattered among several remnant populations. Although protected since 1972, Indian wolves are classed as endangered, with many populations lingering in low numbers or living in areas increasingly used by humans. Although present in Nepal and Bhutan, there is no information of wolves occurring there (200).

Wolf populations throughout Northern and Central Asia are largely unknown, but are estimated in the hundreds of thousands based on annual harvests. Since the fall of the Soviet Union, continent-wide extermination of wolves has ceased, and wolf populations have increased to about 25,000–30,000 animals throughout the former Soviet Union. In China and Mongolia, wolves are only protected in reserves. Mongolian populations have been estimated at 10,000–30,000, while the status of wolves in China is more fragmentary. The north has a declining population of an estimated 400 wolves, while Xinjiang and Tibet hold about 10,000 and 2,000 respectively (207).

North America

Before they were extirpated around 1930, Montana's wolves could be very large. Wolves recolonized the state from Canada beginning in the 1970s.

Historical range and decline

Originally, the gray wolf occupied all of North America north of about 20°N. It occurred all over the mainland, save for the southeastern United States, California west of the Sierra Nevada, and the tropical and subtropical areas of Mexico. Large continental islands occupied by wolves included Newfoundland, Vancouver Island, southeastern Alaskan islands, and throughout the Arctic Archipelago and Greenland (3).

The decline of North American wolf populations coincided with increasing human populations and the expansion of agriculture. By the start of the 20th century, the species had almost disappeared from the eastern USA, excepting some areas of the Appalachians and the northwestern Great Lakes Region. In Canada, the gray wolf was extirpated in New Brunswick and Nova Scotia between 1870 and 1921, and in Newfoundland around 1911. It vanished from the southern regions of Quebec and Ontario between 1850 and 1900. The gray wolf's decline in the prairies began with the extermination of the American bison and other ungulates in the 1860s–70s. From 1900–1930, the gray wolf was virtually eliminated from the western USA and adjoining parts of Canada, because of intensive predator control programs aimed at eradicating the species. The gray wolf was exterminated by federal and state governments from all of the USA by 1960, except in Alaska and northern Minnesota. The decline in North American wolf populations was reversed from the 1930s to the early 1950s, particularly in southwestern Canada, because of expanding ungulate populations resulting from improved regulation of big game hunting. This increase triggered a resumption of wolf control in western and northern Canada. Thousands of wolves were killed from the early 1950s to the early 1960s, mostly because of poisoning. This campaign was halted and wolf populations increased again by the mid-1970s (3).

Modern range

The species' modern range in North America is mostly confined to Alaska and Canada, with populations also occurring in northern Minnesota, northern Wisconsin and Michigan's Upper Peninsula, and portions of Washington, Idaho, northern Oregon, and Montana. A functional wolf population should exist in California by 2024 according to estimates by state wildlife officials (208). Canadian wolves began to naturally re-colonize northern Montana around Glacier National Park in 1979, and the first wolf den in the western U.S. in over half a century was documented there in 1986 (209). The wolf population in northwest Montana initially grew as a result of natural reproduction and dispersal to about 48 wolves by the end of 1994 (210). From 1995-1996, wolves from Alberta and British Columbia were relocated to Yellowstone National Park and Idaho. In addition, the Mexican wolf (*Canis lupus baileyi*) was reintroduced to Arizona and New Mexico in 1998. The gray wolf is found in approximately 80% of its historical range in Canada, thus making it an important stronghold for the species (3).

Canada is home to about 52,000–60,000 wolves, whose legal status varies according to province and territory. First Nations residents may hunt wolves without restriction, and some provinces require licenses for residents to hunt wolves while others do not. In Alberta, wolves on private land may be baited and hunted by the landowner without requiring a license, and in some areas, wolf hunting bounty programs exist (211), (212). Large-scale wolf population control through poisoning, trapping and aerial hunting is also presently conducted by government-mandated programs in order to support populations of endangered prey species such as woodland caribou (213).

In Alaska, the gray wolf population is estimated at 6,000–7,000, and can be legally harvested during hunting and trapping seasons, with bag limits and other restrictions. As of 2002, there are 250 wolves in 28 packs in Yellowstone, and 260 wolves in 25 packs in Idaho. The gray wolf received Endangered Species Act (ESA) protection in Minnesota, Wisconsin, and Michigan in 1974, and was re-classed from endangered to threatened in 2003. Reintroduced Mexican wolves in Arizona and New Mexico are protected under the ESA and, as of late 2002, number 28 individuals in eight packs (214). A female wolf shot in 2013 in Hart County, Kentucky by a hunter was the first gray wolf seen in Kentucky in modern times. DNA analysis by Fish and Wildlife laboratories showed genetic characteristics similar to those of wolves in the Great Lakes Region (215).

Diseases and parasites

Viral and bacterial infections

Viral diseases carried by wolves include rabies, canine distemper, canine parvovirus, infectious canine hepatitis, papillomatosis, and canine coronavirus (216). Wolves are a major host for rabies in Russia, Iran, Afghanistan, Iraq and India (217). In wolves, the incubation period is 8–21 days, and results in the host becoming agitated, deserting its pack, and travelling up to 80 km a day, thus increasing the risk of infecting other wolves. Infected wolves do not show any fear of humans, with most documented wolf attacks on people being attributed to rabid animals. Although canine distemper is lethal in dogs, it has not been recorded to kill wolves, except in Canada and Alaska. The canine parvovirus, which causes death by dehydration, electrolyte imbalance, and endotoxic shock or sepsis, is largely survivable in wolves, but can be lethal to pups. Wolves may catch infectious canine hepatitis from dogs, though there are no records of wolves dying from it. Papillomatosis has been recorded only once in wolves, and likely doesn't cause serious illness or death, though it may alter feeding behaviors. The canine coronavirus has been recorded in Alaskan wolves, with infections being most prevalent in winter months (216).

Bacterial diseases carried by wolves include brucellosis, lyme disease, leptospirosis, tularemia, bovine tuberculosis (218), listeriosis, anthrax and foot and mouth disease (217). Wolves can catch *Brucella suis* from wild and domestic reindeer. While adult wolves tend not to show any clinical signs, it can severely weaken the pups of infected females. Although lyme disease can debilitate individual wolves, it does not appear to have any significant effect on wolf populations. Leptospirosis can be contracted through contact with infected prey or urine, and can cause fever, anorexia, vomiting, anemia, hematuria, icterus, and death. Wolves living near farms are more vulnerable to the disease than those living in the wilderness, probably because of prolonged contact with infected domestic animal waste. Wolves may catch tularemia from lagomorph prey, though its effect on wolves is unknown. Although bovine tuberculosis is not considered a major threat to wolves, it has been recorded to have once killed two wolf pups in Canada (218).

Parasitic infections

Wolves carry ectoparasites and endoparasites, with wolves in the former Soviet Union having been recorded to carry at least 50 species (217). Most of these parasites infect wolves without adverse effects, though the effects may become more serious in sick or malnourished specimens (219). Parasitic infection in wolves is of particular concern to people, as wolves can spread them to dogs, which in turn can carry the parasites to humans. In areas where wolves inhabit pastoral areas, the parasites can be spread to livestock (217).

Wolves are often infested with a variety of arthropod exoparasites, including fleas, ticks, lice, and mites. The most harmful to wolves, particularly pups, is *Sarcoptes scabiei* (or mange mite) (219), though they rarely develop full blown mange, unlike foxes (9). Lice, such as *Trichodectes canis*, may cause sickness in wolves, but rarely death. Ticks of the genus *Ixodes* can infect wolves with Lyme disease and Rocky Mountain spotted fever (219). The tick *Dermacentor pictus* also infests wolves.

Other ectoparasites include biting lice, sucking lice and the fleas *Pulex irritans* and *Ctenocephalides canis* (9).

Endoparasites known to infect wolves include protozoans and helminths (flukes, tapeworms, roundworms and thorny-headed worms). Of 30,000 protozoan species, only a few have been recorded to infect wolves: *Isospora*, *Toxoplasma*, *Sarcocystis*, *Babesia*, and *Giardia* (219). Wolves may carry *Neospora caninum*, which is of particular concern to farmers, as the disease can be spread to livestock, with infected animals being 3–13 times more likely to miscarry than those not infected (220), (221). Among flukes, the most common in North American wolves is *Alaria*, which infects small rodents and amphibians, which are eaten by wolves. Upon reaching maturity, *Alaria* migrates to the wolf's intestine, but harms it little. *Metorchis conjunctus*, which enters wolves through eating fish, infects the wolf's liver or gall bladder, causing liver disease, inflammation of the pancreas, and emaciation. Most other fluke species reside in the wolf's intestine, though *Paragonimus westermani* lives in the lungs. Tapeworms are commonly found in wolves, as their primary hosts are ungulates, small mammals, and fish, which wolves feed upon. Tapeworms generally cause little harm in wolves, though this depends on the number and size of the parasites, and the sensitivity of the host. Symptoms often include constipation, toxic and allergic reactions, irritation of the intestinal mucosa, and malnutrition. Infections by the tapeworm *Echinococcus granulosus* in ungulate populations tend to increase in areas with high wolf densities, as wolves can shed *Echinoccocus* eggs in their feces onto grazing areas. Wolves can carry over 30 roundworm species, though most roundworm infections appear benign, depending on the number of worms and the age of the host. *Ancylostoma caninum* attaches itself on the intestinal wall to feed on the host's blood, and can cause hyperchromic anemia, emaciation, diarrhea, and possibly death. *Toxocara canis*, a hookworm known to infect wolf pups in utero, can cause intestinal irritation, bloating, vomiting, and diarrhea. Wolves may catch *Dioctophyma renale* from minks, which infects the kidneys, and can grow to lengths of 100 cm. *D. renale* causes the complete destruction of the kidney's functional tissue, and can be fatal if both kidneys are infected. Wolves can tolerate low levels of *Dirofilaria immitis* for many years without showing any ill effects, though high levels can kill wolves through cardiac enlargement and congestive hepatopathy. Wolves probably become infected with *Trichinella spiralis* by eating infected ungulates. Although *T. spiralis* isn't known to produce clinical signs in wolves, it can cause emaciation, salivation, and crippling muscle pains in dogs (219). Thorny-headed worms rarely infect wolves, though three species have been identified in Russian wolves: *Nicolla skrjabini*, *Macrocantorhynchus catulinus*, and *Moniliformis moniliformis* (219).

Relationships with humans in culture

In mythology and folklore

See also: Asena, Big Bad Wolf, Capitoline Wolf, Fenris, Skinwalker, Warg, Werewolf and Wolf of Gubbio.

In Norse and Japanese mythology, wolves were portrayed as near deities: in Japan, grain farmers worshiped wolves at shrines and left food offerings near their dens, beseeching them to protect their crops from wild boars and deer (222), while the wolf Fenrir of Norse mythology was depicted as the son of Loki. Other cultures portrayed wolves as part of their foundation myths: in the mythology of the Turks (223), Mongols and Ainu, wolves were believed to be the ancestors of their people (224), while the Dena'ina believed wolves were once men, and viewed them as brothers (225). Wolves were linked to the sun in some Eurasian cultures: the Ancient Greeks and Romans associated wolves with the sun god Apollo (225), while the wolf Sköll in Norse mythology was depicted pursuing the setting sun (226). In Roman mythology, the Capitoline Wolf nurses Romulus and Remus, the future founders of Rome. According to the Pawnee creation myth, the wolf was the first animal to experience death (227). Wolves were sometimes associated with witchcraft in both northern European and some Native American cultures: in Norse folklore, the völva (witch) Hyndla and the giantess Hyrrokin are both portrayed as using wolves as mounts, while in Navajo culture, wolves were feared as witches in wolf's clothing (228). Similarly, the Tsilhqot'in believed that contact with wolves could cause mental illness and death (225).

In fable and literature

One of the earliest written references to gray wolves occurs in the Babylonian epic *Gilgamesh*, in which the titular character rejects the sexual advances of the goddess Ishtar, reminding her that she had transformed a previous lover, a shepherd, into a wolf, thus turning him into the very animal that his flocks must be protected against (229). According to the Avesta, the sacred text of the Zoroastrians, wolves are a creation of the evil spirit Ahriman, and are ranked among the most cruel of animals (230). Aesop featured wolves in several of his fables, playing on the concerns of Ancient Greece's settled, sheep-herding world. His most famous is the fable of The Boy Who Cried Wolf, which is directed at those who knowingly raise false alarms, and from which the idiomatic phrase "to cry wolf" is derived.

Some of his other fables concentrate on maintaining the trust between shepherds and guard dogs in their vigilance against wolves, as well as anxieties over the close relationship between wolves and dogs. Although Aesop used wolves to warn, criticize and moralize about human behavior, his portrayals added to the wolf's image as a deceitful and dangerous animal (231). This is mirrored in the Bible, where wolves are referenced thirteen times as symbols of greed and destructiveness (232). Much of the symbolism Jesus used in the New Testament revolved around the pastoral culture of Israel, and explained his relationship with his followers as analogous to that of a good shepherd protecting his flock from wolves. An innovation in the popular image of wolves started by Jesus includes the concept of the wolf in sheep's clothing, which warns people against false prophets (233). Several authors have proposed that Jesus's portrayal of wolves, comparing them to dangerous and treacherous people, was an important development in perceptions on the species, which legitimized centuries of subsequent wolf persecution in the western world (233), (234), (235). Subsequent medieval Christian literature followed and expanded upon Biblical teachings on the wolf. It appeared in the seventh century edition of the *Physiologus*, which infused pagan tales with the spirit of Christian moral and mystical teaching. The *Physiologus* portrays wolves as being able to strike men dumb on sight, and of having only one cervical vertebra. Dante included a she-wolf, representing greed and fraud, in the first canto of the *Inferno*. The *Malleus Maleficarum*, first published in 1487, states that wolves are either agents of God sent to punish the wicked, or agents of Satan, sent with God's blessing to test the faith of believers (236). Isengrim the wolf, a character first appearing in the 12th-century Latin poem *Ysengrimus*, is a major character in the Reynard Cycle, where he stands for the low nobility, whilst his adversary, Reynard the fox, represents the peasant hero. Although portrayed as loyal, honest and moral, Isengrim is forever the victim of Reynard's wit and cruelty, often dying at the end of each story (237). The tale of Little Red Riding Hood, first written in 1697 by Charles Perrault, is largely considered to have had more influence than any other source of literature in forging the wolf's negative reputation in the western world. The wolf in this story is portrayed as a potential rapist, capable of imitating human speech (238). The hunting of wolves, and their attacks on humans and livestock feature prominently in Russian literature, and are included in the works of Tolstoy, Chekhov, Nekrasov, Bunin, Sabaneyev, and others. Tolstoy's *War and Peace* and Chekhov's *Peasants* both feature scenes in which wolves are hunted with hounds and borzois (239). Farley Mowat's largely fictional 1963 memoir *Never Cry Wolf* was the first positive portrayal of wolves in popular literature, and is largely considered to be the most popular book on wolves, having been adapted into a Hollywood film and taught in several schools decades after its publication. Although credited with having changed popular perceptions on wolves by portraying them as loving, cooperative and noble, it has been criticized for its idealization of wolves and its factual inaccuracies (240), (241), (242).

In heraldry and symbolism

The wolf is a frequent charge in English armory. It is illustrated as a supporter on the shields of Lord Welby, Rendel, and Viscount Wolseley, and can be found on the coat of arms of Lovett and the vast majority of the Wilsons and Lows. The demi-wolf is a common crest, appearing in the arms and crests of members of many families, including that of the Wolfes, whose crest depicts a demi-wolf holding a crown in its paws, in reference to the assistance the family gave to Charles II during the battle of Worcester. Wolf heads are common in Scottish heraldry, particularly in the coats of Clan Robertson and Skene. The wolf is the most common animal in Spanish heraldry, and is often depicted as carrying a lamb in its mouth, or across its back (243). The wolf is featured on the flags of the Confederated Tribes of the Colville Reservation, the Oneida Nation of Wisconsin and the Pawnee (244). In modern times, the wolf is widely used as an emblem for military and paramilitary groups. It is the unofficial symbol of the spetsnaz, and serves as the logo of the Turkish Grey Wolves. During the Yugoslav Wars, several Serb paramilitary units adopted the wolf as their symbol, including the White Wolves and the Wolves of Vučjak (245). A "wolf face" symbol was added to version 6.0 of the unicode character set (🐺, U+1F43A) (246), but only a few fonts (such as Segoe) support it (247).

Livestock and dog predation

Livestock depredation has been one of the primary reasons for hunting wolves, and can pose a severe problem for wolf conservation: as well as causing economic losses, the threat of wolf predation causes great stress on livestock producers, and no foolproof solution of preventing such attacks short of exterminating wolves has been found (248). Some nations help offset economic losses to wolves through compensation programmes or state insurance (249). Domesticated animals are easy prey for wolves, as they have evolved under constant human protection, and are thus unable to defend themselves very well (250). Wolves typically resort to attacking livestock when wild prey is depleted: in Eurasia, a large part of the diet of some wolf populations consists of livestock, while such incidences are rare in North America, where healthy populations of wild prey have been largely restored (248).

The majority of losses occur during the summer grazing period, with untended livestock in remote pastures being the most vulnerable to wolf predation (251). The most frequently targeted livestock species are sheep (Europe), domestic reindeer (northern Scandinavia), goats (India), horses (Mongolia), cattle and turkeys (North America) (248). The number of animals killed in single attacks varies according to species: most attacks on cattle and horses result in one death, while turkeys, sheep and domestic reindeer may be killed in surplus (252). Wolves mainly attack livestock when the animals are grazing, though they occasionally break into fenced enclosures (134). In some cases, wolves do not need to physically attack livestock to negatively affect it: the stress livestock experiences in being vigilant for wolves may result in miscarriages, weight loss and a decrease in meat quality (220).

Wolves kill dogs on occasion, with some wolf populations relying on dogs as an important food source (248). In Croatia, wolves kill more dogs than sheep, and wolves in Russia appear to limit stray dog populations. Wolves may display unusually bold behavior when attacking dogs accompanied by people, sometimes ignoring nearby humans (248). Wolf attacks on dogs may occur both in house yards and in forests (253). Wolf attacks on hunting dogs are considered a major problem in Scandinavia and Wisconsin (248), (253). The most frequently killed hunting breeds in Scandinavia are harriers, with older animals being most at risk, likely because they are less timid than younger animals, and react to the presence of wolves differently. Large hunting dogs such as Swedish elkhounds are more likely to survive wolf attacks because of their better ability to defend themselves (253).

Attacks on humans

The fear of wolves has been pervasive in many societies, though humans are not part of the wolf's natural prey (22). How wolves react to humans depends largely on their prior experience with people: wolves lacking any negative experience of humans, or which are food conditioned, may show little fear of people (254). Although wolves may react aggressively under provocation, such attacks are mostly limited to quick bites on extremities, and the attacks are not pressed. Predatory attacks (attacks by wolves treating humans as food) may be preceded by a long period of habituation, in which wolves gradually lose their fear of humans. The victims are repeatedly bitten on the head and face, and are then dragged off and consumed, unless the wolves are driven off. Such attacks typically occur only locally, and do not stop until the wolves involved are eliminated. Predatory attacks can occur at any time of the year, with a peak in the June–August period, when the chances of people entering forested areas (for livestock grazing or berry and mushroom picking) increase (22), though cases of non-rabid wolf attacks in winter have been recorded in Belarus, the Kirovsk and Irkutsk districts, Karelia and Ukraine (9). Also, wolves with pups experience greater food stresses during this period. The majority of victims of predatory wolf attacks are children under the age of 18 and, in the rare cases where adults are killed, the victims are almost always women. Cases of rabid wolves are low when compared to other species, as wolves do not serve as primary reservoirs of the disease, but can be infected by animals such as dogs, jackals and foxes. Incidents of rabies in wolves are very rare in North America, though numerous in the eastern Mediterranean, Middle East and Central Asia. Wolves apparently develop the "furious" phase of rabies to a very high degree which, coupled with their size and strength, makes rabid wolves perhaps the most dangerous of rabid animals (22), with bites from rabid wolves being 15 times more dangerous than those of rabid dogs (9). Rabid wolves usually act alone, travelling large distances and often biting large numbers of people and domestic animals. Most rabid wolf attacks occur in the spring and autumn periods. Unlike with predatory attacks, the victims of rabid wolves are not eaten, and the attacks generally only occur on a single day. Also, the victims are chosen at random, though the majority of cases involve adult men. In the half-century up to 2002, there were eight fatal attacks in Europe and Russia, and more than 200 in south Asia (22). Between 2005-2010, two people were killed in North America (255), (256).

Hunting

Wolves are notoriously difficult to hunt because of their elusiveness, their sharp senses, their high endurance in the chase and ability to quickly incapacitate and kill hunting dogs (257). Historically, many methods have been devised to hunt wolves, including the killing of spring-born litters in their dens, coursing with dogs (usually combinations of sighthounds, bloodhounds and fox terriers), poisoning with strychnine, and foothold and deadfall traps (258), (259), (260). A popular method of wolf hunting in Russia involves trapping a pack within a small area by encircling it with fladry poles carrying a human scent. This method relies heavily on the wolf's fear of human scents, though it can lose its effectiveness when wolves become accustomed to the smell (260). Some hunters are able to lure wolves by imitating their calls (260). In Kazakhstan and Mongolia, wolves are traditionally hunted with eagles and falcons, though this practise is declining, as experienced falconers are becoming few in number (260). Shooting wolves from aircraft is highly effective, as it allows greater visibility of wolves

than hunting on the ground (260), though this method is controversial, as it allows wolves little chance to escape or defend themselves (261).

Uses

While not in the same class as high grade furbearers like beaver, otter or mink, the gray wolf's fur is nonetheless thick and durable (262), and is primarily used for scarfs and the trimmings of women's garments, though it is occasionally used for jackets, short capes, coats (263), mukluks and rugs (86). Aside from bodily protection and adornment, gray wolf pelts have also been used as camouflage in hunting and warfare, as an insignia among western Native Americans and as a form of currency (262). The quality of wolf peltries rests on the density and strength of the fur fibre, which keeps the fur upright and gives the pelt an appealing bushy aspect. These characteristics are mostly found in northern wolf populations, but gradually lessen further south in warmer climates. North American wolf pelts are among the most valuable, as they are silkier and fluffier than Eurasian peltries (263). In Medieval Europe, pelts were considered the only practical aspect of wolves, though they were seldom used, because of the skin's foul odour (264). In Scandinavian folklore, wolf-skin girdles assisted in transforming the wearers into werewolves (265), while several Native American tribes used wolf pelts for medicinal purposes (259). Plains Indians often wore wolf pelts as disguises to get close to American bison when hunting (266). The Pawnee wore wolf skins as capes when exploring enemy territories (267). The United States Army used wolf skin for parkas during the later stages of World War II and the Korean War to protect the faces of soldiers from frostbite (263). In the Soviet Union, 30,000 wolf pelts were produced annually between 1976 and 1988. Statistics from CITES indicate that 6,000–7,000 wolf skins are internationally traded each year, with Canada, the former Soviet Union, Mongolia and China being the largest exporters, and the United States and Great Britain being the largest importers. Overall, the harvesting of wolves for their fur has little impact on their population, as only the northern varieties (whose numbers are stable) are of commercial value (268). Wolf trapping for fur remains a lucrative source of income for many Native Americans (86).

It is rare for wolves to be hunted for food, though historically, people have resorted to consuming wolf flesh in times of scarcity, or for medicinal reasons. Wolf meat was eaten several times during Vilhjalmur Stefansson's 1913 Arctic expedition, particularly during the summer, when wolves were fat (269). Natives in Transbaikalia reportedly ate wolf meat even when food was plentiful (270). Most Native American tribes, particularly the Naskapis, viewed wolf flesh as edible but inadequate nutrition, as it was not a herbivore and thus did not possess the same healing qualities thought to be distinct in plant eaters (267). The consumption of wolf flesh and organs plays an important role in Asian folk medicine: in Mongolia, eating the meat and lungs of a wolf is said to alleviate colds, and sprinkling food with powdered wolf rectum is said to cure haemorroids (271). Some Japanese mountain people ate wolf meat to give them courage (272). During the filming of *The Grey*, the cast members famously ate wolf meat (273). Accounts on how wolf meat tastes vary greatly, with descriptions ranging from "tough" (272), "gristly" (274), "distasteful" and "smelly" (270), to "somewhat [resembling] chicken" (275), and "very superior to lean venison" (276).

As pets and working animals

American biologist, Stanley P. Young, described tame wolves as thus: Generally speaking, on the basis of their experience, tame wolves are strictly "one-man dogs". They may be confiding and playful with the man who raised them, or even with his whole family, if fed and cared for by them, but they are suspicious and timid in the presence of strangers. They invariably retain certain reactions of wolf nature, as for instance, an incorrigible desire to kill chickens or other small livestock whenever opportunity arises (277).

Several hunters of the USFWS kept wolf pups as pets, with the best results occurring when they were caught just after their eyes began opening. In contrast, pups taken at 3–4 weeks of age proved unmanageable, with only one in 11 of such pups becoming tame, despite one month of eight hours per day of socialization with people (277). Though wolves are trainable, they lack the same degree of tractability seen in dogs. Most attempts to train wolves as working dogs have met with failure. Swedish biologist Erik Zimen attempted to train his captive wolves as sled dogs, and although his wolves eventually accepted the harness and the need to pull the sled in a straight line, they were ultimately unreliable, as they fought for personal space, would ignore commands once tired, and were distracted by other wildlife (278). However, John James Audubon recorded an instance of a wolf being trained to hunt deer in Kentucky (279), and Henry Wharton Shoemaker published a similar account of settlers in western and central Pennsylvania using wolves as hunting dogs (280). Buffon wrote in his *Natural History* of tamed wolves in Persia being trained to perform dances and tricks (281).

GRAY WOLF
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This concludes the Wikipedia file, https://en.wikipedia.org/wiki/Gray_wolf.

APPENDIX 9: RED FOX

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March 2016

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OUR SUMMARY

This appendix identifies aspects of the Red Fox (*Vulpes vulpes*), which we feel are important to the discussion of the complex prehistoric and historic landscape interplay between humans and this four-legged tactical predator in Delaware and the Mid-Atlantic region. Linnaeus first described the Red Fox in 1758, as follows:

Kingdom: Animalia
Phylum: Chordata
Class: Mamalia
Order: Carnivora
Family: Canidae
Genus: *Vulpes*
Species: *V. vulpes*

Historically, forty-four subspecies of Red Fox are identified involving most of both hemispheres. Larivière and Pasitschniak-Arts (1996) summarize the list (see below) although they feel the validity of many of these subspecies designations remain doubtful. The subspecies we are interested in for Delaware and the Mid-Atlantic region is ***V. v. fulva***, as seen below in bold type:

V. v. abietorum (Stuart Lake, British Columbia, Canada)
V. v. alpherakyi (Geok Tepe, Araisk, Kazakhstan)
V. v. anatolica (Smyrna, western Asia Minor, Turkey)
V. v. arabica (Muscat, Oman)
V. v. atlantica (Atlas Mountains, Mitiya, Algeria)
V. v. bangsi (L'Anse au Loup, Strait of Belle Isle, Labrador, Canada)
V. v. barbara (Barbary Coast, north-western Africa)
V. v. beringiana (shore of Bering Strait, north-eastern Siberia)
V. v. cascadensis (Cascade Mountains, Skamania County, Washington, USA)
V. v. caucasica (near Vladikawkaz, Caucasus, Russia)
V. v. crucigera (Thuringia, Germany)
V. v. daurica (Kharangoi, 45km west of Troizkosavsk, Siberia)
V. v. deletrix (Bay St-George, Newfoundland, Canada)
V. v. dolichocrania (Sidemi, southern Ussuri, SE Siberia)
V. v. flavescens (northern Iran)
V. v. aegyptiaca (Egypt)
V. v. alascensis (Andreafski, Alaska, USA)
***V. v. fulva* (Virginia, USA)**
V. v. griffithii (Kandahar, Afghanistan)
V. v. harrimani (Kodiak Island, Alaska, USA)
V. v. hole (near Amoy, Fukien, S. China)
V. v. ichnusae (Sarrabus, Sardinia, Italy)
V. v. induta (Cape Pyla, Cyprus)
V. v. jakutensis (Taiga, south of Yakutsk, E. Siberia)
V. v. japonica (Japan)
V. v. karagan (Kirghiz Steppes, Khirghizia, Russia)
V. v. kenaiensis (Kenai Peninsula, Alaska, USA)
V. v. kurdistanica (Gelsk Valley, NE Turkey)
V. v. macroura (Wasatch Mountains, near Great Salt Lake, Utah, USA)
V. v. montana (Himalaya)
V. v. necator (Whitney Meadow, near Mt Whitney, Tulare County, California, USA)
V. v. ochroxantha (Aksai, Semirechyia, E Russian Turkestan, Kirgizia)
V. v. palaestina (Ramleh, near Jaffa, Occupied Palestinian Territory)
V. v. peculiosa (Korea)
V. v. pusilla (Salt Range, Punjab, Pakistan)

V. v. regalis (Elk River, Sherburne County, Minnesota, USA)
V. v. rubricosa (Digby, Nova Scotia, Canada)
V. v. schrencki (Sakhalin, Russia)
V. v. silacea (near Silos, Burgos, Spain)
V. v. splendidissima (north and central Kurile Islands, Russia)
V. v. strepensis (steppes near Kherson, Russia)
V. v. tobolica (Obdorsk, Tobolsk, Siberia)
V. v. tschiliensis (Peiping, Chihli, NE China)
V. v. vulpes (Sweden)

Genetic studies indicate the Red Fox in North America may have been isolated here for hundreds of thousands of years, certainly offering enough time for unique characteristics to develop. North American Red Fox are fairly gracile, rather long for their physical mass, and with a high sexual dimorphism. British foxes are heavier but relatively short. European foxes are closer to the general average among populations. Additionally, body mass and length are positively related to latitude (i.e., follow Bergmann's Rule), but this is a smaller effect than that related to geographical origin. The Red Fox dental formula is: 3/3-1/1-3/4-3/3=42 (Sillero-Zubiri, 2004:129-136).

See also:
Sillero-Zubiri, Claudio., Michael Hoffmann, and David W. Macdonald, Eds.
2004. **Canids: Foxes, Wolves, Jackals and Dogs.** IUCN--The World Conservation Union, 2004, ISNB 2831707862, 9782831707860. Internet Retrieval, January 28, 2016 at: https://scholar.google.com/scholar?q=Canids:+Foxes,+Wolves,+Jackals+and+Dogs&hl=en&as_sdt=0&as_vis=1&oi=scholart&sa=X&ved=0ahUKEwjD6ZD--tHKAhWHZCYKHfAJDm4QgQMIGzAA.

Finding evidence of Red Fox in archaeological contexts would have direct bearing on the landscape relationships between humans and these four-legged tactical predators in Delaware and the Mid-Atlantic region. In constructing this Appendix, we reviewed several dozen documents, (essays, books, contracted reports, professional papers, Internet sites, etc.). For the purpose of our essay, the Red Fox Wikipedia file establishes a reasonable and sufficient background. We decided to include a portion of the Red Fox Wikipedia file with complete references cited. We closely reviewed, edited, and re-formatted the contents of the open-source Wikipedia file to make a good fit with our research topic.

The following document is a portion of the Red Fox Internet Wikipedia file together with the Wikipedia file references cited. We closely reviewed, edited, and re-formatted the contents of the open-source Wikipedia file to make a good fit with our research topic. The full Wikipedia document can be found and downloaded at https://en.wikipedia.org/wiki/Red_fox.

Introduction

The **red fox**, *(Vulpes vulpes)*, is the largest of the true foxes and the most abundant wild member of the Carnivora, being present across the entire Northern Hemisphere from the Arctic Circle to North Africa, North America and Eurasia. It is listed as least concern by the IUCN (1). Its range has increased alongside human expansion, having been introduced to Australia, where it is considered harmful to native mammals and bird populations. Due to its presence in Australia, it is included among the list of the "world's 100 worst invasive species" (3).

The red fox originated from smaller-sized ancestors from Eurasia during the Middle Villafranchian period (4), and colonised North America shortly after the Wisconsin glaciation (5). Among the true foxes, the red fox represents a more progressive form in the direction of carnivory (6). Apart from its large size, the red fox is distinguished from other fox species by its ability to adapt quickly to new environments. Despite its name, the species often produces individuals with other colourings, including albinos and melanists (7). Forty-five subspecies are currently recognized (8), which are divided into two categories: the large northern foxes, and the small, basal southern foxes of Asia and the Middle East (9).

Red foxes are usually together in pairs or small groups consisting of families, such as a mated pair and their young, or a male with several females having kinship ties. The young of the mated pair remain with their parents to assist in caring for new kits (10). The species primarily feeds on small rodents, though it may also target rabbits, game birds, reptiles, invertebrates (11) and young ungulates (12). Fruit and vegetable matter is also eaten sometimes (13). Although the red fox tends to kill smaller predators, including other fox species, it is vulnerable to attack from larger predators, such as wolves, coyotes, golden jackals and medium- and large-sized felines (14).

The species has a long history of association with humans, having been extensively hunted as a pest and furbearer for many centuries, as well as being represented in human folklore and mythology. Because of its widespread distribution and large population, the red fox is one of the most important furbearing animals harvested for the fur trade (15). Too small to pose a threat to humans, it has successfully colonised many suburban areas. It is the only fox native to Western Europe, and so is simply called "the fox" in colloquial British English.

Terminology

The word "fox" comes from Old English, which derived from Proto-Germanic **fuhsaz*. This, in turn, derives from Proto-Indo-European **puḱ-* 'thick-haired; tail'. Females are called vixens, and young cubs, pups, or kits (16).

Evolution

The red fox is considered a more specialised form of *Vulpes* than the Afghan, corsac and Bengal foxes in the direction of size and adaptation to carnivory; the skull displays much fewer neotenous traits than in other species, and its facial area is more developed (6). It is, however, not as adapted for a purely carnivorous diet as the Tibetan fox (17).

Origins

The species is Eurasian in origin, and may have evolved from either *Vulpes alopecoides* or the related Chinese *V. chikushanensis*, both of which lived during the Middle Villafranchian (4). The earliest fossil specimens of *V. vulpes* were uncovered in Barany, Hungary dating from 3.4 to 1.8 million years ago (19). The ancestral species was likely smaller than the current one, as the earliest red fox fossils are smaller than modern populations (4). The earliest fossil remains of the modern species date back to the mid-Pleistocene in association with the refuse of early human settlements. This has led to the theory that the red fox was hunted by primitive humans as both a source of food and pelts (20).

Colonisation of North America

Red foxes colonised the North American continent in two waves: during or before the Illinoian glaciation, and during the Wisconsinan glaciation (21). Gene mapping demonstrates that red foxes in

North America have been isolated from their Old World counterparts for over 400,000 years, thus raising the possibility that speciation has occurred, and that the previous binomial name of *Vulpes fulva* may be valid (22). In the far north, red fox fossils have been found in Sangamonian deposits in the Fairbanks District and Medicine Hat. Fossils dating from the Wisconsian are present in 25 sites in Arkansas, California, Colorado, Idaho, Missouri, New Mexico, Tennessee, Texas, Virginia, and Wyoming. Although they ranged far south during the Wisconsinan, the onset of warm conditions shrank their range toward the north, and have only recently reclaimed their former American ranges because of human-induced environmental changes (5). Genetic testing indicates two distinct red fox refugia exist in North America, which have been separated since the Wisconsinan. The northern (or boreal) refugium occurs in Alaska and western Canada, and consists of the large subspecies *V. v. alascensis*, *V. v. abietorum*, *V. v. regalis*, and *V. v. rubricosa*. The southern (or montane) refugium occurs in the subalpine parklands and alpine meadows of the Rocky Mountains, the Cascade Range, and Sierra Nevada. It encompasses the subspecies *V. v. macroura*, *V. v. cascadensis*, and *V. v. necator*. The latter clade has been separated from all other red fox populations since the last glacial maximum, and may possess unique ecological or physiological adaptations (21).

Although European foxes were introduced to portions of the United States in the 18th century, recent genetic investigation indicates an absence of European fox haplotypes in any North American populations (23). Also, introduced eastern red foxes have colonized southern California, the San Joaquin Valley, and San Francisco Bay Area, but appear to have mixed with the Sacramento Valley red fox *V. v. patwin* only in a narrow hybrid zone (24). In addition, no evidence is seen of interbreeding of eastern red foxes in California with the montane Sierra Nevada red fox *V. v. necator* or other populations in the Intermountain West (between the Rocky Mountains to the east and the Cascade and Sierra Nevada ranges to the west (25).

Subspecies

As of 2005 (8), 45 subspecies are recognised. In 2010, another distinct subspecies, which inhabits the grasslands of the Sacramento Valley, *V. v. patwin*, was identified through mitochondrial haplotype studies (26). Substantial gene pool mixing between different subspecies is known; British red foxes have crossbred extensively with foxes imported from Germany, France, Belgium, Sardinia, and possibly Siberia and Scandinavia (27). However, genetic studies suggest very little differences between red foxes sampled across Europe (28), (29). Lack of genetic diversity is consistent with the red fox being a highly vagile species, with one red fox covering 320 km (200 mi) in under a year's time (30).

Red fox subspecies in Eurasia and North Africa are divided into two categories (9):

- **Northern foxes** are large and brightly coloured.
- **Southern grey desert foxes** include the Asian subspecies *V. v. griffithi*, *V. v. pusilla*, and *V. v. flavescens*. These foxes display transitional features between northern red foxes and smaller fox species; their skulls possess more primitive, neotenous traits than the northern forms (17), and they are much smaller; the maximum sizes attained by southern foxes are invariably less than the average sizes of northern foxes. Their limbs are also longer, and their ears larger (31).

Red foxes living in Middle Asia show physical traits intermediate to the northern and southern forms (32).

Description

Build

The red fox has an elongated body and relatively short limbs. The tail, which is longer than half the body length (60) (70% of head and body length) (61), is fluffy and reaches the ground when in a standing position. Their pupils are oval and vertically oriented (60). Nictitating membranes are present, but move only when the eyes are closed. The forepaws have five digits, while the hind feet have only four and lack dewclaws (62). They are very agile, being capable of jumping over 2-m-high fences, and swim well (63). Vixens normally have four pairs of teats (60), though vixens with seven, nine, or ten teats are not uncommon (62). The testes of males are smaller than those of Arctic foxes (64).

Their skulls are fairly narrow and elongated, with small braincases. Their canine teeth are relatively long. Sexual dimorphism of the skull is more pronounced than in corsac foxes, with female red foxes tending to have smaller skulls than males, with wider nasal regions and hard palates, as well as having larger canines (65). Their skulls are distinguished from those of dogs by their narrower muzzles, less crowded premolars, more slender canine teeth, and concave rather than convex profiles (66).

Dimensions
Red foxes are the largest species of the genus *Vulpes* (67). However, relative to dimensions, red foxes are much lighter than similarly sized dogs of the genus *Canis*. Their limb bones, for example, weigh 30% less per unit area of bone than expected for similarly sized dogs (68). They display significant individual, sexual, age and geographical variation in size. On average, adults measure 35–50 cm (14–20 in) high at the shoulder and 45 to 90 cm (18 to 35 in) in body length with tails measuring 30 to 55.5 cm (11.8 to 21.9 in). The ears measure 7.7–12.5 cm (3–5 in) and the hind feet 12–18.5 cm (5–7 in). Weights range from 2.2 to 14 kg (4.9 to 30.9 lb), with vixens typically weighing 15–20% less than males (61), (69), (70). Adult red foxes have skulls measuring 129–167 mm (5.1–6.6 in), while those of vixens measure 128–159 mm (5.0–6.3 in) (6). The forefoot print measures 60 mm (2.4 in) in length and 45 mm (1.8 in) in width, while the hind foot print measures 55 mm (2.2 in) long and 38 mm (1.5 in) wide. They trot at a speed of 6–13 km/h, and have a maximum running speed of 50 km/h. They have a stride of 25–35 cm (9.8–13.8 in) when walking at a normal pace (71). North American red foxes are generally lightly built, with comparatively long bodies for their mass and have a high degree of sexual dimorphism. British red foxes are heavily built, but short, while continental European red foxes are closer to the general average among red fox populations (72). The largest red fox on record in Great Britain was a 17.2 kg (38.1 lbs), 1.4-metre (4 ft 7 in) long male, killed in Aberdeenshire, Scotland in early 2012 (73).

Fur
The winter fur is dense, soft, silky and relatively long. For the northern foxes, the fur is very long, dense and fluffy, but is shorter, sparser and coarser in southern forms (60). Among northern foxes, the North American varieties generally have the silkiest guard hairs (74), while most Eurasian red foxes have coarser fur (75). There are three main colour morphs; red, silver/black and cross (see *Mutations*) (61). In the typical red morph, their coats are generally bright reddish-rusty with yellowish tints. A stripe of weak, diffuse patterns of many brown-reddish-chestnut hairs occurs along the spine. Two additional stripes pass down the shoulder blades, which, together with the spinal stripe, form a cross. The lower back is often a mottled silvery colour. The flanks are lighter coloured than the back, while the chin, lower lips, throat and front of the chest are white. The remaining lower surface of the body is dark, brown or reddish (60). During lactation, the belly fur of vixens may turn brick red (62). The upper parts of the limbs are rusty reddish, while the paws are black. The frontal part of the face and upper neck is bright brownish-rusty red, while the upper lips are white. The backs of the ears are black or brownish-reddish, while the inner surface is whitish. The top of the tail is brownish-reddish, but lighter in colour than the back and flanks. The underside of the tail is pale grey with a straw-coloured tint. A black spot, the location of the supracaudal gland, is usually present at the base of the tail. The tip of the tail is white (60).

Mutations
White morph red foxes may be distinguished from Arctic foxes by their 25% greater size, longer muzzles, and longer, pointed ears (76). This captive example shows the dark pigment of the eyes, nose, and lips that would not occur in an albino. Complete albinism in red foxes is rare and primarily occurs in southern forest zones. Typically, albinism is accompanied by deformations and usually develops in years of insufficient food (77). Atypical colourations in red foxes usually represent stages toward full melanism (7), and mostly occur in cold regions (78).

Senses
Red foxes have binocular vision (62), but their sight reacts mainly to movement. Their auditory perception is acute, being able to hear black grouse changing roosts at 600 paces, the flight of crows at 0.25–0.5 kilometres (0.16–0.31 mi) and the squeaking of mice at about 100 metres (330 ft) (82). They are capable of locating sounds to within one degree at 700–3,000 Hz, though less accurately at higher frequencies (63). Their sense of smell is good, but weaker than that of specialised dogs (82).

Scent glands
Red foxes have a pair of anal sacs lined by sebaceous glands, both of which open through a single duct. The anal sacs act as fermentation chambers in which aerobic and anaerobic bacteria convert sebum into odorous compounds, including aliphatic acids. The oval-shaped caudal gland is 25 mm (1.0 in) long and 13 mm (0.51 in) wide, and reportedly smells of violets (62), (83). The presence of foot glands is equivocal. The interdigital cavities are deep, with a reddish tinge and smell strongly. Sebaceous glands are present on the angle of the jaw and mandible (62).

Behaviour

Social and territorial behaviour

Red foxes either establish stable home ranges within particular areas or are itinerant with no fixed abode (84). They use their urine to mark their territories (85). A male fox raises one hind leg and his urine is sprayed forward in front of him, whereas a female fox squats down so that the urine is sprayed in the ground between the hind legs (86). Urine is also used to mark empty cache sites, used to store found food, as reminders not to waste time investigating them (87), (88), (89). The use of up to 12 different urination postures allows them to precisely control the position of the scent mark (90). Red foxes live in family groups sharing a joint territory. In favourable habitats and/or areas with low hunting pressure, subordinate foxes may be present in a range. Subordinate foxes may number 1 or 2, sometimes up to 8 in one territory. These subordinates could be formerly dominant animals, but are mostly young from the previous year, who act as helpers in rearing the breeding vixen's kits. Alternatively, their presence has been explained as being in response to temporary surpluses of food unrelated to assisting reproductive success. Non-breeding vixens will guard, play, groom, provision and retrieve kits (10), an example of kin selection. Red foxes may leave their families once they reach adulthood if the chances of winning a territory of their own are high. If not, they will stay with their parents, at the cost of postponing their own reproduction (91).

Reproduction and development

Red foxes reproduce once a year in spring. Two months prior to oestrus (typically December), the reproductive organs of vixens change shape and size. By the time they enter their oestrus period, their uterine horns double in size, and their ovaries grow 1.5–2 times larger. Sperm formation in males begins in August–September, with the testicles attaining their greatest weight in December–February (92). The vixen's oestrus period lasts three weeks (93), during which the dog-foxes mate with the vixens for several days, often in burrows. Copulation is accompanied by a copulatory tie, which may last for more than an hour (93). The copulatory tie occurs when the male's bulbus glandis enlarges (94). The gestation period lasts 49–58 days (95). Though foxes are largely monogamous, DNA evidence from one population indicated large levels of polygyny, incest and mixed paternity litters (93). Subordinate vixens may become pregnant, but usually fail to whelp, or have their kits killed postpartum by either the dominant female or other subordinates (96).

The average litter size consists of four to six kits, though litters of up to 13 kits have occurred (95). Large litters are typical in areas where fox mortality is high (97). Kits are born blind, deaf and toothless, with dark brown fluffy fur. At birth, they weigh 56–110 g (2.0–3.9 oz) and measure 14.5 cm (5.7 in) in body length and 7.5 cm (3.0 in) in tail length. At birth, they are short-legged, large-headed and have broad chests (98). Mothers remain with the kits for 2–3 weeks, as they are unable to thermoregulate. During this period, the fathers or barren vixens feed the mothers (96). Vixens are very protective of their kits, and have been known to even fight off terriers in their defence (99). If the mother dies before the kits are independent, the father takes over as their provider (100). The kits' eyes open after 13–15 days, during which time their ear canals open and their upper teeth erupt, with the lower teeth emerging 3–4 days later (98). Their eyes are initially blue, but change to amber at 4–5 weeks. Coat colour begins to change at 3 weeks of age, when the black eye streak appears. By one month, red and white patches are apparent on their faces. During this time, their ears erect and their muzzles elongate (96). Kits begin to leave their dens and experiment with solid food brought by their parents at the age of 3–4 weeks. The lactation period lasts 6–7 weeks (92). Their woolly coats begin to be coated by shiny guard hairs after 8 weeks (96). By the age of 3–4 months, the kits are long-legged, narrow-chested and sinewy. They reach adult proportions at the age of 6–7 months (98). Some vixens may reach sexual maturity at the age of 9–10 months, thus bearing their first litters at one year of age (92). In captivity, their longevity can be as long as 15 years, though in the wild they typically do not survive past 5 years of age (101).

Denning behaviour

Outside the breeding season, most red foxes favour living in the open, in densely vegetated areas, though they may enter burrows to escape bad weather (10). Their burrows are often dug on hill or mountain slopes, ravines, bluffs, steep banks of water bodies, ditches, depressions, gutters, in rock clefts and neglected human environments. Red foxes prefer to dig their burrows on well drained soils. Dens built among tree roots can last for decades, while those dug on the steppes last only several years (102). They may permanently abandon their dens during mange outbreaks, possibly as a defence mechanism against the spread of disease (10). In the Eurasian desert regions, foxes may use the burrows of wolves, porcupines and other large mammals, as well as those dug by gerbil colonies. Compared to burrows constructed by Arctic foxes, badgers, marmots and corsac foxes, red fox dens are

not overly complex. Red fox burrows are divided into a den and temporary burrows, which consist only of a small passage or cave for concealment. The main entrance of the burrow leads downwards (40–45°) and broadens into a den, from which numerous side tunnels branch. Burrow depth ranges from 0.5–2.5 metres (1 ft 8 in–8 ft 2 in), rarely extending to ground water. The main passage can reach 17 m (56 ft) in length, standing an average of 5–7 m (16–23 ft). In spring, red foxes clear their dens of excess soil through rapid movements, first with the forepaws then with kicking motions with their hind legs, throwing the discarded soil over 2 m (6 ft 7 in) from the burrow. When kits are born, the discarded debris is trampled, thus forming a spot where the kits can play and receive food (102). They may share their dens with woodchucks (103) or badgers (104). Unlike badgers, which fastidiously clean their earths and defecate in latrines, red foxes habitually leave pieces of prey around their dens (105). The average sleep time of a captive red fox is 9.8 hours per day (106).

Communication

Body language

Red fox body language consists of movements of the ears, tail and postures, with their body markings emphasising certain gestures. Postures can be divided into aggressive/dominant and fearful/submissive categories. Some postures may blend the two together (107).

Inquisitive foxes will rotate and flick their ears whilst sniffing. Playful individuals will perk their ears and rise on their hind legs. Male foxes courting females, or after successfully evicting intruders, will turn their ears outwardly, and raise their tails in a horizontal position, with the tips raised upward. When afraid, red foxes grin in submission, arching their backs, curving their bodies, crouching their legs and lashing their tails back and forth with their ears pointing backwards and pressed against their skulls. When merely expressing submission to a dominant animal, the posture is similar, but without arching the back or curving the body. Submissive foxes will approach dominant animals in a low posture, so that their muzzles reach up in greeting. When two evenly matched foxes confront each other over food, they approach each other sideways and push against each other's flanks, betraying a mixture of fear and aggression through lashing tails and arched backs without crouching and pulling their ears back without flattening them against their skulls. When launching an assertive attack, red foxes approach directly rather than sideways, with their tails aloft and their ears rotated sideways (107). During such fights, red foxes will stand on each other's upper bodies with their forelegs, using open mouthed threats. Such fights typically only occur among juveniles or adults of the same sex (108).

Vocalisations

Red foxes have a wide vocal range, and produce different sounds spanning five octaves, which grade into each other (109). Recent analyses identify 12 different sounds produced by adults and 8 by kits (108). The majority of sounds can be divided into "contact" and "interaction" calls. The former vary according to the distance between individuals, while the latter vary according to the level of aggression (109).

- **Contact calls:** The most commonly heard contact call is a 3–5 syllable barking "*wow wow wow*" sound, which is often made by two foxes approaching one another. This call is most frequently heard from December to February (when they can be confused with the territorial calls of tawny owls). The "*wow wow wow*" call varies according to individual; captive foxes have been recorded to answer pre-recorded calls of their pen-mates, but not those of strangers. Kits begin emitting the "*wow wow wow*" call at the age of 19 days, when craving attention. When red foxes draw close together, they emit trisyllabic greeting warbles similar to the clucking of chickens. Adults greet their kits with gruff huffing noises (109).
- **Interaction calls:** When greeting one another, red foxes emit high pitched whines, particularly submissive animals. A submissive fox approached by a dominant animal will emit a ululating siren-like shriek. During aggressive encounters with conspecifics, they emit a throaty rattling sound, similar to a ratchet, called "gekkering". Gekkering occurs mostly during the courting season from rival males or vixens rejecting advances (109).

Another call that does not fit into the two categories is a long, drawn out, monosyllabic "*waaaaah*" sound. As it is commonly heard during the breeding season, it is thought to be emitted by vixens summoning males. When danger is detected, foxes emit a monosyllabic bark. At close quarters, it is a muffled cough, while at long distances it is sharper. Kits make warbling whimpers when nursing, these calls being especially loud when they are dissatisfied (109).

Ecology

Diet, hunting and feeding behaviour

Red foxes are omnivores with a highly varied diet. In the former Soviet Union, up to 300 animal and a few dozen plant species are known to be consumed by them (11). They primarily feed on small rodents like voles, mice, ground squirrels, hamsters, gerbils (11), woodchucks, pocket gophers and deer mice (13). Secondary prey species include birds (with passeriformes, galliformes and waterfowl predominating), leporids, porcupines, raccoons, opossums, reptiles, insects, other invertebrates and flotsam (marine mammals, fish and echinoderms) (11), (13). On very rare occasions, they may attack young or small ungulates (12). They typically target mammals up to about 3.5 kg (7.7 lb) in weight, and require 500 grams (18 oz) of food daily (63). Red foxes readily eat plant material and in some areas, fruit can amount to 100% of their diet in autumn. Commonly consumed fruits include blueberries, blackberries, raspberries, cherries, persimmons, mulberries, apples, plums, grapes and acorns. Other plant material includes grasses, sedges and tubers (13).

Red foxes are implicated in the predation of game and song birds, hares, rabbits, muskrats and young ungulates, particularly in preserves, reserves, and hunting farms where ground nesting birds are protected and raised, as well as in poultry farms (110).

While the popular consensus is that olfaction is very important for hunting (111), two studies that experimentally investigated the role of olfactory, auditory, and visual cues found that visual cues are the most important ones for hunting in red foxes (112) and coyotes (113), (114).

Red foxes prefer to hunt in the early morning hours before sunrise and late evening (115). Although they typically forage alone, they may aggregate in resource-rich environments (101). When hunting mouse-like prey, they first pinpoint their prey's location by sound, then leap, sailing high above their quarry, steering in mid-air with their tails, before landing on target up to 5 metres (16 ft) away (68). They typically only feed on carrion in the late evening hours and at night (116). They are extremely possessive of their food, and will defend their catches from even dominant animals (117). Red foxes may occasionally commit acts of surplus killing; during one breeding season, four foxes were recorded to have killed circa 200 black-headed gulls each, with peaks during dark, windy hours when flying conditions were unfavourable. Losses to poultry and penned game birds can be substantial because of this (93), (118). Red foxes seem to dislike the taste of moles, but will nonetheless catch them alive and present them to their kits as playthings (119).

A 2008–2010 study of 84 red foxes in the Czech Republic and Germany found that successful hunting in long vegetation or under snow appeared to involve an alignment of the fox with the Earth's magnetic field (120), (121).

Enemies and competitors

Red foxes typically dominate other fox species. Arctic foxes generally escape competition from red foxes by living farther north, where food is too scarce to support the larger-bodied red species. Although the red species' northern limit is linked to the availability of food, the Arctic species' southern range is limited by the presence of the former. Red and Arctic foxes were both introduced to almost every island from the Aleutian Islands to the Alexander Archipelago during the 1830s–1930s by fur companies. The red foxes invariably displaced the Arctic foxes, with one male red fox having been reported to have killed off all resident Arctic foxes on a small island in 1866 (122). Where they are sympatric, Arctic foxes may also escape competition by feeding on lemmings and flotsam, rather than voles, as favoured by red foxes. Both species will kill each other's kits, given the opportunity (123). Red foxes are serious competitors of corsac foxes, as they hunt the same prey all year. The red species is also stronger, is better adapted to hunting in snow deeper than 10 cm (4 in) and is more effective in hunting and catching medium to large-sized rodents. Corsac foxes seem to only outcompete red foxes in semi-desert and steppe areas (124). In Israel, Blanford's foxes escape competition with red foxes by restricting themselves to rocky cliffs and actively avoiding the open plains inhabited by red foxes (122). Red foxes dominate kit and swift foxes. Kit foxes usually avoid competition with their larger cousins by living in more arid environments, though red foxes have been increasing in ranges formerly occupied by kit foxes due to human-induced environmental changes. Red foxes will kill both species, and compete for food and den sites (125). Grey foxes are exceptional, as they dominate red foxes wherever their ranges meet. Historically, interactions between the two species were rare, as grey foxes favoured heavily wooded or semiarid habitats as opposed to the open and mesic ones preferred by red foxes. However, interactions have become more frequent due to deforestation allowing red foxes to colonise grey fox-inhabited areas (125).

Wolves may kill and eat red foxes in disputes over carcasses (126), (127). In areas in North America where red fox and coyote populations are sympatric, fox ranges tend to be located outside coyote territories. The principal cause of this separation is believed to be active avoidance of coyotes by the foxes. Interactions between the two species vary in nature, ranging from active antagonism to indifference. The majority of aggressive encounters are initiated by coyotes, and there are few reports of red foxes acting aggressively toward coyotes except when attacked or when their kits were approached. Foxes and coyotes have sometimes been seen feeding together (128). In Israel, red foxes share their habitat with golden jackals. Where their ranges meet, the two canids compete due to near identical diets. Foxes ignore jackal scents or tracks in their territories, and avoid close physical proximity with jackals themselves. In areas where jackals become very abundant, the population of foxes decreases significantly, apparently because of competitive exclusion (129).

Red foxes dominate raccoon dogs, sometimes killing their kits or biting adults to death. Cases are known of foxes killing raccoon dogs entering their dens. Both species compete for mouse-like prey. This competition reaches a peak during early spring, when food is scarce. In Tartaria, red fox predation accounted for 11.1% of deaths among 54 raccoon dogs, and amounted to 14.3% of 186 raccoon dog deaths in north-western Russia (130).

Red foxes may kill small mustelids like weasels (125), stone martens (131), pine martens, stoats, kolonoks, polecats and young sables. Eurasian badgers may live alongside red foxes in isolated sections of large burrows (104). It is possible that the two species tolerate each other out of commensalism; foxes provide badgers with food scraps, while badgers maintain the shared burrow's cleanliness (105). However, cases are known of badgers driving vixens from their dens and destroying their litters without eating them. Wolverines may kill red foxes, often while the latter are sleeping or near carrion. Foxes in turn may kill unattended young wolverines (104).

Red foxes may compete with striped hyenas on large carcasses. Red foxes may give way to hyenas on unopened carcasses, as the latter's stronger jaws can easily tear open flesh that is too tough for foxes. Foxes may harass hyenas, using their smaller size and greater speed to avoid the hyena's attacks. Sometimes, foxes seem to deliberately torment hyenas even when there is no food at stake. Some foxes may mistime their attacks, and are killed (132). Fox remains are often found in hyena dens, and hyenas may steal foxes from traps (133).

In Eurasia, red foxes may be preyed upon by leopards, caracals and Eurasian lynxes. The lynxes chase red foxes into deep snow, where their longer legs and larger paws give them an advantage over foxes, especially when the depth of the snow exceeds one metre (133). In the Velikoluki district in Russia, red foxes are absent or are seen only occasionally where lynxes establish permanent territories (133). Researchers consider lynxes to represent considerably less danger to red foxes than wolves do (134). North American felid predators of red foxes include cougars, Canadian lynxes and bobcats (61). Occasionally, large raptors such as Eurasian eagle owls will prey on young foxes (135), while golden eagles have been known to kill adults (136).

Range

Red foxes are wide ranging animals, whose range covers nearly 70 million km^2 (27 million mi^2). They are distributed across the entire Northern Hemisphere from the Arctic Circle to North Africa, Central America, and Asia. They are absent in Iceland, the Arctic islands, some parts of Siberia, and in extreme deserts (1). Red foxes are not present in New Zealand and are classed as a "prohibited new organism" under the Hazardous Substances and New Organisms Act 1996, preventing them from being imported (137).

Australia

In Australia, 2012 estimates indicate that there are more than 7.2 million (138) red foxes with a range extending throughout most of the continental mainland (139). The species became established in Australia through successive introductions by settlers in 1830s in the British colonies of Van Diemen's Land (as early as 1833) and the Port Phillip District of New South Wales (as early as 1845) for the purpose of the traditional English sport of fox hunting. A permanent fox population was not established on the island of Tasmania and it is widely held that they were outcompeted by the Tasmanian devil (140). On the mainland, however, the species was successful as an apex predator. It is generally less common in areas where the dingo is more prevalent, however it has, primarily through its burrowing behaviour, achieved niche differentiation with both the feral dog and the feral cat. As such it has

become one of the continent's most invasive species. The red fox has been implicated in the extinction and decline of several native Australian species, particularly those of the family Potoroidae including the desert rat-kangaroo (141). The spread of red foxes across the southern part of the continent has coincided with the spread of rabbits in Australia and corresponds with declines in the distribution of several medium-sized ground-dwelling mammals, including brush-tailed bettongs, burrowing bettongs, rufous bettongs, bilbys, numbats, bridled nailtail wallabys and quokkas (142). Most of these species are now limited areas (such as islands) where red foxes are absent or rare. Local eradication programs exist, although eradication has proven difficult due to the denning behaviour and nocturnal hunting, so the focus is on management with the introduction of state bounties (143). According to the Tasmanian government, red foxes were introduced to the previously fox-free island of Tasmania in 1999 or 2000, posing a significant threat to native wildlife including the eastern bettong, and an eradication program conducted by the Tasmanian Department of Primary Industries and Water has been established (144).

Sardinia

The origin of the Sardinian *ichnusae* subspecies is uncertain, as it is absent from Pleistocene deposits in their current homeland. It is possible it originated during the Neolithic following its introduction to the island by humans. It is likely then that Sardinian fox populations stem from repeated introductions of animals from different localities in the Mediterranean. This latter theory may explain the subspecies' phenotypic diversity (20).

Diseases and parasites

Red foxes are the most important rabies vector in Europe. In London, arthritis is not uncommon in foxes, being particularly frequent in the spine (145). Foxes may be infected with leptospirosis and tularemia, though they are not overly susceptible to the latter. They may also fall ill from listeriosis and spirochetosis, as well as acting as vectors in spreading erysipelas, brucellosis and tick-born encephalitis. A mysterious fatal disease near Lake Sartlan in the Novosibirsk Oblast was noted among local red foxes, but the cause was undetermined. The possibility was considered that it was caused by an acute form of encephalomyelitis, which was first observed in captive bred silver foxes. Individual cases of foxes infected with *Yersinia pestis* are known (146).

Red foxes are not readily prone to infestation with fleas. Species like *Spilopsyllus cuniculi* are probably only caught from the fox's prey species, while others like *Archaeopsylla erinacei* are caught whilst travelling. Fleas that feed on red foxes include *Pulex irritans*, *Ctenocephalides canis* and *Paraceras melis*. Ticks such as *Ixodes ricinus* and *I. hexagonus* are not uncommon in foxes, and are typically found on nursing vixens and kits still in their earths. The louse *Trichodectes vulpis* specifically targets foxes, but is found infrequently. The mite *Sarcoptes scabiei* is the most important cause of mange in red foxes. It causes extensive hair loss, starting from the base of the tail and hindfeet, then the rump before moving on to the rest of the body. In the final stages of the condition, foxes can lose most of their fur, 50% of their body weight and may gnaw at infected extremities. In the epizootic phase of the disease, it usually takes foxes four months to die after infection. Other endoparasites include *Demodex folliculorum*, *Notoderes*, *Otodectes cynotis* (which is frequently found in the ear canal), *Linguatula serrata* (which infects the nasal passages) and ringworms (145), (146).

Up to 60 helminth species are known to infect foxes in fur farms, while 20 are known in the wild. Several coccidian species of the genera *Isospora* and *Eimeria* are also known to infect them.[146] The most common nematode species found in fox guts are *Toxocara canis* and *Uncinaria stenocephala*, *Capillaria aerophila* (147) and *Crenosoma vulpis*, the latter two infect their lungs. *Capillaria plica* infect the fox's bladder. *Trichinella spiralis* rarely affects them. The most common tapeworm species in foxes are *Taenia spiralis* and *T. pisiformis*. Others include *Echinococcus granulosus* and *E. multilocularis*. Eleven trematode species infect red foxes (145), including *Metorchis conjunctus* (148).

Relationships with humans

In folklore and mythology

Red foxes feature prominently in the folklore and mythology of human cultures with which they are sympatric. In Greek mythology, the Teumessian fox (149) or Cadmean vixen, was a gigantic fox that was destined never to be caught. The fox was one of the children of Echidna (159).

In Celtic mythology, the red fox is a symbolic animal. In the Cotswolds, witches were thought to take the shape of foxes to steal butter from their neighbours (151). In later European folklore, the figure of Reynard the Fox symbolises trickery and deceit. He originally appeared (then under the name of

"Reinardus") as a secondary character in the 1150 poem "Ysengrimus". He reappeared in 1175 in Pierre Saint Cloud's *Le Roman de Renart*, and made his debut in England in Geoffrey Chaucer's *The Nun's Priest's Tale*. Many of Reynard's adventures may stem from actual observations on fox behaviour; he is an enemy of the wolf and has a fondness for blackberries and grapes (152).

Chinese folk tales tell of fox-spirits called *huli jing* that may have up to nine tails, or *kumiho* as they are known in Korea (153). In Japanese mythology, the kitsune are fox-like spirits possessing magical abilities that increase with their age and wisdom. Foremost among these is the ability to assume human form. While some folktales speak of kitsune employing this ability to trick others, other stories portray them as faithful guardians, friends, lovers, and wives (154). In Arab folklore, the fox is considered a cowardly, weak, deceitful, and cunning animal, said to feign death by filling its abdomen with air to appear bloated, then lies on its side, awaiting the approach of unwitting prey (155). The animal's cunning was noted by the authors of the Bible, and applied the word "fox" to false prophets (Ezekiel 13:4) and the hypocrisy of Herod Antipas (Luke 13:32) (156).

The cunning Fox is commonly found in Native American mythology, where it is portrayed as an almost constant companion to Coyote. Fox, however, is a deceitful companion that often steals Coyote's food. In the Achomawi creation myth, Fox and Coyote are the co-creators of the world, that leave just before the arrival of humans. The Yurok tribe believed that Fox, in anger, captured the sun, and tied him to a hill, causing him to burn a great hole in the ground. An Inuit story tells of how Fox, portrayed as a beautiful woman, tricks a hunter into marrying her, only to resume her true form and leave after he offends her. A Menominee story tells of how Fox is an untrustworthy friend to the Wolf (157).

Hunting

The earliest historical records of fox hunting come from the fourth century BC; Alexander the Great is known to have hunted foxes and a seal dated from 350 BC depicts a Persian horseman in the process of spearing a fox. Xenophon, who viewed hunting as part of a cultured man's education, advocated the killing of foxes as pests, as they distracted hounds from hares. The Romans were hunting foxes by 80 AD. During the Dark Ages in Europe, foxes were considered secondary quarries, but gradually grew in importance. Cnut the Great reclassed foxes as Beasts of the Chase, a lower category of quarry than Beasts of Venery. Foxes were gradually hunted less as vermin and more as Beasts of the Chase, to the point that by the late 13th century, Edward I had a royal pack of foxhounds and a specialised fox huntsman. In this period, foxes were increasingly hunted above ground with hounds, rather than underground with terriers. Edward, Second Duke of York assisted the climb of foxes as more prestigious quarries in his *The Master of Game*. By the Renaissance, fox hunting became a traditional sport of the nobility. After the English Civil War caused a drop in deer populations, fox hunting grew in popularity. By the mid-17th century, Britain was divided into fox hunting territories, with the first fox hunting clubs being formed (the first was the Charlton Hunt Club in 1737). The popularity of fox hunting in Britain reached a peak during the 18th century (158). Although already native to North America, red foxes from England were imported for sporting purposes to Virginia and Maryland in 1730 by prosperous tobacco planters (159). These American fox hunters considered the red species more sporting than grey species (160).

The grays furnished more fun, the reds more excitement. The grays did not run so far, but usually kept near home, going in a circuit of six or eight miles. 'An old red,, generally so called irrespective of age, as a tribute to his prowess, might lead the dogs all day, and end by losing them as evening fell, after taking them a dead stretch for thirty miles. The capture of a gray was what men boasted of; a chase after 'an old red' was what they 'yarned' about (160).

Red foxes are still widely persecuted as pests, with human-caused deaths among the highest causes of mortality in the species. Annual fox kills are: UK 21,500–25,000 (2000); Germany 600,000 (2000–2001); Austria 58,000 (2000–2001); Sweden 58,000 (1999–2000); Finland 56,000 (2000–2001); Denmark 50,000 (1976–1977); Switzerland 34,832 (2001); Norway 17,000 (2000–2001); Saskatchewan (Canada) 2,000 (2000–2001); Nova Scotia (Canada) 491 (2000–2001); Minnesota (US) 4,000-8,000 (average annual trapping harvest 2002-2009) (161); New Mexico (US) 69 (1999–2000) (131).

Fur use

Red foxes are among the most important furbearing animals harvested by the fur trade. Their pelts are used for trimmings, scarfs, muffs, jackets and coats. They are principally used as trimming for both cloth coats and fur garments, including evening wraps (15). The pelts of silver-morph foxes are

popular as capes (162), while cross foxes are mostly used for scarfs and rarely for trimming (163). The number of sold fox scarfs exceeds the total number of scarfs made from other furbearers. However, this amount is overshadowed by the total number of fox pelts used for trimming purposes (15). The silver morphs are the most valued by furriers, followed by the cross and red morphs respectively (164). In the early 20th century, over 1,000 American fox skins were imported to Britain annually, while 500,000 were exported annually from Germany and Russia (165). The total worldwide trade of wild red foxes in 1985–86 was 1,543,995 pelts. Foxes amounted to 45% of US wild-caught pelts worth $50 million (131). Pelt prices are increasing, with 2012 North American wholesale auction prices averaging $39, and 2013 prices averaging $65.78 (166).

North American red foxes, particularly those of northern Alaska, are the most valued for their fur, as they have guard hairs of a silky texture, which, after dressing, allow the wearer unrestricted mobility. Red foxes living in southern Alaska's coastal areas and the Aleutian Islands are an exception, as they have extremely coarse pelts that rarely exceed one-third of the price of their northern Alaskan cousins (74). Most European peltries have coarse-textured fur compared to North American varieties. The only exceptions are the Nordic and Far Eastern Russian peltries, but they are still inferior to North American peltries in terms of silkiness (75).

Livestock and pet predation

Red foxes may on occasions prey on lambs. Usually, lambs targeted by foxes tend to be physically weakened specimens, but not invariably. Lambs belonging to small breeds, such as Blackface, are more vulnerable than larger breeds such as Merino. Twins may be more vulnerable to foxes than singlets, as ewes cannot effectively defend both simultaneously. Crossbreeding small, upland ewes with larger, lowland rams can cause difficult and prolonged labour for ewes due to the heaviness of the resulting offspring, thus making the lambs more at risk to fox predation. Lambs born from gimmers (ewes breeding for the first time) are more often killed by foxes than those of experienced mothers, who stick closer to their young (167).

Red foxes may prey on domestic rabbits and guinea pigs if they are kept in open runs or are allowed to range freely in gardens. This problem is usually averted by housing them in robust hutches and runs. Urban foxes frequently encounter cats and may feed alongside them. In physical confrontations, the cats usually have the upper hand. Authenticated cases of foxes killing cats usually involve kittens. Although most foxes do not prey on cats, some may do so, and may treat them more as competitors rather than food (168).

Taming and domestication

In their unmodified wild state, red foxes are generally unsuitable as pets. Many supposedly abandoned kits are adopted by well-meaning people during the spring period, though it is unlikely that vixens would abandon their young. Actual orphans are rare, and the ones that are adopted are likely kits that simply strayed from their den site. Kits require almost constant supervision; when still suckling, they require milk at four-hour intervals day and night. Once weaned, they may become destructive to leather objects, furniture and electric cables (169). Though generally friendly toward people when young, captive red foxes become fearful of humans, save for their handlers, once they reach 10 weeks of age (170). They maintain their wild counterpart's strong instinct of concealment, and may pose a threat to domestic birds, even when well fed (171). Although suspicious of strangers, they can form bonds with cats and dogs, even ones bred for fox hunting. Practical uses for tame foxes are few, though they can be encouraged to kill rats and mice in granaries. Tame foxes were once used to draw ducks close to hunting blinds (172).

A strain of truly domesticated red foxes was introduced by Russian geneticist Dmitry Konstantinovich Belyaev who, over a 40-year period, bred several generations of silver morph foxes on fur farms, selecting only those individuals that showed the least fear of humans. Eventually, Belyaev's team selected only those that showed the most positive response to humans, thus resulting in a population of foxes whose behaviour and appearance was significantly changed. After about ten generations of controlled breeding, these foxes no longer showed any fear of humans, and often wagged their tails and licked their human caretakers to show affection. These behavioural changes were accompanied by physical alterations, which included piebald coats, floppy ears in pups, and curled tails, similar to traits that distinguish domestic dogs from wolves (173).

Urban foxes
Distribution
Red foxes have been successful in colonising built-up environments, especially lower-density suburbs (63). Throughout the twentieth century, they established themselves in many Australian, European, Japanese, and North American cities. The species first colonised British cities during the 1930s, entering Bristol and London during the 1940s, and later established themselves in Cambridge and Norwich. In Australia, red foxes were recorded in Melbourne as early as the 1930s, while in Zurich, Switzerland, they only starting appearing in the 1980s (174). Urban red foxes are most common in residential suburbs consisting of privately owned, low-density housing. They are rare in areas where industry, commerce or council-rented houses predominate (63). In these latter areas, the distribution is of a lower average density because they rely less on human resources; the home range of these foxes average from 80 to 90 hectares, whereas those in more residential areas average from 25 to 40 hectares (175).

In 2006 it was estimated that there were 10,000 foxes in London (176). City-dwelling foxes may have the potential to consistently grow larger than their rural counterparts, as a result of abundant scraps and a relative dearth of predators. In cities foxes may scavenge food from litter bins and bin bags, although much of their diet will be similar to rural foxes.

Behaviour
Urban red foxes are most active at dusk and dawn, doing most of their hunting and scavenging at these times. It is uncommon to spot them during the day, but they can be caught sunbathing on roofs of houses or sheds. Foxes will often make their homes in hidden and undisturbed spots in urban areas as well as on the edges of a city, visiting at night for sustenance. While foxes will scavenge successfully in the city (and the foxes tend to eat anything that the humans eat) some urban residents will deliberately leave food out for the animals, finding them endearing (177). Doing this regularly can attract foxes to one's home; they can become accustomed to human presence, warming up to their providers by allowing themselves to be approached and in some cases even played with, particularly young cubs (175).

Urban fox control
Urban foxes can cause problems for local residents. Foxes have been known to steal chickens, disrupt rubbish bins and damage gardens. Most complaints about urban foxes made to local authorities occur during the breeding season in late January/early February or from late April to August, when the new cubs are developing (175). In the UK, hunting foxes in urban areas is banned, and shooting them in an urban environment is not suitable. One alternative to hunting urban foxes has been to trap them, which appears to be a more viable method (178). However, killing foxes has little effect on the population in an urban area; those that are killed are very soon replaced, either by new cubs during the breeding season or by other foxes moving into the territory of those that were killed. A more effective method of fox control is to deter them from the specific areas they inhabit. Deterrents such as creosote, diesel oil, or ammonia can be used. Cleaning up and blocking access to den locations can also discourage a fox's return (175).

Relationship between urban and rural foxes
In January 2014 it was reported that "Fleet", a relatively tame urban fox tracked as part of a wider study by the University of Brighton in partnership with the BBC's *Winterwatch*, had unexpectedly travelled 195 miles in 21 days from his neighbourhood in Hove, at the western edge of East Sussex, across rural countryside as far as Rye, at the eastern edge of the county. He was still continuing his journey when the GPS collar stopped transmitting, due to suspected water damage. Along with setting a record for the longest journey undertaken by a tracked fox in the country, his travels have highlighted the fluidity of movement between rural and urban fox populations (179), (180).

RED FOX
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APPENDIX 10: RED WOLF

Glen Mellin
Lenny Truitt

March 2016

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OUR SUMMARY

This appendix identifies aspects of the Red Wolf (*Canis rufus*), which we feel are important to the discussion of the prehistoric and historic landscape interplay between humans and this four-legged tactical predator in Delaware and the Mid-Atlantic region. Audubon and Bachman first described the Red Wolf in 1851, as follows:

Kingdom: Animalia
Phylum: Chordata
Class: Mamalia
Order: Carnivora
Family: Canidae
Genus: *Canis*
Species: *rufus*

The Red Wolf (particularly in the nineteenth century) had been referred to as *Canis lupus rufus* (Red Wolf derived from Gray Wolf), and as *Canis latrans rufus* (Red Wolf derived from Coyote). These descriptions were based on visual and metric formulations. With the benefit of DNA analysis, there is little support for these descriptions. Additionally, three sub-species were proposed by Goldman (1937), forming *C. rufus gregoryi, C. rufus floridanus,* and *C. rufus rufus*. These three sub-species were supported by Paradiso and Nowak as late as 1972. However, *C. rufus floridanus,* and *C. rufus rufus* are thought to be extirpated at this time. The dental formula for all the above is 3/3-1/1-4/4-2/ 3=42.

According to Sillero-Zubiri et al. (2004:88), "*Canis rufus gregoryi* is thought to be the only surviving subspecies and is the subspecies believed to have been used for the current reintroduction and conservation effort of red wolves in the eastern United States. Genetic methodologies have not been applied to sub-specific designation. Current disagreement about the relatedness of wolves in eastern North America (see Taxonomy section above), if resolved, may alter the currently accepted sub-specific classification of *C. rufus*."

Sillero-Zubiri et al. (2004:88) say, "As recently as 1979, the Red Wolf was believed to have a historical distribution limited to the south-eastern United States (Nowak 1979). However, Nowak (1995) later described the red wolf's historic range as extending northward into central Pennsylvania and more recently has redefined the red wolf's range as extending even further north into the north-eastern USA and extreme eastern Canada (Nowak 2002). Recent genetic evidence (see Taxonomy section above) supports a similar but even greater extension of historic range into Algonquin Provincial Park in southern Ontario, Canada."

Today, Red Wolves (*Canis rufus*) probably exist as a re-introduced and stable population (containing *Canis rufus gregoryi* DNA admixture, which is known to contain Coyote (*Canis latrans*) DNA admixture) in eastern North Carolina on protected land between Albermarle and Pamilico Sounds (Sillero-Zubiri et al. (2004:88). In order to save the remnant population in the east, wolves from the Texas and Mexican population (probably designated (*Canis rufus gregoryi*, which were likely contaminated with as much as 50% Coyote DNA in some samples) were introduced into the dwindling North Carolina population. The Coyote DNA found in the North Carolina DNA samples may have originated in the American Southwest, which would represent a very recent admixture in the East. To fully grasp the range of these issues, researches should become fully versed in all three species: the Red Wolf (Appendix 10), the Eastern Wolf (Appendix 6), and the Coyote (Appendix 3). DNA sequencing of all archaeologically recovered Red Wolf remains from Delaware and the Mid-Atlantic region would make meaningful contributions to these research efforts.

See also:
Sillero-Zubiri, Claudio., Michael Hoffmann, and David W. Macdonald, Eds.
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The following document is a portion of Red Wolf Internet Wikipedia file together with the Wikipedia file references cited. We closely reviewed, edited, and re-formatted the contents of the open-source Wikipedia file to make a good fit with our research topic. The full Wikipedia document can be found and downloaded at https://en.wikipedia.org/wiki/Red_wolf.

Introduction

The **red wolf** (*Canis rufus* (4) /*Canis lupus rufus* (5)), also known as the **Florida wolf** or **Mississippi Valley wolf** (6) is a canid of unresolved taxonomic identity native to the eastern United States (7), (8). It is generally, morphologically, an intermediate between the coyote and gray wolf, and is of a reddish, tawny color (9), (10).

Red wolves were likely the first New World wolf species encountered by European colonists and were originally distributed throughout the eastern United States from the Atlantic Ocean to central Texas, and in the north from the Ohio River Valley, northern Pennsylvania and southern New York south to the Gulf of Mexico (8). The red wolf was nearly driven to extinction by the mid-1900s due to aggressive predator control programs, habitat destruction and extensive hybridization with coyotes. By the late 1960s, it occurred in small numbers in the Gulf Coast of western Louisiana and eastern Texas. Fourteen of these survivors were selected to be the founders of a captively bred population, which was established in the Point Defiance Zoo & Aquarium between 1974 and 1980. After a successful experimental relocation to Bulls Island off the coast of South Carolina in 1978, the red wolf was declared extinct in the wild in 1980 in order to proceed with restoration efforts. In 1987, the captive animals were released into North Carolina's Alligator River National Wildlife Refuge, with a second release taking place two years later in the Great Smoky Mountains National Park (11).

The red wolf's taxonomic status has been a subject of controversy. A 2011 genetic study indicated that it may be a hybrid species between gray wolves and coyotes (12). Re-analysis of this study coupled with a broader contextual analysis including behavioral, morphological and additional genetic information led to arguments that the red wolf is an independent species but has suffered from significant introgression of coyote genes likely due to decimation of red wolf packs with fragmentation of their social structure from hunting (13). A comprehensive review in October 2012 concluded that the red wolf is a distinct species which diverged from the coyote alongside the closely related eastern wolf 150,000-300,000 years ago (4). Although this 2012 review was not universally accepted among relevant authorities (14), two subsequent reviews of updated research in 2013 and 2014 suggest that the red wolf was once a species distinct from the gray wolf and coyote (8), (15). Finally, a 2015 genetics study, using the most comprehensive mitochondrial DNA data, Y-chromosome data and genome-wide 127,235 SNP data, concluded that "the most parsimonious explanation" is that eastern wolves in Algonquin Provincial Park are "a distinct remnant entity of a historical wolf that most likely existed throughout the eastern United States" (16). This view is supported by the idea that the coyote and gray wolf did not historically range into the eastern United States, with current academic debate on red wolf taxonomy shifting to a new question: whether the eastern wolf and red wolf are conspecific (8), a possibility considered by some researchers (13).

Taxonomy

The taxonomic reference Mammal Species of the World (2005) does not recognize *Canis rufus*, however NCBI/Genbank does list it (17). The taxonomy of the red wolf has been debated since before efforts began in 1973 to save it from extinction. In 1971, Atkins and Dillon conducted a study on the brains of canids and confirmed the basal characteristics of the red wolf (18). Many studies throughout the 1970s focused on the morphology of the red wolf came to the conclusion that the red wolf is a distinct species (19). In 1980, a unique allele was found in *Canis* specimens from within the red wolf range, supporting the conclusion that the red wolf is a distinct species (20). Nevertheless, some in the scientific community considered it a subspecies of the gray wolf (21) or a hybrid of the gray wolf and the coyote (22), (23).

In 1992, the USFWS conducted an exhaustive review of the literature, including their own, and concluded that the red wolf is either a separate species unto itself or a subspecies of the gray wolf (24), (25), (26). Many agency reports, books and web pages list the red wolf as *Canis rufus* but genetic research re-opened the debate about the taxonomy of both the red wolf and Canada's eastern wolf (*Canis lupus lycaon*) (18). Wilson et al. (2000) concluded that the eastern wolf and red wolf should be considered as sister taxa due to a shared common ancestor going back 150,000–300,000 years. In addition, Wilson et al. further stated that they should be recognized as distinct species from other

North American canids, and not as subspecies of the gray wolf (*Canis lupus*). However, these conclusions were disputed (27), (28), and *MSW3* (5) listed them both in 2005 as subspecies of the gray wolf.

In May 2011, an analysis of red wolf, eastern wolf, gray wolf, and dog genomes suggested that the red wolf was 76–80 percent coyote and only 20–24 percent gray wolf, suggesting that the red wolf is actually much more coyote in origin than the eastern wolf. This study analyzed 48,000 SNP and found no evidence for a unique eastern wolf or red wolf species (12). However, X-ray analysis of the 16 red wolf specimens used in the SNP study were later shown to be wolf-coyote hybrids via cranial morphometric analysis, rendering the finding that the red wolf was a gray wolf-coyote hybrid inaccurate (29). The U.S. Fish and Wildlife Service (USFWS) still considers the red wolf a valid species (*Canis rufus*) and plans to make no changes to its recovery program (30), (31). In 2012, re-analysis of the 2011 SNP study argued that the original SNP study suffered from insufficient sampling and noted that gray wolves do not mate with coyotes (13). Another Y-chromosome genetic study in 2012 also argued that the eastern wolf and red wolf are not hybrids but rather are a distinct species from the gray wolf, although eastern and red wolves do intermix with coyotes (32). The same authors have argued that the 2011 SNP study finding that red wolves are not an independent species is flawed and that historical hunting and culling of wolves, leading to invasion of coyotes into eastern North America, has led to introgression of coyote mitochondrial and nuclear DNA into fragmented, decimated eastern wolf packs (13). They and other authors have postulated that large populations of eastern and red wolves with intact social/pack structures are less likely to interbreed with coyotes (33). The controversy over the red wolf's species status was the subject of a comprehensive review of the 2011 and 2012 genetics studies, which concluded that there are three separate species of wolf in North America, the red wolf, eastern wolf and gray wolf (4).

In a pair of 2012 reports, scientists critical of the May 2011 paper outlined three main points of criticism (13), (32). First, the 2011 paper relied on mtDNA SNPs derived from boxer and poodle genomes and used these to extrapolate inference about genetic variation within wild canids across the globe. While it is true that many SNPs were examined, it remains unclear whether loci important to red wolf genetic variation were actually identified and analyzed (for example, nuclear DNA was not compared in the SNP analysis). Second, the study sampled modern red wolf specimens, and not historic red wolf specimens from prior to 1900 (when extensive hybridization with coyotes is known to have taken place), which obfuscates the reliability of the study's findings. This is important because using historic red wolf genetic material would have created a baseline genetic profile for the species against which to test the modern captive-bred specimens. (It is common knowledge that the captive-bred red wolves are likely slightly hybridized, but this is a separate issue from interpreting their species origin as due to hybridization.) Third, the authors lumped eastern wolf specimens (which critics from Trent University warn are of unverified origin) with other Great Lakes wolf specimens, and did not test them separately, which again obfuscated any genetic differences that may have been present. The controversy over the eastern wolf's origins is not considered by the scientific community to be laid to rest, although it may be synonymous with the red wolf (4).

When considered as a full species, three subspecies of red wolf were originally recognized by Goldman (34); two of these subspecies are extinct. The Florida black wolf (*Canis rufus floridanus*) (Maine to Florida) (28) has been extinct since 1930 and Gregory's wolf (*Canis rufus gregoryi*) (south-central United States) (28) was declared functionally extinct in the wild by 1980. The Texas red wolf (*Canis rufus rufus*), the third surviving subspecies, was also functionally extinct in the wild by 1980, although that status was changed to critically endangered when captive-bred red wolves from Texas were reintroduced in eastern North Carolina in 1987. The current status of the "non-essential/experimental" population in North Carolina is endangered and the population numbers around 100 wild animals (35). The subspecies designations are essentially moot since two are extinct but the genetic evidence for the three subspecies appears to have been unconvincing anyway (4).

In 2013, an experiment which produced hybrids of coyotes and northwestern gray wolves in captivity using artificial insemination contributed more information to the controversy surrounding the eastern wolf's taxonomy. The purpose of this project was to determine whether or not if the female western coyotes are capable of bearing hybrid western gray wolf-coyote pups as well as to test the hybrid theory surrounding the origin of the eastern and red wolves by comparing them to both. The resulting six hybrids produced in this captive artificial breeding were later on transferred to the Wildlife Science Center of Forest Lake in Minnesota where their behaviors are now being studied (36). While this research is still ongoing, the debate over the eastern wolf's taxonomy remained unsettled. Moreover, in

2014, the review of Chambers et al. (2012) which suggested the eastern wolf should be listed either as a distinct species closely related to the red wolves or conspecific with the latter became controversial, forcing the USFWS to commission a peer review of it, known as NCAES (2014), which took issue with the review (14). However, more recent reviews suggest the evidence has "tilted towards a North American canid assemblage composed of the eastern wolf, red wolf and coyote as distinct taxa...that descended from a common ancestral canid of North American origin" before arrival of the gray wolf from Eurasia (8), (15).

Fossil and historic record

Paleontological evidence has suggested an origin of the red wolf line 1–2 Ma, branching from a wolf-coyote ancestor, which itself appeared about 4.9 Ma. (37), (38). Between 150,000–300,000 years ago, the North American branch evolved into the red wolf, eastern wolf and the coyote (39). Another wolf-like branch migrated to Eurasia and evolved into the gray wolf, which later migrated to North America (38). It is thought that its original distribution included much of eastern North America, where red wolves were found from Maine south to Florida and in south central US westward to Texas. Records of bounty payments to Wappinger Indians in New York in the middle 18th century confirm its range at least that far north (40); it's possible that it could have extended as far as extreme eastern Canada (41).

Physical description and behavior

The red wolf's appearance is typical of the genus *Canis*, and is generally intermediate in size between the coyote and gray wolf, though some specimens may overlap in size with small gray wolves. A study of *Canis* morphometrics conducted in eastern North Carolina reported that red wolves are morphometrically distinct from coyotes and hybrids (42). Adults measure 136–160 cm (53.5–63 in) in length, and weigh 23–39 kg (50-85 lbs) (42). Its pelage is typically more reddish and sparsely furred than the coyote's and gray wolf's, though melanistic individuals do occur (9). Its fur is generally tawny to grayish in color, with light markings around the lips and eyes (10). Like the eastern wolf (42), the red wolf has been compared by some authors to the greyhound in general form, owing to its relatively long and slender limbs. The ears are also proportionately larger than the coyote's and gray wolf's. The skull is typically narrow, with a long and slender rostrum, a small braincase and a well developed sagittal crest. Its cerebellum is unlike that of other *Canis* species, being closer in form to that of canids of the *Vulpes* and *Urocyon* genera, thus indicating that the red wolf is one of the more plesiomorphic members of its genus (9).

The red wolf is more sociable than the coyote, but less so than the gray wolf. It mates in January–February, with an average of 6-7 pups being born in March, April, and May. It is monogamous, with both parents participating the rearing of young (44), (45). Denning sites include hollow tree trunks, along stream banks and the abandoned earths of other animals. By the age of six weeks, the pups distance themselves from the den (44), and reach full size at the age of one year, becoming sexually mature two years later (10).

Prior to its extinction in the wild, the red wolf's diet consisted of nutria, rabbits and rodents (18). In contrast, the red wolves from the restored population rely on white-tailed deer, raccoon, nutria and rabbits (46), (47). It should be noted, however, that white-tailed deer were largely absent from the last wild refuge of red wolves on the Gulf Coast between Texas and Louisiana (where specimens were trapped from the last wild population for captive breeding), which likely accounts for the discrepancy in their dietary habits listed here. Historical accounts of wolves in the southeast by early explorers such as William Hilton, who sailed along the Cape Fear River in what is now North Carolina in 1644, also note that they ate deer (48).

Range and habitat

The originally-recognized red wolf range extended throughout the southeastern United States from the Atlantic and Gulf Coasts, north to the Ohio River Valley and central Pennsylvania, and west to Central Texas and southeastern Missouri (49). But research into paleontological, archaeological and historical specimens of red wolves by Ronald Nowak expanded their known range to include land south of the Saint Lawrence River in Canada, along the eastern seaboard, and west to Missouri and mid-Illinois, terminating in the southern latitudes of Central Texas (50). Since 1987, red wolves have been released into northeastern North Carolina where they roam 1.7 million acres (51). These lands span five counties (Dare, Hyde, Tyrrell, Washington and Beaufort) and include three national wildlife refuges, a U.S. Air Force bombing range, and private land (51). The red wolf recovery program is unique for a large carnivore reintroduction in that more than half of the land used for reintroduction lies on private property. Approximately 680,000 acres (2,800 km^2) are federal and state lands, and 1,002,000 acres

(4,050 km^2) are private lands. Beginning in 1991, red wolves were also released into the Great Smoky Mountains National Park in eastern Tennessee (50). However, due to exposure to environmental disease (parvovirus), parasites and competition (with coyotes as well as intraspecific aggression), the red wolf was unable to successfully establish a wild population in the park. Low prey density was also a problem, forcing the wolves to leave the park boundaries in pursuit of food in lower elevations. In 1998, the FWS removed the remaining red wolves in the Great Smoky Mountains National Park, relocating them to Alligator River National Wildlife Refuge in eastern North Carolina (52). Other red wolves have been released on the coastal islands in Florida, Mississippi, and South Carolina as part of the captive breeding management plan. St. Vincent Island in Florida is currently the only active island propagation site.

Given their wide historical distribution, red wolves probably utilized a large suite of habitat types at one time. The last naturally occurring population utilized coastal prairie marshes, swamps and agricultural fields used to grow rice and cotton. However, this environment probably does not typify preferred red wolf habitat. There is evidence that the species was found in highest numbers in the once extensive bottom land river forests and swamps of the southeastern United States. Red wolves re-introduced into northeastern North Carolina have utilized habitat types ranging from agricultural lands to forest/wetland mosaics characterized by an over story of pine and an understory of evergreen shrubs. This suggests that red wolves are habitat generalists and can thrive in most settings where prey populations are adequate and persecution by humans is slight (53).

History and conservation

Discovery and persecution

Before the arrival of Europeans, the red wolf featured prominently in Cherokee mythology, where it is known as *wa'ya* (Ꭶꮕ), said to be the companion of Kana'ti the hunter and father of the Aniwaya or Wolf Clan (54). Its reddish color was seen as symbolizing war, as well as all things sacred and beloved (55). Cherokees generally avoided killing red wolves, as it was believed that such an act would bring about the vengeance of the killed animals' pack-mates (56).

The red wolf was first described by William Bartram, who encountered it in Florida and wrote of it in his *Travels* (1791), noting that it was smaller and lighter in color than the gray wolves of Canada and Pennsylvania (53). John James Audubon was the first to describe the red wolf in detail, giving it the trinomial name of *Canis lupus rufus* in 1851. He described it as being more fox-like than the gray wolf, but retaining the same "sneaking, cowardly, yet ferocious disposition". Audubon also recounted that red wolves occasionally fed on the battlefield corpses of fallen soldiers during the Mexican–American War (2). The red wolf's full specific rank was first given by Edward Goldman in 1937, who examined a number of skulls and noted that the red wolf's skull and dentition differed from those of gray wolves, and closely approached those of coyotes. He wrote that by the time of writing, the species may have become extinct in the lower Sonoran zone, where it was heavily persecuted by ranchmen. Stanley P. Young noted in 1940 that the red wolf was still common in eastern Texas, where more than 800 had been caught in 1939, and further cast doubt over the prospect of fully exterminating them, due to their habit of living concealed in thickets (6). However, by 1962, red wolf sightings became increasingly rare, and few tracks or scats were found (11).

Captive breeding and reintroduction

Formal efforts backed by the U.S. Fish and Wildlife Service began to save the red wolf from extinction in 1973 when a captive breeding program was established at the Point Defiance Zoological Gardens, Tacoma, Washington. Four hundred animals were captured from southwestern Louisiana and southeastern Texas from 1973 to 1980 by the US Fish and Wildlife Service (57), (58). Measurements, vocalization analyses, and skull X-rays were used to distinguish red wolves from coyotes and red wolf-coyote hybrids (57). Of the 400 animals captured, only 43 were believed to be red wolves and sent to the breeding facility. The first litters were produced in captivity in May 1977. Some of the pups were determined to be hybrids, and they and their parents were removed from the captive breeding program. Of the original 43 animals, only 17 were considered pure red wolves and since three were unable to breed, 14 became the breeding stock for the captive breeding program (58). These 14 were so closely related that they had the genetic effect of being only eight individuals.

In Dec. 1976, two wolves were released onto Cape Romain National Wildlife Refuge's Bulls Island in South Carolina with the intent of testing and honing reintroduction methods. They were not released with the intent of beginning a permanent population on the island (59). The first experimental trans location lasted for 11 days, during which a mated pair of red wolves were monitored day and night

with remote telemetry. A second experimental trans location was tried in 1978 with a different mated pair, and they were allowed to remain on the island for close to nine months (59). After that, a larger project was executed in 1987 to reintroduce a permanent population of red wolves back to the wild in the Alligator River National Wildlife Refuge (ARNWR) on the eastern coast of North Carolina. Also in 1987, Bulls Island became the first island breeding site. Pups were raised on the island and relocated to North Carolina until 2005 (60).

In September 1987, four male-female pairs of red wolves were released in Alligator River National Wildlife Refuge in northeastern North Carolina and designated as an experimental population. Since then, the experimental population has grown and the recovery area expanded to include four national wildlife refuges, a Department of Defense bombing range, state-owned lands, and private lands, encompassing about 1,700,000 acres (6,900 km^2) (61).

In 1989, the second island propagation project was initiated with release of a population on Horn Island off the Mississippi coast. This population was removed in 1998 because of a likelihood of encounters with humans. The third island propagation project introduced a population on St. Vincent Island, Florida offshore between Cape San Blas and Apalachicola, Florida in 1990, and in 1997 the fourth island propagation program introduced a population to Cape St. George Island, Florida south of Apalachicola, Florida.

In 1991, two pairs were reintroduced into the Great Smoky Mountains National Park, where the last known red wolf was killed in 1905. Despite some early success, the wolves were relocated to North Carolina in 1998, ending the effort to reintroduce the species to the park. In 2007, the US Fish and Wildlife Service estimated that there were 300 red wolves remaining in the world, with 207 of those in captivity (62).

According to the latest Red Wolf Recovery Program First Quarter Report (October–December 2010), the US Fish and Wildlife Service estimates that there are currently 110-130 red wolves in the Red Wolf Recovery Area in North Carolina, however, since not all of the newly bred in the wild red wolves have radio collars, they can only confirm a total of 70 "known" individuals, 26 packs, 11 breeding pairs, and 9 additional individuals not associated with a pack (51).

Interbreeding with the coyote has been recognized as a threat affecting the restoration of red wolves. Currently, adaptive management efforts are making progress in reducing the threat of coyotes to the red wolf population in northeastern North Carolina. Other threats, such as habitat fragmentation, disease, and anthropogenic mortality, are of concern in the restoration of red wolves. Efforts to reduce the threats are presently being explored (51). Over 30 facilities participate in the red wolf Species Survival Plan and oversee the breeding and reintroduction of over 150 wolves (63).

In 2012, the Southern Environmental Law Center filed a lawsuit against the North Carolina Wildlife Resources Commission for jeopardizing the existence of the wild red wolf population by allowing nighttime hunting of coyotes in the 5-county restoration area in eastern North Carolina (64). A 2014 court-approved settlement agreement was reached that banned nighttime hunting of coyotes and requires permitting and reporting coyote hunting (64). In response to the settlement, the North Carolina Wildlife Resources Commission adopted a resolution requesting the United States Fish and Wildlife Service to remove all wild red wolves from private lands, terminate recovery efforts, and declare red wolves extinct in the wild (65). This resolution came in the wake of a 2014 programmatic review of the red wolf conservation program conducted by The Wildlife Management Institute (66), (67), (68). The Wildlife Management Institute indicated the reintroduction of the red wolf was an incredible achievement. The report indicated that red wolves could be released and survive in the wild but that illegal killing of red wolves threatens the long-term persistence of the population (68). The report stated that the United States Fish and Wildlife Service needed to update its red wolf recovery plan, thoroughly evaluate its strategy for preventing coyote hybridization and increase its public outreach (69). Since the programmatic review, the United States Fish and Wildlife Service ceased implementing the red wolf adaptive management plan that was responsible for preventing red wolf hybridization with coyotes and allowed the release of captive-born red wolves into the wild population (70). Since then, the wild population has decreased from 100-115 red wolves to 50-65 (71).

In 2014, the United States Fish and Wildlife Service issued the first take permit for a red wolf to a private landowner (72). Since then, the United States Fish and Wildlife Service issued several other take permits to landowners in the 5-county restoration area. During June 2015, a landowner shot and

killed a female red wolf after being authorized a take permit, causing a public outcry (73), (74). In response, the Southern Environmental Law Center filed a lawsuit against the United States Fish and Wildlife Service for violating the Endangered Species Act (75).

RED WOLF
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AN AGROFORESTRY SAMPLER
Lenny Truitt and Glen Mellin
March 2017

(SLIDE 1), TITLE PAGE.

We are assessing the composition, timing, and magnitude of ecological change within Native American traditional landscapes. Following Historical Ecology, we envision culture and the environment as a "two-way street". Signals and feedback were sent and received, resulting in the development of ritualized landscapes.

Our approach recognizes ecological catchment areas as direct results of active human agency. Clearly, we are not talking about forager adaptation to resilient external factors. This approach is particularly useful for the latter half of the Holocene, or from 6,000 to 400 years before present. Our economic model includes Public Landscaping, Agroforestry, and Creating Economic Strategies, forming the acronym, PLACES.

New research topics such as: landscape burning, culling non-beneficial plants, planting and transplanting beneficial plants--manufacturing monoculture woodlots, fruit and berry orchards--utility, vegetable and medicinal gardens—shellfish gardening, applying shellfish debris to acidic soils to support calcareous plant species, and intensified parenting of plants and animals, ALL may be addressed in PLACES.

Because primary and descendent examples of botanical artifacts are still with us, we need to consider Spacetime as the fourth dimension in organizing these features. We are now the trustees, the beneficiaries, and the managers of the remnants of these traditional landscapes. In the time remaining, we highlight two of our research topics: witness tree analysis, and the results of our ethnoecological survey along the Nanticoke River.

WITNESS TREE ANALYSIS

The first large-scale ecological descriptions of the Eastern Woodlands began with the government witness tree surveys. On May 20, 1785, the Continental Congress passed the Land Ordinance Act. This Act authorized the Treasury Department to "survey before settlement" and sell parcels of the Public Domain as a source of revenue.

Literally hundreds of government surveys were recorded as the frontier expanded. Just after the War of 1812, government surveys were conducted to the west end of Lake Superior. As surveyors recorded the quantities and species of trees and bushes along survey lines and axis points, they constructed geographic-botanical grid systems. These descriptions documented the composition of the surveyed landscapes at the very moments Native Americans were losing control of their lands.

Typically recorded on one-mile and quarter-mile grids, these surveys are the best landscape-scale views of what Native American anthropogenic landscapes, and their accumulated ecological capital actually looked like. Typically greater than 60 square miles in size, ecological catchment areas overlay persistent cultural locations.

Core areas, 6 miles in diameter, exhibit species like walnut, butternut, and hazelnut, various gardens, berry and grape arrangements, and fruit orchards. Intermediate areas, 6 miles to 10 miles in diameter, exhibit oak, hickory, and chestnut woodlots. Beyond 10 miles in diameter, surveyors

typically recorded climate-dominated species within the beech, hemlock, and maple biome, with southern and northern pine, and fir communities.

Ecological catchment areas do not occur naturally, they are products of human agency. Dispersed resources were moved to central locations, arranged, and stored as ecological capital. From the hundreds of early witness tree surveys spread out from New York, to Alabama, and as far west as Michigan, we see these anthropogenic landscape patterns repeated.

Agroforestry likely started small in the Lamoka, Bare Island, and Lackawaxen contexts. Archaeological evidence suggests landscape fire was pervasive. In Pennsylvania, the Memorial Park cucurbit, dated to 5,400 ago, likely existed as an adventive, perennial, creeper vine, planted along edge and fringe environments. Open areas likely supported self-seeding annual cultivars, like amaranth, chenopod, sunflower, and little barley.

By the end of Broadspear contexts, about 3,000 years ago, desirable perennials likely replaced most of the undesirable species within prescribed catchment areas. Next, we envision the adoption of a suite of adventive perennial and annual species as gardening intensified, coeval with the distribution of steatite vessels and the development of ceramic containers. The yield from these managed ecologies was likely 2 to 5 times more robust than climate-dominated, unmanaged ecologies found elsewhere on the landscape.

(SLIDE 2) NANTICOKE RIVER WATERSHED.

ETHNOECOLOGICAL SURVEY ALONG THE NANTICOKE RIVER

In 1608, Captain John Smith illustrated three Nanticoke Indian towns; Chicone, Kuskarawack, and Rivers End, evenly spaced about eight miles apart, along the Nanticoke River, a major tributary of the Chesapeake Bay. Our ethnoecological survey of these three locations, demonstrates that remnants of Native American ecological catchment areas are still recognizable today.

(SLIDE 3), BOX HUCKLEBERRY FOUND AT RIVERS END.

THE RIVERS END CATCHMENT AREA

At Rivers End, we surveyed an area about six miles in diameter, in and around a clustering of known archaeological sites. We documented a three-acre box huckleberry cluster (a globally rare, adventive, clone forming, reproductively self-incompatible, evergreen, perennial species).

Margret Pooler from the National Arboretum said (based on this plant's size) Native Americans likely transplanted this clone to this location about 2,000 years ago. We also found several long lines of evenly spaced american chestnut coppices, prickly pear, pitcher plant, and yucca clusters, extensive patches of lowbush berries, two clusters of chinquapin (an adventive, deciduous, perennial, nut species), and maypop (an adventive, deciduous, perennial creeper vine), all nestled within the extensive remains of white oak, hickory, and pine forest settings.

(SLIDE 4) MAYPOP FOUND AT RIVERS END.

Based on the results of our survey, the main economic focus was acorn and nut production, together with upland species, like turkey and deer that would have been attracted to this type of manufactured landscape. Attracting abundant turkey and deer to highly productive anthropogenic landscapes is also an accumulation of ecological capital.

(SLIDE 5) LENNY, MEASURING RESTORED CHINQUAPIN COPPICE WITH FLOWERING CATKINS AT RIVERS END.

We actually own the land parcels containing the box huckleberry cluster and one of the two-acre chinquapin clusters. The box huckleberry is doing fine in its shaded white oak setting, but our chinquapin cluster was suffering from over-crowding and lack of sunlight. We restored about 200 of the chinquapin coppices by removing the forest canopy. These chinquapins are recovering and produce abundant nuts, which we regularly consume. Yes, we do eat these artifacts!

(SLIDE 6) GLEN, MEASURING THE PROGRESS OF A RESTORED CHINQUAPIN COPPICE AT RIVERS END.

(SLIDE 7) ABUNDANT BURRS ON RESTORED CHINQUAPIN COPPICE AT RIVERS END.

THE KUSKARAWACK CATCHMENT AREA

At Kuskarawack, we surveyed twenty square miles in and around the known archaeological sites. We documented an arrow arum starchy tuber complex, an upland game complex, an anadromous fish complex, a two square mile highbush berry cluster, two prickly pear cactus clusters, two yucca clusters, shad bush clusters, christmas fern and crowsfoot garden areas, and creeping cucumber (an adventive, deciduous, perennial creeper vine from Mexico).

(SLIDE 8) CREEPING CUCUMBER FOUND AT KUSKARAWACK.

These little watermelons taste just like cucumbers.

Margret Pooler and colleagues analyzed the genotypes of three box huckleberry clusters located in the Kuskarawack catchment area in 2006. Pooler identified these clusters as direct descents of an ancestral cluster located in southern Kentucky.

<u>ALL OF THESE IDENTIFIED CLUSTERS IN THE KUSKARAWACK CATCHMENT AREA ARE SURROUNDED BY AN AMERICAN CHESTNUT CIRCLE MEASURING SIX-MILES IN DIAMETER.</u>

(SLIDE 9) KUSKARAWACK, SURVEY AREA AND AMERICAN CHESTNUT CIRCLES.

Chestnut circles appear to be important food sources planted along footpaths, as well as serving as symbolic palisades. So far, all chestnut and chinquapin clusters that we identified on the lower coastal plain appear to be cultural arrangements. The Nanticoke River runs through these catchment areas, not around them. The river, it seems, is not a boundary at all, but serves as the physical core of these ritualized landscape areas.

THE CHICONE CATCHMENT AREA

At Chicone, we conducted a very brief two-day assessment. We found the Indian corn soils described by Virginia Busby and others. These soils exhibit very broad, but light scatters of old shellfish remains. There had been an effort to add calcium to these soils. Chicone likely supported Native American cornfields, while the Kuskarawack and Rivers End settlements did not.

Along Chicone Creek, we identified extensive fern gardens, acres of mayapple, clusters of seaside alder (a globally rare, deciduous conifer), and floodplains carpeted with skunk cabbage. A nearby basin still supports a five square mile cluster of edible high-bush berry. The economic focus of the

Chicone catchment area was at minimum, tending a variety of perennials and annuals, growing cultivars and cultigens, together with shellfish processing and storage.

At first glance, these three ecological catchment areas along the Nanticoke River appear to be contiguous, likely abutting one another. They were, contemporaneously occupied by one defined group, the Nanticoke Indian people.

These ecological settings share the same elevation, the same base soils, the same growing seasons, and so on. Yet, the residents of each Indian town, or each lineage appear to have assembled different types of botanical resources as ecological capital.

We can speculate the entire Nanticoke Indian group would have benefited from these diversified, manufactured ecologies. The key concept is organized diversity, that would act as an insurance policy against catastrophic failure.

If the remnants of traditional landscapes are still visible, and we believe they are, then our documentation of PLACES in Spacetime likely details lineage-based relationships within a definable cultural group.

We would like to thank Carol Nash and Heather Wholey for inviting us to share our paper.

And a huge thank you to the Middle Atlantic Arch Conference for sponsoring the conference.

APPENDIX 1

Appendix 1 is a complete list of plants currently found in, and previously found in Delaware. The original excel spreadsheet was created by Dr. William A. McAvoy, state botanist with the Delaware Division of Fish & Wildlife, Species Conservation and Research Program (McAvoy, June 24, 2013, per. com.). For the purposes of this synthesis, we copied Dr. McAvoy's list, cropped many technical columns in order to reduce the document width to one page, retaining information we felt relevant to this synthesis.

Our cropped excel spreadsheet (see below) contains all 1,714 plant species known to exist or have existed in Delaware (some species are extirpated). This spreadsheet is divided into five columns. Column A is the scientific name using Genus and species, and when appropriate, variety. Column B offers synonym when appropriate. Column C is the common name. Column D is the physiographic province in Delaware where the plant is documented. Finally, Column E is the current state status.

SCIENTIFIC NAME	SYNONYM	COMMON NAME	PHYSIOGRAPHIC PROVINCE	STATE STATUS
Acalypha gracilens		slender copperleaf	Piedmont-Coastal Plain	Common
Acalypha rhomboidea		rhomboid copperleaf	Piedmont-Coastal Plain	Common
Acalypha virginica		Virginia copperleaf	Piedmont-Coastal Plain	Common
Acer negundo var. *negundo*		box elder	Piedmont-Coastal Plain	Common
Acer nigrum		black maple	Piedmont	Adventive
Acer rubrum var. *rubrum*		red maple	Piedmont-Coastal Plain	Common
Acer rubrum var. *trilobum*		red maple	Piedmont-Coastal Plain	Common
Acer saccharinum		silver maple	Piedmont	Common
Acer saccharum var. *saccharum*		sugar maple	Piedmont	Uncommon
Acorus americanus		American sweetflag	Coastal Plain	Historical
Actaea pachypoda		white baneberry	Piedmont	Rare
Actaea racemosa	*Cimicifuga racemosa*	black cohosh	Piedmont-Coastal Plain	Common
Adiantum pedatum		maidenhair-fern	Piedmont-Coastal Plain	Uncommon
Adlumia fungosa		climbing fumitory	Piedmont	Extirpated
Aeschynomene virginica		sensitive joint-vetch	Coastal Plain	Extirpated
Agalinis linifolia	*Gerardia linifolia*	flaxleaf flase foxglove	Coastal Plain	Historical
Agalinis maritima var. *maritima*	*Gerardia maritima*	salt marsh false foxglove	Coastal Plain	Rare
Agalinis obtusifolia	*Agalinis decemloba; A. parvifolia; Gerardia decemloba; G. obtusifolia; G. parvifolia*	ten-lobe false foxglove	Coastal Plain	Historical
Agalinis purpurea	*Gerardia purpurea; G. racemulosa*	large-purple false foxglove	Piedmont-Coastal Plain	Common
Agalinis setacea	*Gerardia setacea*	thread-leaved false foxglove	Coastal Plain	Rare
Agalinis tenuifolia var. *tenuifolia*	*Gerardia tenuifolia* var. *tenuifolia*	slender false foxglove	Piedmont-Coastal Plain	Rare
Agastache foeniculum		blue giant-hyssop	Piedmont	Adventive
Agastache nepetoides		yellow giant hyssop	Piedmont-Coastal Plain	Rare
Agastache scrophulariifolia		purple giant hyssop	Piedmont	Historical
Ageratina altissima var. *altissima*	*Eupatorium rugosum*	white snakeroot	Piedmont-Coastal Plain	Common
Ageratina aromatica	*Eupatorium aromaticum*	lesser snakeroot	Piedmont-Coastal Plain	Status Uncertain
Agrimonia gryposepala		tall hairy agrimony	Piedmont-Coastal Plain	Uncommon
Agrimonia parviflora		swamp agrimony	Piedmont-Coastal Plain	Common
Agrimonia pubescens		downy agrimony	Piedmont-Coastal Plain	Uncommon
Agrimonia rostellata		woodland agrimony	Piedmont-Coastal Plain	Uncommon
Agrimonia striata		edge agrimony	Piedmont	Rare
Agrostis hyemalis		winter bentgrass	Piedmont-Coastal Plain	Common
Agrostis perennans		perennial bentgrass	Piedmont-Coastal Plain	Common
Aletris farinosa		white-tubed colicroot	Coastal Plain	Uncommon
Alisma subcordatum		broadleaf water-plantain	Piedmont-Coastal Plain	Common
Allium canadense var. *canadense*		meadow onion	Piedmont-Coastal Plain	Common
Allium tricoccum		ramp	Piedmont	Uncommon
Alnus maritima subsp. *maritima*		Delmarva alder	Coastal Plain	Uncommon
Alnus serrulata		common alder	Piedmont-Coastal Plain	Common

Alopecurus aequalis		short-awn foxtail	Piedmont-Coastal Plain	Common
Alopecurus carolinianus		tufted foxtail	Piedmont-Coastal Plain	Common
Amaranthus albus		white pigweed amaranth	Piedmont-Coastal Plain	Adventive
Amaranthus blitoides	*Amaranthus graecizans*	prostrate amaranth	Piedmont	Adventive
Amaranthus cannabinus	*Acnida cannabina*	waterhemp amaranth	Coastal Plain	Common
Amaranthus palmeri		Palmer's amaranth	Coastal Plain	Adventive
Amaranthus pumilus		seabeach amaranth	Coastal Plain	Rare
Amaranthus tuberculatus	*Acnida tamariscina; Amaranthus rudis*	tall amaranth	Piedmont	Adventive
Ambrosia artemisiifolia		ragweed	Piedmont-Coastal Plain	Common
Ambrosia trifida		giant ragweed	Piedmont-Coastal Plain	Common
Amelanchier arborea		downy shadbush	Piedmont-Coastal Plain	Common
Amelanchier canadensis var. *canadensis*		shadbush	Piedmont-Coastal Plain	Common
Amelanchier canadensis var. *obovalis*	*Amelanchier obovalis*	round-leaf shadbush	Coastal Plain	Status Uncertain
Amianthium muscitoxicum		fly-poison	Piedmont-Coastal Plain	Rare
Ammannia coccinea		toothcup ammannia	Coastal Plain	Common
Ammophila breviligulata		American beachgrass	Coastal Plain	Common
Amorpha fruticosa		false indigo-bush	Piedmont-Coastal Plain	Common
Ampelopsis cordata		raccoon grape	Coastal Plain	Adventive
Amphicarpaea bracteata var. *bracteata*		American hog-peanut	Piedmont-Coastal Plain	Common
Amphicarpaea bracteata var. *comosa*	*Amphicarpaea pitcheri*	hairy American hog-peanut	Piedmont-Coastal Plain	Common
Amphicarpum amphicarpon	*Amphicarpum purshii*	peanut grass	Coastal Plain	Rare
Amsonia tabernaemontana		blue-star	Piedmont	Adventive
Anagallis minima	*Centunculus minimus*	chaffweed	Coastal Plain	Status Uncertain
Anaphalis margaritacea	*Gnaphalium margaritaceum*	pearly everlasting	Piedmont	Historical
Andropogon elliottii	*Andropogon elliottii* var. *projectus; A. gyrans*	Elliott's bluestem	Piedmont-Coastal Plain	Historical
Andropogon gerardii		big bluestem	Piedmont-Coastal Plain	Common
Andropogon glomeratus var. *glomeratus*		common bushy broom-sedge	Piedmont-Coastal Plain	Common
Andropogon hirsutior	*Andropogon glomeratus* var. *hirsutior*	Southern bushy broom-sedge	Coastal Plain	Rare
Andropogon ternarius var. *ternarius*		silver bluestem	Coastal Plain	Common
Andropogon virginicus var. *virginicus*		Virginia broom-sedge	Piedmont-Coastal Plain	Common
Anemone americana	*Hepatica americana; H. nobilis* var. *obtusa*	roundlobed hepatica	Piedmont-Coastal Plain	Uncommon
Anemone quinquefolia var. *quinquefolia*		wood anemone	Piedmont-Coastal Plain	Common
Anemone virginiana var. *virginiana*		Virginia anemone	Piedmont-Coastal Plain	Common
Angelica atropurpurea		great Angelica	Piedmont	Rare
Angelica venenosa		hairy Angelica	Piedmont-Coastal Plain	Rare
Antennaria howellii subsp. *neodioica*	*Antennaria neodioica*	blunt little-leaf pussytoes	Piedmont-Coastal Plain	Common
Antennaria neglecta		pointed little-leaf pussytoes	Piedmont-Coastal Plain	Common
Antennaria parlinii subsp. *fallax*	*Antennaria fallax*	hairy big-leaf pussytoes	Piedmont-Coastal Plain	Common
Antennaria parlinii subsp. *parlinii*		glabrous big-leaf pussytoes	Piedmont-Coastal Plain	Common
Antennaria plantaginifolia		hairy plantain-leaf pussytoes	Piedmont-Coastal Plain	Common
Anthoxanthum hirtum	*Hierochloe odorata*	vanilla grass	Coastal Plain	Rare
Apios americana		swamp groundnut	Piedmont-Coastal Plain	Common
Aplectrum hyemale		puttyroot	Piedmont	Rare
Apocynum androsaemifolium		spreading dogbane	Piedmont-Coastal Plain	Rare
Apocynum cannabinum		clasping-leaf dogbane	Piedmont-Coastal Plain	Common

Apocynum sibiricum		clasping-leaved dogbane	Coastal Plain	Historical
Aquilegia canadensis		wild columbine	Piedmont-Coastal Plain	Rare
Arabidopsis lyrata subsp. *lyrata*	*Arabis lyrata*	lyre-leaf rockcress	Piedmont-Coastal Plain	Rare
Aralia nudicaulis		wild sarsaparilla	Piedmont-Coastal Plain	Common
Aralia racemosa		American spikenard	Piedmont-Coastal Plain	Uncommon
Aralia spinosa		Hercules club	Coastal Plain	Common
Arctostaphylos uva-ursi		bearberry	Coastal Plain	Extirpated
Arethusa bulbosa		dragon's mouth orchid	Coastal Plain	Historical
Arisaema dracontium		green dragon	Piedmont	Rare
Arisaema triphyllum subsp. *pusillum*		small Jack-in-the-Pulpit	Piedmont-Coastal Plain	Common
Arisaema triphyllum subsp. *triphyllum*		swamp Jack-in-the-Pulpit	Piedmont-Coastal Plain	Common
Aristida dichotoma var. *curtissii*		Curtis's three-awn grass	Coastal Plain	Common
Aristida dichotoma var. *dichotoma*		three-awn grass	Piedmont-Coastal Plain	Common
Aristida lanosa		woolly three-awn grass	Coastal Plain	Historical
Aristida longespica var. *longespica*		long-spiked three-awn grass	Piedmont-Coastal Plain	Common
Aristida oligantha		prairie three-awn grass	Piedmont-Coastal Plain	Common
Aristida purpurascens		purple three-awn grass	Coastal Plain	Common
Aristida virgata		wand-like three-awn grass	Coastal Plain	Rare
Arnica acaulis		leopard's-bane	Coastal Plain	Historical
Arnoglossum atriplicifolium	*Cacalia atriplicifolia*	pale Indian-plantain	Piedmont-Coastal Plain	Rare
Aronia arbutifolia	*Pyrus arbutifolia*	red chokeberry	Piedmont-Coastal Plain	Common
Aronia melanocarpa	*Pyrus melanocarpa*	black chokeberry	Piedmont	Historical
Aronia prunifolia	*Aronia* x*prunifolia*	purple chokeberry	Piedmont-Coastal Plain	Status Uncertain
Artemisia biennis		biennial wormwood	Piedmont-Coastal Plain	Adventive
Artemisia ludoviciana		sagebrush wormwood	Piedmont-Coastal Plain	Adventive
Asarum canadense var. *canadense*		Canada wild-ginger	Piedmont-Coastal Plain	Common
Asclepias amplexicaulis		clasping milkweed	Piedmont-Coastal Plain	Uncommon
Asclepias exaltata		poke milkweed	Piedmont	Rare
Asclepias incarnata subsp. *incarnata*		marsh milkweed	Piedmont-Coastal Plain	Status Uncertain
Asclepias incarnata subsp. *pulchra*		swamp milkweed	Piedmont-Coastal Plain	Common
Asclepias lanceolata		lance-leaf orange milkweed	Coastal Plain	Rare
Asclepias longifolia		long-leaf milkweed	Coastal Plain	Extirpated
Asclepias purpurascens		purple milkweed	Piedmont-Coastal Plain	Rare
Asclepias quadrifolia		four-leaved milkweed	Piedmont	Historical
Asclepias rubra		red milkweed	Piedmont-Coastal Plain	Rare
Asclepias syriaca		common milkweed	Piedmont-Coastal Plain	Common
Asclepias tuberosa var. *tuberosa*		butterfly milkweed	Piedmont-Coastal Plain	Common
Asclepias variegata		white milkweed	Piedmont-Coastal Plain	Rare
Asclepias verticillata		whorled milkweed	Piedmont-Coastal Plain	Historical
Asclepias viridiflora		green milkweed	Piedmont-Coastal Plain	Uncommon
Asimina triloba		pawpaw	Piedmont-Coastal Plain	Common
Asplenium platyneuron		ebony spleenwort	Piedmont-Coastal Plain	Common
Asplenium rhizophyllum		walking-fern spleenwort	Piedmont	Extirpated
Asplenium trichomanes subsp. *trichomanes*		maidenhair spleenwort	Piedmont	Rare
Athyrium filix-femina var. *angustum*		Northern lady fern	Piedmont-Coastal Plain	Common
Athyrium filix-femina var. *asplenioides*		Southern lady fern	Piedmont-Coastal Plain	Common
Atriplex mucronata	*Atriplex arenaria; A. cristata*	crested saltbush	Coastal Plain	Uncommon
Aureolaria flava var. *flava*		yellow false-foxglove	Piedmont-Coastal Plain	Rare
Aureolaria pedicularia var. *pedicularia*		fernleaf yellow false foxglove	Piedmont-Coastal Plain	Rare
Aureolaria virginica		downy false-foxglove	Piedmont-Coastal Plain	Common

Avenella flexuosa	*Deschampsia flexuosa*	wavy hairgrass	Coastal Plain	Common
Azolla caroliniana		Eastern mosquito-fern	Piedmont-Coastal Plain	Adventive
Baccharis halimifolia		groundsel tree	Coastal Plain	Common
Baptisia tinctoria		yellow wild indigo	Piedmont-Coastal Plain	Common
Bartonia paniculata subsp. *paniculata*		twining bartonia	Piedmont-Coastal Plain	Rare
Bartonia virginica		yellow screwstem	Piedmont-Coastal Plain	Common
Betula lenta		sweet birch	Piedmont-Coastal Plain	Common
Betula nigra		river birch	Piedmont-Coastal Plain	Common
Betula populifolia		gray birch	Piedmont-Coastal Plain	Rare
Bidens bidentoides		estuary tick-seed	Coastal Plain	Historical
Bidens bipinnata		Spanish-needle tick-seed	Piedmont-Coastal Plain	Common
Bidens cernua		nodding tick-seed	Piedmont-Coastal Plain	Common
Bidens comosa		three-lobe tick-seed	Piedmont-Coastal Plain	Common
Bidens connata		purple-stem tick-seed	Piedmont-Coastal Plain	Status Uncertain
Bidens discoidea		swamp tick-seed	Coastal Plain	Common
Bidens frondosa		devil's tick-seed	Piedmont-Coastal Plain	Common
Bidens laevis		smooth tick-seed	Coastal Plain	Common
Bidens mitis		small-fruited tick-seed	Coastal Plain	Rare
Bidens polylepis		tick-seed sunflower	Piedmont-Coastal Plain	Adventive
Bidens trichosperma	*Bidens coronata* var. *brachyodonata; B. coronata* var. *trichosperma*	Northern tick-seed sunflower	Coastal Plain	Uncommon
Bidens vulgata		tall tick-seed	Piedmont-Coastal Plain	Uncommon
Blephilia ciliata		downy woodmint	Piedmont	Historical
Blephilia hirsuta		hairy woodmint	Piedmont	Historical
Boechera canadensis	*Arabis canadensis*	sicklepod	Piedmont-Coastal Plain	Rare
Boechera laevigata var. *laevigata*	*Arabis laevigata* var. *laevigata*	smooth rockcress	Piedmont	Rare
Boechera stricta	*Arabis drummondii*	Drummond's rockcress	Piedmont	Historical
Boehmeria cylindrica		false nettle	Piedmont-Coastal Plain	Common
Bolboschoenus fluviatilis	*Schoenoplectus fluviatilis; Scirpus fluviatilis*	river bulrush	Coastal Plain	Common
Bolboschoenus novae-angliae	*Schoenoplectus novae-angliae; Scirpus cylindricus*	brackish bulrush	Coastal Plain	Rare
Bolboschoenus robustus	*Schoenoplectus robustus*; *Scirpus robustus*	salt marsh bulrush	Coastal Plain	Common
Boltonia asteroides var. *glastifolia*		aster-like boltonia	Coastal Plain	Rare
Botrychium matricariifolium		daisy-leaf moonwort	Piedmont	Rare
Botrypus virginianus	*Botrychium virginianum*	rattlesnake fern	Piedmont-Coastal Plain	Common
Brachyelytrum erectum		bearded short-husk grass	Piedmont-Coastal Plain	Uncommon
Brasenia schreberi		watershield	Coastal Plain	Common
Bromus latiglumis	*Bromus altissimus*	broad-glumed brome	Piedmont	Rare
Bromus pubescens	*Bromus purgans*	hairy wood brome	Piedmont	Rare
Buchnera americana		bluehearts	Piedmont-Coastal Plain	Historical
Bulbostylis capillaris		dense-tuft hair-sedge	Piedmont-Coastal Plain	Common
Cabomba caroliniana		Carolina fanwort	Coastal Plain	Adventive
Cakile edentula		American sea-rocket	Coastal Plain	Common
Calamagrostis canadensis var. *canadensis*		blue-joint reedgrass	Coastal Plain	Rare
Calamagrostis cinnoides	*Calamagrostis coarctata*	Nuttall's reedgrass	Coastal Plain	Common
Callitriche heterophylla		large water-starwort	Piedmont-Coastal Plain	Common
Callitriche terrestris	*Callitriche austinii*	pond water-starwort	Piedmont-Coastal Plain	Uncommon
Callitriche verna	*Callitriche palustris*	vernal water-starwort	Piedmont-Coastal Plain	Status Uncertain
Calopogon tuberosus var. *tuberosus*		grass-pink orchid	Piedmont-Coastal Plain	Rare
Caltha palustris		marsh marigold	Piedmont-Coastal Plain	Rare
Calycanthus floridus var. *floridus*		hairy sweet-shrub	Coastal Plain	Adventive

Calycanthus floridus var. *glaucus*		smooth sweet-shrub	Piedmont	Adventive
Calystegia sepium var. *sepium*	*Convolvulus sepium*	hedge bindweed	Piedmont-Coastal Plain	Common
Calystegia spithamaea subsp. *spithamaea*	*Convolvulus spithamaeus*	low bindweed	Piedmont	Rare
Campanula aparinoides		marsh bellflower	Piedmont-Coastal Plain	Rare
Campsis radicans		trumpet-creeper	Piedmont-Coastal Plain	Common
Cardamine angustata	*Dentaria heterophylla*	slender toothwort	Piedmont	Rare
Cardamine bulbosa		bulbous bitter-cress	Piedmont-Coastal Plain	Common
Cardamine concatenata	*Dentaria laciniata*	cutleaf toothwort	Piedmont-Coastal Plain	Common
Cardamine diphylla		pepper-root bittercress	Piedmont	Adventive
Cardamine longii		Long's bittercress	Coastal Plain	Rare
Cardamine parviflora var. *arenicola*		small-flower bittercress	Piedmont-Coastal Plain	Rare
Cardamine pensylvanica		Pennsylvania bittercress	Piedmont-Coastal Plain	Common
Cardamine rotundifolia		roundleaf bittercress	Piedmont	Rare
Carex abscondita		thicket sedge	Piedmont-Coastal Plain	Common
Carex aggregata	*Carex sparganioides* var. *aggregata*	glomerate sedge	Piedmont-Coastal Plain	Common
Carex alata		broadwing sedge	Coastal Plain	Common
Carex albicans var. *albicans*	*Carex artiteca*	bellow-beaked sedge	Piedmont-Coastal Plain	Common
Carex albicans var. *emmonsii*	*Carex emmonsii*	Emmons's sedge	Piedmont-Coastal Plain	Common
Carex albolutescens		greenish-white sedge	Coastal Plain	Common
Carex amphibola		Eastern narrowleaf sedge	Piedmont-Coastal Plain	Common
Carex annectens	*Carex annectens* var. *xanthocarpa*	yellow-fruited sedge	Piedmont-Coastal Plain	Common
Carex argyrantha		hay sedge	Piedmont	Extirpated
Carex atlantica subsp. *atlantica*		Atlantic sedge	Piedmont-Coastal Plain	Common
Carex atlantica subsp. *capillacea*	*Carex howei*	narrow-leaf Atlantic sedge	Piedmont-Coastal Plain	Common
Carex barrattii		Barratt's sedge	Coastal Plain	Uncommon
Carex bicknellii		Bicknel's sedge	Piedmont	Extirpated
Carex blanda		woodland sedge	Piedmont-Coastal Plain	Common
Carex brevior		fescue sedge	Piedmont	Extirpated
Carex bromoides subsp. *bromoides*		brome-like sedge	Piedmont-Coastal Plain	Rare
Carex bullata		button sedge	Coastal Plain	Uncommon
Carex bushii		Bush's sedge	Piedmont	Rare
Carex buxbaumii		Buxbaum's sedge	Coastal Plain	Rare
Carex canescens subsp. *canescens*		approximate silvery sedge	Coastal Plain	Status Uncertain
Carex canescens subsp. *disjuncta*		remote silvery sedge	Coastal Plain	Common
Carex caroliniana		hirsute sedge	Piedmont-Coastal Plain	Common
Carex cephalophora		oval-leaved sedge	Piedmont-Coastal Plain	Common
Carex collinsii		Collins' sedge	Coastal Plain	Uncommon
Carex communis var. *communis*		fibrous-root sedge	Piedmont	Rare
Carex comosa		bristly sedge	Piedmont-Coastal Plain	Common
Carex complanata		sedge	Piedmont-Coastal Plain	Common
Carex conjuncta		soft fox sedge	Piedmont	Uncommon
Carex conoidea		field sedge	Piedmont	Rare
Carex crinita var. *brevicrinis*		symmetrical fringed sedge	Coastal Plain	Common
Carex crinita var. *crinita*		asymmetrical fringed sedge	Piedmont-Coastal Plain	Common
Carex cristatella		crested sedge	Piedmont	Rare
Carex davisii		Davis' sedge	Piedmont	Rare
Carex debilis		white-edge sedge	Piedmont-Coastal Plain	Common
Carex decomposita		cypress-knee sedge	Coastal Plain	Rare
Carex digitalis var. *digitalis*		slender wood sedge	Piedmont-Coastal Plain	Common
Carex emoryi		Emory's sedge	Piedmont-Coastal Plain	Rare
Carex exilis		coast sedge	Coastal Plain	Rare
Carex festucacea		fescue sedge	Piedmont-Coastal Plain	Common
Carex folliculata		follicle sedge	Coastal Plain	Common

Carex frankii		Frank's sedge	Piedmont-Coastal Plain	Common
Carex gigantea		giant sedge	Coastal Plain	Uncommon
Carex glaucodea	*Carex flaccosperma* var. *glaucodea*	flaccid sedge	Piedmont-Coastal Plain	Common
Carex gracilescens		slender sedge	Piedmont	Rare
Carex gracillima		graceful sedge	Piedmont-Coastal Plain	Uncommon
Carex granularis		meadow sedge	Piedmont-Coastal Plain	Uncommon
Carex grisea	*Carex amphibola* var. *turgida*	inflated narrowleaf sedge	Piedmont	Rare
Carex gynandra	*Carex crinita* var. *gynandra*	nodding sedge	Piedmont-Coastal Plain	Rare
Carex hirsutella	*Carex complanata* var. *hirsuta*	hirsute sedge	Piedmont-Coastal Plain	Common
Carex hirtifolia		pubescent sedge	Piedmont	Uncommon
Carex hormathodes		marsh straw sedge	Coastal Plain	Uncommon
Carex intumescens		bladder sedge	Piedmont-Coastal Plain	Common
Carex jamesii		James's sedge	Piedmont	Rare
Carex joorii		cypress-swamp sedge	Coastal Plain	Rare
Carex kraliana		Kral's sedge	Coastal Plain	Rare
Carex lacustris		river-bank sedge	Coastal Plain	Rare
Carex laevivaginata		smooth-sheath sedge	Coastal Plain	Common
Carex laxiculmis var. *laxiculmis*		lax-culmed sedge	Piedmont-Coastal Plain	Common
Carex laxiflora		loose-flowered sedge	Piedmont-Coastal Plain	Common
Carex leptalea subsp. *harperi*		Coastal Plain bristly-stalk sedge	Coastal Plain	Uncommon
Carex leptalea subsp. *leptalea*		Piedmont bristly-stalk sedge	Piedmont	Rare
Carex limosa		mud sedge	Coastal Plain	Extirpated
Carex lonchocarpa	*Carex folliculata* var. *australis*	sedge	Coastal Plain	Common
Carex longii		greenish-white sedge	Coastal Plain	Common
Carex lucorum var. *lucorum*	Carex pensylvanica var. *distans*; *C. pensylvanica* var. *lucorum*	long-beaked sedge	Piedmont	Historical
Carex lupuliformis		false hop sedge	Coastal Plain	Rare
Carex lupulina		hop sedge	Piedmont-Coastal Plain	Common
Carex lurida		shallow sedge	Piedmont-Coastal Plain	Common
Carex mesochorea		midland sedge	Piedmont-Coastal Plain	Status Uncertain
Carex mitchelliana	*Carex crinita* var. *mitchelliana*	Mitchell's sedge	Coastal Plain	Uncommon
Carex molesta		troublesome sedge	Piedmont	Status Uncertain
Carex muehlenbergii var. *enervis*		Muhlenberg's nerveless sedge	Piedmont-Coastal Plain	Status Uncertain
muehlenbergii		Muhlenberg's nerved sedge	Piedmont-Coastal Plain	Common
Carex nigromarginata		black-edge sedge	Piedmont-Coastal Plain	Common
Carex normalis		greater straw sedge	Piedmont	Common
Carex oblita	*Carex venusta* var. *minor*	dark green sedge	Coastal Plain	Uncommon
Carex oklahomensis		Oklahoma sedge	Coastal Plain	Adventive
Carex oligocarpa		Eastern few-fruit sedge	Piedmont	Rare
Carex pedunculata var. *pedunculata*		longstalk sedge	Piedmont	Historical
Carex pellita	*Carex lanuginosa* misapplied	woolly sedge	Piedmont-Coastal Plain	Rare
Carex pensylvanica		Pennsylvania sedge	Piedmont-Coastal Plain	Common
Carex planispicata	*Carex amphibola* var. *amphibola*	flat-spiked sedge	Piedmont	Rare
Carex prasina		drooping sedge	Piedmont-Coastal Plain	Common
Carex radiata		stellate sedge	Piedmont-Coastal Plain	Common
Carex retroflexa		reflexed sedge	Piedmont-Coastal Plain	Rare
Carex reznicekii		Reznicek's sedge	Piedmont-Coastal Plain	Uncommon
Carex rosea	*Carex convoluta*	rosy sedge	Piedmont-Coastal Plain	Common
Carex scabrata		rough sedge	Piedmont	Rare
Carex scoparia var. *scoparia*		pointed broom sedge	Piedmont-Coastal Plain	Common
Carex seorsa		weak stellate sedge	Coastal Plain	Common
Carex shortiana		Short's sedge	Piedmont	Adventive
Carex silicea		seabeach sedge	Coastal Plain	Rare
Carex sparganioides		bur-reed sedge	Piedmont-Coastal Plain	Rare

Carex sprengelii		longbeak sedge	Piedmont	Historical
Carex squarrosa		squarrose sedge	Piedmont-Coastal Plain	Uncommon
Carex stipata var. *maxima*		giant stalk-grain sedge	Piedmont-Coastal Plain	Common
Carex stipata var. *stipata*		stalk-grain sedge	Piedmont-Coastal Plain	Common
Carex straminea		straw sedge	Piedmont-Coastal Plain	Rare
Carex striata var. *brevis*	*Carex walteriana* var. *brevis*	Walter's sedge	Piedmont-Coastal Plain	Common
Carex striatula		lined sedge	Piedmont-Coastal Plain	Uncommon
Carex stricta		tussock sedge	Piedmont-Coastal Plain	Common
Carex styloflexa		bent sedge	Piedmont-Coastal Plain	Common
Carex swanii		Swan's sedge	Piedmont-Coastal Plain	Common
Carex tetanica var. *canbyi*	*Carex meadii* misapplied; *C. panicea* var. *canbyi*	sedge	Piedmont	Rare
Carex texensis	*Carex retroflexa* var. *texensis*	sedge	Piedmont	Adventive
Carex tonsa var. *tonsa*		shaved sedge	Coastal Plain	Common
Carex torta		twisted sedge	Piedmont	Rare
Carex tribuloides var. *tribuloides*		blunt broom sedge	Piedmont-Coastal Plain	Common
Carex trichocarpa		hairy-fruit sedge	Piedmont	Rare
Carex trisperma		three-seed sedge	Coastal Plain	Historical
Carex typhina		cattail sedge	Coastal Plain	Uncommon
Carex umbellata		hidden sedge	Piedmont-Coastal Plain	Common
Carex utriculata	*Carex rostrata* misapplied	beaked sedge	Coastal Plain	Historical
Carex vesicaria		inflated sedge	Coastal Plain	Rare
Carex vestita		velvety sedge	Coastal Plain	Rare
Carex virescens		ribbed sedge	Piedmont-Coastal Plain	Common
Carex vulpinoidea		fox sedge	Piedmont-Coastal Plain	Common
Carex willdenowii		Willdenow's sedge	Piedmont	Rare
Carpinus caroliniana	*Carpinus caroliniana* var. *caroliniana; C. caroliniana* var. *virginiana*	ironwood	Piedmont-Coastal Plain	Common
Carya alba	*Carya tomentosa*	mockernut hickory	Piedmont-Coastal Plain	Common
Carya cordiformis		bitternut hickory	Piedmont-Coastal Plain	Common
Carya glabra	*Carya glabra* var. *hirsuta*	pignut hickory	Piedmont-Coastal Plain	Common
Carya ovalis		small-fruited hickory	Piedmont	Common
Carya ovata		shagbark hickory	Piedmont-Coastal Plain	Uncommon
Carya pallida		sand hickory	Coastal Plain	Common
Castanea dentata		American chestnut	Piedmont-Coastal Plain	Common
Castanea pumila		dwarf chestnut	Coastal Plain	Uncommon
Castilleja coccinea		scarlet Indian-paintbrush	Piedmont	Extirpated
Catalpa bignonioides		Southern catalpa	Piedmont-Coastal Plain	Adventive
Caulophyllum thalictroides	*Caulophyllum thalictroides* var. *thalictroides*	blue cohosh	Piedmont	Uncommon
Ceanothus americanus	Ceanothus americanus var. *americanus*; *C. americanus* var. *intermedius*	New Jersey tea	Piedmont-Coastal Plain	Rare
Celastrus scandens		climbing bittersweet	Piedmont-Coastal Plain	Historical
Celtis occidentalis		hackberry	Piedmont-Coastal Plain	Common
Cenchrus longispinus		long-spine sandbur	Coastal Plain	Common
Cenchrus spinifex	*Cenchrus incertus*	field sandbur	Coastal Plain	Adventive
Cenchrus tribuloides		dune sandbur	Coastal Plain	Common
Centella erecta		erect coinleaf	Coastal Plain	Uncommon
Centrosema virginianum		coastal butterfly-pea	Coastal Plain	Historical
Cephalanthus occidentalis		buttonbush	Piedmont-Coastal Plain	Common
Cerastium nutans		nodding chickweed	Piedmont-Coastal Plain	Rare
Cerastium velutinum var. *velutinum*	*Cerastium arvense* var. *villosum*	serpentine chickweed	Piedmont	Rare
Ceratophyllum demersum		coontail	Piedmont-Coastal Plain	Common
Ceratophyllum echinatum		prickly coontail	Coastal Plain	Status Uncertain
Cercis canadensis var. *canadensis*		Eastern redbud	Piedmont	Historical

Chaerophyllum procumbens var. *procumbens*		spreading chervil	Piedmont-Coastal Plain	Rare
Chaerophyllum tainturieri		Tainturier's chervil	Coastal Plain	Adventive
Chamaecrista fasciculata var. *fasciculata*	*Cassia fasciculata*	partridge pea	Piedmont-Coastal Plain	Common
Chamaecrista nictitans var. *nictitans*	*Cassia nictitans*	wild sensitive plant	Piedmont-Coastal Plain	Common
Chamaecyparis thyoides		Atlantic white cedar	Coastal Plain	Uncommon
Chamaedaphne calyculata		leatherleaf	Coastal Plain	Historical
Chamaelirium luteum		devil's-bit	Piedmont	Rare
Chamerion platyphyllum	*Epilobium angustifolium*	fireweed	Piedmont-Coastal Plain	Historical
Chasmanthium latifolium		broad spikegrass	Piedmont	Historical
Chasmanthium laxum		slender spikegrass	Coastal Plain	Common
Cheilanthes lanosa		hairy lipfern	Piedmont	Extirpated
Chelone glabra		white turtlehead	Piedmont-Coastal Plain	Common
Chenopodium berlandieri		pit-seed goosefoot	Piedmont	Common
Chenopodium simplex	*Chenopodium gigantospermum*	giant-seed goosefoot	Piedmont-Coastal Plain	Common
Chimaphila maculata		spotted wintergreen	Piedmont-Coastal Plain	Common
Chimaphila umbellata var. *cisatlantica*		pipsissewa	Coastal Plain	Rare
Chionanthus virginicus		fringetree	Piedmont-Coastal Plain	Common
Chloris verticillata		tumble windmill grass	Coastal Plain	Adventive
Chrysopsis mariana		Maryland golden aster	Piedmont-Coastal Plain	Common
Chrysosplenium americanum		American golden-saxifrage	Piedmont-Coastal Plain	Common
Cicuta bulbifera		bulb-bearing water-hemlock	Coastal Plain	Rare
Cicuta maculata		spotted water-hemlock	Piedmont-Coastal Plain	Common
Cinna arundinacea		stout wood reedgrass	Piedmont-Coastal Plain	Common
Circaea canadensis subsp. canadensis	*Circaea lutetiana* subsp. *canadensis*	Southern broadleaf enchanter's nightshade	Piedmont-Coastal Plain	Common
Cirsium altissimum		tall thistle	Piedmont	Historical
Cirsium discolor		field thistle	Piedmont-Coastal Plain	Common
Cirsium horridulum var. *horridulum*		yellow thistle	Piedmont-Coastal Plain	Common
Cirsium muticum		swamp thistle	Piedmont-Coastal Plain	Historical
Cirsium pumilum		pasture thistle	Piedmont	Uncommon
Cirsium virginianum		Virginia thistle	Coastal Plain	Historical
Cladium mariscoides		twig rush	Coastal Plain	Common
Claytonia virginica var. *virginica*		narrowleaf springbeauty	Piedmont-Coastal Plain	Common
Cleistesiopsis divaricata	*Cleistes divaricata*	spreading pogonia	Coastal Plain	Extirpated
occidentalis		purple clematis	Piedmont	Extirpated
Clematis viorna		vase-vine leatherflower	Piedmont	Rare
Clematis virginiana		Virginia virgin-bower	Piedmont-Coastal Plain	Common
Clethra alnifolia		sweet pepperbush	Piedmont-Coastal Plain	Common
Clitoria mariana var. *mariana*		Maryland butterfly-pea	Piedmont-Coastal Plain	Rare
Coelorachis rugosa	*Manisuris rugosa*	wrinkled jointgrass	Coastal Plain	Rare
Coleataenia anceps subsp. *anceps*	*Panicum anceps* var. *anceps*	beaked panicgrass	Piedmont-Coastal Plain	Common
Coleataenia longifolia subsp. *combsii*	*Panicum longifolium* var. *combsii; P. rigidulum* var. *combsii*	Combs long-leaf panicgrass	Coastal Plain	Status Uncertain
Coleataenia longifolia subsp. *longifolia*	*Panicum longifolium* var. *longifolium; P. rigidulum* var. *pubescens*	long-leaf panicgrass	Coastal Plain	Common
Collinsonia canadensis		Canada horse-balm	Piedmont-Coastal Plain	Common
Comandra umbellata subsp. *umbellata*		umbellate bastard toadflax	Piedmont-Coastal Plain	Common
Commelina erecta	*Commelina erecta* var. *angustifolia*	sand dayflower	Coastal Plain	Rare
Commelina virginica		Virginia dayflower	Coastal Plain	Rare
Comptonia peregrina		sweet-fern	Piedmont-Coastal Plain	Rare
Conoclinium coelestinum	*Eupatorium coelestinum*	blue boneset	Coastal Plain	Common

Conopholis americana		squaw-root	Piedmont	Rare
Conyza canadensis	*Conyza canadensis* var. *pusilla; Erigeron canadensis; E. pusillus*	Canada horseweed	Piedmont-Coastal Plain	Common
Corallorhiza maculata var. *maculata*		spotted coralroot	Piedmont	Historical
Corallorhiza odontorhiza		autumn coralroot	Piedmont-Coastal Plain	Rare
Corallorhiza wisteriana		spring coralroot	Piedmont	Historical
Coreopsis lanceolata		lance-leaf coreopsis	Coastal Plain	Adventive
Coreopsis rosea		rose coreopsis	Coastal Plain	Rare
Coreopsis tinctoria var. *tinctoria*		golden tickseed	Piedmont-Coastal Plain	Adventive
Cornus alternifolia		alternate-leaf dogwood	Piedmont-Coastal Plain	Common
Cornus amomum		silky dogwood	Piedmont-Coastal Plain	Common
Cornus florida		flowering dogwood	Piedmont-Coastal Plain	Common
Cornus racemosa	*Cornus foemina* subsp. *racemosa*	gray dogwood	Piedmont	Historical
Cornus stolonifera	*Cornus sericea*	red-osier dogwood	Piedmont	Status Uncertain
Cornus stricta	*Cornus foemina*	marsh dogwood	Coastal Plain	Rare
Corydalis flavula		yellow corydalis	Piedmont	Rare
Corylus americana		American hazelnut	Piedmont-Coastal Plain	Common
Corylus cornuta		beaked hazelnut	Piedmont	Rare
Crassula aquatica	*Tillaea aquatica*	water-pigmyweed	Coastal Plain	Extirpated
Crataegus coccinea	*Crataegus pedicellata*	scarlet hawthorn	Piedmont	Status Uncertain
Crataegus crus-galli	*Crataegus canbyi*	cockspur hawthorn	Piedmont-Coastal Plain	Status Uncertain
Crataegus disperma		spreading hawthorn	Piedmont	Status Uncertain
Crataegus intricata	*Crataegus foetida*	Copenhagen hawthorn	Piedmont-Coastal Plain	Status Uncertain
Crataegus iracunda	*Crataegus stolonifera*	stolon-bearing hawthorn	Piedmont	Status Uncertain
Crataegus macrosperma		big-fruit hawthorn	Piedmont	Status Uncertain
Crataegus pennsylvanica	*Crataegus tatnalliana*	Pennsylvania hawthorn	Piedmont-Coastal Plain	Status Uncertain
Crataegus phaenopyrum		Washington hawthorn	Piedmont	Adventive
Crataegus pruinosa	*Crataegus delawarensis*; *C. pruinosa* var. *delawarensis*	waxy-fruit hawthorn	Piedmont-Coastal Plain	Status Uncertain
Crataegus punctata		dotted hawthorn	Piedmont	Status Uncertain
Crataegus uniflora		dwarf hawthorn	Coastal Plain	Status Uncertain
Crataegus viridis		green hawthorn	Coastal Plain	Status Uncertain
Crocanthemum bicknellii	*Helianthemum bicknellii*	Bicknell's hoary frostweed	Piedmont	Extirpated
Crocanthemum canadense	*Helianthemum canadense*	Canada frostweed	Piedmont-Coastal Plain	Uncommon
Crocanthemum propinquum	*Helianthemum propinquum*	low frostweed	Coastal Plain	Status Uncertain
Crotalaria sagittalis		arrowhead rattlebox	Coastal Plain	Common
Croton capitatus		woolly croton	Coastal Plain	Adventive
Croton texensis		Texas croton	Coastal Plain	Adventive
Croton willdenowii	*Crotonopsis elliptica*	Willdenow's croton	Coastal Plain	Status Uncertain
Cryptotaenia canadensis		Canada honewort	Piedmont-Coastal Plain	Common
Cunila origanoides		dittany	Piedmont-Coastal Plain	Rare
Cuphea viscosissima		blue waxweed	Piedmont-Coastal Plain	Rare
Cuscuta campestris		yellow dodder	Piedmont	Status Uncertain
Cuscuta compacta		sessile dodder	Piedmont-Coastal Plain	Status Uncertain

Cuscuta coryli		hazel dodder	Coastal Plain	Status Uncertain
Cuscuta gronovii		Gronovius's dodder	Piedmont-Coastal Plain	Common
Cuscuta pentagona		field dodder	Piedmont-Coastal Plain	Status Uncertain
Cuscuta polygonorum		smartweed dodder	Piedmont-Coastal Plain	Status Uncertain
Cynanchum laeve	*Ampelamus albidus*	sandvine	Piedmont-Coastal Plain	Adventive
virginianum		wild comfrey	Piedmont-Coastal Plain	Uncommon
Cyperus bipartitus	*Cyperus rivularis*	shining flatsedge	Piedmont-Coastal Plain	Common
Cyperus compressus		poorland flatsedge	Coastal Plain	Adventive
Cyperus dentatus		toothed flatsedge	Coastal Plain	Historical
Cyperus diandrus		umbrella flatsedge	Coastal Plain	Rare
Cyperus echinatus	*Cyperus ovularis*	globe flatsedge	Piedmont-Coastal Plain	Common
Cyperus erythrorhizos		red-root flatsedge	Piedmont-Coastal Plain	Common
Cyperus esculentus		nut-sedge flatsedge	Piedmont-Coastal Plain	Common
Cyperus filicinus		slender flatsedge	Coastal Plain	Common
Cyperus flavescens		yellow flatsedge	Piedmont-Coastal Plain	Common
Cyperus grayi		Gray's flatsedge	Coastal Plain	Common
Cyperus hystricinus		flatsedge	Coastal Plain	Rare
Cyperus lancastriensis		Lancaster's flatsedge	Piedmont-Coastal Plain	Rare
Cyperus lupulinus	*Cyperus filiculmis; C. lupulinus* subsp. *macilentus*	slender flatsedge	Coastal Plain	Common
Cyperus odoratus var. *engelmannii*	*Cyperus engelmannii*	Engelman's rusty flatsedge	Piedmont-Coastal Plain	Uncommon
Cyperus odoratus var. *odoratus*		rusty flatsedge	Piedmont-Coastal Plain	Common
Cyperus plukenetii		Plukenet's flatsedge	Piedmont-Coastal Plain	Historical
Cyperus polystachyos	*Cyperus polystachyos* var. *texensis*	coast flatsedge	Coastal Plain	Common
Cyperus pseudovegetus		green flatsedge	Coastal Plain	Common
Cyperus refractus		reflexed flatsedge	Coastal Plain	Rare
Cyperus retrofractus	*Cyperus dipsaciformis*	rough flatsedge	Piedmont-Coastal Plain	Historical
Cyperus retrorsus	*Cyperus ovularis* var. *cylindricus; C. retrorsus* var. *cylindricus*	retrorse flatsedge	Coastal Plain	Common
Cyperus squarrosus	*Cyperus aristatus*	awned flatsedge	Piedmont	Status Uncertain
Cyperus strigosus		straw-colored flatsedge	Piedmont-Coastal Plain	Common
Cypripedium acaule		pink lady's-slipper	Piedmont-Coastal Plain	Common
Cypripedium parviflorum var. *pubescens*	*Cypripedium pubescens*	large yellow lady's-slipper	Piedmont-Coastal Plain	Rare
Cyrilla racemiflora		swamp cyrilla	Coastal Plain	Adventive
Cystopteris protrusa	*Cystopteris fragilis* var. *protrusa*	lowland fragile fern	Piedmont-Coastal Plain	Rare
Cystopteris tennesseensis		Tennessee bladderfern	Piedmont	Adventive
Cystopteris tenuis	*Cystopteris fragilis* var. *mackayi*	bladderfern	Piedmont	Rare
Danthonia compressa		flattened oatgrass	Piedmont	Rare
Danthonia sericea		silky oatgrass	Coastal Plain	Rare
Danthonia spicata		poverty oatgrass	Piedmont-Coastal Plain	Common
Datura stramonium		jimsonweed	Piedmont-Coastal Plain	Adventive
Decodon verticillatus		swamp loosestrife	Piedmont-Coastal Plain	Common
Dendrolycopodium obscurum	*Lycopodium obscurum*	tree clubmoss	Piedmont-Coastal Plain	Common
Dennstaedtia punctilobula		hay-scented fern	Piedmont-Coastal Plain	Common
Deparia acrostichoides	*Athyrium thelypterioides*	silvery false spleenwort	Piedmont-Coastal Plain	Common
Desmodium canadense		showy tick-trefoil	Piedmont	Historical
Desmodium canescens		hoary tick-trefoil	Piedmont-Coastal Plain	Rare
Desmodium ciliare		hairy small-leaved tick-trefoil	Piedmont-Coastal Plain	Common
Desmodium cuspidatum var. *cuspidatum*	*Desmodium bracteosum*	toothed tick-trefoil	Piedmont	Historical
Desmodium fernaldii		Fernald's tick-trefoil	Coastal Plain	Rare
Desmodium glabellum		Dillen's tick-trefoil	Piedmont-Coastal Plain	Uncommon
Desmodium humifusum		trailing tick-trefoil	Piedmont	Historical

Desmodium laevigatum		smooth tick-trefoil	Piedmont-Coastal Plain	Common
Desmodium marilandicum		Maryland tick-trefoil	Piedmont-Coastal Plain	Uncommon
Desmodium nuttallii		Nuttall's tick-trefoil	Coastal Plain	Status Uncertain
Desmodium obtusum		stiff tick-trefoil	Piedmont-Coastal Plain	Rare
Desmodium ochroleucum		creamflower tick-trefoil	Coastal Plain	Historical
Desmodium paniculatum var. *paniculatum*		panicled-leaf tick-trefoil	Piedmont-Coastal Plain	Common
Desmodium perplexum	*Desmodium dillenii*	perplexed tick-trefoil	Piedmont-Coastal Plain	Status Uncertain
Desmodium rotundifolium		prostrate tick-trefoil	Piedmont-Coastal Plain	Uncommon
Desmodium strictum		pineland tick-trefoil	Coastal Plain	Rare
Desmodium viridiflorum		velvety tick-trefoil	Coastal Plain	Common
Dicentra cucullaria		Dutchman's breeches	Piedmont	Uncommon
Dichanthelium aciculare	*Panicum aciculare*	needle-leaf witch grass	Coastal Plain	Rare
Dichanthelium acuminatum var. *acuminatum*	*Panicum acuminatum* var. *acuminatum*; *Panicum auburne*; *P. lanuginosum* var. *lanuginosum*	wooly witch grass	Piedmont-Coastal Plain	Common
Dichanthelium acuminatum var. *fasciculatum*	*Panicum acuminatum* var. *fasciculatum; P. lanuginosum* var. *fasciculatum; P. lanuginosum* var. *implicatum*	Western witch grass	Piedmont-Coastal Plain	Common
Dichanthelium acuminatum var. *lindheimeri*	*Panicum acuminatum* var. *lindheimeri; P. lanuginosum* var. *lindheimeri*	Lindheimer's witch grass	Piedmont-Coastal Plain	Common
Dichanthelium angustifolium	*Panicum angustifolium*	narrow-leaved witch grass	Coastal Plain	Historical
Dichanthelium boreale	*Panicum boreale*	Northern witch grass	Coastal Plain	Historical
Dichanthelium boscii	*Panicum boscii; P. boscii* var. *molle*	Bosc's witch grass	Piedmont-Coastal Plain	Common
Dichanthelium caerulescens	*Panicum caerulescens*	blue witch grass	Coastal Plain	Status Uncertain
Dichanthelium clandestinum	*Panicum clandestinum*	deer-tongue witch grass	Piedmont-Coastal Plain	Common
Dichanthelium columbianum	*Panicum columbianum; P. columbianum* var. *oricola; P. oricola; P. tsugetorum*	hemlock witch grass	Piedmont-Coastal Plain	Status Uncertain
Dichanthelium commutatum var. *ashei*	*Panicum commutatum* var. *ashei*	Ashe's variable witch grass	Piedmont-Coastal Plain	Common
Dichanthelium commutatum var. *commutatum*	*Panicum commutatum* var. *commutatum*	variable witch grass	Piedmont-Coastal Plain	Common
Dichanthelium depauperatum	*Panicum depauperatum*	starved witch grass	Piedmont-Coastal Plain	Common
Dichanthelium dichotomum var. *dichotomum*	*Panicum dichotomum* var. *barbulatum; P. dichotomum* var. *dichotomum*	forked witch grass	Piedmont-Coastal Plain	Common
Dichanthelium dichotomum var. *ramulosum*	*Panicum dichotomum* var. *ramulosum; P. microcarpon*	branched witch grass	Piedmont-Coastal Plain	Common
Dichanthelium dichotomum var. *roanokense*	*Panicum dichotomum* var. *roanokense; P. roanokense*	Roanoke witch grass	Coastal Plain	Rare
Dichanthelium ensifolium	*Panicum ensifolium*	witch grass	Coastal Plain	Status Uncertain
Dichanthelium hirstii	*Panicum hirstii*	Hirst Brothers' panic grass	Coastal Plain	Rare
Dichanthelium latifolium	*Panicum latifolium*	broad-leaf witch grass	Piedmont	Status Uncertain
Dichanthelium leucothrix	*Panicum leucothrix*	roughish witch grass	Coastal Plain	Status Uncertain
Dichanthelium linearifolium	*Panicum delawarense; P. linearifolium; P. linearifolium* var. *werneri; P. werneri*	slim-leaf witch grass	Piedmont	Historical
Dichanthelium longiligulatum	*Panicum longiligulatum*	long-ligule witch grass	Piedmont	Status Uncertain
Dichanthelium lucidum	*Panicum lucidum*	bog witch grass	Coastal Plain	Common
Dichanthelium mattamuskeetense	*Panicum mattamuskeetense*	witch grass	Coastal Plain	Common

Dichanthelium meridionale	*Panicum meridionale; P. meridionale* var. *albemarlense*	matting witch grass	Piedmont-Coastal Plain	Common
Dichanthelium oligosanthes var. *oligosanthes*	*Panicum oligosanthes* var. *oligosanthes*	few-flower witch grass	Coastal Plain	Common
Dichanthelium oligosanthes var. *scribnerianum*	*Panicum oligosanthes* var. *scribnerianum; P. scribnerianum*	Scribner's witch grass	Piedmont	Rare
Dichanthelium ovale var. *addisonii*	*Panicum commonsianum; P. commonsianum* var. *addisonii*	Commons's witch grass	Coastal Plain	Common
Dichanthelium ovale var. *ovale*	*Panicum ovale* var. *ovale*	egg-leaf witch grass	Coastal Plain	Common
Dichanthelium polyanthes	*Dichanthelium sphaerocarpon* var. *isophyllum; Panicum polyanthes*	round-seed witch grass	Piedmont-Coastal Plain	Common
Dichanthelium ravenelii	*Panicum ravenelii*	Ravenel's witch grass	Piedmont-Coastal Plain	Status Uncertain
Dichanthelium scabriusculum	*Panicum scabriusculum*	tall swamp witch grass	Coastal Plain	Rare
Dichanthelium scoparium	*Panicum scoparium*	broom witch grass	Piedmont-Coastal Plain	Common
Dichanthelium sphaerocarpon	*Panicum sphaerocarpon*	roundfruit witch grass	Piedmont-Coastal Plain	Uncommon
Dichanthelium spretum	*Panicum spretum*	Eaton's witch grass	Coastal Plain	Common
Dichanthelium villosissimum var. *villosissimum*	*Panicum villosissimum* var. *villosissimum*	white-hair witch grass	Piedmont-Coastal Plain	Common
Dichanthelium wrightianum	*Panicum wrightianum*	Wright's witch grass	Coastal Plain	Rare
Dichanthelium yadkinense	*Panicum yadkinense*	Yadkin's witch grass	Piedmont	Rare
Diervilla lonicera		Northern bush-honeysuckle	Piedmont	Rare
Digitaria cognata	*Leptoloma cognatum*	mountain hairgrass	Coastal Plain	Common
Digitaria filiformis var. *filiformis*		slender crabgrass	Coastal Plain	Status Uncertain
Diodia teres		well-drained buttonweed	Piedmont-Coastal Plain	Common
Diodia virginiana		poorly-drained buttonweed	Piedmont-Coastal Plain	Common
Dioscorea villosa		yellow yam	Piedmont-Coastal Plain	Common
Diospyros virginiana		persimmon	Piedmont-Coastal Plain	Common
Diphasiastrum digitatum	*Lycopodium digitatum*	running-pine clubmoss	Piedmont-Coastal Plain	Common
Diphasiastrum tristachyum	*Lycopodium tristachyum*	ground-cedar clubmoss	Piedmont-Coastal Plain	Rare
Diplazium pycnocarpon		glade fern	Piedmont	Rare
Dirca palustris		Eastern leatherwood	Piedmont	Rare
Distichlis spicata		spike saltgrass	Coastal Plain	Common
Doellingeria infirma	*Aster infirmus*	cornel-leaf aster	Piedmont-Coastal Plain	Rare
Doellingeria umbellata	*Aster umbellatus*	flat-top white aster	Piedmont-Coastal Plain	Uncommon
Dracocephalum parviflorum		American dragonhead	Piedmont	Adventive
Drosera capillaris		pink sundew	Coastal Plain	Historical
Drosera filiformis		thread-leaf sundew	Coastal Plain	Extirpated
Drosera intermedia		spoon-leaved sundew	Coastal Plain	Common
Drosera rotundifolia var. *rotundifolia*		roundleaf sundew	Piedmont-Coastal Plain	Rare
Dryopteris carthusiana		spinulose wood-fern	Piedmont-Coastal Plain	Common
Dryopteris celsa		log wood-fern	Piedmont-Coastal Plain	Rare
Dryopteris clintoniana		Clinton's wood-fern	Coastal Plain	Rare
Dryopteris cristata		crested wood-fern	Piedmont-Coastal Plain	Common
Dryopteris goldiana		Goldie's wood-fern	Piedmont-Coastal Plain	Rare
Dryopteris intermedia		evergreen wood-fern	Piedmont-Coastal Plain	Common
Dryopteris marginalis		marginal wood-fern	Piedmont-Coastal Plain	Uncommon
Dulichium arundinaceum		three-way sedge	Piedmont-Coastal Plain	Common
Echinochloa muricata var. *muricata*	*Echinochloa pungens*	rough barnyard grass	Piedmont-Coastal Plain	Common
Echinochloa walteri		Walter's barnyard grass	Coastal Plain	Common
Echinocystis lobata		wild mock-cucumber	Piedmont-Coastal Plain	Common
Echinodorus tenellus	*Echinodorus parvulus; Helianthium parvulum*	American dwarf burhead	Coastal Plain	Extirpated
Elatine americana		American waterwort	Coastal Plain	Rare
Elatine minima		small waterwort	Coastal Plain	Rare

Eleocharis acicularis		least spikerush	Piedmont-Coastal Plain	Common
Eleocharis aestuum		estuary spikerush	Coastal Plain	Historical
Eleocharis brittonii	*Eleocharis microcarpa* var. *brittonii*	Britton's spikerush	Coastal Plain	Historical
Eleocharis engelmannii		Engelmann's spikerush	Piedmont-Coastal Plain	Status Uncertain
Eleocharis equisetoides		horsetail spikerush	Coastal Plain	Rare
Eleocharis erythropoda	*Eleocharis calva*	bald spikerush	Piedmont-Coastal Plain	Rare
Eleocharis fallax	*Eleocharis ambigens*	creeping spikerush	Coastal Plain	Uncommon
Eleocharis flavescens var. *flavescens*		pale spikerush	Coastal Plain	Historical
Eleocharis halophila		salt marsh spikerush	Coastal Plain	Rare
Eleocharis melanocarpa		black-fruit spikerush	Coastal Plain	Rare
Eleocharis microcarpa var. *filiculmis*		small-fruited spikerush	Coastal Plain	Common
Eleocharis obtusa		blunt spikerush	Piedmont-Coastal Plain	Common
Eleocharis olivacea var. *olivacea*		capitate spikerush	Coastal Plain	Common
Eleocharis palustris	*Eleocharis smallii*	creeping spikerush	Piedmont-Coastal Plain	Common
Eleocharis parvula		small salt marsh spikerush	Coastal Plain	Common
Eleocharis quadrangulata		squarestem spikerush	Coastal Plain	Common
Eleocharis robbinsii		Robbin's spikerush	Coastal Plain	Uncommon
Eleocharis rostellata		beaked spikerush	Coastal Plain	Rare
Eleocharis tenuis var. *pseudoptera*		slender spikerush	Piedmont	Common
Eleocharis tenuis var. *tenuis*		slender spikerush	Piedmont-Coastal Plain	Common
Eleocharis tortilis		twisted spikerush	Coastal Plain	Common
Eleocharis tricostata		tree-angle spikerush	Coastal Plain	Rare
Eleocharis tuberculosa		long-tubercled spikerush	Coastal Plain	Common
Elephantopus carolinianus		Carolina elephant-foot	Piedmont-Coastal Plain	Common
Elephantopus nudatus		smooth elephant-foot	Coastal Plain	Rare
Elodea canadensis		broad-leaved waterweed	Piedmont-Coastal Plain	Status Uncertain
Elodea nuttallii		Nuttall's waterweed	Piedmont-Coastal Plain	Common
Elymus glabriflorus var. *australis*		pubescent Southeastern wild rye	Piedmont	Status Uncertain
Elymus glabriflorus var. *glabriflorus*		glabrous Southeastern wild rye	Piedmont-Coastal Plain	Status Uncertain
Elymus hystrix var. *hystrix*	*Hystrix patula*	bottlebrush wild rye	Piedmont	Rare
Elymus macgregorii		early wild rye	Piedmont	Status Uncertain
Elymus riparius		river wild rye	Piedmont-Coastal Plain	Uncommon
Elymus villosus		hairy wild rye	Piedmont-Coastal Plain	Uncommon
Elymus virginicus var. *halophilus*		salt-loving Virginia wild rye	Coastal Plain	Uncommon
Elymus virginicus var. *virginicus*		Virgina wild rye	Piedmont-Coastal Plain	Common
Endodeca serpentaria	*Aristolochia serpentaria*	Virginia snakeroot	Piedmont-Coastal Plain	Uncommon
Epifagus virginiana		beechdrops	Piedmont-Coastal Plain	Common
Epigaea repens		trailing arbutus	Piedmont-Coastal Plain	Uncommon
Epilobium ciliatum	*Epilobium glandulosum* var. *adenocaulon*	hairy willowherb	Piedmont-Coastal Plain	Status Uncertain
Epilobium coloratum		purple-leaf willowherb	Piedmont-Coastal Plain	Common
Equisetum arvense		field horsetail	Piedmont-Coastal Plain	Common
Equisetum fluviatile		water horsetail	Coastal Plain	Rare
Equisetum hyemale subsp. *affine*	*Equisetum prealtum*	scouring-rush horsetail	Piedmont-Coastal Plain	Rare
Equisetum sylvaticum		woodland horsetail	Piedmont	Rare
Eragrostis capillaris		tiny lovegrass	Piedmont-Coastal Plain	Common
Eragrostis hirsuta		big-top lovegrass	Coastal Plain	Common
Eragrostis hypnoides		teal lovegrass	Piedmont-Coastal Plain	Rare
Eragrostis mexicana		Mexican lovegrass	Piedmont	Adventive
Eragrostis pectinacea var. *pectinacea*		pectinate lovegrass	Coastal Plain	Common

Eragrostis refracta		meadow lovegrass	Coastal Plain	Rare
Eragrostis spectabilis		purple lovegrass	Piedmont-Coastal Plain	Common
Erechtites hieraciifolius		fireweed	Piedmont-Coastal Plain	Common
Erigeron annuus		white-top fleabane	Piedmont-Coastal Plain	Common
Erigeron philadelphicus		Philadelphia fleabane	Piedmont-Coastal Plain	Common
Erigeron pulchellus var. *pulchellus*		Robin's fleabane	Piedmont	Common
Erigeron strigosus var. *strigosus*		daisy fleabane	Piedmont-Coastal Plain	Common
Eriocaulon aquaticum	*Eriocaulon septangulare*	seven-angled pipewort	Coastal Plain	Rare
Eriocaulon compressum		flattened pipewort	Coastal Plain	Rare
Eriocaulon decangulare		ten-angle pipewort	Coastal Plain	Rare
Eriocaulon parkeri		Parker's pipewort	Coastal Plain	Rare
Eriophorum gracile		slender cotton-grass sedge	Coastal Plain	Extirpated
Eriophorum virginicum		tawny cotton-grass sedge	Piedmont-Coastal Plain	Rare
Eryngium aquaticum var. *aquaticum*		rattlesnake-master	Coastal Plain	Rare
Eryngium prostratum		prostrate eryngo	Coastal Plain	Adventive
Erythronium americanum subsp. *americanum*		yellow trout-lily	Piedmont-Coastal Plain	Common
Eschscholzia californica		California poppy	Coastal Plain	Adventive
Eubotrys racemosa	*Leucothoe racemosa*	fetterbush	Coastal Plain	Common
Euonymus americanus		American strawberry-bush	Piedmont-Coastal Plain	Common
Euonymus atropurpureus		wahoo	Piedmont	Rare
Eupatorium album var. *album*		white thoroughwort	Coastal Plain	Common
Eupatorium album var. *subvenosum*		3-nerved basal thoroughwort	Coastal Plain	Status Uncertain
Eupatorium album var. *vaseyi*	*Eupatorium album* var. *monardifolium; E. vaseyi*	Vasey's white thoroughwort	Coastal Plain	Uncommon
Eupatorium altissimum		tall thoroughwort	Coastal Plain	Status Uncertain
Eupatorium capillifolium		dog-fennel thoroughwort	Piedmont-Coastal Plain	Common
Eupatorium hyssopifolium		hyssop-leaf thoroughwort	Piedmont-Coastal Plain	Common
Eupatorium leucolepis		white-bract thoroughwort	Coastal Plain	Uncommon
Eupatorium perfoliatum		perfoliate thoroughwort	Piedmont-Coastal Plain	Common
Eupatorium pilosum	*Eupatorium rotundifolium* var. *saundersii*	ragged thoroughwort	Coastal Plain	Common
Eupatorium resinosum		pine barren boneset	Coastal Plain	Extirpated
Eupatorium rotundifolium var. *ovatum*	*Eupatorium pubescens*	hairy thoroughwort	Piedmont-Coastal Plain	Common
Eupatorium rotundifolium var. *rotundifolium*		roundleaf thoroughwort	Piedmont-Coastal Plain	Common
Eupatorium serotinum		late-flowering thoroughwort	Coastal Plain	Uncommon
Eupatorium sessilifolium var. *sessilifolium*		sessile-leaf thoroughwort	Piedmont-Coastal Plain	Rare
Eupatorium torreyanum	*Eupatorium hyssopifolium* var. *laciniatum*	Torrey's eupatorium	Coastal Plain	Status Uncertain
Euphorbia corollata		flowering spurge	Piedmont-Coastal Plain	Common
Euphorbia hexagona		six-angle spurge	Piedmont	Adventive
Euphorbia ipecacuanhae		variable-leaf spurge	Coastal Plain	Common
Euphorbia maculata	*Chamaesyce maculata*	spotted spurge	Piedmont-Coastal Plain	Common
Euphorbia nutans	*Euphorbia maculata* misapplied; *Chamaesyce nutans*	eyebane spurge	Piedmont-Coastal Plain	Common
Euphorbia polygonifolia	*Chamaesyce polygonifolia*	seaside spurge	Coastal Plain	Common
Euphorbia purpurea		glade spurge	Piedmont-Coastal Plain	Rare
Eurybia compacta	*Aster gracilis*	slender aster	Coastal Plain	Status Uncertain
Eurybia divaricata	*Aster divaricatus*	white wood aster	Piedmont-Coastal Plain	Common
Eurybia radula	*Aster radula*	rough-leaf wood-aster	Coastal Plain	Historical
Eurybia schreberi	*Aster schreberi*	Schreber's aster	Piedmont	Rare
Eurybia spectabilis	*Aster spectabilis*	showy aster	Coastal Plain	Rare

Euthamia caroliniana	*Euthamia tenuifolia* var. *tenuifolia; E. tenuifolia* var. *microcephala*	flat-top goldenrod	Coastal Plain	Common
Euthamia graminifolia	*Euthamia graminifolia* var. *nuttallii*	grassleaf flat-top goldenrod	Piedmont-Coastal Plain	Common
Eutrochium dubium	*Eupatorium dubium*	three-nerved Joe-pye-weed	Piedmont-Coastal Plain	Common
Eutrochium fistulosum	*Eupatorium fistulosum*	hollow-stem Joe-pye-weed	Piedmont-Coastal Plain	Common
Eutrochium purpureum var. *purpureum*	*Eupatorium purpureum*	purple-node Joe-pye-weed	Piedmont-Coastal Plain	Uncommon
Fagus grandifolia		American beech	Piedmont-Coastal Plain	Common
Fallopia scandens	*Polygonum scandens* var. *scandens; P. scandens* var. *cristatum*	crested climbing buckwheat.	Piedmont-Coastal Plain	Status Uncertain
Festuca paradoxa		cluster fescue	Piedmont	Historical
Festuca rubra		red fescue	Piedmont-Coastal Plain	Common
Festuca subverticillata	*Festuca obtusa*	nodding fescue	Piedmont-Coastal Plain	Common
Fimbristylis annua		annual fimbry	Piedmont	Historical
Fimbristylis autumnalis		slender fimbry	Piedmont-Coastal Plain	Common
Fimbristylis caroliniana		Carolina fimbry	Coastal Plain	Rare
Fimbristylis castanea		marsh fimbry	Coastal Plain	Common
Fimbristylis perpusilla		Harper's fimbristylis	Coastal Plain	Rare
Floerkea proserpinacoides		false mermaidweed	Piedmont-Coastal Plain	Uncommon
Fragaria virginiana		Virginia strawberry	Piedmont-Coastal Plain	Common
Fraxinus americana		white ash	Piedmont-Coastal Plain	Common
Fraxinus nigra		black ash	Piedmont-Coastal Plain	Rare
Fraxinus pennsylvanica		green ash	Piedmont-Coastal Plain	Common
Fraxinus profunda		pumpkin ash	Coastal Plain	Common
Froelichia floridana		Florida cottonweed	Coastal Plain	Adventive
Froelichia gracilis		slender cottonweed	Coastal Plain	Adventive
Fuirena pumila		dwarf umbrella-sedge	Coastal Plain	Uncommon
Fuirena squarrosa		hairy umbrella-sedge	Coastal Plain	Uncommon
Gaillardia pulchella var. *pulchella*		fire-wheel blanket-flower	Coastal Plain	Adventive
Galactia regularis		Eastern milkpea	Coastal Plain	Common
Galactia volubilis var. *volubilis*		downy milkpea	Piedmont-Coastal Plain	Common
Galearis spectabilis	*Orchis spectabilis*	showy orchis	Piedmont-Coastal Plain	Uncommon
Galium aparine		catchweed bedstraw	Piedmont-Coastal Plain	Common
Galium asprellum		rough bedstraw	Piedmont	Rare
Galium boreale		Northern bedstraw	Piedmont	Historical
Galium circaezans var. *circaezans*		Southern forest bedstraw	Piedmont-Coastal Plain	Common
hypomalacum		Northern forest bedstraw	Piedmont-Coastal Plain	Common
Galium hispidulum		coast bedstraw	Coastal Plain	Historical
Galium lanceolatum		lance-leaf bedstraw	Piedmont	Uncommon
Galium obtusum subsp. *filifolium*		narrowleaf blunt-leaf bedstraw	Coastal Plain	Common
Galium obtusum subsp. *obtusum*		blunt-leaf bedstraw	Piedmont-Coastal Plain	Common
Galium pilosum var. *pilosum*		hairy bedstraw	Piedmont-Coastal Plain	Common
Galium pilosum var. *puncticulosum*		hairy punctate bedstraw	Piedmont-Coastal Plain	Common
Galium tinctorium	*Galium trifidum* var. *tinctorium*	stiff marsh bedstraw	Piedmont-Coastal Plain	Common
Galium triflorum		sweet-scent bedstraw	Piedmont-Coastal Plain	Common
Gamochaeta purpurea	*Gnaphalium purpureum*	purple cudweed	Piedmont-Coastal Plain	Common
Gaultheria procumbens		teaberry	Piedmont-Coastal Plain	Common
Gaura biennis		biennial gaura	Coastal Plain	Historical
Gaylussacia baccata		black huckleberry	Piedmont-Coastal Plain	Common
Gaylussacia bigeloviana	*Gaylussacia dumosa* var. *bigeloviana*	Northern dwarf huckleberry	Coastal Plain	Historical
Gaylussacia brachycera		box huckleberry	Coastal Plain	Rare
Gaylussacia frondosa		blue huckleberry	Piedmont-Coastal Plain	Common
Gentiana andrewsii var. *andrewsii*		closed-bottle gentian	Piedmont-Coastal Plain	Rare
Gentiana autumnalis		pine barren gentian	Coastal Plain	Extirpated
Gentiana catesbaei		Elliott's gentian	Coastal Plain	Uncommon

Gentiana saponaria		soapwort gentian	Piedmont-Coastal Plain	Uncommon
Gentiana villosa		striped gentian	Piedmont	Historical
Gentianopsis crinita	*Gentiana crinita*	fringed gentian	Piedmont	Extirpated
Geranium carolinianum		Carolina crane's-bill	Piedmont-Coastal Plain	Common
Geranium maculatum		wild geranium	Piedmont-Coastal Plain	Common
Geranium robertianum		Robert's crane's-bill	Piedmont	Adventive
Geum canadense		white avens	Piedmont-Coastal Plain	Common
Geum laciniatum var. *laciniatum*		rough avens	Piedmont-Coastal Plain	Uncommon
Geum vernum		spring avens	Piedmont	Adventive
Geum virginianum		pale avens	Piedmont-Coastal Plain	Rare
Gillenia trifoliata	*Porteranthus trifoliatus*	Bowman's-root	Piedmont	Historical
Gleditsia triacanthos		honey-locust	Piedmont-Coastal Plain	Adventive
Glyceria acutiflora		sharp-scaled mannagrass	Coastal Plain	Rare
Glyceria canadensis		Canada mannagrass	Piedmont-Coastal Plain	Rare
Glyceria grandis		American mannagrass	Piedmont	Rare
Glyceria laxa	*Glyceria canadensis* var. *laxa*	Northern mannagrass	Coastal Plain	Rare
Glyceria obtusa		blunt mannagrass	Coastal Plain	Common
Glyceria septentrionalis		floating mannagrass	Piedmont-Coastal Plain	Common
Glyceria striata var. *striata*		fowl mannagrass	Piedmont-Coastal Plain	Common
Goodyera pubescens		downy rattlesnake-plantain	Piedmont-Coastal Plain	Common
Gratiola aurea		golden hedge-hyssop	Coastal Plain	Uncommon
Gratiola brevifolia		sticky hedge-hyssop	Coastal Plain	Rare
Gratiola neglecta		clammy hedge-hyssop	Piedmont-Coastal Plain	Common
Gratiola virginiana		roundfruit hedge-hyssop	Coastal Plain	Common
Gratiola viscidula		Short's hedge-hyssop	Coastal Plain	Historical
Grindelia squarrosa var. *squarrosa*		broadleaf gumweed	Coastal Plain	Adventive
Gymnopogon ambiguus		Eastern beardgrass	Coastal Plain	Rare
Gymnopogon brevifolius		pineland beardgrass	Coastal Plain	Historical
Hackelia virginiana		Virginia stickseed	Piedmont-Coastal Plain	Common
Hamamelis virginiana var. *virginiana*		American witch-hazel	Piedmont-Coastal Plain	Common
Hedeoma pulegioides		American false pennyroyal	Piedmont-Coastal Plain	Common
Helenium autumnale		autumn sneezeweed	Coastal Plain	Common
Helenium flexuosum	*Helenium nudiflorum*	purple-head sneezeweed	Piedmont-Coastal Plain	Common
Helianthus angustifolius		swamp sunflower	Coastal Plain	Uncommon
Helianthus annuus		domesticated sunflower	Piedmont-Coastal Plain	Adventive
Helianthus decapetalus		thinleaf sunflower	Piedmont	Uncommon
Helianthus divaricatus		woodland sunflower	Piedmont-Coastal Plain	Rare
Helianthus giganteus		tall sunflower	Piedmont-Coastal Plain	Common
Helianthus grosseserratus		sawtooth sunflower	Piedmont-Coastal Plain	Adventive
Helianthus strumosus		pale-leaf sunflower	Piedmont	Historical
Helianthus tuberosus		Jerusalem artichoke	Piedmont-Coastal Plain	Adventive
helianthoides		ox-eye	Piedmont-Coastal Plain	Rare
Heliotropium curassavicum		seaside heliotrope	Coastal Plain	Adventive
Helonias bullata		swamp-pink	Coastal Plain	Rare
Heracleum maximum	*Heracleum lanatum*	cow-parsnip	Piedmont	Uncommon
Heteranthera dubia	*Zosterella dubia*	grassleaf mud-plantain	Piedmont	Rare
Heteranthera multiflora		multiflowered mud-plantain	Coastal Plain	Status Uncertain
Heteranthera reniformis		kidneyleaf mud-plantain	Piedmont-Coastal Plain	Common
Heterotheca subaxillaris		camphorweed goldenaster	Coastal Plain	Common
Heuchera americana	*Heuchera americana* var. *americana*	American alumroot	Piedmont-Coastal Plain	Uncommon
Hibiscus moscheutos	*Hibiscus moscheutos* subsp. *moscheutos*; *H. moscheutos* subsp. *palustris*	rose-mallow	Coastal Plain	Common
Hieracium gronovii		hairy hawkweed	Piedmont-Coastal Plain	Common

Hieracium paniculatum		panicled hawkweed	Piedmont	Common
Hieracium scabrum		rough hawkweed	Piedmont-Coastal Plain	Common
Hieracium venosum		rattlesnake hawkweed	Piedmont-Coastal Plain	Common
Honckenya peploides subsp. *robusta*		seabeach sandwort	Coastal Plain	Historical
Hordeum brachyantherum subsp. *brachyantherum*		meadow barley	Coastal Plain	Adventive
Hordeum jubatum		foxtail barley	Piedmont-Coastal Plain	Adventive
Hordeum pusillum		little barley	Piedmont-Coastal Plain	Common
Hottonia inflata		featherfoil	Coastal Plain	Rare
Houstonia caerulea	*Hedyotis caerulea*	bluet	Piedmont-Coastal Plain	Common
Houstonia purpurea var. *purpurea*	*Hedyotis purpurea*	purple bluet	Piedmont-Coastal Plain	Rare
Houstonia pusilla		tiny bluet	Coastal Plain	Adventive
Hudsonia ericoides		golden-heather	Coastal Plain	Rare
Hudsonia tomentosa		beach-heather	Coastal Plain	Common
Humulus lupulus	*Humulus americanus; H. lupulus* var. *lupuloides; H. lupulus* var. *lupulus*	hops	Piedmont-Coastal Plain	Status Uncertain
Huperzia lucidula	*Lycopodium lucidulum*	shining clubmoss	Piedmont-Coastal Plain	Common
Hybanthus concolor		green violet	Piedmont	Rare
Hydrangea arborescens		wild hydrangea	Piedmont	Historical
Hydrastis canadensis		golden seal	Piedmont-Coastal Plain	Uncommon
Hydrocotyle americana		American water-pennywort	Piedmont-Coastal Plain	Uncommon
Hydrocotyle prolifera	*Hydrocotyle verticillata* var. *triradiata*	whorled pennywort	Coastal Plain	Common
Hydrocotyle ranunculoides		floating pennywort	Piedmont-Coastal Plain	Common
Hydrocotyle umbellata		many-flowered pennywort	Coastal Plain	Common
Hydrocotyle verticillata		whorled pennywort	Coastal Plain	Common
Hydrophyllum virginianum		Eastern waterleaf	Piedmont-Coastal Plain	Uncommon
Hylodesmum glutinosum	*Desmodium glutinosum*	large tick-trefoil	Piedmont-Coastal Plain	Rare
Hylodesmum nudiflorum	*Desmodium nudiflorum*	bare-stemmed tick-trefoil	Piedmont-Coastal Plain	Common
Hypericum adpressum		creeping St. John's-wort	Coastal Plain	Rare
Hypericum boreale		Northern St. John's-wort	Coastal Plain	Rare
Hypericum canadense		Canadian St. John's-wort	Piedmont-Coastal Plain	Common
Hypericum crux-andreae	*Hypericum stans*	St. Peter's-wort	Coastal Plain	Uncommon
Hypericum densiflorum var. *densiflorum*		bushy St. John's-wort	Coastal Plain	Rare
Hypericum denticulatum		coppery St. John's-wort	Coastal Plain	Rare
Hypericum drummondii		Drummond's St. John's-wort	Coastal Plain	Rare
Hypericum ellipticum		pale St. John's-wort	Coastal Plain	Historical
Hypericum fraseri	*Triadenum fraseri*	Northern marsh St. John's-wort	Piedmont	Rare
Hypericum gentianoides		orange-grass St. John's-wort	Piedmont-Coastal Plain	Common
Hypericum gymnanthum		clasping-leaved St. John's-wort	Coastal Plain	Uncommon
Hypericum hypericoides	*Ascyrum hypericoides* var. *hypericoides*; *A. hypericoides* var. *oblongifolium*	erect St. Andrew's cross	Coastal Plain	Uncommon
Hypericum majus		larger Canadian St. John's-wort	Piedmont	Extirpated
Hypericum mutilum var. *mutilum*		slender St. John's-wort	Piedmont-Coastal Plain	Common
Hypericum prolificum		shrubby St. John's-wort	Piedmont	Rare
Hypericum punctatum		dotted St. John's-wort	Piedmont-Coastal Plain	Common
Hypericum stragulum	*Ascyrum hypericoides* var. *multicaule*	decumbent St. Andrew's cross	Piedmont-Coastal Plain	Common
Hypericum virginicum	*Triadenum virginicum*	marsh St. John's-wort	Piedmont-Coastal Plain	Common
Hypericum walteri	*Triadenum walteri*	Walter's St. John's-wort	Coastal Plain	Common
Hypopitys monotropa	*Monotropa hypopithys*	American pinesap	Piedmont-Coastal Plain	Rare
Hypoxis hirsuta		Eastern yellow stargrass	Piedmont-Coastal Plain	Uncommon
Ilex glabra		ink-berry holly	Coastal Plain	Common
Ilex laevigata		smooth winterberry holly	Coastal Plain	Common

Ilex opaca var. *opaca*		American holly	Piedmont-Coastal Plain	Common
Ilex verticillata		winterberry holly	Piedmont-Coastal Plain	Common
Impatiens capensis		spotted jewel-weed	Piedmont-Coastal Plain	Common
Impatiens pallida		pale jewel-weed	Piedmont	Uncommon
Ionactis linariifolia	*Aster linariifolius*	flaxleaf aster	Piedmont-Coastal Plain	Rare
Ipomoea lacunosa		whitestar morning-glory	Piedmont-Coastal Plain	Common
Ipomoea pandurata		big-root morning-glory	Piedmont-Coastal Plain	Common
Ipomopsis rubra	*Gilia rubra*	red standing-cypress	Coastal Plain	Adventive
Iris prismatica		slender blueflag iris	Coastal Plain	Rare
Iris versicolor		blueflag iris	Piedmont-Coastal Plain	Common
Isoetes engelmannii		Engelmann's quillwort	Piedmont-Coastal Plain	Rare
Isoetes riparia	*Isoetes saccharata*	riverbank quillwort	Coastal Plain	Rare
Isoetes tenella	*Isoetes echinospora*	spiny-spored quillwort	Coastal Plain	Rare
Isoetes valida	*Isoetes engelmannii* var. *valida*	Carolina quillwort	Piedmont-Coastal Plain	Historical
Isotria medeoloides		small whorled pogonia	Coastal Plain	Rare
Isotria verticillata		large whorled pogonia	Piedmont-Coastal Plain	Uncommon
Itea virginica		Virginia willow	Coastal Plain	Common
Iva frutescens subsp. *frutescens*		Southern marsh elder	Coastal Plain	Status Uncertain
Iva frutescens subsp. *oraria*		Northern marsh elder	Coastal Plain	Common
Juglans cinerea		butternut	Piedmont	Uncommon
Juglans nigra		black walnut	Piedmont-Coastal Plain	Common
Juncus acuminatus		sharp-fruit rush	Piedmont-Coastal Plain	Common
Juncus biflorus		grassleaf rush	Coastal Plain	Common
Juncus brachycarpus		short-fruited rush	Coastal Plain	Adventive
Juncus bufonius var. *bufonius*		toad rush	Piedmont-Coastal Plain	Common
Juncus canadensis		tailed rush	Piedmont-Coastal Plain	Common
Juncus coriaceus		leathery rush	Coastal Plain	Rare
Juncus debilis		weak rush	Coastal Plain	Common
Juncus dichotomus		forked rush	Coastal Plain	Common
Juncus diffusissimus		diffuse rush	Coastal Plain	Adventive
Juncus effusus var. *solutus*		smooth rush	Piedmont-Coastal Plain	Common
Juncus elliottii		bog rush	Coastal Plain	Historical
Juncus gerardii		black-grass rush	Coastal Plain	Common
Juncus marginatus		marginal grassleaf rush	Piedmont-Coastal Plain	Common
Juncus militaris		bayonet rush	Coastal Plain	Rare
Juncus nodosus		knotted rush	Coastal Plain	Historical
Juncus pelocarpus		brown-fruited rush	Coastal Plain	Rare
Juncus pylaei	J*uncus effusus* var. *costulatus*; *Juncus effusus* var. *pylaei*	ridged rush	Coastal Plain	Status Uncertain
Juncus repens		creeping rush	Coastal Plain	Common
Juncus roemerianus		needle rush	Coastal Plain	Common
Juncus scirpoides var. *compositus*		lobulate round-head rush	Coastal Plain	Adventive
Juncus scirpoides var. *scirpoides*		round-head rush	Coastal Plain	Common
Juncus secundus		one-sided rush	Piedmont-Coastal Plain	Common
Juncus subcaudatus		short-tailed rush	Piedmont-Coastal Plain	Rare
Juncus tenuis		slender rush	Piedmont-Coastal Plain	Common
Juncus torreyi		Torrey's rush	Coastal Plain	Adventive
Juncus validus var. *validus*		vigorous rush	Coastal Plain	Adventive
Juniperus communis		ground juniper	Piedmont	Adventive
Juniperus virginiana var. *virginiana*		Eastern red-cedar	Piedmont-Coastal Plain	Common
Justicia americana		American water-willow	Coastal Plain	Adventive
Kalmia angustifolia	*Kalmia angustifolia* var. *angustifolia*	sheep-laurel	Coastal Plain	Rare
Kalmia latifolia		mountain laurel	Piedmont-Coastal Plain	Common
Koeleria macrantha	*Koeleria cristata* an illegitimate name; *K. pyramidata*	prairie Junegrass	Piedmont	Adventive

Kosteletzkya pentacarpos var. *pentacarpos*	*Kosteletzkya virginica; K. virginica* var. *aquilonia*	Virginia sea-shore mallow	Coastal Plain	Common
Krigia biflora var. *biflora*		two-flowered dwarf dandelion	Piedmont-Coastal Plain	Status Uncertain
Krigia virginica		Virginia dwarf-dandelion	Piedmont-Coastal Plain	Common
Lachnanthes caroliniana		Carolina redroot	Coastal Plain	Rare
Lactuca biennis	*Lactuca spicata*	tall blue lettuce	Piedmont-Coastal Plain	Common
Lactuca canadensis	*Lactuca canadensis* var. *latifolia; L. canadensis* var. *longifolia; L. canadensis* var. *obovata*	Canada lettuce	Piedmont-Coastal Plain	Common
Lactuca floridana	*Lactuca floridana* var. *villosa*	woodland lettuce	Piedmont-Coastal Plain	Rare
Laportea canadensis		Canada wood-nettle	Piedmont-Coastal Plain	Common
Lathyrus palustris	*Lathyrus palustris* var. *myrtifolius*	vetchling peavine	Coastal Plain	Historical
Lechea maritima var. *maritima*		Northern beach pinweed	Coastal Plain	Common
Lechea maritima var. *virginica*		Southern beach pinweed	Coastal Plain	Historical
Lechea minor		thyme-leaf pinweed	Piedmont-Coastal Plain	Common
Lechea mucronata	*Lechea villosa*	hairy pinweed	Coastal Plain	Rare
Lechea pulchella var. *pulchella*	*Lechea leggettii*	Leggett's pinweed	Piedmont-Coastal Plain	Common
Lechea racemulosa		pinweed	Coastal Plain	Common
Leersia oryzoides		rice cutgrass	Piedmont-Coastal Plain	Common
Leersia virginica		Virginia cutgrass	Piedmont-Coastal Plain	Common
Lemna minor		lesser duckweed	Piedmont-Coastal Plain	Common
Lemna obscura		little water duckweed	Coastal Plain	Status Uncertain
Lemna perpusilla		minute duckweed	Piedmont-Coastal Plain	Common
Lepidium densiflorum		dense-flower pepper-grass	Piedmont-Coastal Plain	Adventive
Lepidium virginicum subsp. *virginicum*		poor-man's pepper-grass	Piedmont-Coastal Plain	Common
Leptochloa maritima	*Diplachne maritima*; *Leptochloa fascicularis* var. *maritima*	long-awned sprangletop	Coastal Plain	Common
Lespedeza angustifolia		narrowleaf bushclover	Coastal Plain	Uncommon
Lespedeza capitata		roundhead bushclover	Piedmont-Coastal Plain	Common
Lespedeza frutescens	Lespedeza intermedia misapplied	violet bushclover	Piedmont-Coastal Plain	Status Uncertain
Lespedeza hirta var. *hirta*		hairy bushclover	Piedmont-Coastal Plain	Uncommon
Lespedeza procumbens		trailing bushclover	Piedmont-Coastal Plain	Common
Lespedeza repens		creeping bushclover	Piedmont-Coastal Plain	Common
Lespedeza stuevei		tall bushclover	Coastal Plain	Rare
Lespedeza violacea	*Lespedeza intermedia*	wand bushclover	Piedmont-Coastal Plain	Common
Lespedeza virginica		slender bushclover	Piedmont-Coastal Plain	Common
Leucothoe axillaris		coastal doghobble	Coastal Plain	Adventive
Liatris cylindracea		slender blazingstar	Coastal Plain	Adventive
Liatris pilosa	*Liatris graminifolia*	grassleaf blazingstar	Coastal Plain	Rare
Liatris scariosa var. *scariosa*		round-head blazing-star	Piedmont	Historical
Liatris spicata var. *resinosa*		spicate blazingstar	Coastal Plain	Historical
Liatris spicata var. *spicata*		spicate blazingstar	Piedmont-Coastal Plain	Historical
Liatris squarrosa var. *squarrosa*		Northern blazingstar	Piedmont	Historical
Lilaeopsis chinensis		Eastern lilaeopsis	Coastal Plain	Common
Lilium canadense subsp. *canadense*		Canada lily	Piedmont-Coastal Plain	Rare
Lilium philadelphicum var. *philadelphicum*		wood lily	Piedmont	Extirpated
Lilium superbum		Turk's cap lily	Piedmont-Coastal Plain	Common
Limnobium spongia		American frog's-bit	Coastal Plain	Rare
Limonium carolinianum		sea-lavender	Coastal Plain	Common
Limosella australis		mudwort	Coastal Plain	Extirpated
Lindera benzoin var. *benzoin*		smooth spicebush	Piedmont-Coastal Plain	Common
Lindera benzoin var. *pubescens*		hairy spicebush	Piedmont-Coastal Plain	Common
Lindernia dubia var. *anagallidea*		long yellowseed false pimpernel	Piedmont-Coastal Plain	Common

Lindernia dubia var. *dubia*	*Lindernia dubia* var. *inundata*	short yellowseed false pimpernel	Piedmont-Coastal Plain	Common
Linum intercursum		sandplain flax	Coastal Plain	Rare
Linum medium var. *texanum*		wild flax	Piedmont-Coastal Plain	Common
Linum striatum		ridged yellow flax	Piedmont-Coastal Plain	Common
Linum virginianum		Virginia flax	Piedmont-Coastal Plain	Common
Liparis liliifolia		large twayblade	Piedmont-Coastal Plain	Rare
Liquidambar styraciflua		sweet-gum	Piedmont-Coastal Plain	Common
Liriodendron tulipifera		tuliptree	Piedmont-Coastal Plain	Common
Listera australis		Southern twayblade	Coastal Plain	Uncommon
Lithospermum virginianum	*Onosmodium virginianum*	Virginia false gromwell	Piedmont-Coastal Plain	Historical
Lobelia boykinii		Boykin's lobelia	Coastal Plain	Extirpated
Lobelia canbyi		Canby's lobelia	Coastal Plain	Rare
Lobelia cardinalis		Cardinal-flower	Piedmont-Coastal Plain	Common
Lobelia elongata		Southern blue lobelia	Coastal Plain	Rare
Lobelia inflata		inflated lobelia	Piedmont-Coastal Plain	Common
Lobelia nuttallii		Nuttall's lobelia	Coastal Plain	Common
Lobelia puberula var. *puberula*		downy lobelia	Coastal Plain	Common
Lobelia siphilitica		great blue lobelia	Piedmont	Common
Lobelia spicata var. *campanulata*		pale-spike lobelia	Piedmont	Historical
Lobelia spicata var. *spicata*		pale-spike lobelia	Piedmont-Coastal Plain	Rare
Lonicera sempervirens var. *sempervirens*		trumpet honeysuckle	Piedmont-Coastal Plain	Common
Lophiola aurea		golden crest	Coastal Plain	Extirpated
Ludwigia alternifolia		bushy seedbox	Piedmont-Coastal Plain	Common
Ludwigia hirtella		hairy seedbox	Coastal Plain	Rare
Ludwigia leptocarpa		water-willow seedbox	Coastal Plain	Adventive
Ludwigia linearis var. *linearis*		narrow-leaf seedbox	Coastal Plain	Uncommon
Ludwigia palustris		marsh seedbox	Piedmont-Coastal Plain	Common
Ludwigia peploides subsp. *glabrescens*		floating seedbox	Piedmont-Coastal Plain	Adventive
Ludwigia sphaerocarpa		globe-fruited seedbox	Coastal Plain	Common
Lupinus perennis		purple lupine	Coastal Plain	Rare
Luzula acuminata var. *acuminata*		Northern hairy woodrush	Coastal Plain	Rare
Luzula acuminata var. *carolinae*		Southern hairy woodrush	Coastal Plain	Rare
Luzula bulbosa		bulbous woodrush	Piedmont-Coastal Plain	Common
Luzula echinata		hedgehog woodrush	Piedmont-Coastal Plain	Common
Luzula multiflora		multi-flowered wood rush	Piedmont-Coastal Plain	Common
Lycopodiella alopecuroides	*Lycopodium alopecuroides*	foxtail bog clubmoss	Coastal Plain	Uncommon
Lycopodiella appressa	*Lycopodium adpressum*	appressed bog clubmoss	Coastal Plain	Uncommon
Lycopodium clavatum		staghorn clubmoss	Piedmont-Coastal Plain	Uncommon
Lycopus americanus		American bugleweed	Piedmont-Coastal Plain	Common
Lycopus amplectens		sessile-leaved bugleweed	Coastal Plain	Rare
Lycopus rubellus		taperleaf bugleweed	Coastal Plain	Common
Lycopus uniflorus		Northern bugleweed	Piedmont-Coastal Plain	Common
Lycopus virginicus		Virginia bugleweed	Piedmont-Coastal Plain	Common
Lygodium palmatum		climbing fern	Piedmont-Coastal Plain	Rare
Lyonia ligustrina var. *ligustrina*		Northern maleberry	Piedmont-Coastal Plain	Common
Lyonia mariana		staggerbush	Coastal Plain	Rare
Lysimachia ciliata		fringed loosestrife	Piedmont-Coastal Plain	Common
Lysimachia hybrida	*Lysimachia lanceolata* subsp. *hybrida*	lowland loosestrife	Coastal Plain	Rare
Lysimachia lanceolata		lance-leaf loosestrife	Coastal Plain	Status Uncertain
Lysimachia quadrifolia		whorled loosestrife	Piedmont-Coastal Plain	Common
Lysimachia terrestris		swamp loosestrife	Piedmont-Coastal Plain	Common
Lythrum lineare		narrow loosestrife	Coastal Plain	Common
Maclura pomifera		osage orange	Piedmont-Coastal Plain	Adventive

Magnolia tripetala		umbrella tree	Piedmont	Adventive
Magnolia virginiana var. *virginiana*		Northern sweetbay magnolia	Coastal Plain	Common
Mahonia repens		creeping hollygrape	Piedmont	Adventive
Maianthemum canadense		Canada Mayflower	Piedmont-Coastal Plain	Common
racemosum	*Smilacina racemosa*	Solomon's plume	Piedmont-Coastal Plain	Common
Malaxis unifolia		green adder's-mouth	Piedmont-Coastal Plain	Rare
Malus angustifolia	*Pyrus angustifolia*	Southern crabapple	Coastal Plain	Status Uncertain
Malus coronaria	*Pyrus coronaria*	sweet crabapple	Piedmont-Coastal Plain	Status Uncertain
Matelea carolinensis		Carolina anglepod	Coastal Plain	Rare
Matricaria discoidea		pineapple-weed	Piedmont-Coastal Plain	Adventive
Matteuccia struthiopteris var. *pensylvanica*		ostrich fern	Piedmont	Adventive
Mecardonia acuminata var. *acuminata*		purple mecardonia	Coastal Plain	Uncommon
Medeola virginiana		Indian cucumber-root	Piedmont-Coastal Plain	Common
Melampyrum lineare var. *americanum*	Melampyrum lineare var. *lineare* misapplied	American cow-wheat	Piedmont-Coastal Plain	Common
Melampyrum lineare var. *pectinatum*		pectinate cow-wheat	Coastal Plain	Common
Melothria pendula var. *pendula*		creeping cucumber	Coastal Plain	Adventive
Menispermum canadense		Canada moonseed	Piedmont-Coastal Plain	Common
Mentha canadensis	*Mentha arvensis* var. *canadensis; M. arvensis* var. *villosa; M. gentilis*	Canada mint	Piedmont-Coastal Plain	Status Uncertain
Menyanthes trifoliata		bog buckbean	Coastal Plain	Extirpated
Mertensia virginica		Virginia bluebells	Piedmont-Coastal Plain	Uncommon
Micranthemum micranthemoides		Nuttall's micranthemum	Coastal Plain	Extirpated
Micranthes pensylvanica	*Saxifraga pensylvanica*	swamp saxifrage	Piedmont-Coastal Plain	Rare
Micranthes virginiensis	*Saxifraga virginiensis*	Virginia saxifrage	Piedmont-Coastal Plain	Uncommon
Mikania scandens		climbing hempweed	Coastal Plain	Common
Mimulus alatus		sharp-wing monkeyflower	Piedmont-Coastal Plain	Common
Mimulus ringens		square-stem monkeyflower	Piedmont-Coastal Plain	Common
Minuartia caroliniana		pine barren sandwort	Coastal Plain	Rare
Minuartia michauxii var. *michauxii*	*Arenaria stricta*	rock sandwort	Piedmont	Extirpated
Mirabilis nyctaginea		heart-leaved umbrella-wort	Piedmont-Coastal Plain	Adventive
Mitchella repens		partridge-berry	Piedmont-Coastal Plain	Common
Mitella diphylla		two-leaf Bishop's-cap	Piedmont-Coastal Plain	Rare
Modiola caroliniana		bristly-fruited mallow	Coastal Plain	Adventive
Monarda clinopodia		basil beebalm	Piedmont	Rare
Monarda didyma		Oswego-tea beebalm	Piedmont	Adventive
Monarda fistulosa var. *fistulosa*		wild bergamot beebalm	Piedmont	Status Uncertain
Monarda punctata subsp. *punctata*		horsemint beebalm	Coastal Plain	Common
Monotropa uniflora		Indian-pipe	Piedmont-Coastal Plain	Common
Monotropsis odorata		sweet pinesap	Piedmont-Coastal Plain	Historical
Morella caroliniensis	*Myrica heterophylla*	evergreen bayberry	Coastal Plain	Rare
Morella cerifera	*Myrica cerifera; M. pusilla*	Southern bayberry	Coastal Plain	Common
Morella pensylvanica	*Myrica pensylvanica*	Northern bayberry	Piedmont-Coastal Plain	Common
Morus rubra		red mulberry	Piedmont-Coastal Plain	Uncommon
Muhlenbergia capillaris		long-awn muhly	Piedmont	Historical
Muhlenbergia frondosa	*Muhlenbergia mexicana* misapplied	wirestem muhly	Piedmont-Coastal Plain	Common
Muhlenbergia schreberi		Schreber's muhly	Piedmont-Coastal Plain	Common
Muhlenbergia sobolifera		cliff muhly	Piedmont	Rare
Muhlenbergia sylvatica		woodland muhly	Piedmont	Historical
Muhlenbergia tenuiflora		slender muhly	Piedmont-Coastal Plain	Rare
Muhlenbergia torreyana		Torrey's muhly	Coastal Plain	Extirpated

Muscadinia rotundifolia var. *rotundifolia*	*Vitis rotundifolia* var. *rotundifolia*	Muscadine grape	Coastal Plain	Common
Myosotis laxa subsp. *laxa*		small forget-me-not	Piedmont-Coastal Plain	Uncommon
Myosotis macrosperma		large-seed forget-me-not	Piedmont	Rare
Myosotis verna		spring forget-me-not	Piedmont-Coastal Plain	Historical
Myosurus minimus		Eastern mousetail	Coastal Plain	Adventive
Myriophyllum heterophyllum		broadleaf water-milfoil	Coastal Plain	Status Uncertain
Myriophyllum humile		low water-milfoil	Coastal Plain	Uncommon
Myriophyllum pinnatum		cutleaf water-milfoil	Coastal Plain	Rare
Myriophyllum sibiricum	*Myriophyllum exalbescens*	shortspike water-milfoil	Coastal Plain	Status Uncertain
Myriophyllum verticillatum		whorled water-milfoil	Coastal Plain	Status Uncertain
Nabalus albus	*Prenanthes alba*	white rattlesnake-root	Piedmont	Historical
Nabalus altissimus	*Prenanthes altissima*	tall rattlesnake-root	Piedmont	Common
Nabalus autumnalis	*Prenanthes autumnalis*	slender rattlesnake-root	Coastal Plain	Historical
Nabalus serpentarius	*Prenanthes serpentaria*	lion's-foot rattlesnake-root	Piedmont-Coastal Plain	Common
Nabalus trifoliolatus var. *trifoliolatus*	*Prenanthes trifoliolata*	three-leaved rattlesnake-root	Piedmont-Coastal Plain	Common
Najas flexilis		slender naiad	Piedmont	Status Uncertain
Najas gracillima		thread-like naiad	Coastal Plain	Rare
Najas guadalupensis var. *guadalupensis*		Southern naiad	Coastal Plain	Status Uncertain
Narthecium americanum		bog asphodel	Coastal Plain	Extirpated
Nelumbo lutea		American lotus	Coastal Plain	Rare
Nuphar advena	Nuphar lutea subsp. *advena*	spatterdock	Piedmont-Coastal Plain	Common
Nuphar variegata	*Nuphar lutea* subsp. *variegata*	floating spatterdock	Coastal Plain	Common
Nuttallanthus canadensis	*Linaria canadensis*	old-field toadflax	Piedmont-Coastal Plain	Common
Nymphaea odorata subsp. *odorata*		waterlily	Piedmont-Coastal Plain	Common
Nymphoides aquatica		big floatingheart	Coastal Plain	Status Uncertain
Nymphoides cordata		little floatingheart	Coastal Plain	Rare
Nyssa biflora		swamp blackgum	Coastal Plain	Common
Nyssa sylvatica		blackgum	Piedmont-Coastal Plain	Common
Obolaria virginica		Virginia pennywort	Piedmont-Coastal Plain	Uncommon
Oclemena nemoralis	*Aster nemoralis*	bog aster	Coastal Plain	Extirpated
Oenothera biennis		biennial evening-primrose	Piedmont-Coastal Plain	Common
Oenothera fruticosa var. *fruticosa*		narrow-leaf evening-primrose	Piedmont-Coastal Plain	Rare
Oenothera humifusa		sea-beach evening-primrose	Coastal Plain	Uncommon
Oenothera laciniata		cutleaf evening-primrose	Piedmont-Coastal Plain	Common
Oenothera oakesiana	*Oenothera biennis* var. *oakesiana*	Oake's evening-primrose	Coastal Plain	Status Uncertain
Oenothera parviflora		small flowered evening-primrose	Piedmont-Coastal Plain	Status Uncertain
Oenothera perennis		perennial evening-primrose	Piedmont-Coastal Plain	Status Uncertain
Oenothera tetragona var. *tetragona*	*Oenothera fruticosa* subsp. *glauca*	shrubby evening-primrose	Piedmont-Coastal Plain	Rare
Oldenlandia uniflora	*Hedyotis uniflora*	clustered bluets	Coastal Plain	Common
Onoclea sensibilis		sensitive fern	Piedmont-Coastal Plain	Common
Ophioglossum pusillum	*Ophioglossum vulgatum* var. *pseudopodum*	Northern adder's-tongue	Piedmont	Historical
Ophioglossum vulgatum	*Ophioglossum pycnostichum*	Southern adder's-tongue	Piedmont-Coastal Plain	Uncommon
Opuntia humifusa var. *humifusa*		Eastern prickly-pear cactus	Coastal Plain	Common
Orobanche uniflora		one-flowered broomrape	Piedmont	Uncommon
Orontium aquaticum		golden club	Coastal Plain	Common
Orthilia secunda	*Pyrola secunda*	one-side shinleaf	Coastal Plain	Historical

Osmorhiza claytonii		bland sweet-Cicely	Piedmont-Coastal Plain	Common
Osmorhiza longistylis		scented sweet-Cicely	Piedmont-Coastal Plain	Common
Osmunda claytoniana var. *claytoniana*		interrupted fern	Piedmont-Coastal Plain	Common
Osmunda regalis var. *spectabilis*		royal fern	Piedmont-Coastal Plain	Common
Osmundastrum cinnamomeum var. *cinnamomeum*	*Osmunda cinnamomea*	cinnamon fern	Piedmont-Coastal Plain	Common
Osmundastrum cinnamomeum var. *glandulosum*	Osmunda cinnamomea var. *glandulosa*	glandulose cinnamon fern	Coastal Plain	Rare
Ostrya virginiana		Eastern hop-hornbeam	Piedmont	Rare
Oxalis dillenii	*Oxalis dillenii* subsp. *filipes; O. florida*	Southern yellow woodsorrel	Piedmont-Coastal Plain	Common
Oxalis stricta		upright yellow woodsorrel	Piedmont-Coastal Plain	Common
Oxalis violacea		violet woodsorrel	Piedmont-Coastal Plain	Common
Oxypolis rigidior		stiff cowbane	Piedmont-Coastal Plain	Common
Packera anonyma	*Senecio anonymus*	Small's ragwort	Piedmont	Rare
Packera aurea	*Senecio aureus*	golden ragwort	Piedmont-Coastal Plain	Common
Packera paupercula var. *paupercula*	*Senecio pauperculus*	balsam ragwort	Piedmont-Coastal Plain	Rare
Packera tomentosa	*Senecio tomentosus*	woolly ragwort	Coastal Plain	Common
Panax quinquefolius		American ginseng	Piedmont-Coastal Plain	Rare
Panax trifolius		dwarf ginseng	Piedmont-Coastal Plain	Common
Panicum amarum var. *amarulum*	*Panicum amarulum*	tall beach panicgrass	Coastal Plain	Common
Panicum amarum var. *amarum*		short beach panicgrass	Coastal Plain	Common
Panicum capillare		old witch panicgrass	Piedmont-Coastal Plain	Common
Panicum dichotomiflorum var. *dichotomiflorum*		fall panicgrass	Piedmont-Coastal Plain	Common
Panicum dichotomiflorum var. *puritanorum*		Puritan fall panicgrass	Coastal Plain	Common
Panicum hemitomon		maidencane panicgrass	Coastal Plain	Rare
Panicum philadelphicum		Philadelphia panicgrass	Piedmont-Coastal Plain	Rare
Panicum rigidulum var. *condensum*	*Panicum agrostoides* var. *condensum*	condensed redtop panicgrass	Coastal Plain	Status Uncertain
Panicum rigidulum var. *elongatum*	*Panicum agrostoides* var. *elongatum; P. stipitatum*	elongate redtop panicgrass	Coastal Plain	Status Uncertain
Panicum rigidulum var. *rigidulum*	*Panicum agrostoides* var. *agrostoides*	ridgid redtop panicgrass	Piedmont-Coastal Plain	Common
Panicum verrucosum		warty panicgrass	Coastal Plain	Common
Panicum virgatum var. *cubense*		short switchgrass	Coastal Plain	Status Uncertain
Panicum virgatum var. *spissum*		tufted switchgrass	Coastal Plain	Status Uncertain
Panicum virgatum var. *virgatum*		tall switchgrass	Coastal Plain	Common
Parathelypteris noveboracensis	*Thelypteris noveboracensis*	New York fern	Piedmont-Coastal Plain	Common
Parathelypteris simulata	*Thelypteris simulata*	bog fern	Coastal Plain	Rare
Parietaria floridana	*Parietaria debilis*	Florida pellitory	Piedmont	Adventive
Paronychia canadensis		forked nailwort	Piedmont-Coastal Plain	Rare
Paronychia fastigiata var. *fastigiata*		cluster-stemmed nailwort	Piedmont-Coastal Plain	Rare
Paronychia fastigiata var. *paleacea*		cluster-stemmed nailwort	Piedmont	Rare
Parthenium hysterophorus		Santa Maria feverfew	Coastal Plain	Adventive
Parthenocissus quinquefolia		Virginia creeper	Piedmont-Coastal Plain	Common
Paspalum dissectum		Walter's paspalum	Coastal Plain	Uncommon
Paspalum floridanum		Florida paspalum	Coastal Plain	Common
Paspalum laeve	*Paspalum laeve* var. *circulare*; *P. laeve* var. *laeve*; *P. laeve* var. *pilosum*	field paspalum	Piedmont-Coastal Plain	Common
Paspalum pubiflorum var. *glabrum*		hairyseed paspalum	Piedmont	Adventive

Paspalum setaceum var. *muhlenbergii*	*Paspalum ciliatifolium* var. *muhlenbergii*	slender erect paspalum	Piedmont-Coastal Plain	Common
Paspalum setaceum var. *setaceum*		slender paspalum	Coastal Plain	Uncommon
Passiflora incarnata		purple passion-flower	Coastal Plain	Adventive
Passiflora lutea var. *lutea*		yellow passion-flower	Coastal Plain	Common
Pedicularis canadensis		early wood lousewort	Piedmont	Rare
Pedicularis lanceolata		swamp lousewort	Piedmont-Coastal Plain	Historical
Pellaea atropurpurea		purple-stem cliff-brake	Piedmont	Adventive
Peltandra virginica		arrow-arum	Coastal Plain	Common
Penstemon digitalis		tall white beardtongue	Piedmont-Coastal Plain	Common
Penstemon hirsutus		hairy beardtongue	Piedmont	Historical
Penstemon laevigatus		smooth beardtongue	Piedmont-Coastal Plain	Rare
Penthorum sedoides		ditch stonecrop	Piedmont-Coastal Plain	Common
Persea palustris		red bay	Coastal Plain	Historical
Persicaria amphibia	*Polygonum amphibium* var. *emersum; P. coccineum*	water smartweed	Coastal Plain	Common
Persicaria arifolia	*Polygonum arifolium*	triangle-leaf tearthumb	Piedmont-Coastal Plain	Common
Persicaria careyi	*Polygonum careyi*	Carey's smartweed	Coastal Plain	Historical
Persicaria glabra	*Polygonum densiflorum*	dense-flowered smartweed	Coastal Plain	Common
Persicaria hydropiperoides	*Polygonum hydropiperoides*	water-pepper smartweed	Piedmont-Coastal Plain	Common
Persicaria pensylvanica	*Polygonum pensylvanicum*	Pennsylvania smartweed	Piedmont-Coastal Plain	Common
Persicaria punctata	*Polygonum punctatum* var. *punctatum; P. puncatum* var. *confertiflorum*	dotted smartweed	Piedmont-Coastal Plain	Common
Persicaria sagittata	*Polygonum sagittatum*	arrowleaf tearthumb	Piedmont-Coastal Plain	Common
Persicaria virginiana	*Polygonum virginianum*	Virginia smartweed	Piedmont-Coastal Plain	Common
Phacelia dubia var. *dubia*		small-flower scorpionweed	Coastal Plain	Historical
Phalaris arundinacea		reed canary grass	Piedmont-Coastal Plain	Adventive
Phaseolus polystachios		wild kidney bean	Piedmont-Coastal Plain	Historical
Phegopteris connectilis	*Thelypteris phegopteris; Phegopteris polypodioides*	Northern beech fern	Piedmont	Historical
Phegopteris hexagonoptera	*Thelypteris hexagonoptera*	broad beech fern	Piedmont-Coastal Plain	Common
Phemeranthus teretifolius	*Talinum teretifolium*	round-leaved fame-flower	Piedmont	Extirpated
Phlox divaricata var. *divaricata*		blue phlox	Piedmont	Adventive
Phlox maculata subsp. *maculata*		spotted phlox	Piedmont-Coastal Plain	Status Uncertain
Phlox paniculata		fall phlox	Piedmont-Coastal Plain	Adventive
Phlox pilosa subsp. *pilosa*		downy phlox	Piedmont	Extirpated
Phoradendron serotinum subsp. *serotinum*	*Phoradendron leucarpum*	American mistletoe	Coastal Plain	Common
Phragmites australis subsp. *americanus*		North American reed	Coastal Plain	Rare
Phryma leptostachya var. *leptostachya*		lopseed	Piedmont-Coastal Plain	Common
Phyla lanceolata		fog-fruit	Coastal Plain	Rare
Phyllanthus caroliniensis		Carolina leaf-flower	Coastal Plain	Rare
Physalis angulata var. *angulata*		cutleaf ground-cherry	Coastal Plain	Adventive
Physalis heterophylla		clammy ground-cherry	Piedmont-Coastal Plain	Common
Physalis longifolia var. *subglabrata*	*Physalis subglabrata*	longleaf ground-cherry	Piedmont-Coastal Plain	Common
Physalis pubescens var. *integrifolia*	*Physalis pruinosa*	low hairy ground-cherry	Piedmont-Coastal Plain	Common
Physalis virginiana		Virginia ground-cherry	Coastal Plain	Historical
Physocarpus opulifolius var. *opulifolius*		Eastern ninebark	Piedmont	Historical
Physostegia virginiana subsp. *virginiana*	*Dracocephalum virginianum*	false dragonhead	Piedmont-Coastal Plain	Adventive
Phytolacca americana		pokeweed	Piedmont-Coastal Plain	Common
Picea rubens		red spruce	Piedmont-Coastal Plain	Adventive
Pieris floribunda		evergreen mountain fetterbush	Coastal Plain	Adventive

Pilea fontana		spring clearweed	Piedmont-Coastal Plain	Common
Pilea pumila		Canada clearweed	Piedmont-Coastal Plain	Common
Pinus echinata		shortleaf pine	Piedmont-Coastal Plain	Uncommon
Pinus rigida		pitch pine	Piedmont-Coastal Plain	Uncommon
Pinus serotina		pond pine	Coastal Plain	Common
Pinus strobus		Eastern white pine	Piedmont-Coastal Plain	Adventive
Pinus taeda		loblolly pine	Coastal Plain	Common
Pinus virginiana		Virginia pine	Piedmont-Coastal Plain	Common
Piptatherum racemosum	*Oryzopsis racemosa*	black-fruit mountain-ricegrass	Piedmont	Historical
Piptochaetium avenaceum	*Stipa avenacea*	blackseed needlegrass	Piedmont-Coastal Plain	Uncommon
Pityopsis graminifolia var. *latifolia*	*Chrysopsis graminifolia* var. *latifolia*	grassleaf golden aster	Coastal Plain	Historical
Planodes virginicum	*Sibara virginica*	Virginia-cress	Coastal Plain	Adventive
Plantago aristata		large-bract plantain	Coastal Plain	Adventive
Plantago heterophylla		slender plantain	Coastal Plain	Adventive
Plantago pusilla		dwarf plantain	Piedmont-Coastal Plain	Adventive
Plantago rugelii		black-seed plantain	Piedmont-Coastal Plain	Common
Plantago virginica		Virginia plantain	Piedmont-Coastal Plain	Common
Platanthera blephariglottis	*Habenaria blephariglottis*	white-fringe orchis	Coastal Plain	Rare
Platanthera ciliaris	*Habenaria ciliaris*	yellow-fringe orchid	Piedmont-Coastal Plain	Historical
Platanthera clavellata	*Habenaria clavellata*	small green woodland orchid	Piedmont-Coastal Plain	Common
Platanthera cristata	*Habenaria cristata*	yellow-crested orchis	Coastal Plain	Rare
Platanthera flava var. *flava*	*Habenaria flava* var. *flava*	Southern rein orchid	Coastal Plain	Rare
Platanthera flava var. *herbiola*	*Habenaria flava* var. *herbiola*	Northern rein orchid	Piedmont	Rare
Platanthera grandiflora	*Habenaria fimbriata*	large purple-fringe orchis	Piedmont	Extirpated
Platanthera lacera	*Habenaria lacera*	green-fringe orchis	Piedmont-Coastal Plain	Uncommon
Platanthera nivea	*Habenaria nivea*	snowy orchis	Coastal Plain	Historical
Platanthera peramoena	*Habenaria peramoena*	purple fringeless orchid	Piedmont-Coastal Plain	Rare
Platanthera psycodes	*Habenaria psycodes*	small purple-fringe orchis	Piedmont	Historical
Platanus occidentalis		sycamore	Piedmont-Coastal Plain	Common
Pleopeltis polypodioides subsp. *michauxiana*	*Polypodium polypodioides* var. *michauxianum*	resurrection fern	Coastal Plain	Extirpated
Pluchea camphorata		marsh fleabane	Coastal Plain	Historical
Pluchea foetida var. *foetida*		stinking camphorweed	Coastal Plain	Uncommon
Pluchea odorata var. *odorata*	*Pluchea purpurascens* var. *purpurascens*	salt marsh fleabane	Coastal Plain	Status Uncertain
Pluchea odorata var. *succulenta*	*Pluchea purpurascens*	salt marsh fleabane	Coastal Plain	Common
Poa alsodes		woodland bluegrass	Piedmont-Coastal Plain	Common
Poa autumnalis		autumn bluegrass	Piedmont-Coastal Plain	Uncommon
Poa chapmaniana		Chapman's bluegrass	Coastal Plain	Adventive
Poa cuspidata		early bluegrass	Piedmont	Rare
Poa paludigena		bog bluegrass	Piedmont	Rare
Poa palustris		fowl bluegrass	Piedmont-Coastal Plain	Adventive
Poa sylvestris		forest bluegrass	Piedmont	Common
Podophyllum peltatum		Mayapple	Piedmont-Coastal Plain	Common
Podostemum ceratophyllum		threadfoot	Piedmont	Rare
Pogonia ophioglossoides		rose pogonia	Piedmont-Coastal Plain	Rare
Polemonium reptans var. *reptans*		Greek valerian	Piedmont-Coastal Plain	Uncommon
Polygala ambigua	*Polygala verticillata* var. *ambigua*	whorled milkwort	Piedmont-Coastal Plain	Historical
Polygala cruciata var. *aquilonia*		crossleaf milkwort	Coastal Plain	Rare
Polygala cymosa		tall pine barren milkwort	Coastal Plain	Extirpated
Polygala incarnata		pink milkwort	Piedmont-Coastal Plain	Rare
Polygala lutea		yellow milkwort	Coastal Plain	Common
Polygala mariana		Maryland milkwort	Coastal Plain	Common
Polygala nuttallii		Nuttall's milkwort	Piedmont-Coastal Plain	Common
Polygala ramosa		low pine barren milkwort	Coastal Plain	Extirpated
Polygala sanguinea		field milkwort	Piedmont-Coastal Plain	Common

Polygala senega var. *latifolia*		Seneca milkwort	Piedmont	Extirpated
Polygala verticillata var. *isocycla*		whorled milkwort	Piedmont-Coastal Plain	Common
Polygonatum biflorum var. *biflorum*		Solomon's-seal	Piedmont-Coastal Plain	Common
Polygonatum biflorum var. *commutatum*	*Polygonatum canaliculatum*	giant Solomon's-seal	Piedmont	Uncommon
Polygonatum pubescens		downy Solomon's-seal	Piedmont	Common
Polygonella articulata		Eastern jointweed	Coastal Plain	Common
Polygonum erectum		erect knotweed	Piedmont	Common
Polygonum glaucum		seabeach knotweed	Coastal Plain	Rare
Polygonum ramosissimum	*Polygonum atlanticum; P. ramosissimum* var. *prolificum*; *P. ramosissimum* var. *ramosissimum*	bushy knotweed	Coastal Plain	Rare
Polygonum tenue		slender knotweed	Piedmont-Coastal Plain	Historical
Polypodium virginianum		Virginia polypody	Piedmont-Coastal Plain	Uncommon
Polypremum procumbens		juniper-leaf	Coastal Plain	Common
Polystichum acrostichoides		Christmas fern	Piedmont-Coastal Plain	Common
Pontederia cordata		pickerelweed	Coastal Plain	Common
Populus balsamifera		balsam cottonwood	Piedmont	Adventive
Populus deltoides var. *deltoides*		Eastern cottonwood	Piedmont-Coastal Plain	Adventive
Populus grandidentata		large-tooth cottonwood	Piedmont-Coastal Plain	Common
Populus heterophylla		swamp cottonwood	Coastal Plain	Common
Populus tremuloides		quaking aspen cottonwood	Piedmont	Adventive
Potamogeton diversifolius		water-thread pondweed	Piedmont-Coastal Plain	Common
Potamogeton epihydrus		Nuttall's pondweed	Piedmont-Coastal Plain	Common
Potamogeton foliosus		leafy pondweed	Piedmont-Coastal Plain	Common
Potamogeton natans		floating pondweed	Coastal Plain	Rare
Potamogeton nodosus	*Potamogeton americanus*	longleaf pondweed	Piedmont	Common
Potamogeton perfoliatus		clasping-leaf pondweed	Coastal Plain	Status Uncertain
Potamogeton pulcher		spotted pondweed	Coastal Plain	Common
Potamogeton pusillus var. *tenuissimus*	*Potamogeton berchtoldi* var. *mucronatus; P. berchtoldi* var. *tenuissimus*	slender pondweed	Coastal Plain	Status Uncertain
Potamogeton robbinsii		flatleaf pondweed	Coastal Plain	Extirpated
Potamogeton spirillus		spiral pondweed	Coastal Plain	Common
Potentilla canadensis		Canada cinquefoil	Piedmont-Coastal Plain	Common
Potentilla norvegica		rough cinquefoil	Piedmont-Coastal Plain	Common
Potentilla simplex		simple cinquefoil	Piedmont-Coastal Plain	Common
Proserpinaca palustris var. *crebra*		marsh mermaidweed	Coastal Plain	Common
Proserpinaca palustris var. *palustris*		marsh mermaidweed	Coastal Plain	Common
Proserpinaca pectinata		combleaf mermaidweed	Coastal Plain	Common
Prunella vulgaris var. *lanceolata*		native self-heal	Piedmont-Coastal Plain	Common
Prunus americana		American plum	Piedmont-Coastal Plain	Status Uncertain
Prunus angustifolia var. *angustifolia*		Chickasaw plum	Piedmont-Coastal Plain	Adventive
Prunus maritima		beach plum	Coastal Plain	Uncommon
Prunus serotina var. *serotina*		wild black cherry	Piedmont-Coastal Plain	Common
Pseudognaphalium obtusifolium	*Gnaphalium obtusifolium*	fragrant cudweed	Piedmont-Coastal Plain	Common
Ptelea trifoliata		hoptree	Piedmont	Adventive
Pteridium aquilinum var. *latiusculum*		Northern bracken fern	Piedmont-Coastal Plain	Common
Pteridium aquilinum var. *pseudocaudatum*		Southern bracken fern	Coastal Plain	Common
Ptilimnium capillaceum		mock Bishopweed	Coastal Plain	Common
Puccinellia fasciculata		salt marsh goosegrass	Coastal Plain	Historical

Pycnanthemum clinopodioides		basil mountain-mint	Piedmont	Historical
Pycnanthemum incanum var. *incanum*		hoary mountain-mint	Piedmont-Coastal Plain	Rare
Pycnanthemum muticum		blunt mountain-mint	Piedmont-Coastal Plain	Uncommon
Pycnanthemum setosum		awned mountain-mint	Coastal Plain	Uncommon
Pycnanthemum tenuifolium		slender mountain-mint	Piedmont-Coastal Plain	Common
Pycnanthemum torreyi		Torrey's mountain-mint	Piedmont-Coastal Plain	Historical
Pycnanthemum verticillatum var. *verticillatum*		whorled mountain-mint	Piedmont-Coastal Plain	Uncommon
Pycnanthemum virginianum		Virginia mountain-mint	Piedmont-Coastal Plain	Common
Pyrola americana	*Pyrola rotundifolia* var. *americana*	round-leaf shinleaf	Piedmont-Coastal Plain	Rare
Pyrola chlorantha	*Pyrola virens*	green-flower shinleaf	Coastal Plain	Historical
Pyrola elliptica		elliptic shinleaf	Piedmont	Rare
Pyrrhopappus carolinianus		Carolina false-dandelion	Coastal Plain	Common
Quercus alba		white oak	Piedmont-Coastal Plain	Common
Quercus bicolor		swamp white oak	Piedmont-Coastal Plain	Common
Quercus coccinea		scarlet oak	Piedmont-Coastal Plain	Common
Quercus falcata		Southern red oak	Piedmont-Coastal Plain	Common
Quercus ilicifolia		scrub oak	Piedmont-Coastal Plain	Historical
Quercus imbricaria		shingle oak	Piedmont	Adventive
Quercus lyrata		overcup oak	Coastal Plain	Rare
Quercus macrocarpa		bur oak	Piedmont	Adventive
Quercus marilandica var. *marilandica*		blackjack oak	Coastal Plain	Uncommon
Quercus michauxii		swamp chestnut oak	Piedmont-Coastal Plain	Common
Quercus montana	*Quercus prinus* misapplied	chestnut oak	Piedmont-Coastal Plain	Common
Quercus muehlenbergii		yellow oak	Piedmont	Status Uncertain
Quercus nigra		water oak	Coastal Plain	Common
Quercus pagoda	*Quercus falcata* var. *pagodifolia*	cherrybark oak	Coastal Plain	Status Uncertain
Quercus palustris		pin oak	Piedmont-Coastal Plain	Common
Quercus phellos		willow oak	Coastal Plain	Common
Quercus prinoides		dwarf chinquapin oak	Piedmont-Coastal Plain	Rare
Quercus rubra		Northern red oak	Piedmont-Coastal Plain	Common
Quercus stellata		post oak	Piedmont-Coastal Plain	Common
Quercus velutina		black oak	Piedmont-Coastal Plain	Common
Ranunculus abortivus		kidneyleaf buttercup	Piedmont-Coastal Plain	Common
Ranunculus ambigens		water-plantain buttercup	Coastal Plain	Rare
Ranunculus caricetorum	*Ranunculus hispidus* var. *caricetorum*; *R. septentrionalis* misapplied; *R. septentrionalis* var. *caricetorum*	hispid buttercup	Piedmont	Rare
Ranunculus flabellaris		yellow water-crowfoot	Coastal Plain	Rare
Ranunculus hispidus		bristly buttercup	Piedmont	Rare
Ranunculus laxicaulis		Mississippi buttercup	Coastal Plain	Historical
Ranunculus longirostris		Eastern white water-crowfoot	Coastal Plain	Extirpated
Ranunculus pensylvanicus		bristly buttercup	Coastal Plain	Status Uncertain
Ranunculus pusillus		Pursh's buttercup	Coastal Plain	Uncommon
Ranunculus recurvatus var. *recurvatus*		hooked buttercup	Piedmont-Coastal Plain	Common
Ranunculus sceleratus var. *sceleratus*		cursed buttercup	Piedmont-Coastal Plain	Common
Ranunculus septentrionalis	*Ranunculus carolinianus; R. hispidus* var. *nitidus*	shining hispid buttercup	Coastal Plain	Rare
Ratibida columnifera		columnar prairie coneflower	Piedmont	Adventive
Rhexia aristosa		awned meadowbeauty	Coastal Plain	Rare

Rhexia mariana var. *mariana*		Maryland meadowbeauty	Coastal Plain	Common
Rhexia ventricosa	*Rhexia mariana* var. *ventricosa*	square-stem Maryland meadowbeauty	Coastal Plain	Common
Rhexia virginica		Virginia meadowbeauty	Coastal Plain	Common
Rhododendron atlanticum		coast azalea	Coastal Plain	Uncommon
Rhododendron maximum		great rhododendron	Piedmont-Coastal Plain	Adventive
Rhododendron periclymenoides	*Rhododendron nudiflorum*	pinxterbloom azalea	Piedmont-Coastal Plain	Common
Rhododendron prinophyllum		roseshell azalea	Piedmont-Coastal Plain	Historical
Rhododendron viscosum		swamp azalea	Coastal Plain	Common
Rhus copallinum		winged sumac	Piedmont-Coastal Plain	Common
Rhus glabra		smooth sumac	Piedmont-Coastal Plain	Common
Rhus typhina		hairy sumac	Piedmont-Coastal Plain	Common
Rhynchosia tomentosa		hairy snoutbean	Coastal Plain	Rare
Rhynchospora alba		white beakrush	Coastal Plain	Rare
Rhynchospora capitellata		brownish beakrush	Piedmont-Coastal Plain	Common
Rhynchospora careyana		Carey's beakrush	Coastal Plain	Historical
Rhynchospora cephalantha var. *cephalantha*		capitate beakrush	Coastal Plain	Rare
Rhynchospora chalarocephala		loose-head beakrush	Coastal Plain	Common
Rhynchospora corniculata		short-bristle beakrush	Coastal Plain	Rare
Rhynchospora filifolia		thread-leaved beakrush	Coastal Plain	Rare
Rhynchospora fusca		brown beakrush	Coastal Plain	Rare
Rhynchospora glomerata		clustered beakrush	Coastal Plain	Rare
Rhynchospora gracilenta		slender beakrush	Coastal Plain	Common
Rhynchospora harperi		Harper's beakrush	Coastal Plain	Rare
Rhynchospora inexpansa		nodding beakrush	Coastal Plain	Adventive
Rhynchospora inundata		drowned beakrush	Coastal Plain	Rare
Rhynchospora knieskernii		Knieskern's beakrush	Coastal Plain	Extirpated
Rhynchospora macrostachya	*Rhynchospora macrostachya* var. *colpophila*	tall beakrush	Coastal Plain	Common
Rhynchospora microcephala	*Rhynchospora cephalantha* var. *microcephala*	tiny-headed beakrush	Coastal Plain	Rare
Rhynchospora nitens	*Psilocarya nitens*	short-beaked beakrush	Coastal Plain	Rare
Rhynchospora oligantha		feather-bristle beakrush	Coastal Plain	Historical
Rhynchospora pallida		pale beakrush	Coastal Plain	Historical
Rhynchospora rariflora		few-flowered beakrush	Coastal Plain	Rare
Rhynchospora recognita	*Rhynchospora globularis* var. *recognita*	robust globe beakrush	Piedmont-Coastal Plain	Rare
Rhynchospora scirpoides	*Psilocarya scirpoides*	long-beaked beakrush	Coastal Plain	Rare
Rhynchospora torreyana		Torrey's beakrush	Coastal Plain	Rare
Ribes americanum		wild black gooseberry	Piedmont	Historical
Ribes hirtellum		Northern gooseberry	Piedmont	Historical
Robinia hispida var. *hispida*		bristly locust	Piedmont-Coastal Plain	Adventive
Robinia pseudoacacia		black locust	Piedmont-Coastal Plain	Adventive
Rorippa palustris var. *hispida*	*Rorippa islandica* var. *hispida*	hairy bog yellowcress	Piedmont-Coastal Plain	Adventive
Rorippa palustris var. *palustris*	Rorippa islandica var. *microcarpa*	bog yellowcress	Piedmont-Coastal Plain	Adventive
Rosa carolina subsp. *carolina*		Carolina rose	Piedmont-Coastal Plain	Uncommon
Rosa palustris		swamp rose	Piedmont-Coastal Plain	Common
Rosa setigera		prairie rose	Coastal Plain	Adventive
Rosa virginiana		Virginia rose	Piedmont-Coastal Plain	Status Uncertain
Rotala ramosior		toothcup	Piedmont-Coastal Plain	Common
Rubus allegheniensis		Allegheny blackberry	Piedmont	Status Uncertain
Rubus argutus		prickly Florida blackberry	Piedmont	Status Uncertain
Rubus cuneifolius		sand blackberry	Coastal Plain	Status Uncertain

Rubus flagellaris	*Rubus enslenii*	Yankee blackberry	Piedmont-Coastal Plain	Status Uncertain
Rubus frondosus		bramble	Piedmont-Coastal Plain	Status Uncertain
Rubus hispidus		bristly dewberry	Coastal Plain	Common
Rubus occidentalis		black raspberry	Piedmont	Status Uncertain
Rubus odoratus		purple-flowering raspberry	Piedmont	Rare
Rudbeckia fulgida var. *fulgida*		orange coneflower	Piedmont	Historical
Rudbeckia fulgida var. *speciosa*		orange coneflower	Coastal Plain	Adventive
Rudbeckia hirta var. *pulcherrima*		black-eyed-Susan	Piedmont-Coastal Plain	Adventive
Rudbeckia laciniata var. *laciniata*		green-head coneflower	Piedmont-Coastal Plain	Common
Rudbeckia triloba		brown-eyed Susan	Piedmont-Coastal Plain	Adventive
Ruellia caroliniensis		Carolina wild petunia	Coastal Plain	Uncommon
Rumex altissimus		tall dock	Piedmont	Rare
Rumex verticillatus		swamp dock	Coastal Plain	Common
Ruppia maritima		ditch-grass	Coastal Plain	Common
Sabatia angularis		square-stemmed rose pink	Piedmont-Coastal Plain	Uncommon
Sabatia campanulata		slender marsh pink	Coastal Plain	Rare
Sabatia difformis		two-formed pink	Coastal Plain	Rare
Sabatia dodecandra		large marsh pink	Coastal Plain	Rare
Sabatia stellaris		sea pink	Coastal Plain	Uncommon
Saccharum brevibarbe var. *contortum*	*Erianthus contortus*	bent-awn plumegrass	Coastal Plain	Rare
Saccharum coarctatum	*Erianthus brevibarbis* misapplied; *E. coarctatus*	bunched plumegrass	Coastal Plain	Rare
Saccharum giganteum	*Erianthus giganteus*	giant plumegrass	Coastal Plain	Common
Sacciolepis striata		gibbous grass	Coastal Plain	Rare
Sagina decumbens		small-flowered pearlwort	Coastal Plain	Common
Sagittaria australis		longbeak arrowhead	Piedmont-Coastal Plain	Common
Sagittaria calycina	*Lophotocarpus calycinus; Sagittaria montevidensis* subsp. *calycina*	spongy arrowhead	Coastal Plain	Uncommon
Sagittaria engelmanniana		Engelmann's arrowhead	Coastal Plain	Rare
Sagittaria graminea		grassleaf arrowhead	Coastal Plain	Rare
Sagittaria lancifolia var. *media*	*Sagittaria falcata*	bull-tongue arrowhead	Coastal Plain	Rare
Sagittaria latifolia var. *latifolia*		broadleaf arrowhead	Piedmont-Coastal Plain	Common
Sagittaria latifolia var. *pubescens*		hairy arrowhead	Piedmont	Uncommon
Sagittaria rigida		sessile-fruited arrowhead	Coastal Plain	Historical
Sagittaria spatulata	*Lophotocarpus spongiosus; Sagittaria calycina* var. *spongiosa; S. montevidensis* subsp. *spongiosa*	tidal arrowhead	Coastal Plain	Rare
Sagittaria subulata		strap-leaf arrowhead	Coastal Plain	Rare
Salicornia bigelovii		dwarf glasswort	Coastal Plain	Rare
Salicornia virginica	*Salicornia europea* misapplied; *S. maritima* misapplied	glasswort	Coastal Plain	Common
Salix discolor		pussy willow	Piedmont	Status Uncertain
Salix eriocephala	*Salix cordata* misapplied	heart-leaved willow	Piedmont	Status Uncertain
Salix humilis var. *humilis*		prairie willow	Piedmont-Coastal Plain	Status Uncertain
Salix humilis var. *tristis*	*Salix occidentalis; S. tristis*	dwarf prairie willow	Piedmont	Status Uncertain
Salix interior	*Salix exigua* var. *sericans*	sandbar willow	Coastal Plain	Historical
Salix lucida		shining willow	Piedmont-Coastal Plain	Status Uncertain
Salix nigra		black willow	Piedmont-Coastal Plain	Common
Salix sericea		silky willow	Piedmont-Coastal Plain	Rare

Salvia lyrata		lyre-leaf sage	Piedmont-Coastal Plain	Common
Sambucus canadensis		elderberry	Piedmont-Coastal Plain	Common
Samolus parviflorus		water pimpernel	Coastal Plain	Common
Sanguinaria canadensis		bloodroot	Piedmont-Coastal Plain	Common
Sanguisorba canadensis		Canada burnet	Coastal Plain	Historical
Sanicula canadensis var. *canadensis*		Canadian black snakeroot	Piedmont-Coastal Plain	Common
Sanicula marilandica		Maryland black snakeroot	Piedmont	Rare
Sanicula odorata	*Sanicula gregaria*	clustered black snakeroot	Piedmont-Coastal Plain	Common
Sanicula trifoliata		large-fruited snakeroot	Piedmont	Rare
Sarcocornia pacifica	*Salicornia virginica* misapplied; *Sarcocornia perennis* misapplied	perennial glasswort	Coastal Plain	Uncommon
Sarracenia purpurea var. *purpurea*		Northern purple pitcherplant	Piedmont-Coastal Plain	Rare
Sassafras albidum		sassafras	Piedmont-Coastal Plain	Common
Saururus cernuus		lizard's-tail	Piedmont-Coastal Plain	Common
Sceptridium biternatum	*Botrychium biternatum*	Southern grapefern	Piedmont-Coastal Plain	Common
Sceptridium dissectum	*Botrychium dissectum*	cutleaf grapefern	Piedmont-Coastal Plain	Common
Sceptridium oneidense	*Botrychium oneidense*	blunt-lobe grapefern	Coastal Plain	Status Uncertain
Schizachyrium littorale	*Andropogon littoralis*	seaside bluestem	Coastal Plain	Uncommon
Schizachyrium scoparium var. *scoparium*	*Andropogon scoparius*	little bluestem	Piedmont-Coastal Plain	Common
Schizaea pusilla		curly-grass fern	Coastal Plain	Rare
Schoenoplectiella purshiana var. *purshiana*	*Schoenoplectus purshianus* var. *purshianus; Scirpus purshianus* var. *purshianus*	bristled weakstalk bulrush	Piedmont-Coastal Plain	Rare
Schoenoplectiella purshiana var. *williamsii*	*Schoenoplectus purshianus* var. *williamsii; Scirpus purshianus* var. *williamsii*	bristleless weakstalk bulrush	Coastal Plain	Rare
Schoenoplectiella smithii var. *setosa*	*Schoenoplectus smithii* var. *setosus; Scirpus smithii* var. *setosus*	Smith's bristled bulrush	Coastal Plain	Rare
Schoenoplectiella smithii var. *smithii*	*Schoenoplectus smithii* var. *smithii; Scirpus smithii* var. *smithii*	Smith's bulrush	Coastal Plain	Historical
Schoenoplectus americanus	*Scirpus americanus*	Olney's three-square bulrush	Coastal Plain	Common
Schoenoplectus etuberculatus	*Scirpus etuberculatus*	Canby's bulrush	Coastal Plain	Rare
Schoenoplectus pungens	*Scirpus pungens*	three-square bulrush	Coastal Plain	Common
Schoenoplectus subterminalis	*Scirpus subterminalis*	water bulrush	Coastal Plain	Rare
Schoenoplectus tabernaemontani	*Scirpus validus*	softstem bulrush	Piedmont-Coastal Plain	Common
Schwalbea americana		American chaffseed	Coastal Plain	Extirpated
Scirpus atrovirens		a bulrush	Piedmont	Rare
Scirpus cyperinus		woolgrass bulrush	Piedmont-Coastal Plain	Common
Scirpus expansus		red-stem bulrush	Piedmont	Rare
Scirpus georgianus		Georgia bulrush	Piedmont-Coastal Plain	Common
Scirpus hattorianus		bulrush	Piedmont	Status Uncertain
Scirpus pendulus		pendulous bulrush	Piedmont-Coastal Plain	Rare
Scirpus polyphyllus		leafy bulrush	Piedmont-Coastal Plain	Common
Scleria muehlenbergii		Muhlenberg's nutrush	Coastal Plain	Rare
Scleria nitida		shining nutrush	Piedmont-Coastal Plain	Historical
Scleria pauciflora var. *caroliniana*		hairy few-flowered nutrush	Coastal Plain	Rare
Scleria pauciflora var. *pauciflora*		smooth few-flowered nutrush	Piedmont-Coastal Plain	Rare
Scleria reticularis		reticulated nutrush	Coastal Plain	Uncommon
Scleria triglomerata		whip nutrush	Coastal Plain	Rare
Sclerolepis uniflora		one-flowered bog button	Coastal Plain	Rare
Scrophularia lanceolata		hare's figwort	Coastal Plain	Historical
Scrophularia marilandica		Carpenter's square figwort	Piedmont-Coastal Plain	Common
Scutellaria elliptica var. *elliptica*		hairy skullcap	Piedmont-Coastal Plain	Common
Scutellaria galericulata		hooded skullcap	Coastal Plain	Rare

Scutellaria integrifolia		hyssop skullcap	Piedmont-Coastal Plain	Common
Scutellaria lateriflora		mad-dog skullcap	Piedmont-Coastal Plain	Common
Scutellaria leonardii	*Scutellaria parvula* var. *leonardii*	dwarf skullcap	Coastal Plain	Historical
Scutellaria nervosa		veined skullcap	Piedmont	Historical
Scutellaria saxatilis		rock skullcap	Piedmont	Historical
Sedum ternatum		woodland stonecrop	Piedmont	Rare
Selaginella apoda		meadow spikemoss	Piedmont-Coastal Plain	Uncommon
Selaginella rupestris		ledge spikemoss	Piedmont	Extirpated
Senna hebecarpa	*Cassia hebecarpa*	wild senna	Piedmont-Coastal Plain	Common
Senna marilandica	*Cassia marilandica*	Maryland senna	Coastal Plain	Historical
Sericocarpus asteroides	*Aster paternus*	stiff aster	Piedmont-Coastal Plain	Common
Sericocarpus linifolius	*Aster solidagineus*	narrowleaf aster	Piedmont-Coastal Plain	Common
Sesuvium maritimum		sea-purslane	Coastal Plain	Common
Setaria magna		giant foxtail	Coastal Plain	Common
Setaria parviflora	*Setaria geniculata*	bristly foxtail	Piedmont-Coastal Plain	Common
Sicyos angulatus		one-seed bur-cucumber	Piedmont-Coastal Plain	Common
Sideroxylon lycioides	*Bumelia lycioides*	buckthorn	Coastal Plain	Rare
Silene antirrhina		sleepy catchfly	Piedmont-Coastal Plain	Common
Silene caroliniana var. *pensylvanica*		Northern wild pink	Coastal Plain	Rare
Silene stellata		starry catchfly	Piedmont-Coastal Plain	Common
Silene virginica		fire-pink	Piedmont-Coastal Plain	Rare
Silphium perfoliatum		cup-plant	Coastal Plain	Adventive
Sisyrinchium angustifolium		pointed blue-eyed-grass	Piedmont-Coastal Plain	Common
Sisyrinchium atlanticum		Eastern blue-eyed-grass	Piedmont-Coastal Plain	Uncommon
Sisyrinchium mucronatum		Michaux's blue-eyed-grass	Piedmont-Coastal Plain	Rare
Sium suave		hemlock water-parsnip	Piedmont-Coastal Plain	Common
Smallanthus uvedalius	*Polymnia uvedalia*	yellow-flowered leafcup	Piedmont-Coastal Plain	Uncommon
Smilax bona-nox		saw greenbrier	Coastal Plain	Rare
Smilax glauca		whiteleaf greenbrier	Piedmont-Coastal Plain	Common
Smilax herbacea		smooth carrion-flower greenbrier	Piedmont-Coastal Plain	Common
Smilax hispida	*Smilax tamnoides*	weak-prickle greenbrier	Piedmont	Rare
Smilax laurifolia		laurel-leaf greenbrier	Coastal Plain	Common
Smilax pseudochina		long-stalk greenbrier	Coastal Plain	Rare
Smilax pulverulenta		downy carrion-flower greenbrier	Piedmont-Coastal Plain	Common
Smilax rotundifolia		round-leaf greenbrier	Piedmont-Coastal Plain	Common
Smilax walteri		Walter's greenbrier	Coastal Plain	Uncommon
Solanum carolinense var. *carolinense*		Carolina nightshade	Piedmont-Coastal Plain	Adventive
Solanum citrullifolium		watermelon nightshade	Piedmont	Adventive
Solanum ptychanthum	*Solanum nigrum* misapplied	American black nightshade	Piedmont-Coastal Plain	Common
Solanum rostratum		buffalo bur nightshade	Piedmont	Adventive
Solidago altissima var. *altissima*	*Solidago canadensis* var. *scabra*	rough Canada goldenrod	Piedmont-Coastal Plain	Common
Solidago arguta var. *arguta*		cutleaf goldenrod	Piedmont-Coastal Plain	Rare
Solidago bicolor		white goldenrod	Piedmont-Coastal Plain	Common
Solidago caesia var. *caesia*		bluestem goldenrod	Piedmont-Coastal Plain	Common
Solidago canadensis var. *canadensis*		Canada goldenrod	Piedmont-Coastal Plain	Common
Solidago erecta		slender goldenrod	Coastal Plain	Common
Solidago fistulosa		pine barren goldenrod	Coastal Plain	Common
Solidago flexicaulis		broadleaf goldenrod	Piedmont-Coastal Plain	Common
Solidago gigantea		smooth goldenrod	Piedmont-Coastal Plain	Common
Solidago hispida	*Solidago bicolor* var. *ovalis*	hairy goldenrod	Piedmont	Status Uncertain
Solidago juncea		early goldenrod	Piedmont-Coastal Plain	Common
Solidago latissimifolia	*Solidago elliottii*	Elliott's goldenrod	Coastal Plain	Rare
Solidago nemoralis var. *nemoralis*		gray goldenrod	Piedmont-Coastal Plain	Common
Solidago odora		sweet goldenrod	Piedmont-Coastal Plain	Common

Solidago patula var. *patula*		roundleaf goldenrod	Piedmont-Coastal Plain	Uncommon
Solidago puberula var. *puberula*		downy goldenrod	Coastal Plain	Common
Solidago puberula var. *pulverulenta*		small leaf downy goldenrod	Coastal Plain	Common
Solidago rugosa var. *aspera*		thick rough-leaf goldenrod	Piedmont-Coastal Plain	Common
Solidago rugosa var. *rugosa*		thin hairy rough-leaf goldenrod	Piedmont-Coastal Plain	Common
Solidago rugosa var. *sphagnophila*		thin glabrous rough-leaf goldenrod	Coastal Plain	Common
Solidago sempervirens var. *mexicana*		small-headed seaside goldenrod	Coastal Plain	Status Uncertain
Solidago sempervirens var. *sempervirens*		seaside goldenrod	Coastal Plain	Common
Solidago squarrosa		squarrose goldenrod	Piedmont	Historical
Solidago stricta		wandlike goldenrod	Coastal Plain	Extirpated
Solidago tarda		late goldenrod	Coastal Plain	Rare
Solidago uliginosa		bog goldenrod	Coastal Plain	Rare
Solidago ulmifolia var. *ulmifolia*		elm-leaf goldenrod	Piedmont-Coastal Plain	Rare
Sophronanthe pilosa	*Gratiola pilosa*; *Tragiola pilosa*	shaggy hedge-hyssop	Coastal Plain	Common
Sorghastrum nutans		yellow Indian-grass	Piedmont-Coastal Plain	Common
Sparganium americanum		American bur-reed	Piedmont-Coastal Plain	Common
Sparganium eurycarpum		large bur-reed	Piedmont-Coastal Plain	Common
Spartina alterniflora		salt marsh cordgrass	Coastal Plain	Common
Spartina cynosuroides		big salt marsh cordgrass	Coastal Plain	Common
Spartina patens		salt-meadow cordgrass	Coastal Plain	Common
Spartina pectinata		fresh water cordgrass	Coastal Plain	Rare
Spergularia salina	*Spergularia marina*	salt marsh sandspurry	Coastal Plain	Status Uncertain
Sphenopholis intermedia	*Sphenopholis obtusata* var. *major*	slender wedgescale grass	Piedmont-Coastal Plain	Status Uncertain
Sphenopholis nitida		shiny wedgescale grass	Piedmont-Coastal Plain	Common
Sphenopholis obtusata	*Sphenopholis obtusata* var. *obtusata*; *S. obtusata* var. *pubescens*	prairie wedgescale grass	Piedmont-Coastal Plain	Status Uncertain
Sphenopholis pensylvanica		swamp wedgescale grass	Piedmont-Coastal Plain	Rare
Spiraea alba var. *alba*		narrowleaf white spiraea	Piedmont	Rare
Spiraea alba var. *latifolia*		broad-leaf white spiraea	Piedmont-Coastal Plain	Rare
Spiraea tomentosa		meadowsweet spiraea	Piedmont-Coastal Plain	Common
Spiranthes cernua		nodding ladies'-tresses	Piedmont-Coastal Plain	Common
Spiranthes lacera var. *gracilis*		Southern slender ladies'-tresses	Piedmont-Coastal Plain	Uncommon
Spiranthes lucida		shining ladies'-tresses	Piedmont-Coastal Plain	Historical
Spiranthes odorata	*Spiranthes cernua* var. *odorata*	fragrant ladies'-tresses	Coastal Plain	Historical
Spiranthes praecox		grassleaf ladies'-tresses	Piedmont-Coastal Plain	Historical
Spiranthes tuberosa		little ladies'-tresses	Piedmont-Coastal Plain	Historical
Spiranthes vernalis		twisted ladies'-tresses	Coastal Plain	Rare
Spirodela polyrrhiza		many-root duckweed	Piedmont-Coastal Plain	Common
Sporobolus clandestinus		rough dropseed	Coastal Plain	Uncommon
Sporobolus compositus var. *compositus*	*Sporobolus asper*	tall dropseed	Coastal Plain	Historical
Sporobolus vaginiflorus		sheathed dropseed	Piedmont-Coastal Plain	Common
Stachys aspera	*Stachys hyssopifolia* var. *ambigua*	rough hedge-nettle	Coastal Plain	Status Uncertain
Stachys hispida		hispid hedge-nettle	Piedmont-Coastal Plain	Uncommon
Stachys hyssopifolia var. *hyssopifolia*		hyssopleaf hedge-nettle	Coastal Plain	Status Uncertain
Stachys pilosa	Stachys palustris var. *pilosa*	marsh hedge-nettle	Coastal Plain	Status Uncertain
Stachys tenuifolia		smooth hedge-nettle	Piedmont-Coastal Plain	Rare
Staphylea trifolia		American bladdernut	Piedmont-Coastal Plain	Common
Stellaria alsine		trailing starwort	Piedmont	Rare
Stellaria corei		Tennessee starwort	Piedmont	Adventive

Stellaria longifolia		longleaf starwort	Piedmont	Common
Stenanthium leimanthoides	*Zigadenus leimanthoides*	death-camus	Coastal Plain	Historical
Strophostyles helvola		trailing wild bean	Coastal Plain	Common
Strophostyles umbellata		pink wild bean	Piedmont-Coastal Plain	Common
Stuckenia pectinata	*Potamogeton pectinatus*	Sago pondweed	Coastal Plain	Common
Stylophorum diphyllum		celandine poppy	Piedmont	Adventive
Stylosanthes biflora		pencil-flower	Coastal Plain	Common
Suaeda linearis		narrow-leaf seepweed	Coastal Plain	Uncommon
Suaeda maritima		herbaceous seepweed	Coastal Plain	Common
Symphoricarpos albus var. *laevigatus*		white coral-berry	Piedmont	Adventive
Symphoricarpos orbiculatus		coral-berry	Piedmont-Coastal Plain	Adventive
Symphyotrichum concolor var. *concolor*	*Aster concolor*	Eastern silvery aster	Coastal Plain	Historical
Symphyotrichum cordifolium	*Aster cordifolius*; *A. cordifolius* var. *sagittifolius*; *A. sagittifolius*	heart-leaf aster	Piedmont-Coastal Plain	Uncommon
Symphyotrichum dumosum	*Aster dumosus*	bushy aster	Piedmont-Coastal Plain	Status Uncertain
Symphyotrichum ericoides var. *ericoides*	*Aster ericoides* var. *ericoides*	white heath aster	Piedmont-Coastal Plain	Status Uncertain
Symphyotrichum laeve var. *concinnum*	*Aster concinnus*	narrow-leaved smooth blue aster	Piedmont	Rare
Symphyotrichum laeve var. *laeve*	*Aster laevis* var. *laevis*	smooth blue aster	Piedmont-Coastal Plain	Rare
Symphyotrichum lanceolatum var. *lanceolatum*	*Aster lanceolatus* subsp. *lanceolatus; A. paniculatus*	narrow-leaf panicled aster	Piedmont-Coastal Plain	Common
Symphyotrichum lanceolatum var. *latifolium*	*Aster lanceolatus* var. *simplex; A. simplex*	broad-leaf panicled aster	Coastal Plain	Common
Symphyotrichum lateriflorum var. *horizontale*	*Aster lateriflorus* var. *pendulus*	goblet aster	Piedmont-Coastal Plain	Common
Symphyotrichum lateriflorum var. *lateriflorum*	*Aster lateriflorus* var. *lateriflorus*	starved aster	Piedmont-Coastal Plain	Common
Symphyotrichum novae-angliae	*Aster novae-angliae*	New England aster	Piedmont-Coastal Plain	Common
Symphyotrichum novi-belgii var. *elodes*	*Aster novi-belgii* var. *elodes*	longleaf New York aster	Coastal Plain	Common
Symphyotrichum novi-belgii var. *novi-belgii*	*Aster novi-belgii* var. *novi-belgii*	shortleaf New York aster	Coastal Plain	Common
Symphyotrichum patens var. *patens*	*Aster patens* var. *patens*	late purple aster	Piedmont-Coastal Plain	Common
Symphyotrichum pilosum var. *pilosum*	*Aster pilosus* var. *pilosus*	smooth heath aster	Piedmont-Coastal Plain	Common
Symphyotrichum pilosum var. *pringlei*	*Aster pilosus* var. *demotus*	hairy heath aster	Piedmont-Coastal Plain	Common
Symphyotrichum prenanthoides	*Aster prenanthoides*	crooked-stem aster	Piedmont	Rare
Symphyotrichum puniceum var. *puniceum*	*Aster puniceus* var. *puniceus*	bristly aster	Piedmont-Coastal Plain	Common
Symphyotrichum racemosum	*Aster fragilis; A. racemosus; A. vimineus* misapplied	small white aster	Coastal Plain	Status Uncertain
Symphyotrichum subulatum	*Aster subulatus* var. *subulatus*	annual salt marsh aster	Coastal Plain	Common
Symphyotrichum tenuifolium	*Aster tenuifolius*	perennial salt marsh aster	Coastal Plain	Common
Symphyotrichum undulatum	*Aster undulatus*	clasping heart-leaved aster	Piedmont-Coastal Plain	Common
Symplocarpus foetidus		skunk cabbage	Piedmont-Coastal Plain	Common
Symplocos tinctoria		sweetleaf	Coastal Plain	Common
Taenidia integerrima		yellow pimpernel	Piedmont	Rare
Taxodium ascendens		pond cypress	Coastal Plain	Adventive
Taxodium distichum		bald cypress	Coastal Plain	Rare
Tephrosia spicata		spiked hoary-pea	Coastal Plain	Historical
Tephrosia virginiana		goat's-rue	Piedmont-Coastal Plain	Common
Teucrium canadense var. *canadense*		Canadian germander	Coastal Plain	Common
Teucrium canadense var. *virginicum*		American germander	Piedmont	Uncommon

Thalictrum dioicum		early meadowrue	Piedmont	Rare
Thalictrum pubescens		tall meadowrue	Piedmont-Coastal Plain	Common
Thalictrum revolutum		waxleaf meadowrue	Piedmont-Coastal Plain	Rare
Thalictrum thalictroides	*Anemonella thalictroides*	rue anemone	Piedmont-Coastal Plain	Common
Thaspium barbinode		hairy-jointed meadow-parsnip	Piedmont	Rare
Thelypteris palustris var. *pubescens*		marsh fern	Piedmont-Coastal Plain	Common
Thyrsanthella difformis	*Trachelospermum difforme*	climbing dogbane	Coastal Plain	Rare
Tiedemannia canbyi	*Oxypolis canbyi*	Canby's dropwort	Coastal Plain	Extirpated
Tilia americana var. *americana*		American basswood	Piedmont-Coastal Plain	Common
Tipularia discolor		cranefly orchid	Piedmont-Coastal Plain	Common
Torreyochloa pallida var. *pallida*	*Glyceria pallida*	pale mannagrass	Coastal Plain	Common
Toxicodendron pubescens		poison oak	Coastal Plain	Rare
Toxicodendron radicans var. *radicans*		poison ivy	Piedmont-Coastal Plain	Common
Toxicodendron vernix		poison sumac	Coastal Plain	Uncommon
Tradescantia ohiensis		Ohio spiderwort	Coastal Plain	Adventive
Tradescantia virginiana		Virginia spiderwort	Piedmont	Uncommon
Triantha racemosa	*Tofieldia racemosa*	coastal false-asphodel	Coastal Plain	Extirpated
Trichophorum planifolium	*Scirpus verecundus*	bashful bulrush	Piedmont	Rare
Trichostema dichotomum		forked bluecurls	Piedmont-Coastal Plain	Common
Trichostema setaceum		narrowleaf bluecurls	Coastal Plain	Rare
Triclisperma paucifolia	*Polygala paucifolia*	gay-wing milkwort	Piedmont	Extirpated
Tridens chapmanii	*Tridens flavus* var. *chapmanii*	Chapman's purple-top	Coastal Plain	Rare
Tridens flavus		purple-top	Piedmont-Coastal Plain	Common
Trientalis borealis subsp. *borealis*		Northern starflower	Coastal Plain	Rare
Trifolium carolinianum		Carolina clover	Coastal Plain	Adventive
Triglochin striata		three-ribbed arrow-grass	Coastal Plain	Historical
Trillium cernuum		nodding trillium	Piedmont-Coastal Plain	Rare
Trillium erectum		ill-scented trillium	Piedmont	Rare
Trillium grandiflorum		great white trillium	Piedmont	Adventive
Triodanis perfoliata		Venus'-looking-glass	Piedmont-Coastal Plain	Common
angustifolium		yellowleaf tinker's-weed	Piedmont-Coastal Plain	Rare
aurantiacum		coffee tinker's-weed	Piedmont	Rare
Triosteum perfoliatum		perfoliate tinker's-weed	Piedmont-Coastal Plain	Rare
Triphora trianthophoros		three-birds orchid	Coastal Plain	Rare
Triplasis purpurea var. *purpurea*		purple sandgrass	Coastal Plain	Common
Tripsacum dactyloides var. *dactyloides*		gamagrass	Coastal Plain	Adventive
Tsuga canadensis		Eastern hemlock	Piedmont-Coastal Plain	Rare
Turritis glabra	*Arabis glabra*	tower-mustard	Piedmont	Historical
Typha domingensis		Southern cattail	Coastal Plain	Status Uncertain
Typha latifolia		broadleaf cattail	Piedmont-Coastal Plain	Common
Ulmus americana var. *americana*		American elm	Piedmont-Coastal Plain	Common
Ulmus rubra		slippery elm	Piedmont-Coastal Plain	Common
Uniola paniculata		sea oats	Coastal Plain	Adventive
Urochloa texana	*Panicum texanum*	Texas signalgrass	Coastal Plain	Adventive
Utricularia cornuta		horned bladderwort	Coastal Plain	Historical
Utricularia geminiscapa		hidden-fruited bladderwort	Coastal Plain	Uncommon
Utricularia gibba	*Utricularia biflora*	humped bladderwort	Coastal Plain	Uncommon
Utricularia inflata		large swollen bladderwort	Coastal Plain	Rare
Utricularia juncea		Southern bladderwort	Coastal Plain	Rare
Utricularia macrorhiza	*Utricularia vulgaris*	greater bladderwort	Piedmont-Coastal Plain	Common
Utricularia minor		lesser bladderwort	Piedmont	Extirpated
Utricularia purpurea		purple bladderwort	Coastal Plain	Rare
Utricularia radiata		small swollen bladderwort	Coastal Plain	Common
Utricularia resupinata		Northeastern bladderwort	Coastal Plain	Rare

Utricularia striata	*Utricularia fibrosa*	fibrous bladderwort	Coastal Plain	Uncommon
Utricularia subulata		zigzag bladderwort	Coastal Plain	Rare
Uvularia perfoliata		perfoliate bellwort	Piedmont-Coastal Plain	Common
Uvularia sessilifolia		sessile-leaf bellwort	Piedmont-Coastal Plain	Common
Vaccinium angustifolium		late lowbush blueberry	Piedmont	Historical
Vaccinium corymbosum		highbush blueberry	Piedmont-Coastal Plain	Common
Vaccinium fuscatum	*Vaccinium atrococcum*	black highbush blueberry	Piedmont-Coastal Plain	Status Uncertain
Vaccinium macrocarpon		large cranberry	Coastal Plain	Uncommon
Vaccinium pallidum	*Vaccinium vacillans*	lowbush blueberry	Piedmont-Coastal Plain	Common
Vaccinium stamineum var. *stamineum*		sand blueberry	Piedmont-Coastal Plain	Common
Valerianella radiata		beaked cornsalad	Coastal Plain	Common
Vallisneria americana		tape-grass	Piedmont-Coastal Plain	Uncommon
Veratrum latifolium	*Melanthium hybridum; M. latifolium*	broadleaf bunchflower	Piedmont	Historical
Veratrum virginicum	*Melanthium virginicum*	Virginia bunchflower	Coastal Plain	Rare
Veratrum viride		American false hellebore	Piedmont-Coastal Plain	Common
Verbena hastata		blue vervain	Piedmont-Coastal Plain	Common
Verbena simplex		narrowleaf vervain	Piedmont-Coastal Plain	Status Uncertain
Verbena stricta		hoary vervain	Piedmont-Coastal Plain	Adventive
Verbena urticifolia var. *urticifolia*		white vervain	Piedmont-Coastal Plain	Common
Verbesina alternifolia	*Actinomeris alternifolia*; *A. squarrosa*	wingstem	Piedmont	Rare
Verbesina occidentalis		yellow crownbeard	Piedmont-Coastal Plain	Common
Vernonia glauca		woodland ironweed	Piedmont-Coastal Plain	Uncommon
Vernonia noveboracensis		New York ironweed	Piedmont-Coastal Plain	Common
Veronica americana		American speedwell	Piedmont	Rare
Veronica anagallis-aquatica		water speedwell	Piedmont-Coastal Plain	Status Uncertain
Veronica peregrina var. *peregrina*		purslane speedwell	Piedmont-Coastal Plain	Common
Veronicastrum virginicum		Culver's-root	Piedmont-Coastal Plain	Rare
Viburnum acerifolium		mapleleaf viburnum	Piedmont-Coastal Plain	Common
Viburnum cassinoides		Northern wild raisin	Coastal Plain	Historical
Viburnum dentatum var. *dentatum*		Southern arrow-wood	Piedmont-Coastal Plain	Common
Viburnum dentatum var. *lucidum*	*Viburnum recognitum*	Northern arrow-wood	Piedmont-Coastal Plain	Common
Viburnum lentago		nannyberry	Piedmont	Rare
Viburnum nudum		possum-haw viburnum	Piedmont-Coastal Plain	Common
Viburnum prunifolium		smooth blackhaw	Piedmont-Coastal Plain	Common
Viburnum rafinesquianum		downy arrow-wood	Coastal Plain	Rare
Viola bicolor	*Viola rafinesquii*	field pansy	Piedmont-Coastal Plain	Common
Viola blanda		sweet white violet	Piedmont	Uncommon
Viola brittoniana var. *brittoniana*		blue coast violet	Coastal Plain	Uncommon
Viola cucullata		blue marsh violet	Piedmont-Coastal Plain	Common
Viola fimbriatula	*Viola sagittata* var. *ovata*	blue fringed violet	Piedmont-Coastal Plain	Status Uncertain
Viola hirsutula		Southern blue wood violet	Piedmont	Common
Viola labradorica	*Viola conspersa*	blue American dog violet	Piedmont	Uncommon
Viola lanceolata var. *lanceolata*		white lance-leaf violet	Piedmont-Coastal Plain	Common
Viola macloskeyi var. *pallens*	*Viola pallens*	smooth white violet	Piedmont-Coastal Plain	Rare
Viola palmata	Viola stoneana; *V. triloba*	blue palmate-leaved violet	Piedmont-Coastal Plain	Uncommon
Viola pedata		blue bird's-foot violet	Piedmont-Coastal Plain	Rare
Viola primulifolia		white primrose-leaved violet	Piedmont-Coastal Plain	Common
Viola pubescens var. *pubescens*		downy yellow violet	Piedmont-Coastal Plain	Common
Viola pubescens var. *scabriuscula*	*Viola eriocarpa*	smooth yellow violet	Piedmont-Coastal Plain	Common
Viola rotundifolia		yellow roundleaf violet	Piedmont	Rare

Viola sagittata		blue arrowleaf violet	Piedmont-Coastal Plain	Status Uncertain
Viola sororia	*Viola papilionacea*	woolly blue violet	Piedmont-Coastal Plain	Common
Viola striata		striped white violet	Piedmont	Uncommon
Vitis aestivalis var. *aestivalis*		summer grape	Piedmont-Coastal Plain	Common
Vitis labrusca		Northern fox grape	Piedmont-Coastal Plain	Common
Vitis vulpina		winter grape	Piedmont-Coastal Plain	Status Uncertain
Vulpia octoflora var. *glauca*	*Vulpia octoflora* var. *tenella*	northern six-weeks grass	Piedmont-Coastal Plain	Common
Vulpia octoflora var. *octoflora*		southern six-weeks grass	Coastal Plain	Common
Vulpia sciurea	*Vulpia elliotea*	squirrel six-weeks grass	Coastal Plain	Status Uncertain
Wisteria frutescens	*Wisteria macrostachya*	American wisteria	Coastal Plain	Adventive
Wolffia brasiliensis	*Wolffia papulifera; W. punctata*	pointed watermeal	Piedmont-Coastal Plain	Common
Wolffia columbiana		Columbia watermeal	Coastal Plain	Status Uncertain
Wolffiella gladiata	*Wolffiella floridana*	sword bogmat	Coastal Plain	Status Uncertain
Woodsia obtusa subsp. *obtusa*		blunt-lobe woodsia	Piedmont-Coastal Plain	Rare
Woodwardia areolata	*Lorinseria areolata*	netted chainfern	Piedmont-Coastal Plain	Common
Woodwardia virginica	*Anchistea virginica*	Virginia chainfern	Coastal Plain	Common
Xanthium strumarium	*Xanthium echinatum*	rough cocklebur	Piedmont-Coastal Plain	Common
Xerophyllum asphodeloides		Eastern turkeybeard	Coastal Plain	Extirpated
Xyris difformis		pink-based yellow-eyed-grass	Coastal Plain	Common
Xyris fimbriata		fringed yellow-eyed-grass	Coastal Plain	Rare
Xyris smalliana		Small's yellow-eyed-grass	Coastal Plain	Rare
Xyris torta		twisted yellow-eyed-grass	Piedmont-Coastal Plain	Uncommon
Yucca filamentosa		yucca	Coastal Plain	Common
Zannichellia palustris		horned pondweed	Piedmont-Coastal Plain	Rare
Zanthoxylum americanum		Northern prickly-ash	Piedmont	Historical
Zizania aquatica var. *aquatica*		wild rice	Piedmont-Coastal Plain	Common
Zizia aptera		wingless Alexander	Piedmont	Rare
Zizia aurea		golden Alexander	Piedmont	Rare
Zostera marina var. *stenophylla*		eel-grass	Coastal Plain	Rare

APPENDIX 2

Appendix 2 is a compilation of all archaeobotanicals identified in twenty-eight DelDOT sponsored archaeological projects (Mellin and Truitt, 2013g). Although we have strived to present a fair and meaningful representation of the results, we strongly encourage readers to review the original reports to view and assess the original findings for themselves.

SCIENTIFIC NAME	COMMON NAME		SCIENTIFIC NAME	COMMON NAME
Acalypha	Three-sided Mercury, Copperleaf		*EUPHORBIACEAE*	Spurge Family
Acer	Maple		*Euphorbia*	Spurge
Acer or *Betula*	Maple or Birch		*Euphorbia corrollata*	Flowering Spurge
Alnus	Alder		*Fagus grandifolia*	American Beech
AMARANTHACEAE	Pigweed Family		*Filicineae*	Undifferentiated Ferns
Amaranthus	Amaranth		*Fimbristylis*	Sedge
Amaranthus retroflexus	Pigweed		*Frageria*	Strawberry
Ambrosia artemisiifolia	Ragweed		*Fraxinus americana*	White Ash
Ampelopsis arborea	Peppervine		*Galium asprellum*	Goosegrass
Amphicarpa bracteata	Hog Peanut		*Galium asprellum*	Bedstraw
Asteraceae	Sneezeweed		*Gaylussacia*	Hucklebery
Asteraceae inflorescence	Daisey/Sunflower (phytolith)		*Gilia*	Gilia
Betula	Birch		*Gramminaea*	Grass Family
Brassicaceae	Mustard		*Hibiscus palustris*	Swamp Rose Mallow
Carmelina microcarpa	Small Seeded False Flax		*Honckenya peploides*	Sandwort
Carex	Sedge		*Hordeum Elymus*	Barley-Wildrye type
Carya	Hickory		*Hordeum pusillum*	Little Barley
Castanea dentata	American Chestnut		*Hypericum*	Saint John's Wort
Celtis	Hackberry		*Ilex laevigata*	Winterberry
Cephalanthos	Buttonbush		*Ilex opaca*	American Holly
Chenopodium album	Lamb's Quarters, Goosefoot		*JUGLANDACEAE*	Walnut/Hickory Family
Clitonia	Butterflypea		*Juglans nigra*	Black Walnut
Collomia grandiflora	Collomia		*Juniperus*	Red Cedar
Commelina	Dayflower		*Labiatae*	Mint Family
Comus florida	Flowering Dogwood		*Lamiaceae*	Bugleweed
Conopholis americana	Squawroot		*Lamiaceae*	Pennyroyal
Corylus	Hazelnut		*Lecha*	Pinweed
Crataegus	Possoin Haw		*Legumineae*	Legume Family
Crotolaria sagittalis	Rattlebox		*LEGUMINOSEA*	Bean Family
Croton texensis	Doveweed		*Lespedeza*	Slender Bush Clover
Cruciferae	Mustard Family		*LEUCOBALANUS*	Oak (White Group)
Cruciferae brassica	Mustard Seed		*Liliaceae*	Cucumber-root
Cuscuta	Smartweed		*Linum*	Flax
CYPERACEAE	Sedge Family		*Liquidambar styracif.*	Sweetgum
Datura stramonium	Jimsonweed		*Lirodendron tulipifera*	Tulip Poplar
Descurainia pinnata manziesii	Tansy Mustard		*Lobelia spicata*	Stachys/Lobelia
Digitana	Crabgrass		*Lonicera*	Honeysuckle
Diospyros virginiana	Persimmon		*Lotus*	Deer Vetch
Dryopteris	Wood Fern		*Magnolia*	Magnolia
Eleusine indica	Goosegrass		*Mollugo verticillata*	Carpetweed
ERICACEAE	Blueberry Family		*Monarda*	Mint
ERYTHROBALANUS	Oak (Red Family)		*Morella*	Bayberry

Morus ruba	Mulberry		*Rumex*	Dock
MYRICACEAE	Myrtle Family		*Rumex acetosella*	Sheep Sorel
Myrica pennsylvanica	Bayberry		*Ruppia maritima*	Widgeongrass
Nelumbo lutea (poss.)	American Lotus (poss.)		*Sagittaria*	Arrowhead
NYMPHEACEAE	Water Lilly Family		*Sagittaria latifolia*	Wapato, Indian Potato
Nyssa	Black Gum		*Salix*	Willow
Oenothera biennis	Evening Primrose		*Salvia lyrata*	Sage
Osmunda	Cinnamon Fern		*Sambucus canadensis*	Elderberry
Oxalis stricta	Woodsorrel		*Sassafras*	Sassafras
Panicum	Panic Grass, Wartgrass		*SAXIFRAGACEAE*	Saxifrage Family
Persicaria	Smartweed		*Scleria triglomerata*	Scleria
Phasectus meticalfi	Wild Bean		*Scirpus*	Bulrush
Phleum pratense	Timothy		*Scutellaria galericulata*	Skullcap
Phytolocca americana	Pokeberry		*Setania*	Bristlegrass
Plantago	Plantain		*Seteria*	Maize or Grass (Starch)
Platanus	Sycamore		*Setaria glauca/lutescens*	Foxtail Bristlegrass
Pinus	Pine		*Sheperdia rotundifolia*	Buffalo Berry
POACEAE	Grass Family		*Silene* or *Cerastium*	Catchfly or Chickweed
Polanisia	Clammyweed		*Smilax*	Greenbriar
POLYGONACEAE	Knotweed Family		*SOLANACEAE*	Nightshade Family
Polygonatum aviculare	Knotweed		*Solanum rostratum*	Buffalobur
Polygonatum biflorum	Solomon's Seal		*Solarium*	Nightshade
Polygonatum commutatum	Solomon's Seal		*Solidago*	Golenrod
Polygonatum lepathilolium	Smartweed		*Sparganium*	Bur-reed
Polygonum/Rumex	Knotweed/Dock		*Sphagnum*	Sphagnum Moss
Potentilla arguta	Tall Cinquefoil		*Stellaria media*	Chickweed
Portulaca oleracea	Purslane		*Taraxacum officinale*	Dandelion
Prunus	Cherry		*Teucrium*	Wood Sage
Prunus	Cherry/Plum		*Thymus serpyllum*	Wild Thyme
Prunus serotina	Cherry		*Tilia*	Basswood
Pyrus	Chokeberry		*Tragia urens*	Noseburn
Quercus	Oak		*Trianthema*	Sea Purslane
Quercus	Acorn		*Trichostema dischotomum*	Forked Bluecurls
Quercus	Red Oak Group		*Trifolium*	Clover
Quercus	White Oak Group		*Triticum aestivum*	Wheat
Quercus prinus	(Acorn)		*Tsuga*	Hemlock
Ranunculus	Buttercup		*Typha*	Cattail
Rhamnus	Buckthorn		*Ulmus*	Elm
Rhus	Sumac		*Umbelliferae*	Parsley Family
Rhus radicans	Poison Ivy		*Viburnum*	Arrowwood
Robinia pseudoacacia	Black Locust		*Vicia americana*	Vetch
Prunetta vulgaris	Self Heal		*Vitis*	Grape
Rubus	Raspberry/Blackberry		*Vitis labrusca*	Fox Grape
Rubus occidentalis	Raspberry		*Vitus riparia*	Wild Grape

Box Huckleberry and Chinquapin Clusters:
Ancestral Native Plantations?

Glen Mellin
Lenny Truitt
January 01, 2013

A Background Narrative

Experienced archaeologists use vegetation changes and the presence of botanical clusters as indicators of cultural activity. Especially noted for the eighteenth and nineteenth centuries, a cluster of mature walnut trees, a cluster of old red cedars, or the neglected bed of yellow daffodils can be the same as seeing a large red X on a map—it screams out, DIG HERE! That's why we follow the old cart road in the woods, to see where it leads. And, we are always searching for that carpet of flowering periwinkle to get a glimpse at the long-forgotten tombstone veiled within.

However, identifying vegetation changes and botanical clusters dating to pre-colonial times has about the same risks attached as teasing a rattlesnake on a summer afternoon. Perhaps the number one topic most archaeologists would prefer to avoid, identifying ancestral Native plantations, is the direction this narrative is headed. So, buckle up, it's likely to be a bumpy ride.

We really got inspired when we read Cronon's (1995) Changes in the Land. Cronon cited hundreds of examples where Colonials in New England described in detail how the Indians had altered their landscape. These landscape management techniques, Cronon suggests, were designed to increase and concentrate desirable species of plants and animals, as well as to discourage undesirable species of plants and animals.

Cronon did not convince us that these pre-colonial alterations are easily observed today. Typically, in today's world, documenting ancient botanicals takes one of two forms. 1) We either identify the largest surviving botanical example, with little or no cultural meaning attached. Such specimens may be included in a "big tree" list. Or 2), we identify historic trees because of their cultural significance, more or less as cultural "landmark features".

What would evidence of a pre-colonial, natural landscape look like? Because Natives were always part of the landscape, we wondered (as Cronon wondered), that thinking there ever was an untamed or unaltered natural landscape may be unrealistic assumption. Ironic, isn't it? We have arrived at the idea that the remains of possible ancestral Native botanical clusters, or plantations, may be easier to identify than naturally occurring, supposedly untamed, or unaltered landscapes!

The remains of ancestral Native botanical clusters, or plantations, may be difficult to quantify. They may, at the same time, be all around us, yet they may be hard to put your finger on. A couple of years ago, we found encouraging support from The Delaware State Forestry Department (DSFD) (Taber: 1960, no page number, Preface to the Second Edition) with their staggeringly insightful statement:

> Of the *native* list, plus or minus 115 species and their varieties may be found in Delaware. To this may be added some 12-15 species of naturalized trees. However, it is now generally conceded that not all introductions were of Old World origin and that some owe their presence in Delaware to aboriginal trade and culture within this Continent.

Although DSFD doesn't really have a list of species found in Delaware owing their presence to aboriginal trade and culture (that would be way too easy—right?), they instead, have a number of species, which through speculation, may be candidates. Speculation of this sort typically involves rarity and location or arrangement. Moving one step further along, we are seriously interested in quantifying these plants at or within proximity to known archaeological sites, illuminating their potential to be cultural artifacts, which is after all, the main topic of this essay.

In Delaware, the box huckleberry and the chinquapin are plant species, which may owe their position in time and space to aboriginal trade and culture. If we can show that pre-colonial clusters of these plants, and others, still exist, then they may be considered cultural artifacts. The meaning derived from such a breakthrough would, of course, have great cultural value to living people of Native descent, as well as others interested in this topic.

Statement of Research Questions

Newly identified box huckleberry and chinquapin clusters lay adjacent to habitation site 7S-E-19 along the riverbank of the upper Nanticoke River in Sussex County, Delaware. Can we identify these botanical clusters as cultural artifacts? Are these clusters the remains of Native plantations dating back to the Woodland I Cultural Period? How do these questions, and answers, change the way we look for, identify, analyze, and protect these interesting "heirloom" landscapes?

Gatherings of Berries and Nuts

This brings us full circle; we are back to the gatherings of berries and nuts. A box huckleberry (berry) cluster and a chinquapin (nut) cluster are found in close proximity to ancestral Native habitation site 7S-E-19. We surveyed about 200 acres of upland, unplowed woods around 7S-E-19 and determined these two botanical clusters are indeed rare and isolated, illustrating the uniqueness of these clusters.

Within our 200-acre unplowed, wooded research area around site 7S-E-19, we noted a number of useful botanicals that seemed randomly spaced--not appearing in cluster form. For example, we observed various aquatic tubers, beechnuts, blackberries, black cherries, butternuts, cactuses, concord grape, elderberries, fox grape, hickories, honeysuckle, huckleberries, mulberries, oaks, persimmon, raspberries, walnut, and yucca specimens.

In 1991, we conducted an exploratory archaeological test excavation at site 7S-E-19 (Mellin, 1991) where we delimited the basic geological strata and available cultural contexts. The site consisted predominantly of Mockley shell tempered ceramics, which appeared in an unusually thick soil package believed to represent an accretive sand sheet. We hypothesized that this sand sheet (and subtle dune feature formation where the box huckleberry is located) accumulated as a result of cultural landscape alteration. We introduced and explored a theory suggesting ancestral Native white-tailed deer browse lot manufacture and maintenance (Mellin, 2000, 2009).

The ancestral people who lived at that site made what we call Mockley style ceramic containers with a carbon-dated timeframe from about 200bce to about 500ce. Basically, this Native habitation site is about 1,800 years old. We are suggesting the people living at that site, at that time, manufactured both the box huckleberry cluster and the chinquapin cluster as botanical plantations in an effort to increase and concentrate these specific species for their own use.

The Box Huckleberry Cluster

The box huckleberry cluster (*Gaylussacia brachycera*) illustrated in this paper covers about one hectare or one and one half acres and is estimated to be 1,500 to 2,000 years old. That is the same

age as adjacent habitation site, 7S-E-19. The only reasonable explanation for the occurrence of this plant, in time and space, is that an ancestral Native person(s) planted it there some 1,500 to 2,000 years ago. How can we be sure? To be sure, we need to understand the unique characteristics of the box huckleberry species itself.

The box huckleberry is a globally endangered, edible berry producing plant with a worldwide count of about 100 known specimens. The incredible rarity of this plant is surpassed only by its unique history--having lost its ability to sexually reproduce during the Pleistocene, all Holocene occurrences are self-sterile. Only found in isolated colonies, optimally growing at an overall rate of 15 centimeters per year, the species is only able to sustain itself through cloning in a subsurface process known as root extension (a natural process), or physically transplanting prepared settings through relocation (a cultural process).

Pennsylvania may have the largest (therefore oldest?) known box huckleberry plant in the world, dating to about 5,000bce. DNA tests (Pooler et al., 2006, 2008) demonstrate several genetic strains within that cluster, an indication there are likely several different plants, or "plantings", contributing to the overall cluster. An interpretation of those Pennsylvania DNA tests strongly suggest the genetic strains present are not cloned sister plants, but they are probably more like cloned aunts, or cloned grandmothers--genetically separated from each other prior to the Holocene.

Various writings concerning the box huckleberry suggest some sort of co-occurrence association between mountain-laurel (*Kalmia latifolia*) and possibly other rhododendrons with the box huckleberry. We confirmed this association at the box huckleberry cluster adjacent to habitation site 7S-E-19. In fact, mountain-laurel and other rhododendrons occupy a similar spatial "footprint" as the box huckleberry cluster. In addition, we identified six American chestnut stump sprouts, forming a linear pattern, spanning between the habitation site 7S-E-19 and the box huckleberry cluster. The co-occurrence of surviving American chestnut may, or may not, be coincidental. We were thinking about devising a management plan for this box huckleberry cluster, but because it is an example of the rarest plant species in the world, we need to get professional guidance before any action is taken.

We recorded the GPS UTM location of the box huckleberry cluster in a useful log (attached). Location and arrangement of the box huckleberry cluster, as well as the archaeological site is plotted on the Box Huckleberry Cluster Map (see below).

The Chinquapin Cluster

The chinquapin cluster (*Castanea pumila pumila*) illustrated in this paper covers about one hectare or one and one half acres consisting of about 200 chinquapin trees. Again, an exhaustive search on several hundred acres surrounding ancestral Native habitation site 7S-E-19 found no other chinquapin trees, which illustrates the uniqueness of this intense cluster. This chinquapin cluster is of undetermined age.

It is important to note that chinquapin does not produce any known beneficial toxin, as black walnut does, to discourage other botanical species from growing within the species cluster. Therefore, it is evident that humans got this chinquapin cluster arranged and maintained it for an extended period of time. There is no known documentation of Colonials arranging or maintaining chinquapin clusters. However, there is written documentation, as well as physical evidence of arranging and maintaining groves, gardens, and small orchards of American and Asian chestnuts starting around the 1860s.

Before the twentieth century, chinquapins were documented in Delaware as obtaining a height of forty to fifty feet with a girth of perhaps two feet at chest height. The species is characterized as a mid-range tree, normally not reaching the upper canopy, but does benefit from some direct sunlight. The species is noted as growing best on acidic, xeric landscapes. In Delaware, chinquapin is listed as being a State Rare species. Taber (2012:99) claimed, chinquapin "is derived from two words: *chinkwa* and *min* of the Delaware Indian language". In the Eastern Cherokee language, chinquapin means squirrel-tree.

Early in the twentieth century, an Asian bark fungus, or chestnut blight, wiped out mature chinquapins. Subsequently, some stump shoots appeared as regenerative growth. However, these slender shoots are also susceptible to the persistent fungus when the regenerative growth reaches sexual maturity. Consequently, the new growth very rarely produces a seed burr, which normally would contain a fertile nut. Taber (2012:99) said, "The chinquapin is somewhat more resistant to the chestnut blight than the American chestnut but because of its slow growth and limited distribution is perhaps more susceptible to extermination than the chestnut".

Research suggests these root shoots rarely obtain a height above three meters with a stem diameter of about three centimeters (dimensions needed to achieve sexual maturity and initiate the flowering process) before the fungus kills the regenerative growth. Because our newly identified chinquapin cluster has many specimens that currently are at least twice as big, occasionally three times bigger, some specimens in this cluster are likely more resistant to the fungus than published research would suggest.

Management Plan

Since we started actively managing the chinquapin cluster over two years ago: ground brush clearing, opening up the canopy, and applying limited fertilizer has increased the vibrancy of both individual specimens and the overall cluster. During the summer of 2012, we counted over sixty seed burrs on at least four of the chinquapin specimens. Since some of the specimens appear to be young seed sprouts, we assume at least some of the seeds are fertile, which means this chinquapin cluster appears to be self-sustaining despite the adverse effects of the fungus blight.

We recorded the GPS UTM location of each living chinquapin specimen and created a useful specimen log (attached). Location and arrangement of each specimen is plotted on the Chinquapin Cluster Map (see below).

Summary

This essay presents existing box huckleberry and chinquapin clusters as likely cultural elements of Native habitation site 7S-E-19 (see Cultural Landscape Map). We have no way to prove these clusters were created and maintained by ancestral Natives. However, based on the preponderance of evidence including the rarity and likely ages of origin of these botanical clusters, we assume they owe their existence to pre-colonial Native activities. So, what are the ramifications of such thinking?

With this essay, we strongly support the likelihood of identifying existing, pre-colonial botanical clusters as cultural artifacts. How does this thinking change the way we think about the pre-colonial terrestrial landscape? Archaeologists and Botanists need to share their ideas to broaden the view of what the pre-colonial landscapes looked like. For example, we think it is becoming much more realistic to think that pre-colonial Natives were much more involved with their landscape than we have previously given them credit.

We envision pre-colonial Natives selecting, digging up, transplanting, arranging, and managing botanicals in locations that benefited their lifestyle. Thus, increasing and concentrating perhaps sparsely occurring natural specimens into readily available and productive, clustered forms of desirable resources. The reasons for botanical manipulation may be very wide ranging. For examples, we could speculate that acorns, nuts, cactus, and fruit are edibles, as well as being good bait, yucca twists nicely into strong cordage, and plants such as the box huckleberry may hold spiritual or medicinal potentials.

Entertaining botanical clusters as plantations--as living cultural artifacts both broadens and complicates our existing world-views. Looking for evidence of pre-colonial botanicals requires new and creative attempts at comprehensive field survey. For our survey, we literally crawled around on our hands and knees for several weeks covering 200 acres of unplowed woodlot. Of course, spaces that have been plowed, clear-cut, or paved over have likely lost their potential to reveal their pre-colonial terrestrial content.

Thinking About The Future

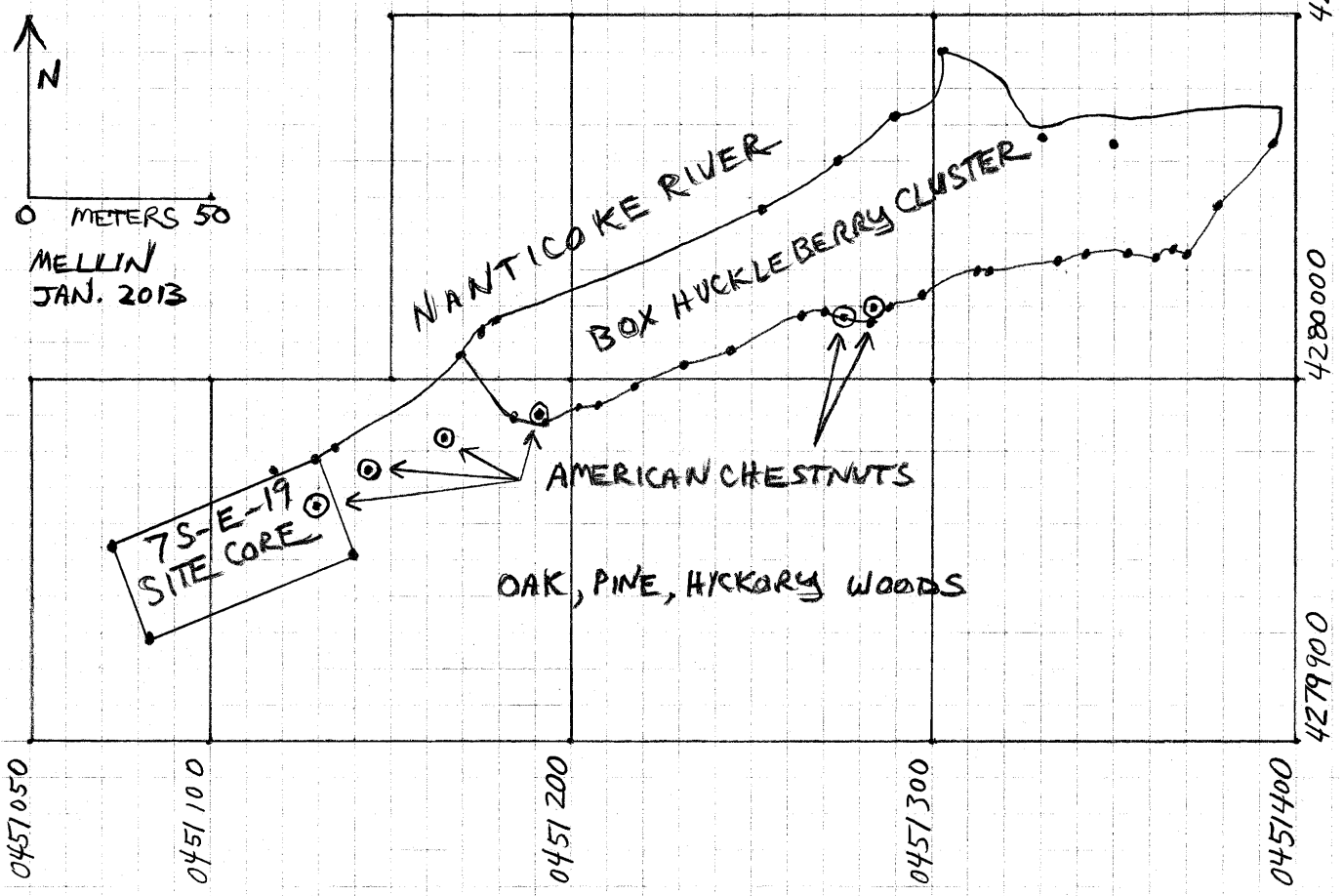
We chose to illustrate this box huckleberry and this chinquapin cluster as ancestral Native plantations because of their rarity, their unique characteristics, and their geographical position in time and space. However, as noted above, there are a lot of other species found in the present day botanical landscape that may be potential candidates for further research and discussion.

We often think we're being creative when we name pre-colonial habitation sites according to their present day, dominant botanical species. We make names for such places, like--an Oak Orchard, or a Hickory Bluff, or a Cactus Hill, or a Prickly Pear Island. But, what we need to focus on is whether ancestral Natives were simply attracted to these naturally occurring botanical resources, or did our ancestral Natives actually create and maintain botanical clusters as plantations? What a wonderful gift to future generations, heirloom botanicals, living artifacts, artifacts with DNA! The box huckleberry and chinquapin clusters cited in this essay are likely two examples of surviving cultural botanicals, excellent examples of what insightful, thoughtful people have given to each other.

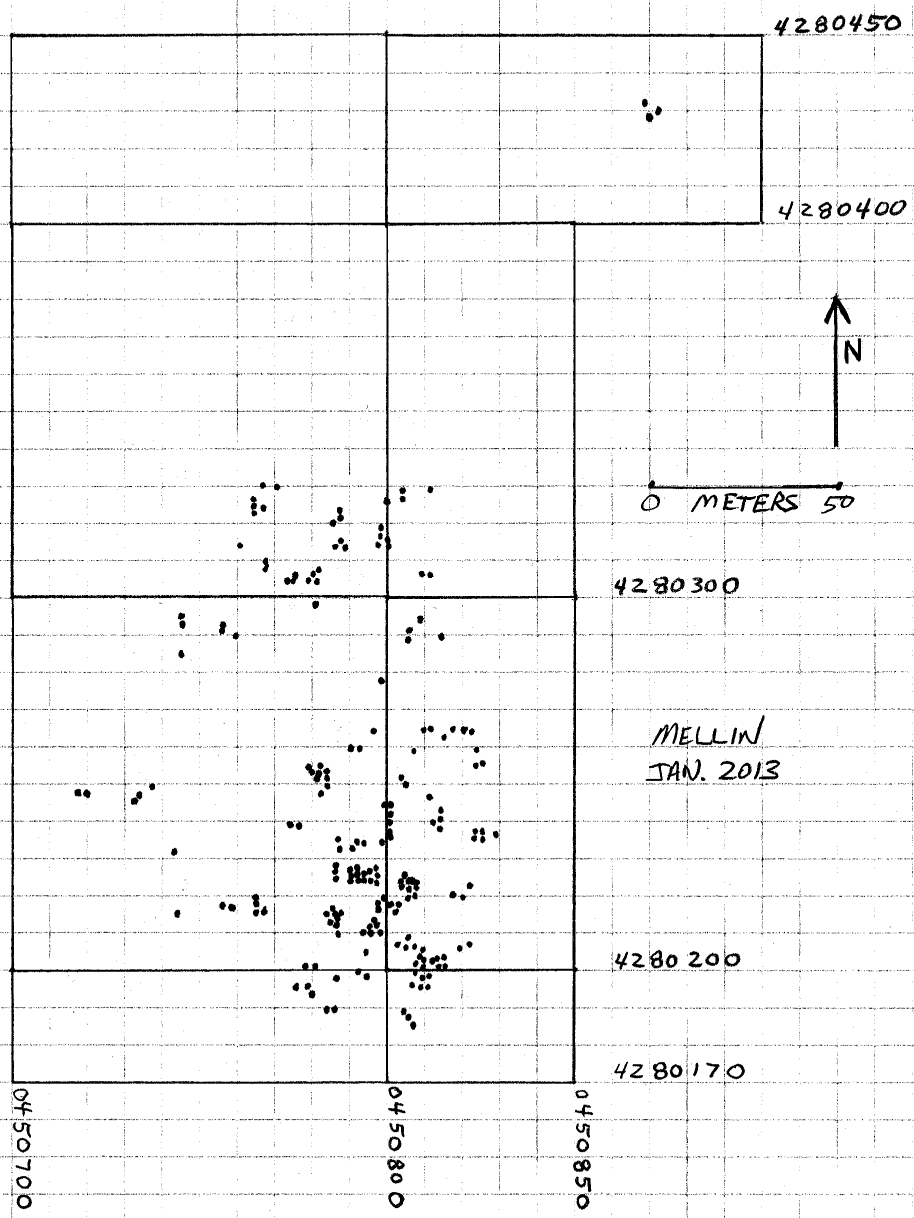
Mapping

All recordation and mapping contained in this essay was achieved using a Garmin Etrex 10 hand held device running WAAS software, configured to the GPS UTM 18S datum, overlaid on an enlarged portion of the digital Seaford East, 7.5minute, Delaware quadrangle map.

BOX HUCKLEBERRY CLUSTER MAP



CHINQUAPIN CLUSTER MAP



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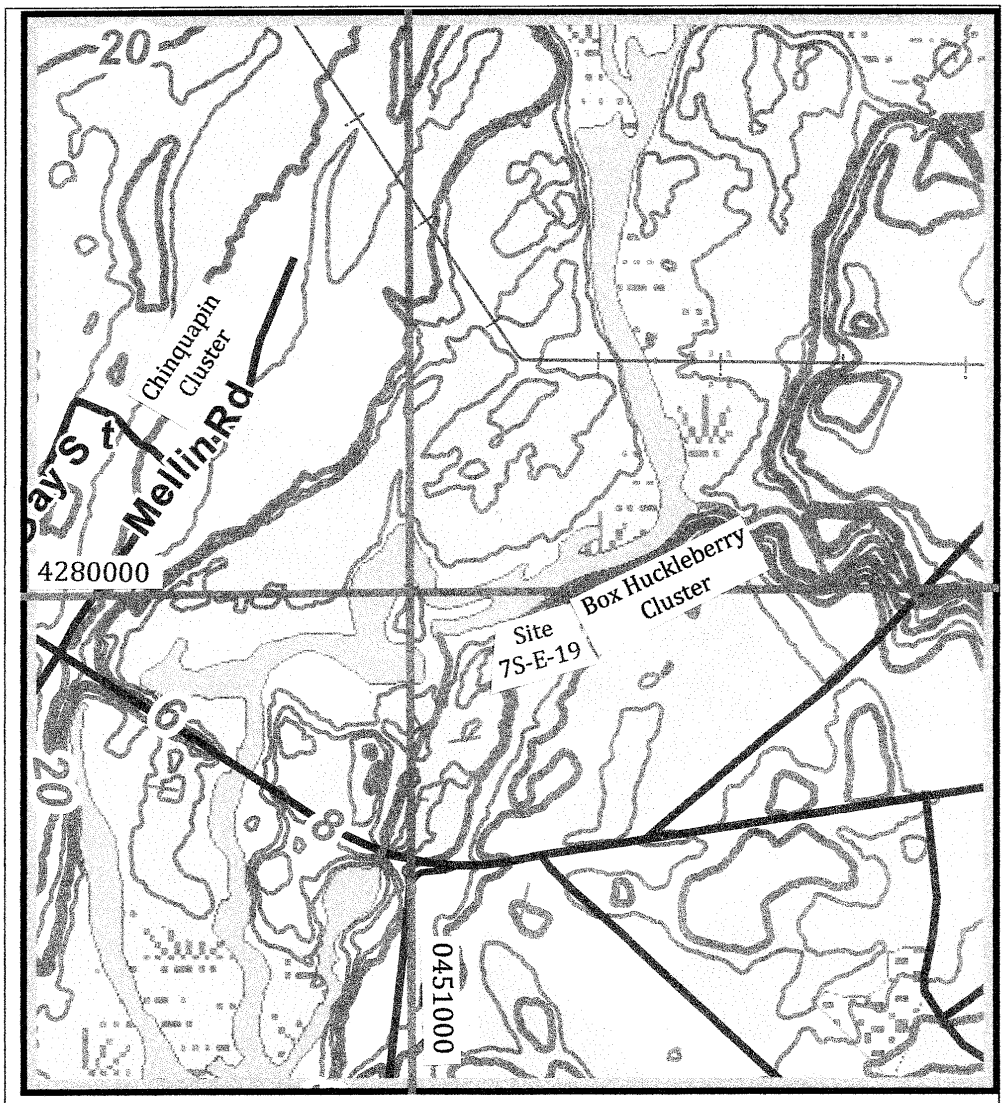

Cultural Landscape Map

Enlargement of Seaford East Quadrangle, Delaware

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End file

INTERESTING BOTANICALS ON A HISTORIC SITE IN DELAWARE: RECOGNITION, SIGNIFICANCE, AND MEANING

Glen Mellin
Lenny Truitt

June 01, 2013

INTRODUCTION

The purpose of this essay is twofold: 1) to demonstrate that important historic botanicals exist at historic locations in Delaware, and 2) that these botanicals can be easily recognized, they are significant, and they assist us in telling a more complete story of the cultural history at each location. Indeed, the presence of many of these historic botanicals represents more than simply an expression of local lifeways participating in local, state, and regional economics; their presence in Delaware, as living artifacts, owe their position in time and space to increasing development of globally oriented trade and exchange networks.

This essay focuses on specific activities that took place at this mid-nineteenth century agricultural complex in west-central Sussex County, Delaware. The residence was occupied until after World War II, and it was razed by fire in the 1960s. The specific location is described as a substantial brick foundation with two chimney bases located in a four-acre grove of trees and brush, which has not been subjected to mechanical degradation. As a historic archaeological site, it remains in pristine condition.

FIELD NARRATIVE

We walked around and viewed the remains of the brick foundation from every angle. On the north side of the house foundation there is an iron pipe well, there are several small piles of rusted roofing material, and some elevated, linear earthworks, which look like platforms for outbuildings. Scattered around the house location are clusters of daffodils and some long neglected climbing rose bushes. In a broader view, however, there are trees—curiously shaped and curiously placed trees. These trees are the main focus of this essay.

We made a basic inventory of the tree species present. We identified tree species native and non-native to Delaware. Our field sketch indicated that specific species formed clusters and that there were some spaces between species clusters. Larger trees were probably planted in the mid-nineteenth century, and one grouping (map area A) is likely to be an incidental emergent cluster only twenty years old.

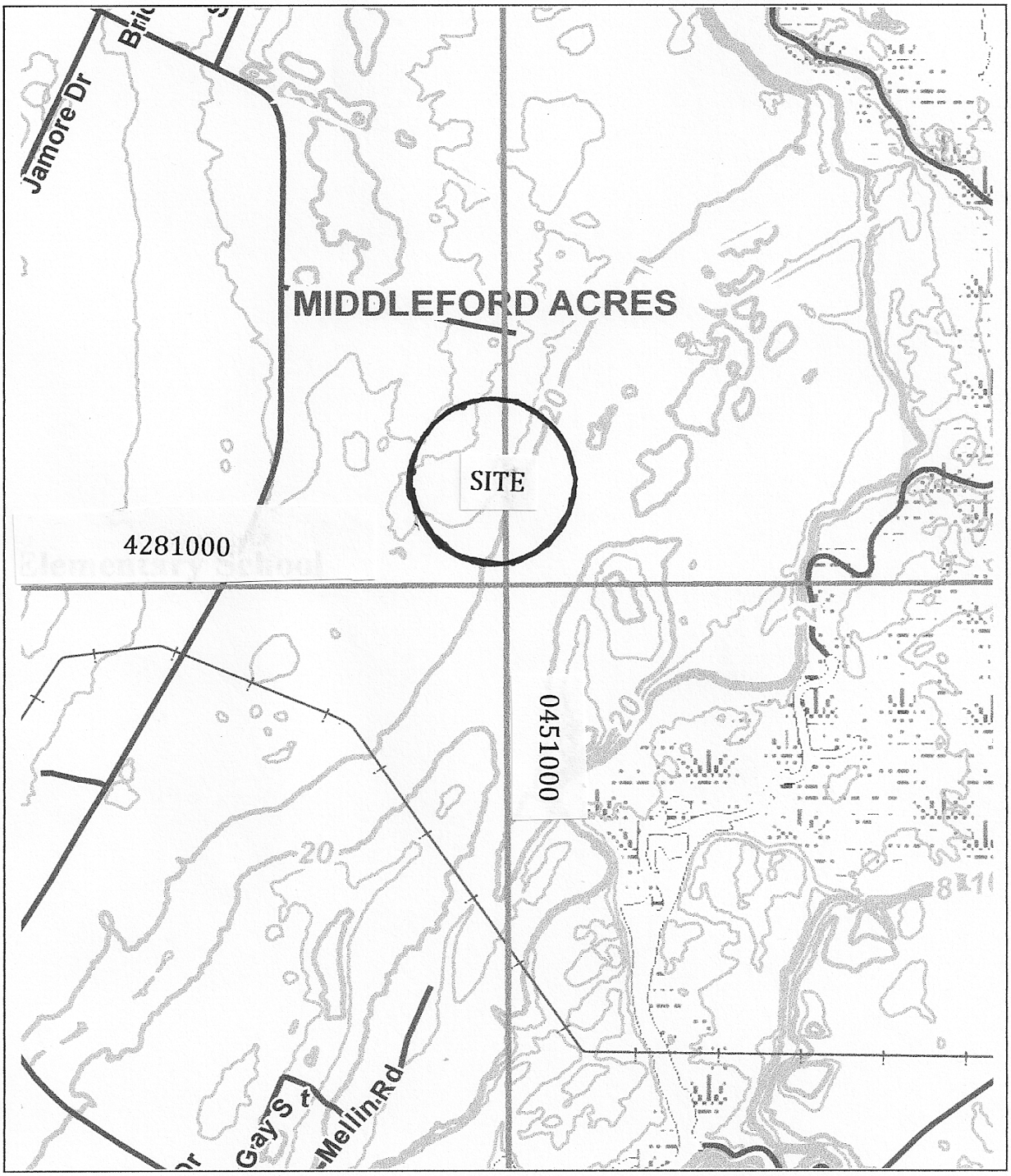
Overall, we thought, the recognition of these historic tree clusters substantially added to our understanding of how this mid-nineteenth agricultural complex was organized. On our site map (see below) we discuss five areas, area A through area E.

AREA IDENTITY

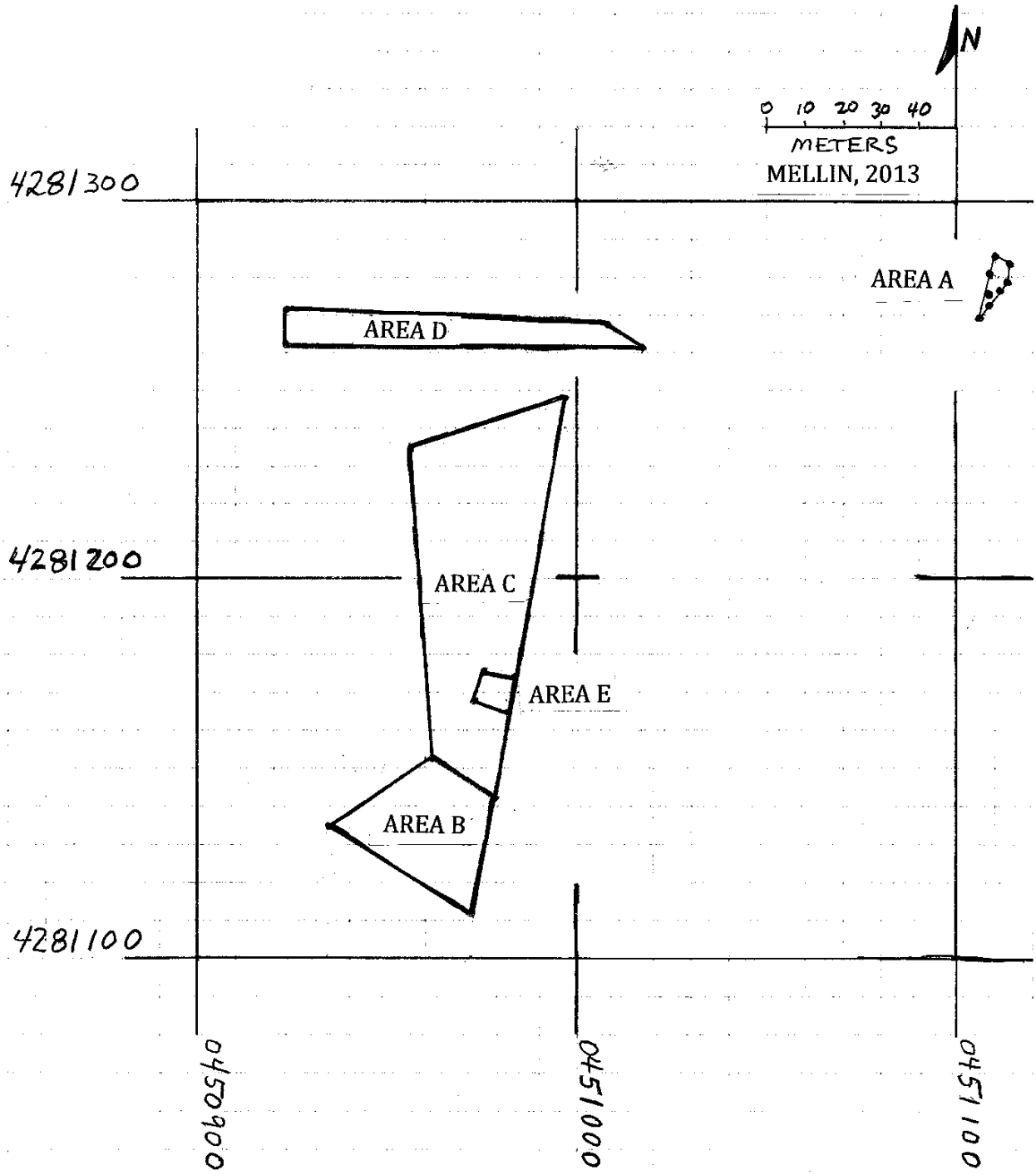
Area A—Emergent Sawtooth Oak Cluster

Area A is located in a formerly plowed agricultural field that went fallow some twenty years ago when the property changed hands and a preservation agreement was arranged by the State of Delaware (approximately 1993). We counted and mapped eight individual, small specimens of

LOCATION MAP, PORTION OF SEAFORD EAST QUADRANGLE, DELAWARE.



DETAIL OF HISTORIC SITE WITH AREAS A THROUGH E



Sawtooth Oak. Apparently, some unknown quantity of Sawtooth Oak acorns, likely grown in Area B, were dispersed into Area A about the time the field went fallow.

Area B—Chinese Chestnut and Sawtooth Oak Cluster
Area B is located just south of the residential brick foundation. Chinese Chestnut and Sawtooth Oak are the dominant species within this area.

Area C—Red Mulberry and Black Walnut Cluster
Area C contains the historic residential brick foundation, the well, the rusted roofing material, the elevated earthen pads of likely outbuildings and probably contains most, if not all of the important archaeological features of the agricultural complex. This area is dominated by mature Red Mulberry and Black Walnut, both species, interestingly, native to Delaware.

Area D—Norway Spruce Cluster
Area D, located well north of the residential brick foundation, appears as an east by west strip of mature Norway Spruce trees. These spruce trees have just fallen short of being the dominant species within Area D, being recently challenged by Loblolly Pine.

Area E—Historic House Foundation
Area E is the immediate location of the residence. I visited the house after it was abandoned in the 1960s. It was a substantial house, two story, probably 10-foot ceilings, with one massive fireplace in the east pallor, and a northern add-on with another massive fireplace. My recollection is that it resembled a mansion type house with a slate roof, and probably played a significant economic and architectural role in what is locally known as the Governor Ross (of Seaford, Delaware) economic and political era; slightly before, during, and after the War Between the States. Suffice it to say, the family that built and owned the house was rather well connected to the powers that were.

SIGNIFICANT BOTANICALS DISCUSSED (in alphabetical order)

BLACK WALNUT
Black Walnut, *Juglans nigra*, is a native tree in Delaware. The Black Walnut is an edible nut producing deciduous tree that may attain a height in excess of 100 feet with a diameter of 4 feet. This tree is noted for its distinctive flavored nut, and its high quality, valuable wood. In addition, Black Walnut drupes contain abundant juglone (hydroxy-naphthoquinone), plumbagin (yellow quinone pigments), and tannin. These compounds were widely used and highly valued. Some examples include dyeing human hair, coloring various textiles, and for staining and preserving handicrafts.

CHINESE CHESTNUT
Chinese Chestnut, *Castanea mollissima*, is a non-native tree in Delaware. The Chinese Chestnut is an edible nut producing deciduous tree attaining a height of 60 feet with a diameter of 3 feet. This tree is noted for its abundant nut production, and readily cross-pollinates with American Chestnut, *Castanea dentate*.

Starting in the colonial era, the Chinese Chestnut was imported from Asia and Europe. The Chinese Chestnut is resistant to the Asian Chestnut bark disease, *Endothia parasitica*, which arrived in North American in the early twentieth century, where the American Chestnut is far less resistant. Further complicating proper species identification is the importation of the Italian Chestnut, *Castanea sativa*, as well as the Japanese Chestnut, *Castanea crenata*.

NORWAY SPRUCE

Norway spruce, *Picea abies*, is a non-native tree in Delaware. The Norway spruce is an evergreen coniferous tree that may attain a height in excess of 100 feet with a diameter of 4 feet. This tree is noted for an accelerated pubescent growth rate of 3 feet per year for about two decades, followed by a slower growth rate and cone production.

Norway spruce, also known as European spruce, or the old fashion "Christmas" tree, are native to central Europe from Norway to Greece, but are documented to have been imported to various colonies from England. Classified in North America as an ornamental, clustering in geometric forms provide adequate and attractive windbreaks, as well as functioning as useful physical and visual barriers.

RED MULBERRY

Red Mulberry, *Morus rubra*, is a native tree in Delaware. The Red Mulberry is an edible berry producing deciduous tree that may attain a height of 45 feet with a diameter of 1½ feet. Red Mulberries may be found in close proximity to historic houses and historic archaeological sites.

Some Red Mulberries retain their original, pure North American genetic makeup. However, a large amount of hybridization continues with both the White Mulberry, *Morus alba*, a native of Asia, but also imported from Europe, and the Black Mulberry, *Morus nigra*, a native of southwestern Asia (Afghanistan through India), but also imported from Europe.

Simply put, the famous silkworm liked to eat the Silkworm Mulberry, *Morus multicaulis*, a sub-species of the White, but not the Black, and not the Red. Through much misunderstanding and disappointment, these Asian varieties were spread around the world in an effort to manufacture silk, but never seemed to produce a positive outcome.

SAWTOOTH OAK

Sawtooth Oak, *Quercuts acutissima*, is a non-native tree in Delaware. The Sawtooth Oak is an edible acorn producing deciduous tree that may attain a height of 90 feet with a diameter of 4 feet. Sawtooth Oak is rarely found in close proximity to historic houses and historic archaeological sites in Delaware, yet it is not rare and sometimes referred to as invasive, west of the Alleghenies.

This oak is native to eastern Asia, in China, Korea, and Japan, but was also imported to colonial America from Europe. Acorns are abundantly produced, but taste very bitter. This tree was typically planted for the benefit of chickens, turkeys, pigeons, and hogs. Squirrels and deer will eat these acorns when preferable food sources are depleted.

INTERPRETATION

For the purpose of this essay, five botanical species were successfully identified at a pristine historic archaeological site in west-central Sussex County, Delaware. We recorded locations using a handheld Garmin Etrex GPS, measuring from the 18S datum.

Two botanical species; Black Walnut and Red Mulberry are native to Delaware. Three botanical species; Chinese Chestnut, Norway Spruce, and Sawtooth Oak are not native to Delaware, but were likely imported to North American colonies and the United States from various ports in western Europe. There is no direct evidence that either of these three botanical species were imported directly from their original, indigenous range. The extensiveness of global movement of these botanicals is truly fascinating.

What we did not see at the site, but what were likely present at the site include, but would not be limited to, various peaches from the Netherlands, barley and wheat from Europe, corn from Mexico, potatoes from Peru, and an extensive list could be endless!

By the mid-nineteenth century, the United States government as well as various educational universities were promoting a new paradigm called "scientific agriculture." The "official" promotion recommended the planting and propagation of specific, beneficial, native and non-native botanicals, such as the ones we found at this historic site.

CONCLUSIONS

RECOGNITION. We successfully demonstrated that important historical botanicals exist at this historic location in west-central Sussex County, Delaware. We used a hand held GPS device to record the tree locations and determined that geometric clusters of like botanicals are real, they can be recorded, and they are important.

SIGNIFICANCE. The individual botanical specimens and the clusters they form are indeed living cultural artifacts. These geometric botanical clusters aided in our understanding of how this mid-nineteenth century agricultural complex was organized. These botanicals provided nut, berry, and acorn products for humans and animals, and the spruces likely provided a windbreak barrier for undetermined agricultural assets.

MEANING. Three of these botanical species (Chinese Chestnut, Norway Spruce, and Sawtooth Oak) are non-native to Delaware. Their occurrence, at this particular historic archaeological site, demonstrates that the owners of this agricultural complex were participating in the mid-nineteenth century paradigm of scientific agriculture. Furthermore, these actual trees are the tangible result of the owner's participation in increasing developed, globally oriented trade and exchange networks.

GPS LOCATION AND DESCRIPTION OF HISTORIC SITE BOTANICAL CHARACTERISTICS

EMERGENT SAWTOOTH OAK (MAP AREA A)

GPS 18S UTM LOCATION		DESCRIPTION
0451114	4281283	Sawtooth Oak single mast tree growing in formerly plowed field. Estimated age of existing above ground growth is less than 20 years old. Height is 4m. Diameter is 6cm.
0451111	4281285	Sawtooth Oak single mast tree growing in formerly plowed field. Estimated age of existing above ground growth is less than 20 years old. Height is 6m. Diameter is 12cm.
0451109	4281280	Sawtooth Oak single mast tree growing in formerly plowed field. Estimated age of existing above ground growth is less than 20 years old. Height is 3m. Diameter is 4cm.
0451115	4281278	Sawtooth Oak single mast tree growing in formerly plowed field. Estimated age of existing above ground growth is less than 20 years old. Height is 5m. Diameter is 7cm.
0451112	4281277	Sawtooth Oak single mast tree growing in formerly plowed field. Estimated age of existing above ground growth is less than 20 years old. Height is 5m. Diameter is 9cm.
0451109	4281275	Sawtooth Oak single mast tree growing in formerly plowed field. Estimated age of existing above ground growth is less than 20 years old. Height is 8m. Diameter is 13cm.
0451109	4281271	Sawtooth Oak single mast tree growing in formerly plowed field. Estimated age of existing above ground growth is less than 20 years old. Height is 5m. Diameter is 6cm.
0451108	4281269	Sawtooth Oak single mast tree growing in formerly plowed field. Estimated age of existing above ground growth is less than 20 years old. Height is 7m. Diameter is 15cm.

CHINESE CHESTNUT AND SAWTOOTH OAK BOTANICAL CLUSTER (MAP AREA B)

GPS 18S UTM LOCATION		DESCRIPTION
0450933	4281134	Southwest corner of Chinese Chestnut and Sawtooth Oak botanical cluster.
0450971	4281111	Southeast corner of Chinese Chestnut and Sawtooth Oak botanical cluster.
0450978	4281141	Northeast corner of Chinese Chestnut and Sawtooth Oak botanical cluster.
0450961	4281152	Northwest corner of Chinese Chestnut and Sawtooth Oak botanical cluster.

RED MULBERRY AND BLACK WALNUT BOTANICAL CLUSTER (MAP AREA C)		
GPS 18S UTM LOCATION		DESCRIPTION
0450961	4281152	Southwest corner of Red Mulberry and Black Walnut botanical cluster.
0450978	4281141	Southeast corner of Red Mulberry and Black Walnut botanical cluster.
0450956	4281236	Northwest corner of Red Mulberry and Black Walnut botanical cluster.
0450997	4281249	Northeast corner of Red Mulberry and Black Walnut botanical cluster.

NORWAY SPRUCE BOTANICAL CLUSTER (MAP AREA D)		
GPS 18S UTM LOCATION		DESCRIPTION
0451008	4281268	Southwest corner of Norway Spruce botanical cluster.
0451017	4281261	Southeast corner of Norway Spruce botanical cluster.
0450923	4281271	Northwest corner of Norway Spruce botanical cluster.
0450923	4281262	Northeast corner of Norway Spruce botanical cluster.

HISTORIC HOUSE FOUNDATION (MAP AREA E)		
GPS 18S UTM LOCATION		DESCRIPTION
0450972	4281168	Southwest corner of historic house foundation.
0450981	4281163	Southeast corner of historic house foundation.
0450975	4281175	Northwest corner of historic house foundation.
0450983	4281175	Northeast corner of historic house foundation.

PRICKLY PEAR AND AMERICAN CHESTNUT CLUSTERS IDENTIFIED IN THE LOWER NANTICOKE RIVER BASIN

Glen Mellin
Lenny Truitt

July 01, 2013

INTRODUCTION

In June 2013, we surveyed an area of the southern shoreline of the lower Nanticoke River basin in an effort to identify living botanical species that may have been used by ancestral Native Americans. We identified a cluster of Prickly Pear cactus growing in a Native American shell-midden on Prickly Pear Island. We also identified a cluster of American Chestnut growing on the Native American site at Phillips Landing. What really makes these finds interesting is that we found no other meaningful botanical clusters within our two-mile shoreline survey. Indeed, the cactus cluster and the chestnut cluster are both unique and occur, each at previously identified Native American archaeological sites.

Aided by our enclosed maps and documentation logs, we exhibit the uniqueness of these finds. We discuss the potential for these living plants to be the actual descendants of plants that Native Americans used in their yearly subsistence. And lastly, we begin to question how, why, and when the Prickly Pear became a native plant in Delaware.

FIELD NARRATIVE

This project began with one of those weird, Monday morning questions; do you think there are Prickly Pear cacti growing at the Prickly Pear archaeological site on Prickly Pear Island? Well, we assumed there would be cacti there, but we needed a presence or absence framework, a survey to contemplate what we were looking at. We began at the east end of the Phillips Landing State Park. We then made a pedestrian, botanical survey all along the wooded, south shoreline for about two miles west, traveling along an ancient trail called Cherry Walk, from point "B" to point "A", and then made our way out across the swamp to Prickly Pear Island (see Figure 1).

As we walked along, we recorded various species, for examples: the shoreline exhibited some Atlantic White Cedar and Sweet Bay, the slopes were crawling with Mountain Laurel and various common huckleberries, and the uplands were covered with the typical mix of dominant species. The vast majority of the ground surveyed had never been plowed, although the absence of "big trees" indicated some forest product recovery had taken place. In essence, the two-mile pedestrian survey provided a large amount of negative information—species that weren't what we were looking for. Beneficially, however, the pedestrian survey provided a large negative frame that permitted the Prickly Pear cluster and the American Chestnut cluster to really stand out, in isolation!

We found the Prickly Pear cactus growing in bunches, forming a cluster, largely within the confines of a Native American shell-midden. The context of this shell-midden is probably of Late Woodland (1000ce—1650ce) origin (see Figure 2).

We found the American Chestnuts growing as individuals, forming a cluster, probably along the south and west perimeters of the Native American site. The exact contexts of this site are

Figure 1. Magnified portion of USGS Sharptown Quadrangle, MD.

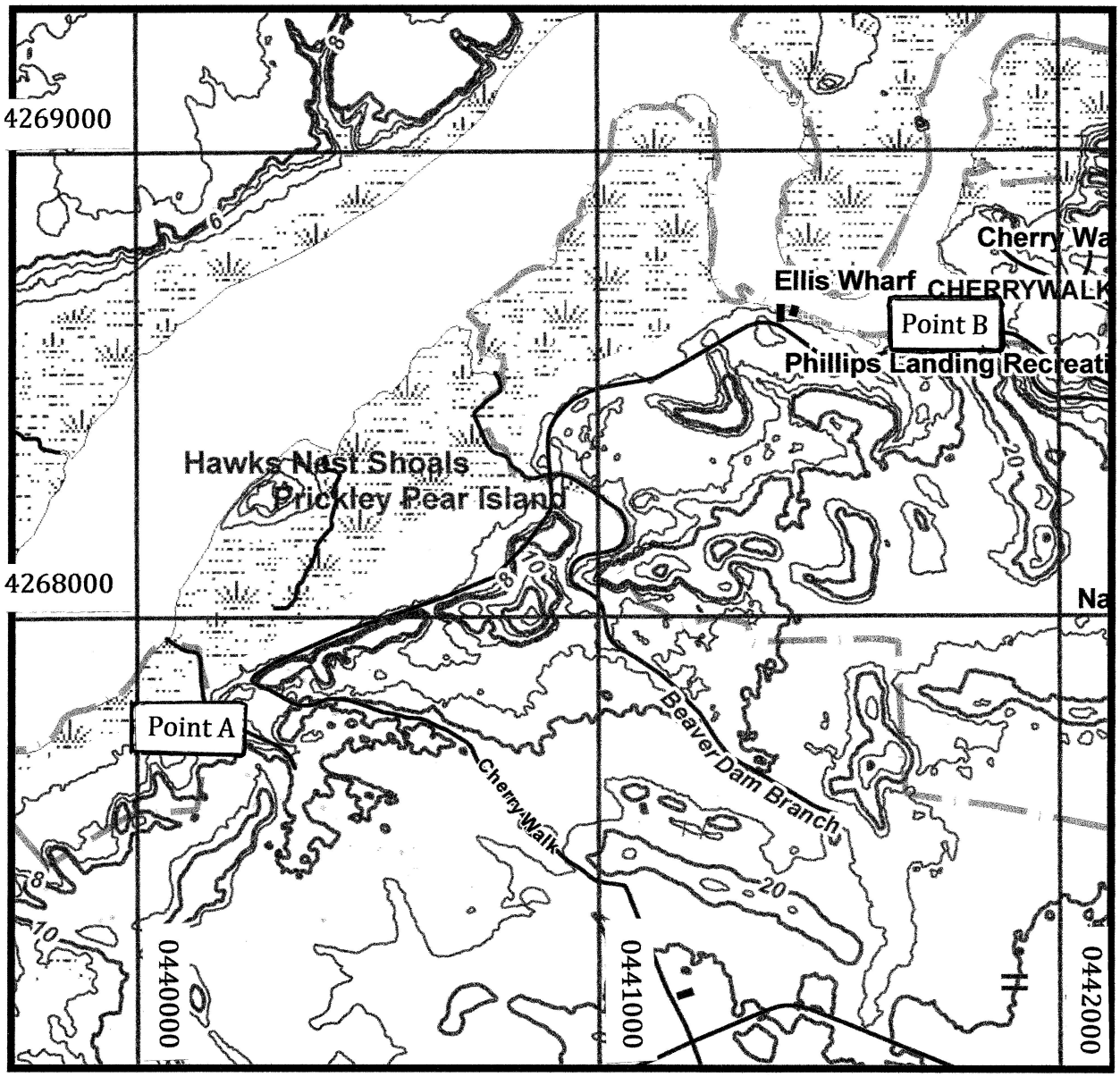


Figure 2, Prickly Pear Island Botanical Survey

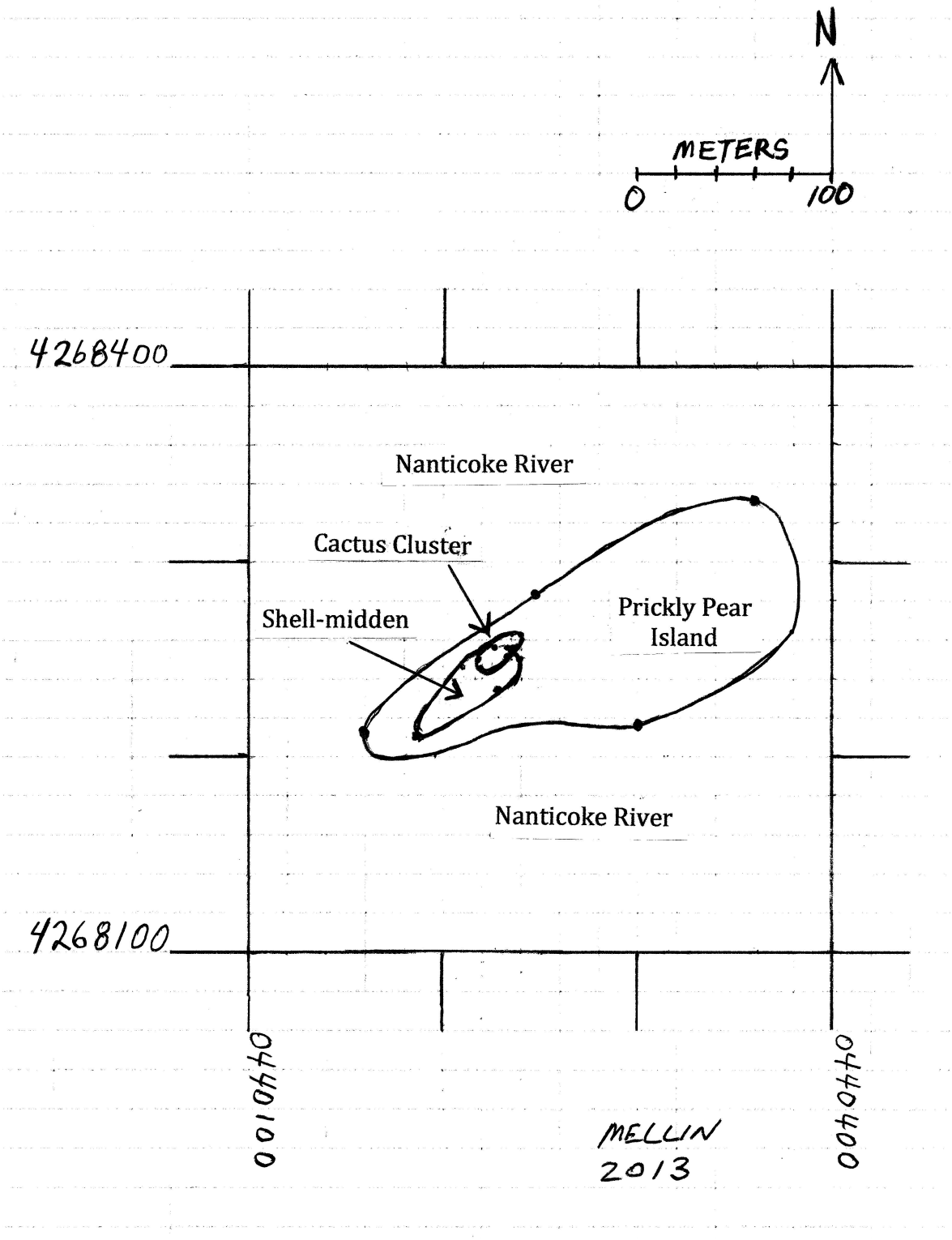
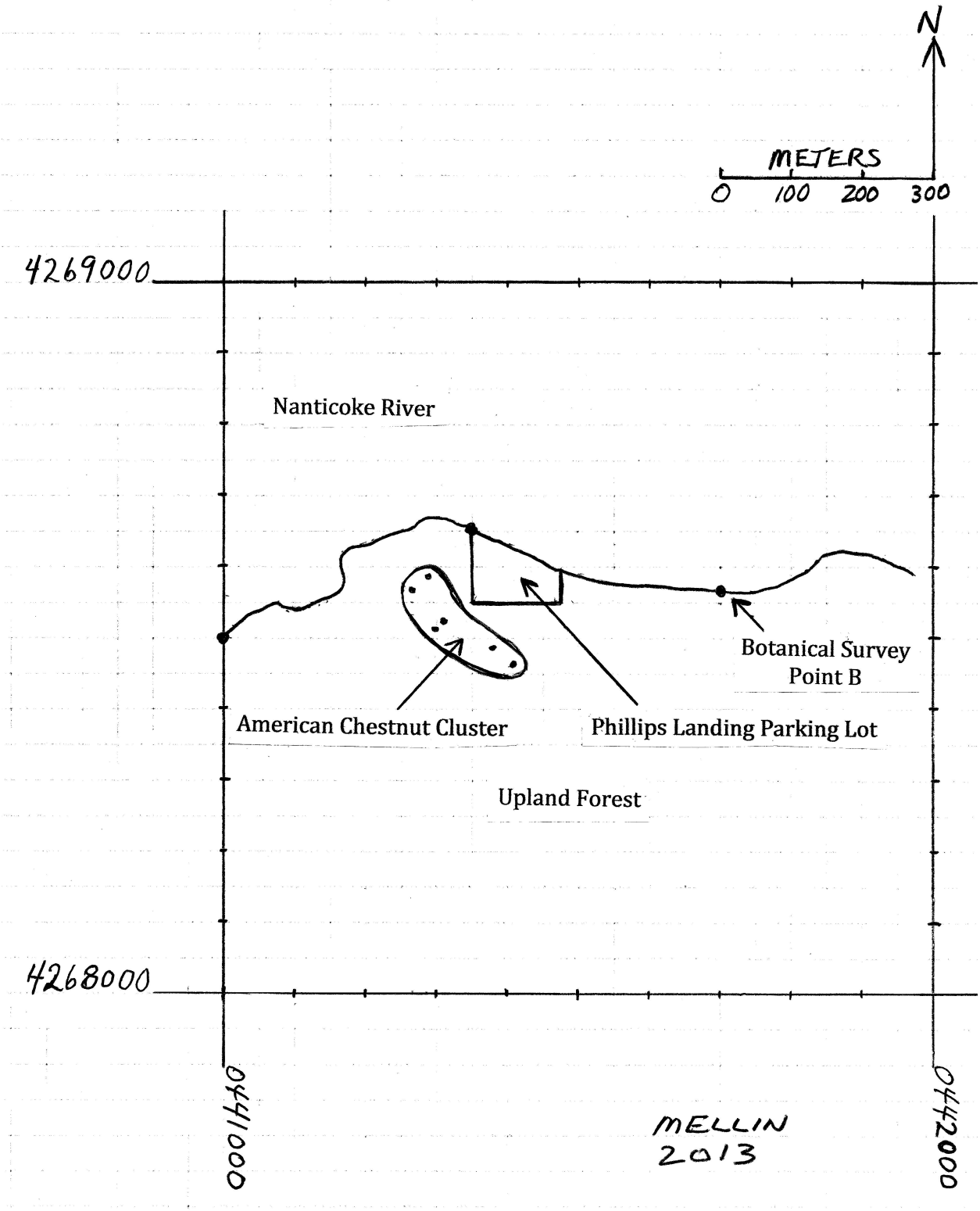


Figure 3, Phillips Landing Botanical Survey



undetermined, yet the site undoubtedly contains a Late Woodland (1000ce—1650ce) component (see Figure 3).

TWO BOTANICAL SPECIES, THE PRICKLY PEAR AND THE AMERICAN CHESTNUT

PRICKLY PEAR CACTUS

Plant Characteristics.
Prickly Pear cactus, *Opuntia humifusa*, is the only cactus native to Delaware. The plant typically appears as a flattish, rounded assemblage, or cladode of greenish, spiny cactus paddles, which may attain 50 cm. in diameter, and 40 cm. in height. Prickly Pear plants are usually found in clusters where sandy, xeric soils (may) have experienced some degree of natural or cultural disturbance.

For the purpose of this essay, we will address the four primary parts of the plant: the rootstock, the paddles, the flowers, and the pears. Root systems are below ground and extensive. The root system has the ability to periodically sprout new plants. Each paddle (actually a modified branch) is photosynthetic, stores water, and exhibits spiny nodes, as well as flower bud nodes. When in contact with soil, spiny nodes are capable of rooting, thus producing a new plant. In the month of June, a flower bud node may produce a large yellow flower, and after fertilization, a pear develops at the juncture of the flower base and the paddle. As the pear enlarges, it becomes somewhat globular and exhibits spiny nodes similar to the nodes on the flattish paddles.

The paddles, the pears, and the flowers are edible. The complicated ancestry of this native plant, as far as its presence in Delaware is concerned, may allow us to speculate which Native Americans ate this cactus and when it became available for consumption.

Complicated History.
Indigenous only to the Western Hemisphere, and curiously, the Galapagos Islands, the genus *Opuntia* (the Prickly Pear) contains about two hundred species. The vast majority of Prickly Pear species are found only in Meso-America, probably a result of extensive Pre-Columbian cultivation. Curiously, some species of Prickly Pear are found in far-flung regions. Our Prickly Pear, the *O. humifusa* is considered to be native to most areas north of Mexico, including Delaware. And after European contact, some varieties of the Prickly Pear were spread around the world.

Because we think many questions are certainly warranted, we are advocates of an indigenous range(s) and transplantation debate. Our overarching queries involve these two basic questions: 1) was the Prickly Pear (*O. humifusa*) spread out from Mexico in a cultural way, being moved around, transplanted, and exploited by indigenous North American populations, and if so, then 2) when did the Prickly Pear (*O. humifusa*) cactus become naturalized or native in Delaware?

The Prickly Pear as an Edible Plant.
Because the Prickly Pear, in Delaware, is not severely "burnt" by frost or freezing temperatures, it's paddles are available and edible on a year-round basis. After the Prickly Pear blooms, the red or yellowish-green pears mature in mid-late summer. Paddles and pears have to be carefully prepared before they are ready to consume. Large spines and tiny spines on the outer skin need to be respected. Held over an open fire until the outer skin blisters, both renders the spines harmless and allows the outer skin to be more easily peeled from the edible pulp.

Cosmetic, Medicinal, and Ceremonial Uses.
The Prickly Pear's gel-like sap may be used to clean and condition human hair. Strong alkaloids in the sap offer topical anti-bacterial treatments for wounds, and also is reported to reduce swelling from insect bites. Raw sap can be ingested in quantity to cure urinary tract infection (UTI), but a steady diet of sap will eventually have a toxic effect on the liver.

Some Recent Comments by Local Researchers.
McAvoy and Harrison (2012:18, 29) note the presence of Prickly Pear cactus at two of their fourteen shell-midden study group sites on the Delmarva Peninsula. If we may paraphrase their thoughts; their assumption is the presence of Prickly Pear at these two locations were capable of preceding the Woodland shell-midden (essentially, the cactus was initially growing on fairly acidic, xeric soils). And, the documented presence of Prickly Pear in two of the shell-middens demonstrates the Prickly Pear is capable of persisting on the calciphyte habitats produced by the weathering of shells in the midden. So, our understanding of what McAvoy and Harrison are saying is that they carefully point out that Prickly Pear, on Delmarva, is observed on both acidic-xeric and calcareous-xeric soils. We commend McAvoy and Harrison for their excellent and judicious work! Nevertheless, that pesky relationship question remains; did the Prickly Pear grow on Delmarva before Native Americans arrived, or did Native Americans transport the Prickly Pear to Delmarva?

As we were discussing these thoughts with Daniel Griffith (personal communication, May, 2013), Mr. Griffith told us he had always held the opinion there is an association between Prickly Pear cactus and Late Woodland occupation. We share this opinion of association: in summary, in Delaware, better preserved Late Woodland sites (i.e. those sites containing at least Rappahannock and/or Townsend series ceramics and have experienced little, or no mechanical degradation) typically exhibit a remnant cluster of Prickly Pear cactus.

AMERICAN CHESTNUT

Plant Characteristics.
American Chestnut, *Castanea dentata*, is a native tree in Delaware. The American Chestnut is an nut producing deciduous tree attaining a height of 90 feet with a diameter of 8 feet. This tree is noted for its abundant edible nut production, which used to be an important food source for humans and animals alike. In the nineteenth century, the American Chestnut occupied up to twenty-five percent of the forestland in some areas of the Northeast, Mid-Atlantic, and Appalachian ranges.

Complicated History.
An Asian bark fungus, or blight, *Endothia parasitica*, was introduced at a New York harbor in 1904. This fungus immediately attacked the American Chestnut trees in the Bronx Zoo and initially spread out at over the landscape at a rate up to fifty miles per year. The fungus disrupts the xylem process of a stem or mast as the plant reaches sexual maturity. Immature stems and masts are somewhat resistant to the fungus, but because the tree succeeds best as an upper canopy species, these immature stems and masts are subject to being crowded out. As far back as 1937, Taber (1937:95, and 2012:97) said of the remaining American Chestnut in the northeastern and Central Atlantic regions, "…one is fortunate today in finding a sprout or stump shoot which does not show the telltale cankers of the blight before it has attained a height of 15′ and a diameter of 3″." The future of the American Chestnut is dimmer still, given increased development and overall degradation of prime forested environments.

Today, in Delaware, there are few American Chestnut sprouts growing from old rootstock, rootstock of trees that were growing prior to the local arrival of the fungus. Because the species is

known to be attacked by the fungus, which causes the stems or mast to dieback at sexual maturity, fertile fruit, in Delaware, is virtually non-existent. Therefore; natural reseeding, in Delaware, is virtually non-existent. The American Chestnut species is counted by fewer and fewer native specimens.

INTERPRETATIONS

We had asked these two research questions: are there Prickly Pear cacti growing at the Prickly Pear archaeological site on Prickly Pear Island? And if so, what are the possible explanations for such an occurrence? We devised a pedestrian botanical survey—survey and record the available vegetation along two miles of Nanticoke River basin shoreline, and compare that with what we might discover on the island itself.

We were aware of previously recorded Native American archaeological sites at both the Phillips Landing State Park and on Prickly Pear Island. The topic of this essay, however, is surveying, recording, and building a database of edible and culturally beneficial botanicals. No archaeological testing was performed, and no archaeological materials were collected or disturbed.

We indeed found bunches of Prickly Pear cactus, forming a cluster, growing in the Native American, archaeological shell-midden on Prickly Pear Island. And, we found a cluster of American Chestnut trees growing along the west and south perimeter of the Phillip Landing State Park archaeological site. The two-mile pedestrian shoreline botanical survey produced a large amount of negative data and put a very nice frame around our positive data, comparable to observing two black bugs in a bowlful of white rice!

CONCLUSIONS

My wife and I began this survey by going to view and record the GPS UTM location of the alleged cactus patch on Prickly Pear Island. But, like most interesting research, there is always a fork in the road. We found and recorded the Prickly Pear cactus patch, and we found and recorded an American Chestnut cluster, each at a known Native American archaeological site; Prickly Pear at the Prickly Pear Site and American Chestnut at the Phillips Landing Site. These are two very interesting and perhaps very important discoveries, and that is the extent of our conclusions.

ABOUT THE FORMATION OF OUR RESEARCH PROJECT

We have received some email comments on our work, some positive, some negative, and some telling us our work is too casual. Some have said that we can't prove there was any Native American involvement in anything we are talking about. We appreciate all comments.

First of all, our efforts to properly identify, record, and report our finds take place in our spare time and is totally self-funded. Second, there is no accepted "blueprint" for doing what we are doing. We are simply doing this because we feel it has multi-disciplinary value.

The name of our project is Transformation of Native American and Historic Botanicals. Our thesis is that humans transform botanicals all the time—into food, tools, shelter, fuel, medicine, ceremonial objects, and art, etc. Transformed botanicals are fairly easy to recognize at Historic locations, for example, we identify a grove of old walnut trees, or we identify an old patch of neglected daffodils. Transformed botanicals on ancestral Native American locations are, well, lets just say that has been a neglected topic until quite recently. There just aren't any two thousand year old trees to core, and

there are no bronze plaques in the woods identifying where a transformation may have taken place. The topic of ancestral Native American botanical transformation is in its infancy. One reason, perhaps the major reason for the lack of a robust discussion is that we are just, now beginning to put together a candidate database of possible Native American botanical transformation species and locations.

So, what do we mean by ancestral Native American transformation of botanicals? Transformation might be noted through a positive effort to increase the cultural value of a naturally occurring resource—for example, increasing the number (thus increasing yield) of, say persimmon trees at a specific location. We call this type of transformation, clustering. Another type of transformation is transplantation, either accidentally, or on purpose. McAvoy and Harrison's (2012) work is a great example. They identified some calciphytes growing in Native American shell-middens, far beyond their natural, or indigenous ranges—they postulated that transplantation might be an acceptable explanation for their finds. We must also consider another type of transformation, eradication, the removal of, or at least suppression of undesirable species, like the weeds in your garden, or the dandelions on your lawn.

With the above, simple descriptions of botanical transformation, we thought it might be a good idea to actually survey some wooded environments to see what we could find. Basically, we look for odd or rare individuals, clusters, or groves of trees and bushes that seem to be out of place in otherwise normal, natural settings. We think these finds might represent indications of human activity—i.e. cultural activity. We describe the species found, record the GPS UTM locations, and when the survey is completed, we put together an essay and distribute it through email.

Our first essay, Box Huckleberry and Chinquapin Clusters: Ancestral Native Plantations? (Mellin and Truitt, 2013a) reported that these two clusters are located adjacent to a known Native American archaeological site, and may actually be cultural botanical transformation artifacts.

Our second essay, Interesting Botanicals on a Historic Site in Delaware: Recognition, Significance, and Meaning. (Mellin and Truitt, 2013b) discusses Black Walnut, Chinese Chestnut, Norway Spruce, Red Mulberry, and Sawtooth Oak clusters located at a known mid-nineteenth century agricultural complex archaeological site.

In this essay, our third essay, Prickly Pear and American Chestnut Clusters Identified in the Lower Nanticoke River Basin we discovered that each of these two clusters is found at a known Native American archaeological site.

In each of the three (above) botanical surveys, we surveyed approximately one hundred acres of forestland and found that each of the species discussed is indeed an isolated cluster located at a known archaeological site. We think we see patterns developing. It would appear that each of these well preserved archaeological sites support a definable botanical cluster. Are each of these botanical clusters a cultural phenomenon?

It is one thing to document a Norway Spruce cluster, or a Chinese Chestnut cluster on a Historic site and reliably state that these individuals, and the clusters they form have been transformed in time and space, these are artifacts, and this is science. It is an entirely different thing to document a native species cluster, for example the Chinquapin cluster, or the Prickly Pear cluster and speculate that those clusters have been transformed into cultural artifacts—that would be speculation, there is no proof. Nevertheless, our ongoing effort to document a series of speculative ancestral Native American botanical clusters is forming a useful database.

GPS LOCATION AND DESCRIPTION OF PRICKLY PEAR ISLAND SURVEY		
NANTICOKE RIVER SOUTH SHORELINE BOTANICAL SURVEY		
GPS 18S UTM LOCATION		DESCRIPTION
0440180	4267800	Point A. West end of our Nanticoke River South Shoreline Botanical Survey.
0441670	4268560	Point B. East end of our Nanticoke River South Shoreline Botanical Survey.
PHILLIPS LANDING ARCHAEOLOGICAL SITE AMERICAN CHESTNUT BOTANICAL CLUSTER		
GPS 18S UTM LOCATION		DESCRIPTION
0441263	4268568	American Chestnut, multiple stems, 3m high, 3m wide, largest stem 4cm wide. On June 11, no catkins visible. Old dead mast lying on the ground measures 8m long, 14cm wide.
0441282	4268589	American Chestnut, multiple stems, 4m high, 3m wide, largest stem 3cm wide. On June 11, no catkins visible. Old dead mast lying on the ground measures 4m+ long, 20cm wide.
0441302	4268526	American Chestnut, multiple stems, 4m high, 2m wide, largest stem 3cm wide. On June 11, no catkins visible. Dead mast measures 2m+ high, 11cm wide.
0441315	4268540	American Chestnut, multiple stems, 6m high, 4m wide, largest stem 12cm wide. On June 11, no catkins visible. No visible dead mast.
0441379	4268481	American Chestnut, multiple stems, 6m high, 4m wide, largest stem 10cm wide. On June 11, no catkins visible. No visible dead mast.
0441404	4268459	American Chestnut, multiple stems, 3m high, 3m wide, largest stem 3cm wide. On June 11, no catkins visible. Old dead mast measures 5m+ high, 12cm wide.
PRICKLY PEAR ISLAND LANDMASS		
GPS 18S UTM LOCATION		DESCRIPTION
0440160	4268210	West end of Prickly Pear Island.
0440249	4268283	North end of Prickly Pear Island.
0440305	4268216	South end of Prickly Pear Island.
0440361	4268333	East end of Prickly Pear Island.

SHELL ACCUMULATION (MIDDEN) ON PRICKLY PEAR ISLAND		
GPS 18S UTM LOCATION		DESCRIPTION
0440189	4268210	West end of shell accumulation (midden)
0440210	4268246	North end of shell accumulation (midden)
0440225	4268237	South end of shell accumulation (midden)
0440241	4268247	East end of shell accumulation (midden)
PRICKLY PEAR CACTUS CLUSTER ON PRICKLY PEAR ISLAND		
GPS 18S UTM LOCATION		DESCRIPTION
0440240	4268262	Prickly Pear cactus bunch.
0440236	4268262	Prickly Pear cactus bunch.
0440234	4268251	Prickly Pear cactus bunch.
0440234	4268254	Prickly Pear cactus bunch.
0440234	4268257	Prickly Pear cactus bunch.
0440233	4268254	Prickly Pear cactus bunch.
0440224	4268257	Prickly Pear cactus bunch.
0440220	4268251	Prickly Pear cactus bunch.
0440218	4268249	Prickly Pear cactus bunch.

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A BOTANICAL SURVEY IN TRAP POND STATE PARK IDENTIFIES THREE CHINQUAPIN CLUSTERS.

Glen Mellin and Lenny Truitt
August 2013

About Trap Pond State Park

Located east of Laurel, Delaware, Trap Pond State Park consists of 2,109 acres of waters and lands managed by the Delaware Department of Natural Resources. It survives as a fragment of the once extensive wetland—upland associations, once typical of the upper, tidal Nanticoke River drainage patterns. These associations extend through the Raccoon Pond area and into non-tidal runoff and seepage patterns. Historically, some of these non-tidal runoffs and seepages have been ditched and straightened to increase agricultural production.

These two historic impoundment locations (Trap Pond and Raccoon Pond) are remnants of late 18th century industrial operations designed to harvest and process bald cypress and other valuable timber within the area. During the 1930s, the Federal government acquired the ponds, the surrounding forestland, and farmland. A Civilian Conservation Corp project initiated the first phase of "ecological restoration." These locations were acquired by the Delaware State Park system in 1951. Today, a network of hiking trails afford pedestrian access along miles of ecological transition zones between upland and wetland. A number of Native American archaeological sites have been discovered throughout the parks, examples of why this productive terrain offered subsistence benefits to ancestral Native American populations (see map).

Research Questions

We wanted to conduct a botanical survey in an area along the upper reaches of the Nanticoke River, the zone where the upper tidal region transitions into non-tidal runoff and seepage patterns. Trap Pond and Raccoon Pond offer great locations to conduct this type of botanical survey. Of course, the various dams and impoundments in the area, as well as downstream near Laurel, have eliminated the stream's natural tidal influences. However, the plant species we were looking for would predate the Colonial Period, and if found, could yield important interpretations about ancestral Native Americans' relationship to the environment, and about which botanical species they found beneficial. Specifically, we wanted to see if there was any evidence of chinquapin, or dwarf chestnut, a nut-producing tree with low branches, recognized as being a beneficial species to ancestral Native Americans.

Our Survey

Our botanical survey of the Trap Pond and Raccoon Pond areas made good use of these aforementioned hiking trails. In total, we walked along four and three quarter miles of trails, peering fifty feet or so off the trails, establishing a visual survey with frequent physical inspection approximately one hundred feet wide. The vast majority of our botanical survey produced expected results, finding and identifying a variety of standard and random specimens. As expected, bald cypress examples are confined to wetter zones. Big trees are absent, as they were likely processed through the pond's historic sawmills. Some large tulip poplars and oaks are likely to be over one hundred years old, but probably not as old as two hundred years.

Of particular interest, our botanical survey identified three clusters of chinquapin and three individual American chestnut trees. We speculate that some of the larger chinquapin examples we observed are likely examples of the oldest, continuous copse rootstock, found in the entire park.

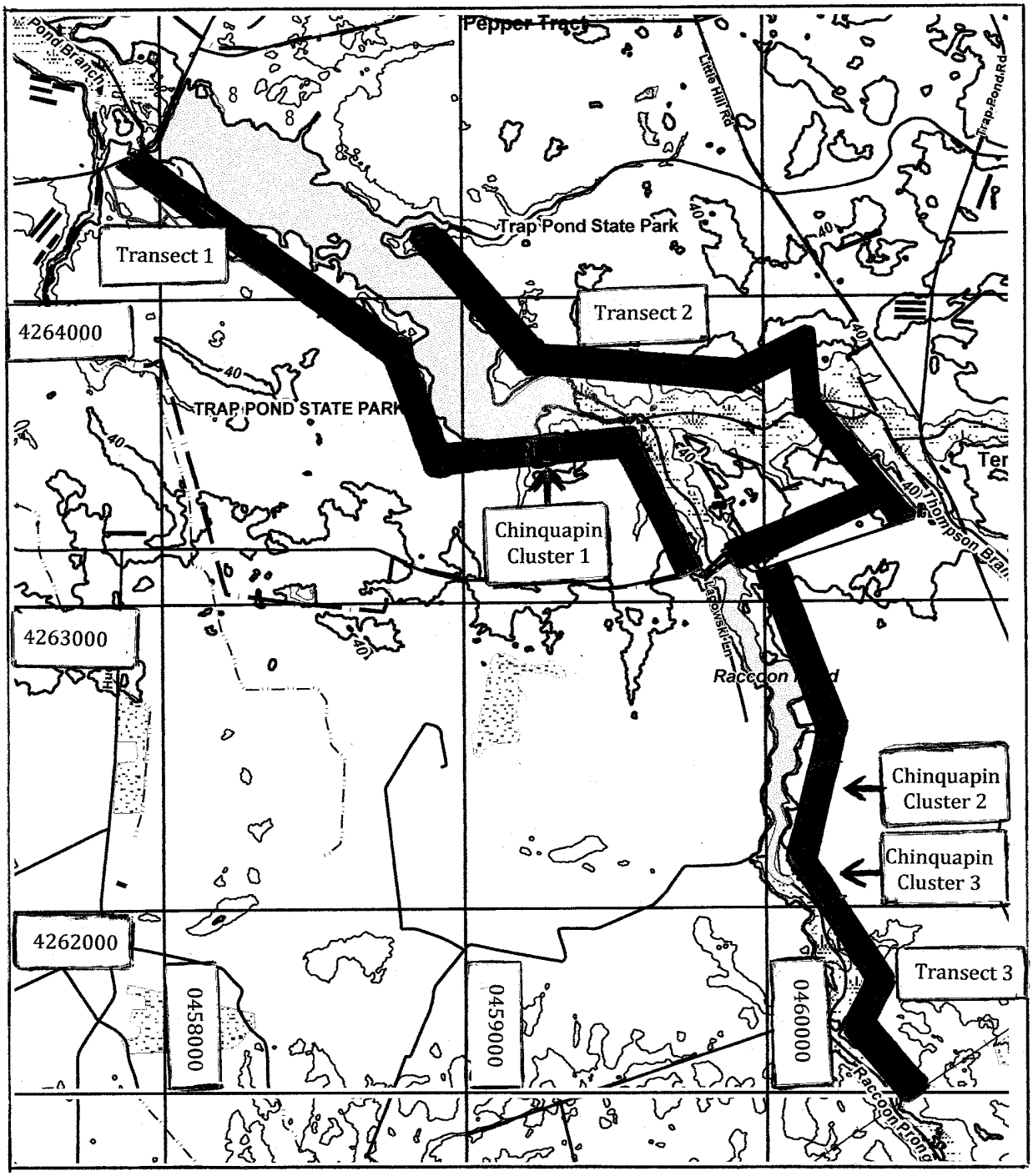
Transect 1

Transect 1 begins at Road 449, runs southward along the elevated ground on the west side of Trap Pond, and ends at the bridge on Road 72. We found the highest point along the entire trail exhibited a chinquapin cluster (chinquapin cluster 1) consisting of at least forty individuals. Although many of these chinquapin trees are well established and certainly sexually mature, not one had any nut burs. We noted this cluster is crowned-over by tulip poplar and other upper canopy species, leaving no direct sunlight to reach the chinquapins, or the forest floor.

TRAP POND / RACCOON POND BOTANICAL SURVEY, JULY 26, 2013.

TRANSECTS 1, 2, AND 3.

TRAP POND QUADRANGLE, DELAWARE.



Transect 2
Transect 2 begins at a macadam parking lot (E0458950, S4264200), runs generally in a southeast direction along the elevated ground on the east side of Trap Pond, then turns southwest and ends at the bridge on Road 72. We found no chinquapin trees, but we did indentify three dispersed examples of American chestnut. With only three examples found, it is tough to call these examples a cluster. However, it is likely a more thorough botanical survey would produce more examples.

Transect 3
Transect 3 begins at the bridge on Road 72, runs southward along the east side of Raccoon Pond and its main tributary and ends at the center line of a Delmarva Power transmission line (E0460540, S4261427). We found two sandy knolls along the trail, separated by an ephemeral stream, each exhibiting a chinquapin cluster (chinquapin clusters 2 and 3). Although many of these chinquapin trees are well established and certainly sexually mature, not one of them had any nut burs. We noted these two clusters are crowned-over by tulip poplar and other upper canopy species, leaving no direct sunlight to reach the chinquapins, or the forest floor.

It is possible these two chinquapin clusters, currently separated by an ephemeral stream valley, were at one time a single cluster. We documented evidence of individual specimen(s) and cluster decay. In cluster 3, we found two examples of large, dead specimens. Judging by the absence of bark and amount of wood decay, we estimated these examples had died more than twenty years ago. Both of these dead examples exhibited large skeletal stems (12cm in diameter) loosely set in above ground level basal galls measuring 40 centimeters in diameter. No new shoots are evident. These two ancient trees are indeed, dead.

Summary
We set out to conduct a botanical survey of the Trap Pond and Raccoon Pond areas in southwestern Sussex County, Delaware. We surveyed four and three quarter miles of accessible uplands adjacent to river, stream, and runoff-seepage associations. These associations are prime locations for ancestral Native American activities.

We discovered and documented three chinquapin clusters (one in Transect 1, and two in Transect 3) and a loose scattering of American chestnuts in Transect 2 (see attached data logs for GPS coordinates). We found no evidence to indicate any association that chinquapin and American chestnut are found growing together, in fact, the evidence we documented shows the opposite.

Interpretations
On July 26, 2013, we identified and documented three chinquapin clusters in Trap Pond State Park. These three clusters are found on elevated, well-drained soils next to adjacent streambeds, prime locations for ancestral Native American activities.

The individual chinquapin specimens in all three clusters suffer from the effects of canopy crowding, a naturally occurring condition where sunlight is blocked, or absorbed at the upper canopy level and does not get down to the lower levels where the chinquapins grow. We documented in all three chinquapin clusters a total absence of fruit, even though most of the trees are of robust size. In cluster 3, we documented two chinquapins have died-out in the latter portion of the twentieth century. These observations indicate the three chinquapin clusters at Trap Pond State Park are currently in a state of decline.

Because we have extensive experience actively managing our chinquapin cluster located in Middleford, Delaware, along the Nanticoke River (c.p. E4280300, S0450800), we are able to share the following generalized observations. When a mature chinquapin receives no direct sunlight, it produces no catkins and no fruit. When a mature chinquapin receives about two hours of direct sunlight, it produces about a dozen catkins and about a dozen burs. When a mature chinquapin receives five hours or more direct sunlight, it produces hundreds of catkins and about one hundred burs. Optimally, healthy chinquapins, chinquapins that produce a bountiful yield, require at least half a day's direct sunlight. That is to say, the chinquapin is characterized as a very beneficial, edible nut producing, understory tree that only thrives in fringe or semi-open environments.

This type of small tree is much more suited for growing on ravine faces or accelerated slopes typical of the Upper Coastal Plain or in the Piedmont where this species can take full advantage of angled sunlight. Chinquapin is not at all suited to live in the triple canopy forests of the Lower Coastal Plain, as we have in Sussex County, Delaware. These are the main reasons we strongly argue that chinquapin should be considered an "adventive species" in the Lower Coastal Plain. The species is simply too prone to being crowded-out of the triple canopy forests without human intervention.

Another point to assert here is that all chinquapin clusters documented thus far, by these authors, are situated in areas that experienced intensive timber harvesting in the late 18th and early 19th centuries. We have surveyed elsewhere, and have had no results--so, we are pretty sure our results are not due to sampling bias. We think, for these known chinquapin clusters to have survived into the twenty-first century, they have had to experience major disturbances in the dominant, triple canopy forest near the end of the Colonial era. And, before the Colonial era, these chinquapin clusters must have been maintained in fringe, or semi-open, grove, or garden environments through the efforts of ancestral Native Americans.

TRAP POND/RACCOON POND BOTANICAL SURVEY, TRANSECT 1, CLUSTER 1 (CHINQUAPIN), July 26, 2013

GPS UTM 18S DATUM		Specimen Dimensions	Conditions
0459250	4263484	West end of Cluster	July 26--more than forty individuals, overly crowded, no visible burs.
0459365	4263471	East end of Cluster	

TRAP POND/RACCOON POND BOTANICAL SURVEY, TRANSECT 2, INDIVIDUAL SPECIMENS (AMERICAN CHESTNUT), July 26, 2013

GPS UTM 18S DATUM		Specimen Dimensions	Conditions
0459128	4263914	4m high, 2m wide, 5cm basal diameter.	July 26--overly crowded, no visible burs.
0459123	4263732	4m high, 2m wide, 5cm basal diameter.	July 26--overly crowded, no visible burs.
0459950	4263740	5m high, 2m wide, 6cm basal diameter.	July 26--overly crowded, no visible burs.

TRAP POND/RACCOON POND BOTANICAL SURVEY, TRANSECT 3, CLUSTER 2 (CHINQUAPIN), July 26, 2013

GPS UTM 18S DATUM		Specimen Dimensions	Conditions
0460183	4262489	3m high, 3m wide, 6cm basal diameter.	July 26--overly crowded, no visible burs.
0460162	4262479	8m high, 5m wide, 32cm basal diameter.	July 26--overly crowded, no visible burs.
0460158	4262388	5m high, 5m wide, 12cm basal diameter.	July 26--overly crowded, no visible burs.
0460155	4262390	5m high, 3m wide, 8cm basal diameter.	July 26--overly crowded, no visible burs.
0460147	4262442	4m high, 6m wide, 6cm basal diameter.	July 26--overly crowded, no visible burs.
0460136	4262474	2m high, 1m wide, 2cm basal diameter.	July 26--overly crowded, no visible burs.
0460132	4262420	2m high, 2m wide, 2cm basal diameter.	July 26--overly crowded, no visible burs.
0460131	4262471	1m high, 1m wide, 1cm basal diameter.	July 26--overly crowded, no visible burs.
0460130	4262471	2m high, 1m wide, 2cm basal diameter.	July 26--overly crowded, no visible burs.
0460130	4262474	2m high, 1m wide, 2cm basal diameter.	July 26--overly crowded, no visible burs.
0460121	4262389	2m high, 1m wide, 2cm basal diameter.	July 26--overly crowded, no visible burs.
0460121	4262436	4m high, 3m wide, 4cm basal diameter.	July 26--overly crowded, no visible burs.
0460120	4262432	4m high, 4m wide, 5cm basal diameter.	July 26--overly crowded, no visible burs.
0460114	4262352	7m high, 6m wide, 12cm basal diameter.	July 26--overly crowded, no visible burs.

TRAP POND/RACCOON POND BOTANICAL SURVEY, TRANSECT 3, CLUSTER 3 (CHINQUAPIN), July 26, 2013

GPS UTM 18S DATUM		SPECIMEN DIMENSIONS	CONDITIONS
0460149	4262150	1m high, 1m wide, 1cm basal diameter.	July 26--overly crowded, no visible burs.
0460180	4262132	1m high, 1m wide, 1cm basal diameter.	July 26--overly crowded, no visible burs.
0460186	4262098	1m high, 1m wide, 1cm basal diameter.	July 26--overly crowded, no visible burs.
0460187	4262097	2m high, 1m wide, 1cm basal diameter.	July 26--overly crowded, no visible burs.
0460190	4262084	3m high, 1m wide, 2cm basal diameter.	July 26--overly crowded, no visible burs.
0460190	4262082	1m high, 1m wide, 1cm basal diameter.	July 26--overly crowded, no visible burs.
0460200	4262077	4m high, 3m wide, 6cm basal diameter.	July 26--overly crowded, no visible burs.
0460202	4262071	7m high, 5m wide, 20cm basal diameter.	July 26--overly crowded, no visible burs.
0460201	4262068	7m high, 5m wide, 30cm basal diameter.	July 26--overly crowded, no visible burs.
0460190	4262065	4m high, 3m wide, 6cm basal diameter.	July 26--overly crowded, no visible burs.
0460190	4262052	4m high, 3m wide, 6cm basal diameter.	July 26--overly crowded, no visible burs.
0460198	4262041	7m high, 5m wide, 30cm basal diameter.	July 26--overly crowded, no visible burs.
0460178	4262056	4m high, 4m wide, 6cm basal diameter.	July 26--overly crowded, no visible burs.
0460175	4262058	4m high, 4m wide, 6cm basal diameter.	July 26--overly crowded, no visible burs.
0460174	4262058	4m high, 4m wide, 6cm basal diameter.	July 26--overly crowded, no visible burs.
0460189	4262080	1m high, 1m wide, 1cm basal diameter.	July 26--overly crowded, no visible burs.
0460179	4262063	4m high, 2m wide, 4cm basal diameter.	July 26--overly crowded, no visible burs.
0460188	4262051	5m high, 4m wide, 20cm basal diameter.	July 26--overly crowded, no visible burs.
0460208	4262031	6m high, 2m wide, 20cm basal diameter.	July 26--overly crowded, no visible burs.
0460229	4262015	6m high, 3m wide, 20cm basal diameter.	July 26--overly crowded, no visible burs.

A BOTANICAL SURVEY OF KILLEN POND STATE PARK IN KENT COUNTY, DELAWARE.

Glen Mellin and Lenny Truitt
August 2013

ABOUT KILLEN POND STATE PARK

Located along the upper tidal region of the Murderkill River, four miles northeast of Harrington, Delaware, we find Killen Pond. The pond is a sixty-six acre water impoundment, or former millpond. The industrial mill complex got its start in the late eighteenth century. Today, the millpond, surrounding woods, grassy meadows, water amusement park, camping area, boat ramp, and sports fields provide a diverse mix of recreational and preservation opportunities. These lands are managed by the Delaware Department of Natural Resources.

We focused on the wooded, 2.6 mile-long "Pondside Nature Trail" including several wooded spur trails, which totaled 3.2 miles. These trails offered an excellent opportunity for a botanical survey. We wanted to survey these woods because they are associated with several known ancestral Native American activity areas. These woods lie in the upper tidal reaches of the Murderkill River, a Delaware Bay drainage, which flows through the town of Frederica, and ultimately to its outflow at Bowers Beach, Delaware.

RESEARCH QUESTIONS

Killen Pond State Park offers our first view of a moderately sized botanical survey in preserved, wooded, largely unplowed land along the upper Murderkill River. This botanical survey is also our first attempt to conduct a botanical survey within the Delaware Bay drainage basin. We had hoped newly gathered botanical data would be added to the database of our four previous botanical surveys in various regions of the Nanticoke River. So, we asked, what botanicals does this portion of the Murderkill River have to offer? And, how would this information relate to previously gathered botanical information from our Nanticoke River surveys?

Our main reason for doing these botanical surveys is to build a database of botanical species; especially clusters of species that may be remnant, Native American husbanded botanical species. We look for rare plants, adentive species, oddly spaced clusters of culturally beneficial species; plants of edible, medicinal, and ceremonial value to ancestral Native Americans.

Our previous finds appear to be in various degrees of association with known, ancestral archaeological sites. Within the larger framework, we are conducting these surveys, gathering up pieces of a puzzle, and at some point in the future, we anticipate detailing our finds, and thoughts in a comprehensive synthesis.

FIELD NARRATIVE

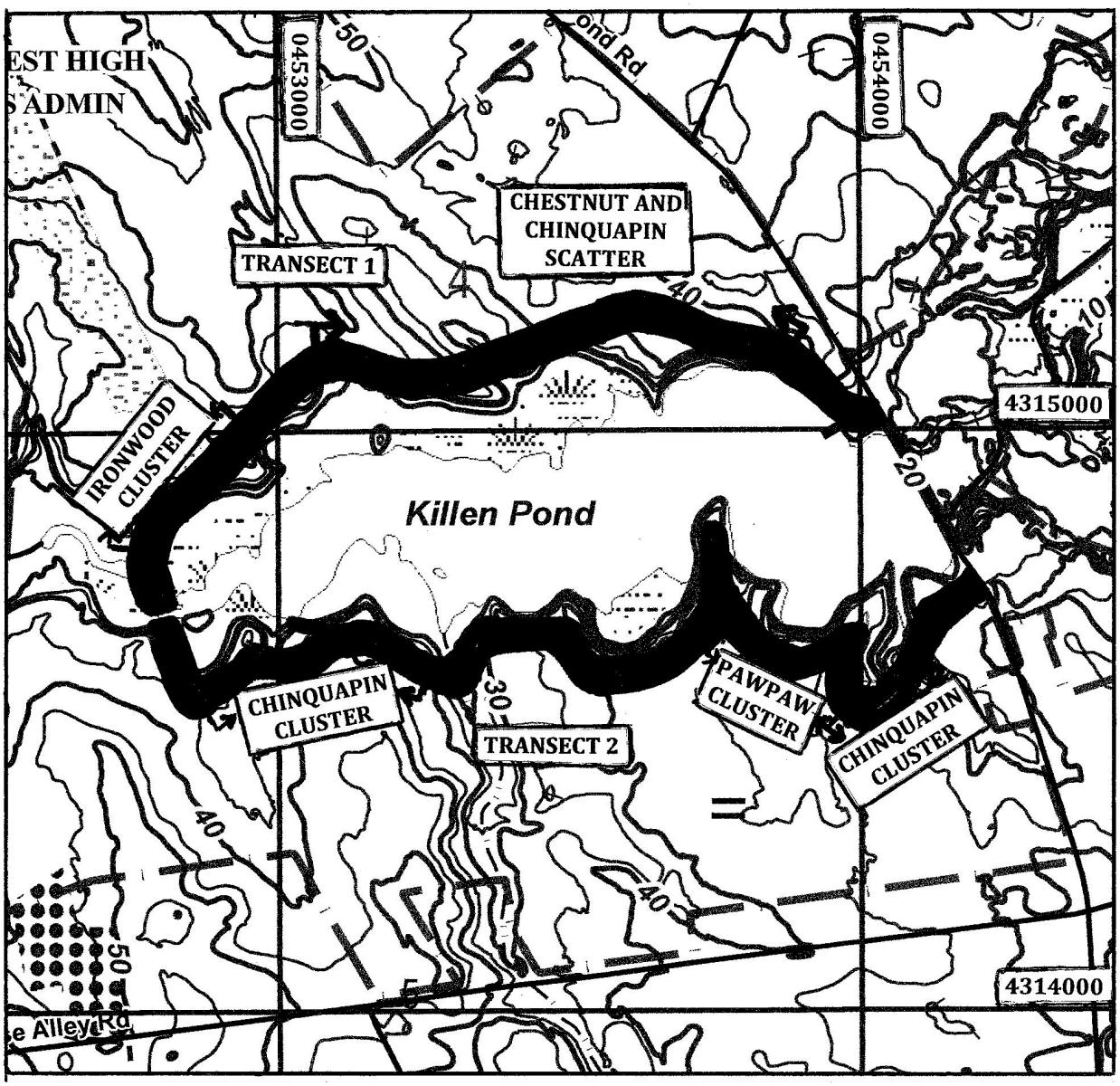
When we looked at the Killen Pond property, we thought we could make excellent use of the Pondside Nature Trail. We organized Transect one, starting at the dam, or Killen Pond Road (County Road 384), walking on the trail and its spurs westward along the north side of the pond to the steel arched bridge at the west end on the pond (see map). We organized Transect two starting at the above, steel arched bridge, walking on the trail and its spurs eastward along the south side of the pond back to the dam, or the starting point. The main trail and spurs combined totaled 3.2 miles.

During our survey, we discovered many interesting botanical species and clusters of species. In order to simplify the arrangement of the data found, we simply listed our finds in Transect 1 from east to west, and in Transect 2 from west to east. Through this simple arrangement of data, our readers can easily follow how the results of our walking survey actually detail patches of analogous plants, forming botanical specie clusters (see data log spreadsheets).

Along Transect 1 (the north side of Killen Pond) we identified scattered American Chestnut, scattered Chinquapin, and clustered Ironwood. Along Transect 2 (the south side of Killen Pond) we identified two clusters of Chinquapin, and one cluster of Pawpaw.

BOTANICAL SURVEY OF KILLEN POND, AUGUST 26, 2013

TRANSECTS 1 AND 2



SPECIES IDENTIFIED IN THIS SURVEY

AMERICAN CHESTNUT

American Chestnut, *Castanea dentate*, is a tall tree that produces large edible nuts. It is native to Delaware. As this tree reaches the upper canopy, adequate sunlight and deep, moist soils support abundant nut production. Once a common tree throughout the state, American Chestnut is rarely seen today. In 1904, an Asian bark fungus was introduced. The fungus attacks the species at sexual maturity, consequently; the species is

endangered for the following two reasons. 1), Examples of American Chestnut trees that tolerate the fungus and produce fertile fruit are exceedingly rare, and 2), the vast majority of living American Chestnut trees, which do not tolerate the fungus, are in a vicious cycle of sprout growth and die-back. These latter forms rarely achieve a height of thirty feet and rarely receive direct sunlight.

One of the six American Chestnuts identified in the Killen Pond botanical survey exhibited fruit. This tree is twelve meters high, with a five-meter canopy, and measures twenty-eight centimeters in diameter (chest high). It currently receives four or more hours of sunshine daily because it grows very near the edge of the macadam parking lot of the Killen Pond Nature Center. There are 100+ fresh seed burs on the ground, and 20+ seed burs still on the tree. This tree is located at: GPS UTM 18S DATUM E0453903 S4315162. We reported this tree to Dr. William McAvoy (Delaware Division of Fish and Wildlife, Species Conservation and Research Program), and he passed this information on to the folks at the Chestnut Foundation. Because this individual tree is located in a blight prone state, it qualifies as a tree of National importance.

CHINQUAPIN

Chinquapin, *Castanea pumila*, (also known as Dwarf Chestnut) is a short tree that produces edible nuts. It is considered native to Delaware. Over the past few years, we have observed peculiar behavior concerning this tree. This tree appears to require direct sunlight in order to produce fertile fruit. But, as a lower canopy tree, it can only thrive in areas where there are openings in the upper canopy or on slopes where periods of angled sunlight occur. Chinquapin suffers from the effects of the Asian bark fungus, however; when there is adequate sunlight combined with deep moist soils, the tree can be an abundant nut producer.

Of the thirty-one Chinquapins identified during the Killen Pond survey, only one exhibited nut burs. This particular Chinquapin was growing on an historic causeway at: GPS UTM 18S DATUM E0452799 S4314711, in partial sunlight, and exhibited ten nut burs.

IRONWOOD

Ironwood, (probably *Carpinus caroliniana* var. undetermined) is in the Hornbeam family, and sometimes called Blue Beech. This Genus and species is commonly found in all three counties of Delaware. This species produces tiny nuts commonly eaten by birds and squirrels. Deer will eat the leaf buds in winter. We could not find any documents where this species is reported to have edible, medicinal, or ceremonial value for humans.

We discovered this dense population of low growing Ironwood along the slopes in the northwestern pond area, and some sparsely distributed examples growing along the slopes in the southeastern pond area. Leaves were egg-shaped, double-toothed, and more often than not, long-pointed. We plucked and inspected many leaves from many trees. We observed parallel side veins, definitely not forked. Although our leaf examples presented an overall shape very similar to those of Eastern Hornbeam, or Hop-Hornbeam, *Ostrya virginiana*, the side vein, non-forking issue likely prescribes a variety of *Carpinus sp*.

Our tree reference books (for examples, Petrides 1998:318-20, and Taber 2012:84-7) offer various discussions. Some of the discussions are challenging. Nevertheless, according to McAvoy (2013: Pers. Comm., *Carpinus caroliniana*, line 316), the *Carpinus caroliniana* var. *caroliniana*, and the *Carpinus caroliniana* var. *virginiana* (Ironwoods) consist of "two geographical subspecies that hybridize or intergrade (making distinction difficult) along the Atlantic coast, from Long Island, New York, south through Delaware, to Virginia and North Carolina." One variety, or one sub-variety, of the *C. caroliniana* is alleged to exhibit parallel, non-forked side veins. So, whatever the professionals want to call this tree, it is fine with us. The Killen Pond population of *Carpinus* definitely exhibits leaves with parallel, non-forking, side veins. The Killen Pond population, or cluster, appears to be rare, and may actually be statistically significant. We do not know why it is found here in abundance.

PAWPAW

Pawpaw, *Asimina triloba*, generally appears as a large shrub or small tree native to Delaware. The Pawpaw can be found in all three counties, but nowhere is it common. Habitat is described as preferring protected, moist borders of streams and swamps. A mature patch of Pawpaw may reach forty feet high and individual trees can reach one foot in diameter. Under excellent growing conditions, or in a managed environment, the

Pawpaw may produce a large amount of three to five inch long, sausage balloon-shaped fruit. This fruit, variously named wild banana, custard apple, or papaw, ripens in September. According to Taber (2012:147), "The genus name *Asimina* is Latinized from the Indian name asmin for the tree." None of the Pawpaw we documented exhibited any fruit.

SPECIE CLUSTERS

Our Killen Pond botanical survey was conducted in an expedient manner. On our north transect (Transect 1) we walked and measured east to west. Conversely, on our south transect (Transect 2) we walked and measured west to east. The progression of recorded data easily supports the identification of the following specie clusters.

Transect One (North side of pond).

Scattered American Chestnut and Chinquapin trees from E0453903 to E0453063. In our opinion, these finds are fairly diffuse. At this time, none of them truly configure into a noticeable, or healthy cluster.

Ironwood cluster is very map-able from E0452911 to E0452783.

Transect Two (South side of pond).

Chinquapin cluster is very map-able from E0452888 to E0453263.

Pawpaw clustered, and clumpy occurrences are map-able from E0453785 to E0453980.

Chinquapin cluster is very map-able from E0454026 to E0454040.

INTERPRETATIONS

Our pedestrian botanical survey of Killen Pond State Park was very successful. Several important discoveries were made, and several important interpretations will be discussed.

1) This survey represents our first attempt at surveying a drainage (the Murderkill River), which flows into the Delaware Bay estuary.

2) The land surveyed (around Killen Pond, a water impoundment) previously existed as the upper tidal region of a major, Delaware, river basin. This upper tidal region is environmentally comparable to our botanical survey on the Nanticoke River above the town of Seaford, Delaware, and similarly, on Broad Creek above the town of Laurel, Delaware.

3) We identified and mapped examples of American Chestnut, Chinquapin, Ironwood, and Pawpaw. All of these plants were found growing on slopes, or just above slopes, where angled sunlight had more opportunity to penetrate the forest canopy. However, these environments are composed of a fairly mature triple canopy forest. As we looked around, we observed the upland environments sloping toward wetlands were noticeable brighter than other uplands further back from the slopes. Some of these areas, under stands of tulip poplars for example, we severely darkened, even at mid-day. Even though our survey was conducted on a sunny day, we observed only brief, chance situations where sunlight actually reached the forest floor. Only two examples, one American Chestnut, and one Chinquapin, which did support nut burs, had the opportunity to be bathed in mid-day sunshine due to enduring Historic forest canopy disruption.

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1998. Peterson Field Guide: Eastern Trees. Houghton Mifflin, NY.

KILLEN POND BOTANICAL SURVEY, TRANSECT 1.
DATA ARRANGED EAST TO WEST, AUGUST 26, 2013.

GPS UTM 18S DATUM		COMMON NAME	SCIENTIFIC NAME	MEASUREMENTS	FRUIT
E0453903	S4315162	American Chestnut	*Castanea dentata*	12m high, 5m high, 28cm dia.	
E0453881	S4315172	American Chestnut	*Castanea dentata*	2m high, 2m wide, 2cm dia.	
E0453880	S4315178	American Chestnut	*Castanea dentata*	14m high, 7m wide, 35cm dia.	20+ burs
E0453614	S4315110	American Chestnut	*Castanea dentata*	3m high, 3m wide, 5cm dia.	
E0453523	S4315162	American Chestnut	*Castanea dentata*	2m high, 2m wide, 2cm dia.	
E0453502	S4315164	Chinquapin	*Castanea pumila*	2m high, 3m wide, 2cm dia.	
E0453489	S4315178	Chinquapin	*Castanea pumila*	2m high, 2m wide, 2cm dia.	
E0453485	S4315204	American Chestnut	*Castanea dentata*	4m high, 3m wide, 7cm dia.	
E0453442	S4315121	Chinquapin	*Castanea pumila*	2m high, 1m wide, 2cm dia.	
E0453429	S4315109	Chinquapin	*Castanea pumila*	3m high, 2m wide, 4cm dia.	
E0453381	S4315078	Chinquapin	*Castanea pumila*	4m high, 3m wide, 6cm dia.	
E0453063	S4315066	Chinquapin	*Castanea pumila*	1m high, 1m wide, 1cm dia.	
E0452911	S4314896	Ironwood	*Carpinus sp.*	4m high, 6m wide, 20cm dia.	
E0452896	S4314904	Ironwood	*Carpinus sp.*	6m high, 6m wide, 18cm dia.	
E0452895	S4314902	Ironwood	*Carpinus sp.*	6m high, 6m wide, 30cm dia.	
E0452894	S4314909	Ironwood	*Carpinus sp.*	6m high, 6m wide, 14cm dia.	
E0452893	S4314910	Ironwood	*Carpinus sp.*	5m high, 5m wide, 12cm dia.	
E0452891	S4314909	Ironwood	*Carpinus sp.*	6m high, 6m wide, 12cm dia.	
E0452888	S4314907	Ironwood	*Carpinus sp.*	6m high, 6m wide, 15cm dia.	
E0452886	S4314899	Ironwood	*Carpinus sp.*	3m high, 2m wide, 5cm dia.	
E0452875	S4314891	Ironwood	*Carpinus sp.*	4m high, 4m wide, 9cm dia.	
E0452873	S4314888	Ironwood	*Carpinus sp.*	4m high, 4m wide, 9cm dia.	
E0452848	S4314859	Ironwood	*Carpinus sp.*	4m high, 4m wide, 10cm dia.	
E0452847	S4314857	Ironwood	*Carpinus sp.*	3m high, 2m wide, 7cm dia.	
E0452837	S4314851	Ironwood	*Carpinus sp.*	4m high, 4m wide, 10cm dia.	
E0452813	S4314688	Arched Steel Bridge			
E0452809	S4314845	Ironwood	*Carpinus sp.*	3m high, 3m wide, 6cm dia.	
E0452799	S4314711	Chinquapin	*Castanea pumila*	3m high, 2m wide, 4cm dia.	10+ burs
E0452792	S4314824	Ironwood	*Carpinus sp.*	3m high, 3m wide, 6cm dia.	
E0452783	S4314782	Ironwood	*Carpinus sp.*	4m high, 4m wide, 8cm dia.	

KILLEN POND BOTANICAL SURVEY, TRANSECT 2.
DATA ARRANGED WEST TO EAST, AUGUST 26, 2013.

GPS UTM 18S	DATUM	COMMON NAME	SCIENTIFIC NAME	MEASUREMENTS	FRUIT
E0432967	S4314639	Ironwood	*Carpinus sp.*	2m high, 1m wide, 2cm dia.	
E0452826	S4314657	Ironwood	*Carpinus sp.*	2m high, 2m wide, 3cm dia.	
E0452841	S4314680	Ironwood	*Carpinus sp.*	4m high, 3m wide, 6cm dia.	
E0452876	S4314586	Ironwood	*Carpinus sp.*	3m high, 2m wide, 4cm dia.	
E0452887	S4314593	Ironwood	*Carpinus sp.*	4m high, 3m wide, 5cm dia.	
E0452888	S4314678	Chinquapin	*Castanea pumila*	2m high, 2m wide, 4cm dia.	
E0452895	S4314603	Ironwood	*Carpinus sp.*	3m high, 2m wide, 3cm dia.	
E0452938	S4314664	Chinquapin	*Castanea pumila*	2m high, 2m wide, 4cm dia.	
E0452939	S4314663	Chinquapin	*Castanea pumila*	2m high, 2m wide, 4cm dia.	
E0452944	S4314665	Chinquapin	*Castanea pumila*	1m high, 1m wide, 1cm dia.	
E0452945	S4314667	Chinquapin	*Castanea pumila*	2m high, 2m wide, 2cm dia.	
E0452947	S4314667	Chinquapin	*Castanea pumila*	3m high, 3m wide, 5cm dia.	
E0452953	S4314669	Chinquapin	*Castanea pumila*	2m high, 2m wide, 2cm dia.	
E0452954	S4314669	Chinquapin	*Castanea pumila*	2m high, 2m wide, 2cm dia.	
E0452955	S4314669	Chinquapin	*Castanea pumila*	2m high, 2m wide, 2cm dia.	
E0452971	S4314660	Chinquapin	*Castanea pumila*	4m high, 3m wide, 5cm dia.	
E0452974	S4314651	Chinquapin	*Castanea pumila*	2m high, 2m wide, 3cm dia.	
E0452979	S4314648	Chinquapin	*Castanea pumila*	1m high, 1m wide, 1cm dia.	
E0453022	S4314644	Ironwood	*Carpinus sp.*	2m high, 1m wide, 2cm dia.	
E0453027	S4314636	Chinquapin	*Castanea pumila*	2m high, 2m wide, 2cm dia.	
E0453029	S4314640	Ironwood	*Carpinus sp.*	5m high, 3m wide, 6cm dia.	
E0453030	S4314640	Chinquapin	*Castanea pumila*	1m high, 1m wide, 1cm dia.	
E0453033	S4314640	Chinquapin	*Castanea pumila*	2m high, 2m wide, 3cm dia.	
E0453071	S4314674	Chinquapin	*Castanea pumila*	2m high, 2m wide, 3cm dia.	
E0453086	S4314677	Chinquapin	*Castanea pumila*	2m high, 2m wide, 3cm dia.	
E0453263	S4314616	Chinquapin	*Castanea pumila*	1m high, 1m wide, 1cm dia.	
E0453785	S4314696	Pawpaw	*Asimina triloba*	3m high, 2m wide, 5cm dia.	
E0453785	S4314696	Pawpaw	*Asimina triloba*	1m high, 1m wide, 1cm dia.	
E0453785	S4314701	Pawpaw	*Asimina triloba*	4m high, 3m wide, 6cm dia.	
E0453785	S4314704	Pawpaw	*Asimina triloba*	4m high, 3m wide, 8cm dia.	
E0453786	S4314696	Pawpaw	*Asimina triloba*	3m high, 2m wide, 6cm dia.	
E0453786	S4314696	Pawpaw	*Asimina triloba*	2m high, 1m wide, 4cm dia.	
E0453786	S4314696	Pawpaw	*Asimina triloba*	2m high, 1m wide, 3cm dia.	
E0453787	S4314688	Pawpaw	*Asimina triloba*	1m high, 1m wide, 1cm dia.	
E0453787	S4314696	Pawpaw	*Asimina triloba*	4m high, 3m wide, 6cm dia.	
E0453787	S4314696	Pawpaw	*Asimina triloba*	4m high, 3m wide, 8cm dia.	
E0453787	S4314697	Pawpaw	*Asimina triloba*	1m high, 1m wide, 2cm dia.	
E0453787	S4314697	Pawpaw	*Asimina triloba*	3m high, 2m wide, 6cm dia.	
E0453788	S4314696	Pawpaw	*Asimina triloba*	2m high, 2m wide, 2cm dia.	
E0453788	S4314697	Pawpaw	*Asimina triloba*	2m high, 2m wide, 3cm dia.	
E0453789	S4314689	Pawpaw	*Asimina triloba*	5m high, 3m wide, 8cm dia.	
E0453878	S4314652	Pawpaw	*Asimina triloba*	4m high, 3m wide, 5cm dia.	
E0453881	S4314647	Pawpaw	*Asimina triloba*	5m high, 4m wide, 16cm dia.	
E0453889	S4314638	Pawpaw	*Asimina triloba*	5m high, 3m wide, 12cm dia.	

E0453889	S4314639	Pawpaw	*Asimina triloba*	4m high, 2m wide, 8cm dia.
E0453890	S4314639	Pawpaw	*Asimina triloba*	1m high, 1m wide, 1cm dia.
E0453952	S4314652	Pawpaw	*Asimina triloba*	2m high, 1m wide, 5cm dia.
E0453960	S4314646	Pawpaw	*Asimina triloba*	1m high, 1m wide, 1cm dia.
E0453978	S4314678	Pawpaw	*Asimina triloba*	3m high, 2m wide, 7cm dia.
E0453980	S4314678	Pawpaw	*Asimina triloba*	2m high, 1m wide, 3cm dia.
E0454026	S4314675	Chinquapin	*Castanea pumila*	1m high, 2m wide, 3cm dia.
E0454031	S4314725	Chinquapin	*Castanea pumila*	4m high, 4m wide, 8cm dia.
E0454032	S4314724	Chinquapin	*Castanea pumila*	1m high, 1m wide, 1cm dia.
E0454037	S4314698	Chinquapin	*Castanea pumila*	2m high, 2m wide, 3cm dia.
E0454039	S4314706	Chinquapin	*Castanea pumila*	2m high, 2m wide, 2cm dia.
E0454040	S4314724	Chinquapin	*Castanea pumila*	1m high, 3m wide, 2cm dia.
E0454043	S4314721	Pawpaw	*Asimina triloba*	2m high, 1m wide, 2cm dia.
E0454098	S4314698	Ironwood	*Carpinus sp.*	3m high, 2m wide, 4cm dia.
E0454102	S4314693	Ironwood	*Carpinus sp.*	3m high, 3m wide, 6cm dia.
E0454106	S4314676	Ironwood	*Carpinus sp.*	2m high, 1m wide, 3cm dia.
E0454106	S4314680	Ironwood	*Carpinus sp.*	3m high, 2m wide, 6cm dia.

A BOTANICAL SURVEY OF THE ROBERT GRAHAM PRESERVE AND THE BARNES WOODS PRESERVE IN SUSSEX COUNTY, DELAWARE.

Glen Mellin and Lenny Truitt
August 2013

About These Preserves

Located along the banks of the Nanticoke River southwest of Seaford, Delaware, these two preserves were placed under the management of the Delaware Department of Natural Resources in the late twentieth century. These two preserves are joined with a number of nearby and/or contiguous lands, north and south of the Nanticoke River. Together, these preserved parcels of land total 4,415 acres, and are collectively known as the Nanticoke Wildlife Area.

The Robert Graham Preserve is accessible east of Red House Road (no known road number, west of County Road 487A). The Barnes Woods Preserve is accessible south of Woodland Road (County Road 536) (see attached Sharptown Quadrangle Map).

Today, the Nanticoke River at these locations supports a deep river channel (10 to 12 feet), and continues to have a significant tidal range (2 to 3 feet). Slow water areas of the meandering river currently support muddy shallows, extensive tidal mud flats, and fields of lily pads and other tidal related plants.

The Robert Graham Preserve, located on the south side of the Nanticoke River, and the Barnes Woods Preserve, located on the north side of the Nanticoke River, offered numerous hiking trails adjacent to wetlands of the Nanticoke River where additional botanical survey could be conducted. Furthermore, the Graham Preserve is known to contain one Native American archaeological location and the Barnes Preserve is known to contain four Native American archaeological locations.

RESEARCH QUESTIONS

We set out to conduct a botanical survey of the Graham and the Barnes Preserves. We had hoped to gather more data from this portion of the Nanticoke River, to add to our previous survey of the Prickly Pear Island and Philips Landing botanical survey (Mellin and Truitt 2013). Our previous survey identified Prickly Pear cactus at the known Native American archaeological site on Prickly Pear Island, but, we found no Chinquapin trees growing anywhere in that surveyed area, especially along the southern shoreline of the Nanticoke River where we had suspected they might be found.

Our revised research questions asked: 1) if there might be additional cactus patches growing along the river and, 2) are there really no Chinquapins to be found along this portion of the overall Nanticoke River basin?

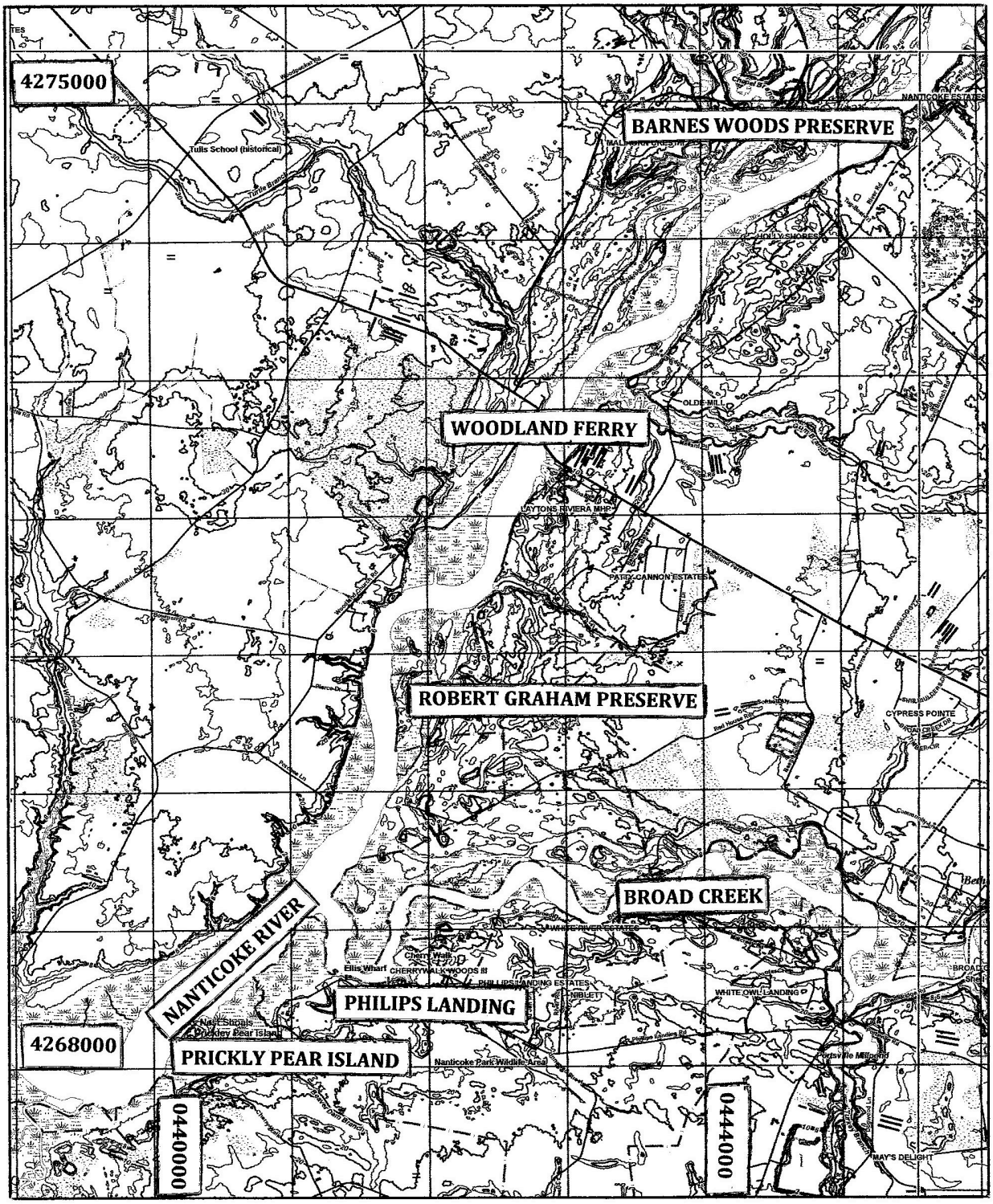
FIELD NARRATIVES

THE ROBERT GRAHAM PRESERVE

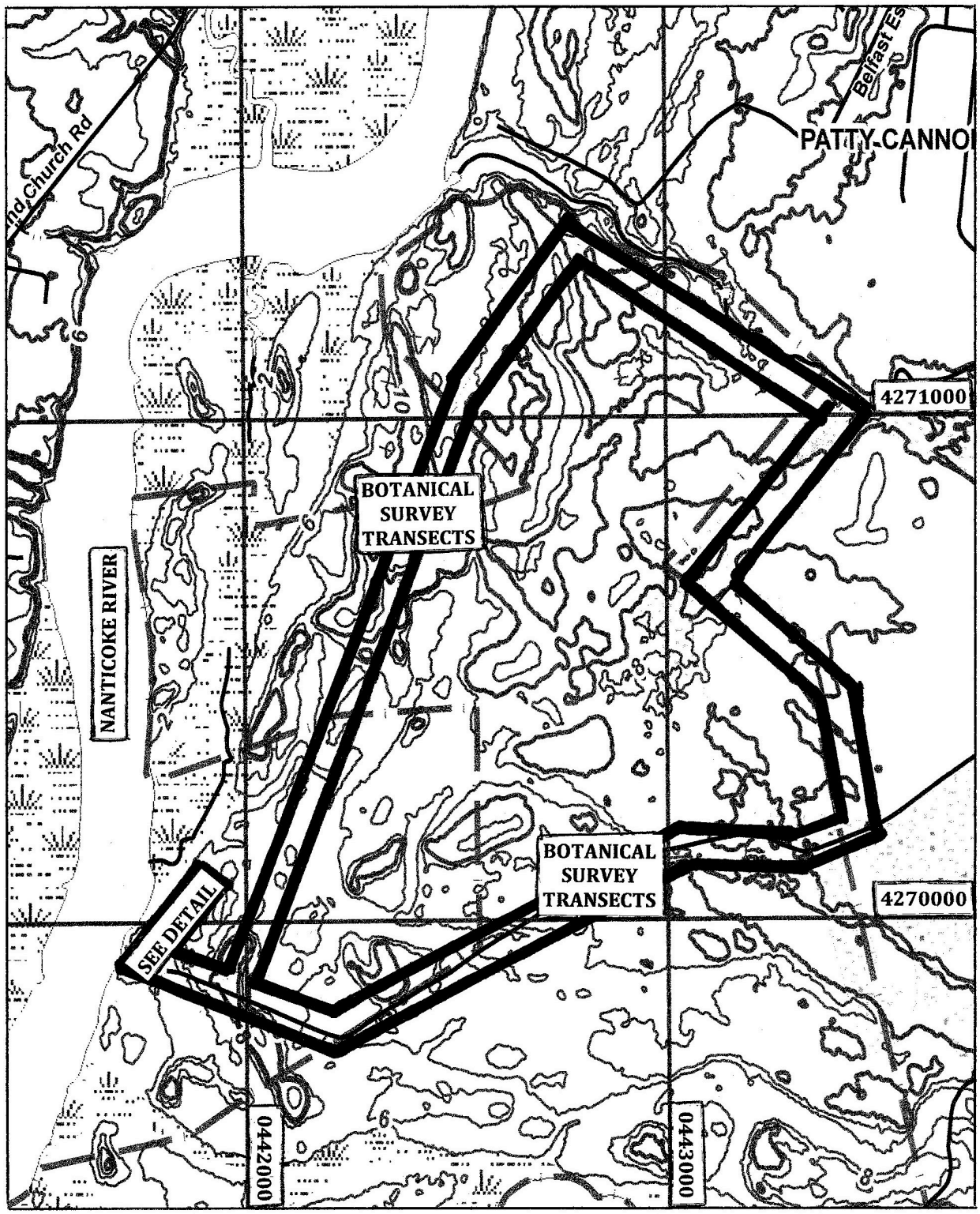
We drove west on Red House Road and parked in a small grass parking lot at the southeastern corner of the Graham Preserve at GPS E0443229 S4270169 (see Graham Preserve map). We walked west along the gravel road, identifying various vegetation species about 100 feet north and 100 feet south of the road. Since this forest has a relatively open understory, we were able to establish a 200-foot wide botanical survey. We continued down this transect and located one living American Chestnut at GPS E0442654 S4269977.

We crossed over a slight, wooded sand dune within 400 feet of the Nanticoke River. On the riverside of the dune we encountered the southern limit of a Native American oyster shell scatter. We identified various pieces of fire-cracked rock and one medium sized, multifaceted percussor. This immediate location supported a cluster of Prickly Pear cactus. We recorded the GPS coordinates of seven cacti bunches (see attached Graham Preserve data log). We also discovered some small, old brick fragments, and one shard of white slip-glazed redware.

PORTION OF SHARPTOWN QUADRANGLE



ROBERT GRAHAM PRESERVE
WITH TRANSECTS SURVEYED



Closer to the shoreline, and the core area of the previously recorded archaeological site; we discovered two distinct clusters of Yucca (cluster 1 exhibits 24 individuals, and cluster 2 exhibits 14 individuals), a cluster of mature Catalpa trees, and perhaps a dozen mature Black Walnut trees. All of these plants are growing within the Native American oyster shell scatter. Along the shoreline area of site, we identified artifact oyster, clam, and fresh water mussel shells. (see attached Graham Preserve detail map). There is some artifact evidence of Historic use, beyond the now razed early twentieth century bungalow known locally as the Red House. The edge of the Nanticoke River is at GPS E0441698 S4269936, and other pertinent GPS readings are found in the attached Graham Preserve data log.

From Yucca Cluster 1, we hiked northward along the shoreline trail (identifying four additional living American Chestnut trees) to the confluence of an unnamed stream and the Nanticoke River at GPS E0442794 S4271383. From that location we walked eastward along the unnamed stream (identifying one additional living American Chestnut tree) to a point where the hiking trail emerges in an agricultural field at GPS E0443413 S4270937. From that point, we walked along the edge of the agricultural field back to our parked car. Total distance of this botanical survey was 3.0 miles.

During this botanical survey, we found the location of the previously identified Native American archaeological site. This site location exhibits a large, surface shell scatter. Within that shell scatter we identified a Prickly Pear cactus cluster, two Yucca clusters, a Catalpa cluster, and numerous Black Walnuts. Additionally, we identified 6 examples of American Chestnuts growing within the surveyed transects. We did not, however, find any examples of Chinquapin.

THE BARNES WOODS PRESERVE

We parked along Woodland Road and entered the preserve via a well-maintained hiking trail heading in a southerly direction (see attached Barnes Woods Preserve map). We observed and identifying various botanical species about 100 feet east and 100 feet west of the trail. Since this forest has a relatively open understory, we were able to establish a 200-foot wide botanical survey.

We hiked to the south end of the preserve, and then walked along the southern shoreline, an unnamed tributary to Bulter Mill Branch. Then, we turned northward and walked along a winding trail adjacent to Butler Mill Branch back to the place of beginning. These trails encompassed a total distance of 0.7 miles. We found no interesting botanicals pertinent to the research questions addressed in these surveys.

SPECIES DISCUSSED IN THIS SURVEY

American Chestnut, *Castanea dentate*, a tall tree, native to Delaware, produces large edible nuts.

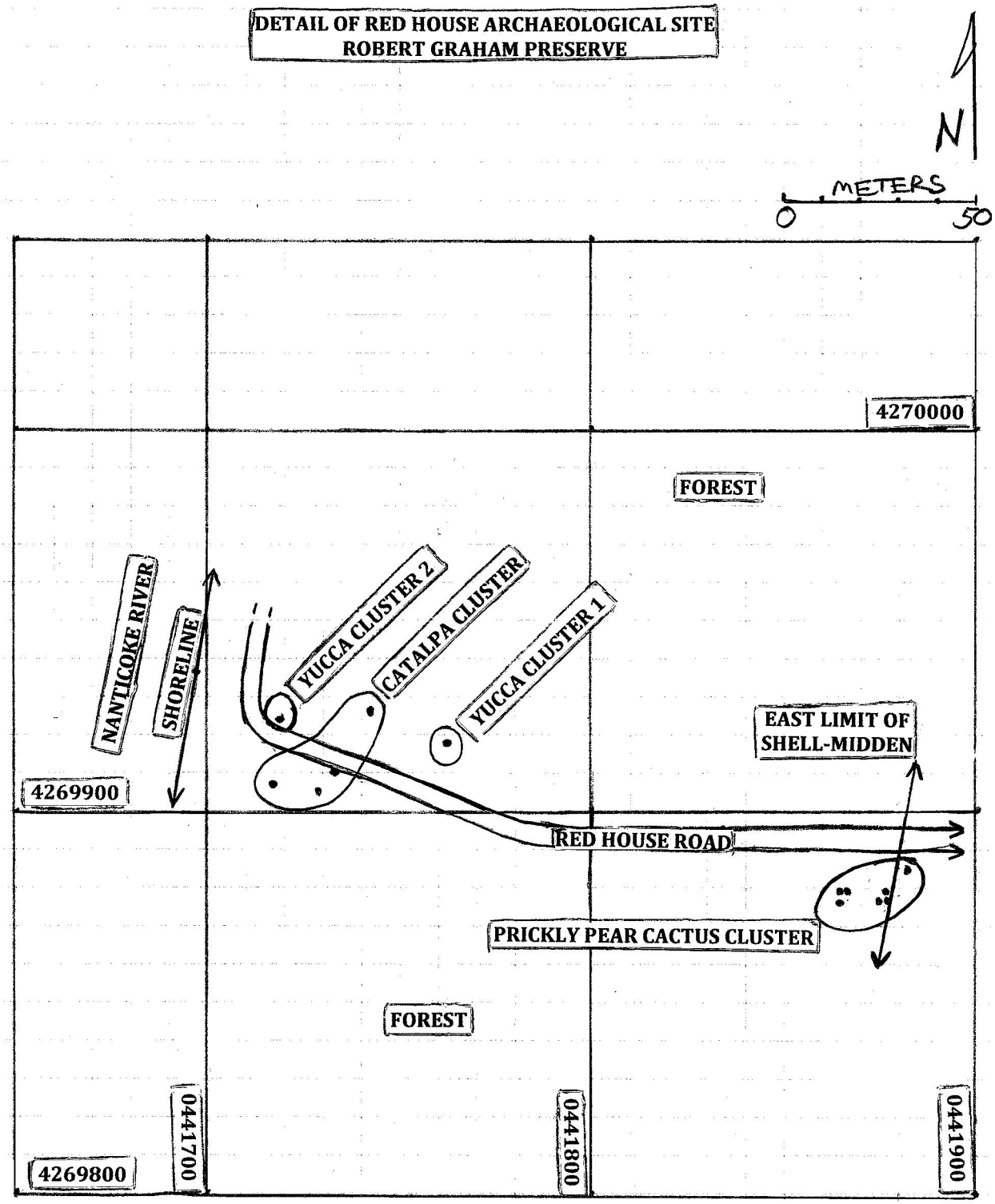
Black Walnut, *Juglans nigra*, a tall tree, native to Delaware, produces large edible nuts.

Catalpa, or Indian Cigar Tree is a medium sized tree with 6-12 inch heart-shaped leaves also bearing 10-12 inch long cigar shaped seed capsules. McAvoy (pers. comm., email, 06/24/2013) has a single "adventive" listing for Catalpa in Delaware and that is the *Catalpa bignonioides*, or Southern Catalpa, thought to be indigenous to MS, AL, GA, and FL. However, the Northern Catalpa, *Catalpa speciosa* is thought to be indigenous from IN to AK. Whichever species (or both) species we have, it remains an intriguing dilemma as to how and when it arrived here on the Delmarva Peninsula. The bark and seedpods of Catalpa contain a sedative or cardioactive chemical compounds, which likely have curative and/or ceremonial uses.

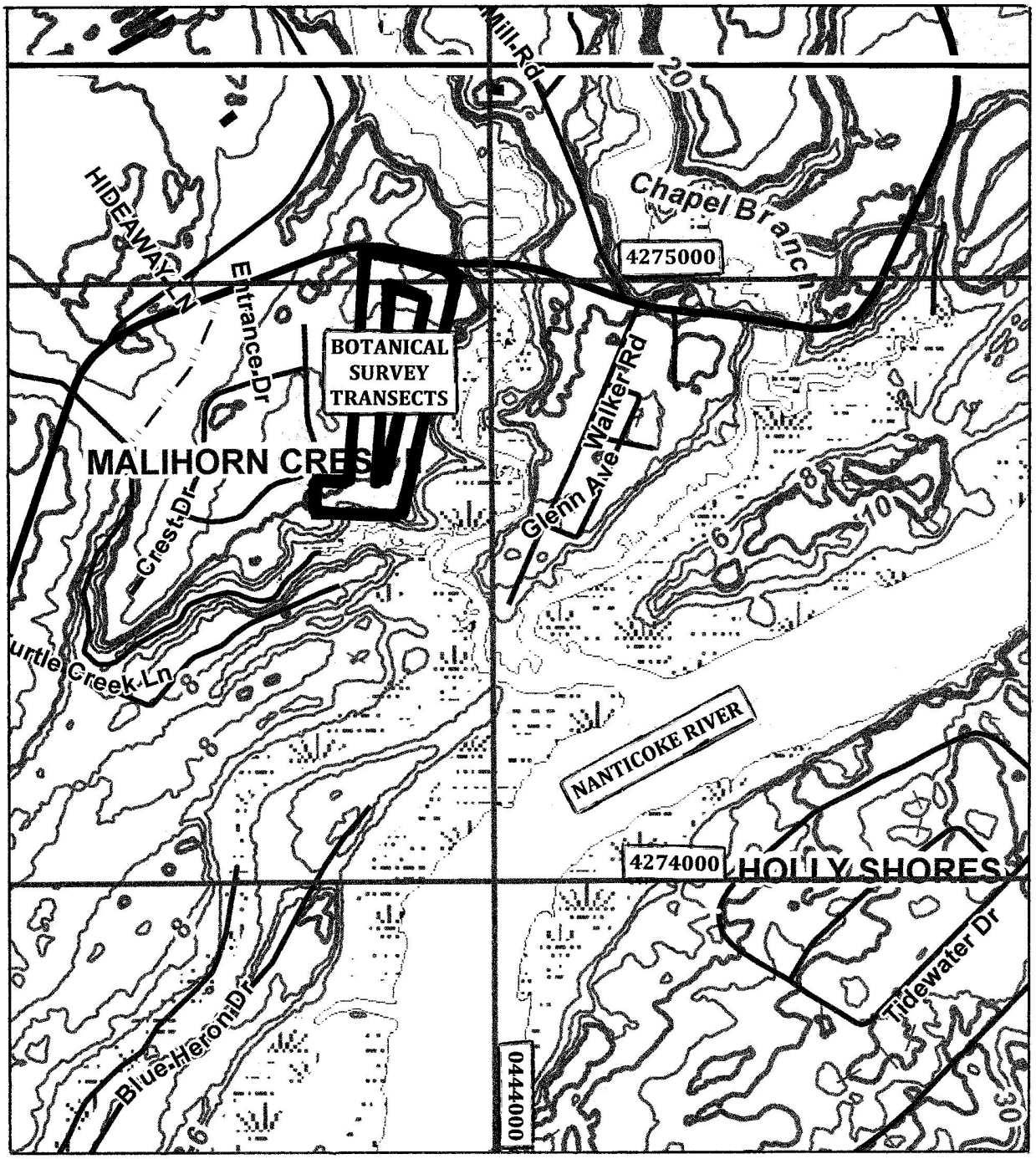
Prickly Pear Cactus, *Opuntia humifusa*, is the only cactus native to Delaware. All aboveground parts of the plant are edible, and the sap may be used as both topical, and internal medicines. Prickly Pear cactus has been found growing in Native American archaeological shell-middens (McAvoy and Harrison 2012, and Mellin and Truitt 2013).

Yucca, or Adam's Needles, or Dogbane, *Yucca filamentosa*, forms a low rosette of lance-shaped leaves native to Delaware. Produces a flower stalk, which may reach up to 9 feet high. Native Americans processed the leaves to make cordage and salves for topical treatments.

DETAIL OF RED HOUSE ARCHAEOLOGICAL SITE
ROBERT GRAHAM PRESERVE



BARNES WOODS PRESERVE
WITH TRANSECTS SURVEYED



RESULTS OF ROBERT GRAHAM PRESERVE BOTANICAL SURVEY, August 17, 2013.

GPS 18S UTM DATUM		DESCRIPTION
		PRICKLY PEAR CACTUS CLUSTER
E0441864	S4269877	Bunch of Prickly Pear Cactus Growing in a Native American Shell Scatter (Midden?).
E0441865	S4269879	Bunch of Prickly Pear Cactus Growing in a Native American Shell Scatter (Midden?).
E0441866	S4269879	Bunch of Prickly Pear Cactus Growing in a Native American Shell Scatter (Midden?).
E0441875	S4269878	Bunch of Prickly Pear Cactus Growing in a Native American Shell Scatter (Midden?).
E0441876	S4269878	Bunch of Prickly Pear Cactus Growing in a Native American Shell Scatter (Midden?).
E0441877	S4269879	Bunch of Prickly Pear Cactus Growing in a Native American Shell Scatter (Midden?).
E0441882	S4269885	Bunch of Prickly Pear Cactus Growing in a Native American Shell Scatter (Midden?).
		YUCCA CLUSTER 1
E0441761	S4269918	Center of Yucca Cluster 1. 24 Individual Plants Growing in a Native American Shell Scatter (Midden?).
		YUCCA CLUSTER 2
E0441719	S4269924	Center of Yucca Cluster 2. 14 Individual Plants Growing in a Native American Shell Scatter (Midden?).
		AMERICAN CHESTNUT, INDIVIDUAL SPECIMENS
E0442654	S4269977	5m high, 3m wide, 5cm basal diameter.
E0442246	S4270939	5m high, 3m wide, 7cm basal diameter.
E0442227	S4270936	7m high, 4m wide, 14cm basal diameter.
E0442634	S4271284	4m high, 3m wide, 8cm basal diameter.
E0442627	S4271284	5m high, 3m wide, 10cm basal diameter.
E0442809	S4271356	4m high, 2m wide, 6cm basal diameter.
		CATALPA CLUSTER, INDIVIDUAL SPECIMENS
E0441742	S4269926	Mature Catalpa Tree Growing in a Native American Shell Scatter (Midden?).
E0441716	S4269908	Mature Catalpa Tree Growing in a Native American Shell Scatter (Midden?).
E0441732	S4269910	Mature Catalpa Tree Growing in a Native American Shell Scatter (Midden?).
E0441729	S4269904	Mature Catalpa Tree Growing in a Native American Shell Scatter (Midden?).
		EAST END OF OYSTER SHELL SCATTER (SURFACE, OBSERVED)
E0441875	S4269878	Eastern Observed Limit of Surface Oyster Shells (Midden?).
		WEST END OF OYSTER SHELL SCATTER AT NANTICOKE RIVER (SURFACE, OBSERVED)
E0441698	S4269936	Western Observed Limit of Surface Oyster Shells (Midden?) at Eastern Shoreline of Nanticoke River.

RESULTS OF BARNES WOODS PRESERVE BOTANICAL SURVEY, August 17, 2013.

No Significant Botanicals Observed.

INTERPRETATIONS

We selected the Graham and Barnes Preserves for further botanical survey in this portion of the tidal Nanticoke River basin. We were successful in gathering more information about Prickly Pear cactus growing on Native American shell-middens. In addition, we again, found no evidence of Chinquapins in this portion of the river basin.

To date, we have been unable to identify Chinquapins in the portion of the river where lily pads are found in abundance. We assume there is no natural, biological reason for this, but there seems to be a suggestion of selective botanical clustering on the part of Native American choices, selecting land management allocation according to environmental characteristics. We are finding abundant Chinquapin clusters in the upper Nanticoke River basin, but we have found no Chinquapin clusters in the mid-river basin.

We were quite surprised to find this incidence of a Prickly Pear cactus cluster growing on the Native American shell-midden at the Red House Site. It is like viewing a carbon copy of what we found on Prickly Pear Island, only better, because here, we found two separate clusters of Yucca, a plant vital to Native Americans for making cordage.

The cluster of Catalpa and perhaps a dozen Black Walnut trees is an enigma and requires further study. We simply do not know if the clustering of these beneficial plants is due to Native American or Historical origin. However, we feel certain that a cultural explanation is the correct explanation.

We do not know if the six, dispersed American Chestnut trees found in the Graham Preserve are associated with Native American activity locations. We seem to find individual and small clusters of living chestnut trees practically everywhere there is unplowed, well-drained woodland near tidal water. However, we have noted we do not find American Chestnut and Chinquapin growing together.

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SAMPLING ARCHAEOBOTANICALS:
PAST, PRESENT, AND FUTURE.

GLEN MELLIN and LENNY TRUITT

AUGUST, 2013

ABSTRACT

The recovery, analysis, and explanation of archaeobotanical remains provide a necessary, botanical description of changing Native American behavior within a changing environmental landscape. We have made great discoveries. After a thirty-year history of implementing archaeobotanical recovery programs, in Delaware, this essay seeks to ask, where are we now? Section I offers two related topics, first, we review recovery efforts listed in twenty-eight DelDOT sponsored archaeological reports, and second, we review recent advances in identifying living plants and living plant clusters that likely qualify as Native American artifact botanicals. Section II is a current list of adventive plants in Delaware compiled by William McAvoy, state botanist, Delaware Division of Fish and Wildlife, Species Conservation and Research Program. Section III is a list of references cited in this essay.

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INTRODUCTION

This essay is a broad inquiry into the importance of collecting, processing, and analyzing archaeobotanical species. Why do we collect soil flotation samples? What are we looking for? Do the results justify the time and money spent? Are we doing too much, not enough, or just about the right amount? Are the results from each collection program comparable, if not—why not? What plants might we find growing today that owe their existence or arrangement to Native American horticultural efforts? Finally, we provide an assessment of what we might be missing.

SECTION I

Section I presents our selection and arrangement of various attempts to gather meaningful archaeobotanical specimens from twenty-eight DelDOT sponsored archaeological projects. Although we have strived to present a fair and meaningful representation of the results, we strongly encourage readers to review the original reports to view and assess the original findings for themselves.

Of these twenty-eight reports, Delaware Park Site is the oldest, published in 1981, and Gray Farm Site is the newest, published (as revised) in 2013. Because the authors collected many of the flotation samples from Delaware Park and from Gray Farm, as well as on many of the other projects through the ensuing years, we speak with some authority on the soil flotation collection process. However, we are not authorities on the physical identification of either archaeobotanical or ethnobotanical specimens.

A wide range of data collection has been accomplished. We have collected and processed soil flotation samples from "cultural features," "natural features," and "living floors", and we have collected off-site samples for controlled comparison. We have used 3" and 4" bucket augers, and 3" vibra-core tube samples to collect data from wet and sub-aqueous environments. From these various sampling techniques, we have found and identified a variety of wood carbon, nut hulls, seeds, plant fibers, pollen, spores, starch grains, and phytoliths. All of these found items, viewed in context, help to describe changing Native American behavior within a changing environmental landscape.

As scientists, we view every newly identified plant species as an important addition to the overall database. But, when it comes down to comparing species found from one site to another, we have a problem. The process of comparative study usually requires a comparative database generated through sets of comparative samples. The problem is not with the size or locations of the sites themselves, or with the overall integrity of the samples collected. The problem is in the lack of controlled sample size, and in some cases, no samples at all.

At the Delaware Park Site, flotation samples were counted in full, five-gallon bucket loads. The wealth of archaeobotanical specimens identified was, consequently, a reflection of the massive soil volumes sampled. Essentially, we were looking to identify as many plant species as possible. At the time, one of our objectives was to create a database where results of future excavations could be compared.

We will see in some of the following twenty-eight DelDOT sponsored archaeological projects, some researchers decided to forego collecting flotation samples altogether, and some others collected flotation samples at ridiculously small volumes, soil volumes that appear to be testing for mere presence or absence instead of collecting reasonable sample sizes for a reasonable description of archaeobotanicals present.

So, how have these efforts, and in some cases, lack of effort, affected the comparative ability of our overall archaeobotanical database. Well, the combined database of identified archaeobotanicals, in Delaware, is largely not comparative, except for a few nut hull species and a small grouping of seemingly ubiquitous carbonized seed species.

Despite these obvious sampling shortcomings, the processing and identification side of archaeobotanical and ethnobotanical reporting remains stellar. Although we see some reluctance in these labs' published comments—in not instructing us how to collect our samples, we do see their repeated advice--they suggest that scantly identified botanical remains is due to small soil sample size. And, where we do take larger

samples, we get robust results. So, it would appear that some level of botanical remains are recoverable from all archaeological sites, and that the measure of results are proportional to the measure of sampled soil collected.

Collecting and processing large, uniform, measured soil flotation samples is the only way to achieve large, uniform, measured archaeobotanical results.

The Hickory Bluff Site and the Puncheon Run Site excavation programs include significant surveys and records of the present day botanical landscapes, larger than the affected areas of the archaeological sites themselves. The resulting archaeobotanical descriptions appear within a realistic botanical landscape. These efforts and descriptions are well worth a detailed read, especially the milestone syntheses compiled by Justine McKnight. These syntheses appear in the appendices of the Puncheon Run Site report (Berger, 2005).

Not only has the bar been placed higher for individual site, and site complex interpretations, the concepts of past and present day environments serve as a more inclusive context for these cultural explanations. McKnight has demonstrated we need to understand that what grows on the land and in the water are "incentive factors" for site formation and cultural durability. And, that site formation and cultural durability, in a very real sense, differentiates what species, and the quantities of those species, are found on the land and in the water.

We provide discussion of two plant species, recently identified as likely remnant populations of Native American horticultural efforts. The first is a tiny remnant population of American lotus (*Nelumbo lutea*), located off Lotus Lane in the immediate vicinity of the Puncheon Run Site (Berger 2005). McKnight and McAvoy (McKnight, personal communication, July 22, 2013) attribute this population, as well as other populations, or clusters of American lotus, on the Sassafras and Potomac rivers to likely Native American horticultural efforts.

In addition, McKinght and McAvoy (McKnight, personal communication, July 22, 2013, and McAvoy, personal communication, July 22, 2013), also, McAvoy (2000), describe a native population of holy grass (*Hierochloe odorata*) located at the east end of Thompson Island, Delaware, and is known to exist at other locations Maryland, and Virginia. McAvoy suggests, "*H odorata* found on the Delmarva Peninsula may be a result of it being dispersed here by Native Americans." (McAvoy, personal communication, July 22, 2013).

Furthermore, Mellin and Truitt (2013a and 2013b) identified and used GPS mapping to document a variety of botanical clusters at known archaeological sites along the upper Nanticoke River, in Sussex County, Delaware. Mellin and Truitt think these Box Huckleberry (*Gaylussacia brachycera*), Chinquapin (*Castanea pumilla*), American Chestnut (*Castanea dentate*), and Prickly Pear (*Opuntia humifusa*) clusters are likely Native American, remnant, husbanded groves of beneficial species. We suspect ancestral Native Americans planted, transplanted, and husbanded a wide range of plant species that they found beneficial. They likely positioned these plants where they considered them to be conveniently accessible.

William McAvoy applies the term "adventive" to a select group, (one hundred and thirty individual plant species) found in Delaware. All of these adventive plants are considered indigenous to North America. Even though they now occur in Delaware, they are likely naturalized to Delaware from other areas, at various times in the past, and under various circumstances in the past (see McAvoy's list of adventive species for Delaware in Section II).

SECTION II

The following caption from William McAvoy explains his current definition of "adventive" species in Delaware (McAvoy, personal communication, July 22, 2013).

> Section II is a list of plant species considered to be adventive in the state of Delaware. This list was compiled by William A. McAvoy, state botanist with the Delaware Division of Fish & Wildlife, Species Conservation and Research Program. McAvoy defines an adventive species as: a species native to North America, but not to Delaware that is now found growing in

> Delaware outside of its natural range. Adventive species are not considered to be part of Delaware's native flora. These species usually arrive due to the human-caused breakdown of natural barriers to dispersal. Adventive species also include plants that have been introduced, or intentionally planted in Delaware and are now escaping and surviving without cultivation. We feel that many of these plants thought to be adventive in the state, may actually be native and could have become established in the state sometime during the Holocene and may owe their position in time and space to human involvement.

William McAvoy emailed the above caption to the authors for inclusion in this essay on July 22, 2013. Please view the spreadsheet describing all one hundred and thirty adventive plant species in Delaware, Section II, pages 39 through 46 in this essay.

SECTION II

Section III is a useful list of all references cited in this essay.

SITE 7K-C-360, AND DOVER DOWNS 7K-C-365A, and 365B, page 1 of 1

UDCAR, (Lynn Riley, Scott C. Watson, and Jay F. Custer). 1994.
Final Archaeological Investigations at Prehistoric Sites 7K-C-360 and Dover Downs (7K-C-365A and B),
State Route 1 Corridor, Kent County, Delaware.
www.deldot.gov/archaeology/dover_downs... July 7, 2013.

CARBONIZED ARCHAEOBOTANICALS RECOVERED FROM FLOTATION SAMPLES

		7K-C-360	7K-C-365A	7K-C-365B
Eleusine indica	Goosegrass	1	0	0
Chenopodium	Lamb's Quarters	6	0	0
Amaranthus retroflexus	Pigweed	1	0	1
Phytolocca americana	Pokeberry	0	1	0
	Unidentifiable Seeds	1	10	1239
	Spores	76	25	0
	Nut Fragments	23	3	2
	Charcoal	18.55gm	190.54gm	38.64gm

URS Corporation, (Patricia Miller, Douglas Mooney, and Jennifer Rankin).
Archaeological Data-Recovery at Site 7NC-E-152 Airport and Churchman's Road Intersection Improvement Project, Duross Heights New Castle County, Delaware. 2011.
www.deldot.gov/archaeology/airport_churchmans/data_recovery... July 3, 2013.

The above document exhibits no relevant presentation or discussion of recovered archaeobotanical remains. On page 4.9, the authors claim that "charcoal-rich features with seeds and nutshell were not identified at the site" and that "...research issues related to subsistence could not be addressed."

HCI, Inc. (Edward F. Heite, Cara L. Blume, John E. Foss, Inez Reed Hoffman, Peter B. Mires, Bryan D. Much, and William Sandy).
Phase I and Phase II Archaeological Investigations at Beech Ridge Site on the Proposed Route of Crawford Carroll Avenue in the City of Dover, Kent County, Delaware. 2002.
www.deldot.gov/archaeology/beech_ridge/phase1_2... July 11, 2013.

SAMPLE FLOTATION FROM THE EAST PIT FEATURE, UNIT 54

Feature Level (spatial context)	Munsell	Soil Des.	Charcoal	Soil Volume Tested (liters)	Species Identified
1		Root mat			
2		Recent humic soil			
3	10YR7/4	Hard, compact	0.9g	12	Raspberry, sclerotia, nut, poke
3a			0.4g	5	Raspberry, sclerotia, tulip tree, acorn, grass.
3a/3b			trace	0.25	Sclerotia, crabgrass.
3b			0.3g	6	Raspberry, sclerotia, tulip tree.
4	10YR5/2	Greyish, charcoal	2.4g	10	Raspberry, sclerotia, tulip tree, nut, grass.
5	10YR6/4	Silt loam	0.1g	4	Sclerotia.
6	10YR6/4	Silt loam	trace	4	Raspberry, bayberry, sclerotia.
7	10YR7/3	Compact fill	1.1g	14	Raspberry, bayberry, sclerotia, copperleaf, grass, poke.
8	10YR6/4	Fill, clay nodules	0.5g	8	Raspberry, grape, sclerotia
9	10YR7/4	Mottled fill	trace	7	Sclerotia, grass.
10	10YR6/4	Reddish fill	0.1g	2	Sclerotia.
11	10YR6/6	Compact, silty	1.8g	28	Violet, sclerotia.
12	10YR7/3	Grey, powdery	1.7g	10	Raspberry, elderberry, bayberry(?), oxalis, sclerotia.
13	10YR6/4	Sandy lens			None
14	10YR6/4	Appears sterile	0.5g	16	Sclerotia.
15	10YR7/4	Loose, grey, powdery	1.5g	8	Sclerotia.
16	10YR6/4 10YR6/6	Loose fill	0.8g	8	Sclerotia.
17	10YR7/4	Fill	0.1g	4	Sclerotia.

URS Corporation, (William P. Barse and Jennifer Marston).
Phase III Investigations at the Beech Ridge Site for the Crawford Carroll Avenue Project. 2007.
www.deldot.gov/archaeology/beech_ridge/phase3… July 11, 3013.

As detailed in the above report on page 1.1: "…Beech Ridge Site, while not characterized by large quantities of material cultural remains, did preserve a remarkable stratigraphic sequence of classic late Paleoindian through Late Archaic point types." Nevertheless, there is no mention of collecting or processing flotation samples from that stratigraphic sequence. The only reference to archaeobotanicals is the carbon gathered for carbon14 processing.

Versar, Inc. The Archaeology of a Stone Tool Industry: The Black Diamond Site (7NC-J-225)
New Castle County, Delaware. 2011.
www.deldot.gov/archaeology/blackdiamond… July 8, 2013.

FLOTATION RECOVERED CARBONIZED PLANT REMAINS

		#5004 N245 E412-413 Fea. 9	#5020 N248 E414-415 Fea. 11	#5017 N248 E414 Fea. 19	#5058 N294 E412 Fea. 24	#5023 N253 E421 Fea. 29	#5030 N238 E407 Fea. 60 w1/2	#5003 N245 E410 Fea. 46	#5003 N245 E410 Fea. 46	#5042 N236 E412 Fea. 69	#5052 N237 E411 Fea. 71
Soil Volume Tested (liters)		2	2	2	2	2	2	2	2	2	2
Wood Charcoal Recovered (grams)		0.02	0.01	0.01	0.02	0.01	0	0	0	0	0
Deciduous taxa (Count)		4	0	0	3	0	0	0	0	0	0
Unidentifiable (Count)		0	1	1	0	1	0	0	0	0	0

FLOTATION RECOVERED NON-CARBONIZED PLANT REMAINS

		#5004 N245 E412-413 Fea. 9	#5020 N248 E414-415 Fea. 11	#5017 N248 E414 Fea. 19	#5058 N294 E412 Fea. 24	#5023 N253 E421 Fea. 29	#5030 N238 E407 Fea. 60 w1/2	#5003 N245 E410 Fea. 46	#5003 N245 E410 Fea. 46	#5042 N236 E412 Fea. 69	#5052 N237 E411 Fea. 71
Soil Volume Tested (liters)		2	2	2	2	2	2	2	2	2	2
Acalypha	Three-sided Mercury	1	1	1	2	0	1	2	0	1	5
Mollugo verticillata	Carpetweed	0	0	0	0	0	0	0	0	1	0
Rubus	Raspberry/Blackberry	0	0	0	1	0	0	0	0	0	0
SOLANACEAE		1	0	0	0	0	0	0	0	0	0
POLYGONACEAE	Knotweed Family	0	0	0	7	0	0	1	0	0	0
	Unidentifiable	0	0	0	0	0	0	1	0	0	0

Versar, Inc. Early Ceramic Occupations Along Blackbird Creek: Archaeological Investigations at the Blackbird Creek Site (7NC-J-195D) New Castle County, Delaware. March 2012. www.deldot/archaeology/Blackbird Creek… July 3, 2013

CARBONIZED ARCHAEOBOTANICALS FROM SITE 7NC-J-195D		
Acer	Maple	Wood (Found in Feature 159)
Carya	Hickory	Wood (Found in Features 39, 95, 96, and 191)
Carya	Hickory	Nut (Found in Feature 145)
Castanea dentata	American Chestnut	Wood (Found in Feature 112)
Lirodendron tulipifera	Tulip Poplar	Wood (Found in Features 96, 112)
Fagus grandifolia	Beech	Wood (Found in Feature 112)
Fagus grandifolia	Beech	Nut (Found in Features 52, 112,and 167)
Juglans nigra	Black Walnut	Wood (Found in Feature 170)
Quercus	White Oak Group	Wood (Found in Features 95,112, 136, 170, and 167)
Quercus	Red Oak Group	Wood (Found in Features 52, 96, 159)
Quercus	Oak	Acorn (Found in Feature 170)
JUGLANDACEAE	NA	Wood (Found in Feature 112)
NA	Deciduous Taxa	Wood, (Found in Features 39, 52, 96, 112, 136, 140, 145, 159, and 191)
NA	Diffuse Porous	Wood, (Found in Features 96, 159, and 170)
NA	Ring Porous	Wood, (Found in Features 39, 52, 95, 145, and 191)
NA	Unidentifiable	Wood, (Found in Features 52, 96, 112, 140, 145, 191)

NON-CARBONIZED SEEDS FROM SITE 7NC-J-195D		
Acalypha	Three-sided Mercury	Seed (Found in Feature 145)
Amaranthus	Pigweed	Seed (Found in Features 145, and 191)
Carex	Sedge	Seed (Found in Features 52, and 145)
Datura stramonium	Jimsonweed	Seed (Found in Feature 191)
Eleusine indica	Goose Grass	Seed (Found in Features 39, 52, 95, and 145)
Mollugo verticillate	Carpetweed	Seed (Found in Features 39, 95, and 145)
Stellaria media	Chickweed	Seed (Found in Feature 145)
AMARANTHACEAE	Pigweed Family	Seed (Found in Feature 39)
POACEAE	Grass Family	Seed (Found in Feature 52)
NA	Unidentifiable	Seed (Found in Feature 39)

Heite Consulting, Inc., (Edward F. Heite and Cara L. Blume).
Archaeological Discoveries in Connection with Scarborough Road Data Recovery Excavations
at the Blueberry Hill Prehistoric Site (7K-C-107) Dover, Kent County, Delaware. 1995.
www.deldot.gov/archaeology/blueberry_hill... July 3, 2013.

POLLEN TAXA IDENTIFIED IN CORES PC14 AND PC17

CONIFERS			**PTEROPSIDA**	
Juniperus	Red Cedar		*Dryopteris*	Wood Fern
Pinus	Pine		Filicineae	Undifferentiated Ferns
Tsuga	Hemlock		*Osmunda*	Cinnamon Fern
			Sphagnum	Sphagnum Moss

ANGIOSPERMS (Arboreal)			**ANGIOSPERMS (Non-arboreal)**	
Alnus	Alder		*Ambrosia*	Ragweed
Betula	Birch		*Cephalanthos*	Buttonbush
Carya	Hickory		Cyperaceae	Sedge Family
Castanea	Chestnut		Ericaceae	Blueberry Family
Celtis	Hackberry		Gramineae	Grass Family
Corylus	Hazelnut		Leguminosae	Legume Family
Fagus	Beech		Myricaceae	Myrtle Family
Fraxinus	Ash		Nympheaceae	Water Lily Family
Ilex	Holly		*Plantago*	Plantain
Juglans	Walnut		Polygonaceae	Buckwheat Family
Liquidambar	Sweet Gum		*Sagittaria*	Arrowhead
Magnolia	Magnolia		Saxifragaceae	Saxifrage Family
Morus	Mulberry		*Sparganium*	Bur-reed
Nyssa	Black Gum		*Solidago*	Golenrod
Platanus	Sycamore		*Stellaria*	Chickweed
Prunus	Cherry		*Typha*	Cattail
Quercus	Oak		Umbelliferae	Parsley Family
Robinia	Black Locust		*Viburnum*	Arrowwood
Salix	Willow		*Vitis*	Grape
Tilia	Basswood			
Ulmus	Elm			

		BRENNAN SITE, page 1 of 1
UDCAR, (Scott C. Watson and Lynn Riley). Final Archaeological Excavations at the Brennan Site (7NC-F-61A) State Route 896, New Castle County, Delaware. 1994. Archaeological Series No. 116. www.deldot.gov.archaeology/brennan… July 3, 2013.		
Amaranthus	Amaranth	Found Carbonized Amaranth Seeds in Heavy and Light Fractions of Feature 4 (Probably Non-cultural). Found Carbonized Amaranth Seeds in TU S9W33 and TU S11W34.
Acalypha	Copperleaf	Found Non-carbonized Copperleaf Seeds in Heavy and Light Fractions of Feature 4 (Probably non-cultural). Found Non-carbonized Copperleaf Seeds in TU S9W33 and TU S11W34.
Chenopodium	Chenopodium Goosefoot	Found Non-carbonized Chenopodium Seeds in TU S9W33 and TU S11W34.
Morus rubra	Mulberry	Found Non-carbonized Mulberry Seeds in TU S9W33.
Oxalis stricta	Woodsorrel	Found Non-carbonized Seeds in TU S11W34.
Honckenya peploides	Sandwort	Found Non-carbonized Sandwort Seeds in TU S9W33.
Lobelia spicata	Stachys/Lobelia	Found Non-carbonized Seeds in TU S9W33 and TU S11W34.

UDCAR, (Jay F. Custer, Scott C. Watson, and Barbara Hsiao Silber). 1996.
Final Archaeological Investigations at the Carey Farm (7K-D-3) and Island Farm (7K-C-13) Sites,
State Route 1 Corridor, Kent County, Delaware.
www.deldot.gov/archaeology/carey… July 7, 2013.

SEEDS IN FLOTATION SAMPLES RECORDED BY SITE AREAS

		South	South Central	North Central	North	The Woods	Island Farm
Chenopodium album	Lamb's Quarter	35	52	10	7	0	5
Tragia urens	Noseburn	1	0	0	0	0	1
Acalypha	Copperleaf	11	3	15	7	0	20
Polygonatum commutatum	Solomon's Seal	0	0	1	1	0	0
Pyrus	Chokeberry	1	0	0	1	0	0
Euphorbia	Spurge	0	2	1	1	0	1
Ilax verticillata	Winterberry	0	1	0	1	0	0
Oenothera biennis	Evening Primrose	0	1	0	0	0	0
Setaria	Bristlegrass	0	1	1	0	0	0
Shepherdia rotundifolia	Buffalo Berry	0	1	0	1	0	0
Liriodendron tulipfeca	Tulip Tree	0	2	0	0	0	0
Croton texensis	Dove Weed	0	1	0	0	0	1
Scleria triglomerata	Scleria	0	0	0	1	0	0
Sassafras	Sassafras	1	2	0	0	0	0
Rubus occidentalis	Raspberry	0	3	1	1	0	0
Polygonatum lepathilolium	Smartweed	0	1	0	0	0	1
Polygonatum aviculare	Knotweed	1	0	0	0	0	0
Phleum pratense	Timothy	0	0	0	1	0	0
Galium asprellum	Bedstraw	0	0	1	1	0	0
Phytolacca americana	Pokeberry	1	0	0	0	0	0
Myrica pennsylvanica	Bayberry	0	1	1	0	0	0
Salvia lyrata	Sage	0	2	1	0	0	0
Amaranth retroflexus	Pigweed	0	31	22	60	0	28
NA	Nut Fragments	0	0	0	0	0	0

DELAWARE AIRPARK, (EAST) 7K-C-431 AND (WEST) 7K-C-382, page 1 of 1

John Milner Associates, Inc. (Robert G. Kingsley, Ph.D., Tod L. Benedict, Matthew D. Harris, and Jennifer A. Ort). Archaeological Data Recovery Investigations at the Delaware Airpark, Airpark East (7K-C-431) and Airpark West (7K-C-382) Sites, Cheswold, Kent County, Delaware. Volume I. 2010. www.deldot.gov/archaeology/del_air_park/final... July 3, 2013.

According to the Phase III Scope of Work (see Appendix 1 , page 5 of the above report), the following strategy was proposed for collecting and analyzing soil flotation samples as subsection 3.2.4 reads:

> 3.2.4 ENVIRONMENT AND ADAPTATION
> Soil samples will be collected for specific sets of data to address the paleoenvironment and adaptive strategies. Flotation samples will be collected to assist in the recovery of charred plant and animal remains. Based on the Phase II investigations in the Delaware Airpark sites (Siegel et al. 2004) and results reported in the Frederick Lodge excavations (Egghart et al. 2003:7-21–7-23) poor preservation of organic remains is expected. Flotation samples, approximately 10 liters in volume, will be collected from features and from selected excavation units across each site. In total, up to 20 flotation samples will be collected and processed. The water separation of these samples will be performed in JMA's laboratory in West Chester, Pennsylvania. Sorting and analysis of the heavy and light fractions will be conducted in the ethnobiological laboratory of New South Associates in Stone Mountain, Georgia.

However, on page 17 of the Delaware Airpark Phase III report, we find the statement: "...no floral or faunal samples were procured, nor was charcoal for radiocarbon dating. Flotation samples from the few features that were excavated did not produce organic matter. This lack of appropriate organic data further confounded the attempted paleoenvironmental reconstruction."

We are uncomfortable with the concept of citing poor preservation or organic remains at the Fredrick Lodge excavations, as justification, to expect poor preservation of organic remains at the Delaware Airpark. A closer look at the evidence from those archaeobotanical recovery efforts shows that only 18 liters of soil was tested from the entire Phase III effort of three sites at Frederick Lodge (7NC-J-97, 98, and 99), and only a total of 18 liters of soil was tested from the entire Phase III effort of one site at Black Diamond (7NC-J-225). As a visual aid, think of 18 liters of soil as a total volume less than 3 gallons of milk, or, about 1 case of beer.

Mid-Atlantic Archaeological Research, Inc. (Ronal A. Thomas), Archaeological Investigations at the Delaware Park Site (7NC-E-41) Stanton, New Castle County, Delaware. 1981.
www.deldot.gov/archaeology/del_park… July 3, 2013

FLOTATION RECOVERED ARCHAEOBOTANICAL REMAINS

CARBONIZED SEEDS

Mollugo verticillata	Carpetweed	Edible (Found in 28 features)
Amaranthus	Pigweed	Edible (Found in 30 features)
Chenopodium	Pigweed Goosefoot Lambsquarters	Edible, medicinal (Found in 30 features)
Lonicera	Honeysuckle	Edible, medicinal (Found in 1 feature)
Sambucus	Elderberry	Edible, medicinal (Found in 4 features)
Polanisia	Clammyweed	(Found in 1 feature)
Silene or C*erastium*	Catchfly or Chickweed	Edible, medicinal (Found in 23 features)
Taraxacum officinale	Dandelion	Introduced from Europe (Found in 3 features)
Cruciferae	Mustard Family	(Found in 1 feature)
Cruciferae brassica	Mustard Seed	Edible, medicinal (Found in 7 features)
Carmelina microcarpa	Small Seeded False Flax	(Found in 1 feature)
Carex	Sedge	(Found in 1 feature)
Fimbristylis	Sedge	(Found in 1 feature)
Scirpus	Bulrush	(Found in 1 feature)
EUPHORBIACEAE	Spurge Family	Toxic (Found in 2 features)
Acaylpha	Copperleaf or Three-seeded Mercury	Found in 31 features)
Euphorbia	Spurge	Toxic (Found in 8 features)
Euphorbia corrollata	Flowering Spurge	Toxic, medicinal (Found in 2 features)
Graminae	Grass Family	(Found in 7 features)
Eleusine indica	Goosegrass	Introduced from Europe (Found in 4 features)
Setaria glauca/lutescens	Foxtail Bristlegrass	(Found in 18 features)
Hypericum	Saint John's Wort	Introduced from Europe (Found in 1 feature)
Labiatae	Mint Family	(Found in 3 features)
Monarda	Mint	Edible, medicinal (Found in 1 feature)
Scutellaria	Skullcap	Medicinal (laxative, and to promote retarded menstruation) (Found in 4 features)
Teucrium	Wood Sage	[No data]
Thymus serpyllum	Wild Thyme	Edible, medicinal (Found in 1 feature)
Trichostema dichotomum		(Found in 1 feature)

		DELAWARE PARK SITE, page 2 of 2
Sassafras	Sassafras	Medicinal (Found in 1 feature)
Legumineae	Bean family	(Found in 3 features)
Amphicarpa bracteata	Hog Peanut	Edible (Found in 1 feature)
Lespedeza	Slender Bush Clover	Possible medicinal (Found in 1 feature)
Lotus	Deer Vetch	(Found in 2 features)
Polygonatum biflorum	Solomon's Seal	Edible, medicinal (Found in 1 feature)
Myrica pennsylvanica	Bayberry	Edible, medicinal (Found in 1 feature)
Conopholis americana	Squawroot	(Found in 1 feature)
Oxalis stricta	Oxalis	(Found in 8 features)
Phytolacca	Pokeweed	Edible, medicinal (Found in 9 features)
Polygonum	Smartweed	Edible, medicinal (Found in 27 features)
Polygonum lapathifolium	Dock-leaved Smartweed	(Found in 2 features)
Rumex acetosella	Sheep Sorel	Edible, medicinal (Found in 2 features)
Ranunculus	Buttercup	Edible, medicinal (Found in 1 feature)
Potentilla arguta	Tall Cinquefoil	medicinal (Found in 1 feature)
Prunus	Plum/Cherry	Edible, medicinal (Found in 2 features)
Rubus	Blackberry/Raspberry	Edible, medicinal (Found in 13 features)
Galium	Bedstraw	Edible, medicinal (Found in 1 feature)
Solarum	Nightshade	medicinal (Found in 1 feature)
Vitis riparia	Wild Grape	Edible, medicinal (Found in 4 features)
CARBONIZED NUT FRAGMENTS		
Quercus	Acorn	Edible (Found in 1 feature)
Juglandaceae	Walnut/Hickory Family	Edible (Found in 16 features)
Carya	Hickory	Edible, medicinal (Found in 14 features)

Versar, Inc. (Christopher Egghart, Dennis Knepper, and Chris Bowen).
American Indian Settlement of Bay/Basin Landscapes in the Archaic and Woodland Periods:
The Frederick Lodge Site Complex, 7NC-J-97, 7NC-J-98, and 7NC-J-99 New Castle County, Delaware. June 2011.
www.deldot.gov/archaeology/frederick_lodge… July 3, 2013.

ARCHAEOBOTANICAL RESULTS FROM SITES 7NC-J-97, 7NC-J-98, AND 7NC-J-99
(a combined total of 18 liters was tested)

CARBONIZED BOTANICALS

Pinus	Pine	Wood, Found in Block E N306 E567 Feature 10, and N298 E546 Feature 32.
Quercus	Oak	Wood, Found in N285 E575-576 Feature 2.
NA	NA	Wood, Deciduous Taxa Found in Block E N306 E567 Feature 10.
NA	NA	Wood, Ring Porous Found in N298 E 546 Feature 32.
NA	NA	Wood, Unidentifiable Found in N205 E664 Feature 23, N298 E 546 Feature 32, Block D N294 E551 Strata B Level 2, Block D N294 E552 Strata B Level 2.
Myrica	Bayberry	Seed fragment, Found in N205 E664 Strata I Level 2.

NON-CARBONIZED BOTANICALS
(a combined total of 18 liters of soil was tested)

Acalypha	Three-sided Mercury	Seed, Found in Block D N296 E540 Feature 30, N296 E549 Strata B Level 2, Block D N294 E552 Strata B Level 2.
Amaranthus	Pigweed	Seed, Found in Block I N221 E717 Strata B Level 2.
Mollugo verticillata	Carpetweed	Seed, Found in N205 E664 Feature 23 Strata I Level 2, N285 E575-576 Feature 2 Strata B Level 1, Block D N296 E540 Feature 30 Strata B Level 1, Trench I N219 E720 Strata B Level 1, and Block I N221 E717 Strata B Level 2.
Panicum	Panic Grass	Seed, Found in N205 E664 Feature 23 Strata I Level 2, N285 E575-576 Feature 2 Strata B Level 1, Trench I N219 E720 Strata B Level 1, and Block I N221 E717 Strata B Level 2.
POACEAE	Grass Family	Seed, Found in N205 E664 Feature 23 Strata I Level 2, N285 E575-576 Feature 2 Strata B Level I, Block E N306 E567 Feature 10 Strata II Level 7, Block D N296 E540 Feature 30 Strata B Level 1, N298 E546 Feature 32, Block D N294 E551 Strata B Level 2, N296 E549 Strata B Level 2, Block D N294 E552 Strata B Level 2, Trench I N219 E720 Strata B Level 1, and Block I N221 E717 Strata B level 2.
POLYGONACEAE	Knotweed Family	Seed, Found in N285 E575-576 Feature 2 Strata B Level 1.

URS Corporation, (William P. Barse and Daniel Eichinger).
Phase III Excavations at the Gabor Prehistoric Site (7NC-D-131B), S.R. 4, Ogletown Interchange, New Castle County, Delaware. 2003.
www.deldot.gov/archaeology/gabor… July 9, 2013.

Flotaion samples were collected during the Phase II, determination of eligibility process. However, on page 1.2 of the above report, we read: "Although numerous flotation samples had been taken, none were present with the materials retrieved from Rutgers, and no data indicating the processing of such material was evident." There is no indication that flotation samples were taken during the Phase III process. Furthermore, there is no indication of an effort to look for and describe archaeobotanicals, even though the authors speculate in their Abstract (p.i): "The Late Woodland component, characterized by a small assemblage of Riggins Fabric-Impressed pottery, may represent a small, seasonal hamlet occupation, perhaps tied to the location of a swidden field."

Archaeological & Historical Consultants, Inc. (Conran A. Hay, Ph.D., Melissa Diamanti, Ph.D., and David Rue, Ph D.)
Gray Farm Site: Phase II and III Excavations on the Murderkill River (Sites 7K-F-11 and 7K-F-169).
Revised, March 2013. www.deldot.gov/archaeology/north_frederica/grayfarmsite...

FLOTATION-RECOVERED ARCHEOBOTANICAL REMAINS (Table 02)

	Wood Charcoal	
Acer sp.	Maple	6 Pieces
Carya spp.	Hickory	73 Pieces
Castanea sp.	Chestnut	1 Piece
Pinus spp.	Pine	2 Pieces
Quercus spp.	Oak	15 Pieces
Quercus spp.	White oak	53 Pieces
Quercus spp.	Red oak	24 Pieces
NA	Ring Porous	6 Pieces
NA	Deciduous	215 Pieces
NA	Unidentifiable	70 Pieces
	Carbonized Nuts	
Carya spp.	Hickory (Thick-walled)	540 Pieces
	Carbonized Seeds	
Rubus spp.	Raspberry or blackberry	1 Seed
Vitis sp.	Grape	1 Seed
POACEAE (possible)	Grass	1 Seed
NA	Unid. Large Frag.	1 Seed
NA	Unid. Ovoid	1 Seed
NA	Unidentifiable	2 Seeds
	Miscellaneous Plant Remains (carbonized)	
NA	Monocot Stem Frag.	9 Pieces
NA	Gall	1 Piece
NA	Fungal Fructification	4 Pieces
NA	Amorphous Carbon	85 Pieces
NA	Unknown Fragments	3
	Non-carbonized Seeds, (Percentages)	
Acalypha sp.	Copperleaves	3%
Amaranthus sp.	Pigweed	20%
Mollugo verticillata	Carpetweed	67%
Phytolacca americana	Poke	3%
Polygonum/Rumex	Knotweed/dock	3%
Rhus sp.	Sumac	0%
Rubus sp.	Blackberry/raspberry	3%
Stellaria media	Chickweed	40%
Taraxacum sp.	Dandelion	3%
Trifolium sp.	Clover	3%
POACEAE	Grass Family	3%
SOLANACEAE	Nightshade Family	10%
NA	Unknown	3%

		GRAY FARM SITE, page 2 of 2
STARCH GRAIN (Figure 1)		
Seteria	Maize or grass	Starch-subangular, maize or grass. (Feature 10, Sample 11, Woodland II ceramic), (Feature 185, Sample 13, Middle Woodland I ceramic), (Feature 344, Sample 7, metate).
Seteria	Maize or grass	Starch-angular, maize or grass. (Feature 10, Sample 9, Woodland II ceramic), (Feature 3, Sample 6, Late Woodland I steatite), (Feature 279, Sample 4, Early Woodland I ground stone), (Test Unit 38, Sample 14, Middle Woodland I ceramic).
POACEAE	Grass seed	Starch-centric, grass seed. (Feature 10, Sample 8, Woodland II ceramic), Feature 3, Sample 6, Late Woodland I? steatite), Feature 344, Sample 7, metate).
POACEAE	Grass seed	Starch-centric/elongate, grass seed. (Feature 10, Sample 9, Woodland II ceramic), (Feature 10, Sample 8, Woodland II ceramic).
Hordeum pusillum	Little barley	Starch-lenticular with lamellae. (Test Unit 38, Sample 14, Middle Woodland I ceramic).
Hordeum pusillum	Little barley	Starch-large lenticular with lamellae. (Feature 10, Sample 9, Woodland II ceramic), (Feature 10, Sample 8, Woodland II ceramic).
Hordeum pusillum	Little barley	Starch-lenticular with lamellae cluster. (Feature 10, Sample 9, Woodland II ceramic), (Feature 10, Sample 8, Woodland II ceramic).
Hordeum Elymus	Barley-wildrye type	Starch-small lenticular cluster. (Feature 10, Sample 8, Woodland II ceramic).
Sagittaria latifolia	Wapato, Indian Potato	Starch-eccentric wapato type. (Test Unit 38, Sample 14, Middle Woodland I ceramic).
PHYTOLITH (FIGURE 1)		
CYPERACEAE	Sedge, achene	Cone-cell sedge, achene. (Feature 344, Sample 7, metate).
CYPERACEAE	Sedge, root-type	Irregular with cylindric projection, sedge, root-type. (Test unit 38, Sample 14, Middle Woodland I ceramic).
POACEAE	Grass seed	Dendriform grass seed indicator. (Feature 10, Sample 12, Woodland II ceramic), (Feature 10, Sample 9, Woodland II ceramic), (Feature 10, Sample 10, Woodland II ceramic), Feature 3, Sample 6, Late Woodland I? steatite), (Feature 279, Sample 3, Early Woodland I ground stone), (Feature 279, Sample 4, Early Woodland I ground stone), (Feature 344, Sample 7, metate).
NA	NA	Non-phytolith xylem fragment. (Feature 10, Sample 9, Woodland II ceramic), Feature 280, Sample 1, lithic micro-tool).
Asteraceae inflorescence	[daisey and/or sunflower]	Opaque perf. plate. [of the daisey and sunflower family] (Feature 3, Sample 6, Late Woodland I? steatite), (Feature 279, Sample 4, Early Woodland I ground stone), (Feature 344, Sample 7, metate).

UDCAR, (Jay F. Custer and David C. Bachman). Phase III Data Recovery Excavations of the Prehistoric Components from the Hawthorn Site 7NC-E-46 New Churchman's Road Christiana, New Castle County, Delaware. 1984.
www.deldot.gov/archaeology/hawthorne… July 7, 2013.

CARBONIZED ARCHAEOBOTANICALS RECOVERED FROM FLOTATION (HEAVY FRACTION ONLY)

	Charcoal (grams)	Hickory (grams)	Chenopodium Seed (Count)	Hackberry Seed (Count)
E203 S50 L.4	0.28	0	0	0
E198 S65 L.3 ss.12	0.06	0	0	0
E183 S60 L.4 ss.13	2.08	0	0	1
E198 S65 L.3 ss.13	0.55	0	0	0
E198 S65 L.3 ss.2	2.36	0	0	1
E183 S60 L.3	2.62	0.02	0	0
E198 S65 L.3 ss.1	0.18	0	0	0
E213 S50 L.5	1.19	0.08	0	0
E208 S60 L.2 ss.13	2.54	0.11	0	0
E198 S65 L.3 ss.13	6.23	0.57	0	0
E183 S60 L.3 ss.13	0.39	0	0	0
E198 S65 L.3 ss.24	2.79	0.57	2	1
E193 S70 L.2	1.38	0.09	0	0
E178 S50 L.2 ss.13	0.75	0	0	0
E208 S65 L.5	0.44	0	1	4
E198 S65 L.3 ss.23	0.17	0.18	0	1
E188 S55 L.2 ss.13	0.38	0.07	0	0
E198 S65 L.2	0.03	0	0	0
E198 S70 L.4	0.03	0	0	0
E173 S60 L.2	0.01	0	1	0
E198 S65 L.3 ss.16	0.01	0	0	0
E198 S65 L.3 ss.19	0.05	0	0	5
E208 S55 L.2 ss.13	0.06	0.09	0	0
E208 S65 L.3	0.09	0	0	0
E173 S65 L.2 ss.13	0.01	0	1	0
E183 S60 L.2 ss.13	0.01	0.01	0	0
E198 S65 L.3 ss.21	0.01	0	0	0
E198 S65 L.3 ss.6	0.01	0	0	0
E173 S65 L.3 ss.13	0.01	0	0	0
E188 S55 L.3 ss.13	0.01	0	0	2
E203 S70 L.2 ss.13	0.02	0.01	0	
E208 S50 L.5 ss.13	0.03	0.02	0	
E203 S70 L.4 ss.13	6.39	2.83	5	15
E203 S70 L.3 ss.13	0.54	0.32	0	0
E203 S50 L.4 ss.13	0.03	0	0	0
E193 S65 L.4 ss.13	0.01	0.01	0	0

HAWTHORN SITE, page 2 of 2				
	Charcoal (grams)	Hickory (grams)	Chenopodium Seed (Count)	Hackberry Seed (Count)
E188 S65 L.2 ss.13	0.01	0	0	0
E198 S65 L.3 ss.18	0.01	0.01	0	0
E198 S65 L.3 ss.17	0.01	0	0	0
E198 S65 L.3 ss.13	0.02	0.01	0	2
E198 S65 L.3 ss.5	0.02	0.13	0	0
E198 S65 L.3 ss.15	0.01	0.01	0	0
E148 S65 L.3 ss.12	0.01	0	0	0
E198 S65 L.3 ss.8	0.01	0	0	0
E198 S65 L.3 ss.3	0.52	0	0	0
E198 S65 L.3 ss.9	0.01	0	0	0
E178 S50 L.3 ss.13	0.01	0	0	0
E203 S55 L.2 ss.13	0.01	0	0	0
E193 S70 L.3 ss.13	0.01	0	0	0
E193 S60 L.4 ss.13	0.01	0	0	0
E203 S45 L.3 ss.13	0.38	0	0	0
E203 S55 L.3	0.01	0	1	0
E163 S70 L.4 ss.13	0.01	0	0	0
E203 S50 L.3	0.01	0	0	0
E198 S70 L.3	0.01	0.01	0	0
E183 S60 L.2	0.01	0	0	0
E198 S55 L.2 ss.13	0.01	0	1	0
E213 S50 L.4 ss.13	0.01	0.01	0	0
E178 S65 L.4	0.01	0	0	0
E183 S60 L.3 ss.13	0.93	0.13	0	0
E198 S65 L.3 ss25	0.67	0.07	0	2
E198 S65 L.3 ss.10	0.02	0	0	0
E198 S60 L.4	0.01	0	0	0
E163 S70 L.5 ss.13	0.01	0	0	0
E183 S60 L.1 ss.10	0.01	0	0	0
E188 S65 L.3 ss.13	0.01	0	5	0
E173 S55 L.2 ss.13	0.01	0.01	0	0
E198 S65 L.3 ss.7	0.01	0	0	0
E173 S55 L.3 ss.13	0.01	0	0	0
E208 S65 L.2 ss.13	0.01	0	0	0
E198 S65 L.3 ss.11	0.01	0	0	0
E198 S65 L.3 ss.14	0.01	0	0	0
E198 S65 L.3 ss.20	7.30	2.30	0	0
E198 S65 L.3 ss.4	5.20	1.93	0	0
E198 S70 L.4 Fea. 1	19.75	25.36	0	0
E198 S70 L.2 ss.13	0.01	0	0	0
E198 S70 L.4 ss.13	0.01	0	0	0

Parsons Inc. (Michael D. Petraglia, Susan L. Bupp, Sean P. Fitzell, and Kevin W. Cunningham).
Hickory Bluff: Changing Perceptions of Delmarva Archaeology. 2022.
www.deldot.gov/archaeology/hickory_bluff… July 9, 2013.

SPECIES SPECIFIC CHARCOAL RECOVERED FROM FEATURE SPECIFIC, 2 LITER FLOTATION SAMPLES

Acer	Maple	Found in Features 90, 99, 166, and 249.
Acer or *Betula*	Maple or Birch	Found in Features 87, and 165.
Carya	Hickory	Found in Features 87, 99, 120, 137, 165, 166, 174, 230, 249, 253, 281, 296, 298, and 310.
Castanea dentata	American Chestnut	Found in Features 176, 227, and 298.
Juglans nigra	Black Walnut	Found in Features 87, 120, 165, and 176.
Prunus serotina	Cherry	Found in Feature 174.
Quercus	Oak (White Group)	Found in Features 2, 46, 90, 165, 174, and 176.
Quercus	Oak (Red Group)	Found in Feature 289.
Quercus	Oak (Unspec.)	Found in Features 98, 174, 176, and 414.
NA	Diffuse Porous	Found in Feature 87.
NA	Ring Porous	Found in Features 46, 120, 227, and 230.
NA	Deciduous Taxa	Found in Features 46, 87, 90, 99, 137, 165, 166, 174, 176, 227, 230, 240, 249, 253, 281, 289, 296, 298, and 310.
NA	Unidentifiable	Found in Features 46, 87, 98, 120, 165, 169, 175, and 310.

CARBONIZED NUT AND SEED SPCIMEN(S) FOUND IN FEATURE SPECIFIC, 2 LITER FLOTATION SAMPLES

Carya	Hickory (Thick Wall)	Nut Fragment(s) Found in Features 2, 46, 90, 98, 99, 137, 165, 174, 176, 230, 249, 289, and 310.
Juglandaceae	Walnut (Family)	1 Nut Fragment Found in Feature 98.
NA	NA	1 Seed Found in Feature 120.

NON-CARBONIZED SEED SPECIMEN(S) FOUND IN FEATURE SPECIFIC, 2 LITER FLOTATION SAMPLES		
Amaranthus	Pigweed	Found in Features 98, 202, 230, and 414.
Crotolaria	Rattlebox	Found in Features 99, and 298.
Euphorbia	Spurge	Found in Features 46, 87, 98, 118, 120, 165, 166, 169, 174, 175, 176, 202, 227, 249, 281, 296, 298, 310, and 414.
Liriodendron tulipifera	Tulip Poplar	Found in Features 87, 98, 99, 137, 176, and 281.
Panicum	Panic Grass	Found in Feature 296.
Phytolacca americana	Pokeweed	Found in Feature 87.
Polygonum pennsylvanicum	Knotweed	Found in Feature 166.
Polygonum	Knotweed	Found in Features 99, 120, 227, and 298.
Prunus serotina	Cherry	Found in Features 99, 174, 253, and 281.
Rubus	Raspberry/Blackberry	Found in Features 46, 87, 98, 99, 137, 176, 227, 230, and 281.
Sambucus canadensis	Elderberry	Found in Feature 99.
Trifolium	Clover	Found in Features 46, 99, 230, 281, and 310.
Vitis labrusca	Fox Grape	Found in Features 87, 98, and 281.
Polygonaceae	Knotweed (Family)	Found in Feature 166.
NA	Unidentifiable	Found in Features 118, 169, and 253.

UDCAR, (Jay F. Custer and Jay Hodny).
Final Archaeological Investigations at the Hockessin Valley Site (7NC-A-17). 1989.
www.deldot.gov/archaeology/hockessin_valley… July 7, 2013.

CARBONIZED ARCHAEOBOTANICALS RECOVERED FROM FEATURES

Vitis	Grape	2 Seeds in Feature 8
Chenopodium	Goosefoot	1 Seed in Feature 24
Carya	Hickory	Charcoal Found in Features 1 and the Hearth, 1 Nut Fragment Found in Feature 9.
Quercus	Oak	Charcoal Found in Features 23, and the Hearth
Juglans	Walnut	Charcoal Found in Features 23, and the Hearth
Fagus grandifolia	American Beech	Charcoal Found in the Hearth

CHARCOAL WEIGHTS IN FEATURE SAMPLES

Feature 1		3.11gm Charcoal Recovered
Feature 8		1.29gm Charcoal Recovered
Feature 9	S 1/2 Lv. 2	24.72gm Charcoal Recovered
Feature 12	NE Area 0-10cm.	0.07gm Charcoal Recovered
Feature 12	NE Area 10-20cm.	4.24gm Charcoal Recovered
Feature 12	S 1/2 10-20cm.	1.13gm Charcoal Recovered
Feature 12	N 1/2 20cm--Bottom	3.99gm Charcoal Recovered
Feature 12	S 1/2 20-30cm.	1.13gm Charcoal Recovered
Feature 18	N19W13 N 1/2 (Silty)	1.97gm Charcoal Recovered
Feature 18	N 1/2	4.90gm Charcoal Recovered
Feature 23	N 1/2	1.12gm Charcoal Recovered
Feature 23	S 1/2	0.16gm Charcoal Recovered
Feature 24	NW 1/2	1.85gm Charcoal Recovered
Feature 26	NW 1/2	31.96gm Charcoal Recovered
Feature 26	SE 1/2	12.76gm Charcoal Recovered

UDCAR, (Jay F. Custer, Lynn Riley, and Glen Mellin).
Archaeology--Leipsic Site (7K-C-194A) Kent County, Delaware. 1996.
www.deldot.gov/archaeology/leipsic_site_sr1… July 3, 2013.

EXCAVATED ARCHAEOLOBOTANICALS OF EUROPEAN ORIGIN		
Setania	Bristlegrass	Seeds, 1 Carbonized, 301 Non-carbonized
Mollugo verticillata	Carpetweed	Seeds, 4 Carbonized, 297 Non-Carbonized
Acalypha	Copperleaf	Seeds, 54 Carbonized, 5,049 Non-carbonized
Digitana	Crabgrass	Seeds, 3 Carbonized, 534 Non-carbonized
Gramminaea	Grass	Seeds, 4 Carbonized, 9 Non-carbonized
Panicum	Wartgrass	Seeds, 4 Carbonized, 588 Non-carbonized
Triticum aestivum	Wheat	Seeds, 2 Carbonized, 4 Non-carbonized
Salvia	Sage	Seeds, 1 Carbonized, 1 Non-carbonized
Euphorbia	Spurge	Seeds, 2 Carbonized, 54 Non-carbonized
Portulaca oleracea	Purslane	Seeds, 2 Carbonized, 63 Non-carbonized
EXCAVATED ARCHAEOBOTANICALS OF NATIVE ORIGIN		
Chenopodium	Lambsquarter	Seeds, 18 Carbonized, 215 Non-carbonized
Amaranthus retroflexus	Pigweed	Seeds, 1 Carbonized, 102 Non-carbonized
Clitonia	Butterflypea	Seeds, 1 Carbonized, 0 Non-carbonized
Pyrus	Chokeberry	Seeds, 1 Carbonized, 0 Non-carbonized
Oenothera	Evening primrose	Seeds, 6 Carbonized, 8 Non-carbonized
Comus florida	Flowering Dogwood	Seeds, 18 Carbonized, 0 Non-carbonized
Vitis	Grape	Seeds, 2 Carbonized, 8 Non-carbonized
Smilax	Greenbriar	Seeds, 1 Carbonized, 2 Non-carbonized
Lechea	Pinweed	Seeds, 1 Carbonized, 0 Non-carbonized
Rubus occidentalis	Raspberry	Seeds, 1 Carbonized, 1 Non-carbonized
Trianthema	Sea Purslane	Seeds, 3 Carbonized, 2 Non-carbonized
Rumex acetosella	Sheep Sorrel	Seeds, 2 Carbonized, 4 Non-carbonized
Polygonatum	Solomon's Seal	Seeds, 1 Carbonized, 2 Non-carbonized
Liriodendron tulipfera	Tuliptree	Seeds, 3 Carbonized, 6 Non-carbonized
NA	Spores	Spores, 6,439 Carbonized, 91,439 Non-carbonized
Carya	Hickory	Nut, Carbonized, Present
Erythrobalanus	Oak (Red family)	Wood, Carbonized, Present
NA	Unidentified	211 Carbonized, 0 Non-carbonized

UDCAR, (Jay F. Custer, Wade P. Catts, Jay Hodny, and Colleen DeSantis Leithren).
Final Archaeological Investigations at the Lewden Green Site (7NC-E-9),
Christiana, New Castle County, Delaware. 1990.
www.deldot.gov/archaeology/lewden_green… July 7, 2013.

We include the Lewden Green Site (a terminal Phase II project) in this synthesis because the site was a special situation, an important ceramic yielding location. In the Abstract (p.i) we find: "Phase II excavations at the Lewden Green Prehistoric Site in northern New Castle County, Delaware, recovered numerous artifacts from plowzone contexts. No features or in situ archaeological deposits are present at the site." Consequently, no attempt was made to recover archaeobotanical samples from soil flotation.

LUMS POND SITE, page 1 of 1

Parsons Engineering Science, (Michael Petraglia, Dennis Knepper, John Rutherford, Philip LaPorta, Kathryn Puseman, Joseph Schuldenrein, and Noreen Tuross). The Prehistory of Lums Pond: The Formation of an Archaeological Site in Delaware, Volume II. 1998. www.deldot.gov/archaeology/lums_pond... July 9, 2013.

		No. 3392 (Fea. 2) 3.35 Liters	No. 3394 (Fea. 14) 5.4 Liters	No. 3395 (Fea. 16) 3.0 Liters	No. 3397 (Fea. 19) 3.5 Liters	No. 3398 (Fea. 23) 4.5 Liters	No. 3400 N314 E332 7.1 Liters	No. 3401 N230 E241 3.6 Liters	No. 3405 N232 E242 etc. 2.0 Liters	No. 3402 N232 E242 5.5 Liters	No. 3406 N230 E240 etc. 5.2 Liters	No. 3407 N238 E254 etc. 3.9 Liters	No. 3404 N241 E258 3.3 Liters
CARBONIZED													
Carya	Hickory (Wood, Frags.)	0	3	0	1	0	0	0	0	0	0	0	0
Quercus	Oak (Wood, Frags.)	30	47	12	19	10	9	6	20	17	0	4	2
NA	Unident. (Wood, Frags.)	0	0	0	0	0	0	4	0	3	0	4	3
Carya	Hickory (Nut, Frags.)	3	1	0	0	9	1	0	0	1	0	0	0
Quercus	Oak (Acorn, Frags.)	0	0	2	0	0	0	0	0	0	0	1	0
Gaylussacia	Huckleberry (Seed)	0	0	0	0	0	0	1	1	0	3	0	0
Lamiaceae	Pennyroyal (Seed)	0	0	0	0	0	0	1	0	0	0	0	0
NA	Unidentified (Seed)	0	0	0	0	0	0	0	0	1	0	0	0
NON-CARBONIZED													
Amaranthus	Pigweed (Seed)	0	0	0	0	0	1	0	0	0	0	0	0
Asteraceae	Sneezeweed (Seed)	0	0	0	0	0	1	0	0	0	0	0	0
Brassicaceae	Mustard (Seed)	0	0	0	0	0	0	1	0	0	0	0	0
Euphorbia	Spurge (Seed)	0	0	0	0	0	2	0	0	0	0	0	0
Lamiaceae	Bugleweed (Seed)	0	0	0	0	0	5	4	4	0	2	2	0
Liliaceae	Cucumber-root (Seed)	0	0	0	0	0	0	0	0	1	0	0	0
Mollugo verticillata	Carpetweed (Seed)	0	0	0	0	0	20	0	2	0	0	0	0
Oenothera	Evening Primrose (Seed)	0	0	0	0	0	4	3	2	0	0	0	0
Oxalis stricta	Oxalis (Seed)	0	0	0	0	0	0	1	0	1	0	0	0
Polanisia	Clammyweed (Seed)	0	0	0	0	0	1	0	0	0	0	0	0
Polygonum	Solomon's Seal (Seed)	0	0	0	0	0	1	0	0	0	0	0	0
Portulaca	Purslane (Seed)	0	3	0	0	1	0	0	0	0	0	0	0
Rubus	Rasp/Blackberry (Seed)	0	0	0	0	0	0	0	0	0	5	0	0
Trifolium	Clover (Seed)	0	0	0	0	0	0	20	0	0	0	0	0
NA	Unidentified (Seed)	0	0	0	0	0	6	0	0	0	2	1	0

UDCAR, (Jay F. Custer, Angela Hoseth, Barbara Hsiao Silber, David J. Grettler, and Glen Mellin). 1997.
Final Archaeological Investigations at the Pollack Prehistoric Site (7K-C-203),
State Route 1 Corridor, Kent County, Delaware.
www.deldot.gov/archaeology/pollack/final... July 7, 2013.

SEEDS IN FLOTATION SAMPLES RECORDED BY SITE AREAS

		Area A	**Area B**	**Area C**	**Area D**	**Area E**	**Area F**	**Area G**
Chenopodium album	Lamb's-quarters	13	3	3	2	0	0	0
Tragia urens	Noseburn	5	2	1	2	0	0	0
Acalypha	Copperleaf	13	0	0	0	0	0	0
Portulaca oleracea	Purslane	14	0	0	1	0	0	0
Polygonatum commutatum	Solomon's Seal	2	0	0	3	0	0	0
Hypericum	St. John's Wort	6	0	0	0	0	0	0
Pyrus	Chokeberry	1	0	0	1	0	0	0
Quercus prinus	Acorn	1	0	0	0	0	0	0
Euphorbia	Spurge	1	0	0	0	0	1	0
Comus florida	Dogwood	1	0	0	0	0	0	0
Ilax verticillata	Winterberry	2	0	0	0	0	0	0
Crataegus	Possoin Haw	1	0	0	0	0	0	0
Oenothera biennis	Evening Primrose	2	0	0	0	0	0	0
Setaria	Bristlegrass	1	0	0	1	0	0	0
Collomia grandiflora	Collomia	1	0	0	0	0	0	0
Shepherdia rotundifolia	Buffalo Berry	1	0	0	0	0	0	0
Prunetta vulgaris	Self Heal	1	0	0	0	0	0	0
Liriodendron tulipifeca	Tulip Tree	1	0	0	1	0	0	0
Croton texensis	Dove Weed	0	2	0	0	0	0	0
Scleria triglomerata	Scleria	0	12	6	2	1	0	0
Amaranth retroflexus	Pigweed	0	1	2	1	0	0	0
Carex	Sedge	0	1	0	0	0	0	0
Ampelopsis arborea	Peppervine	0	1	0	0	1	0	0
Sassafras	Sassafrass	0	1	1	1	0	0	0
Rubus occidentalis	Raspberry	0	1	0	0	0	0	0
Polygonatum lepathilolium	Smartweed	0	0	1	0	0	0	0
Vicia americana	Vetch	0	0	2	2	0	0	0
Polygonatum aviculare	Knotweed	0	0	1	0	0	0	0
Smilax	Greenbriar	0	0	0	1	0	0	0

								POLLACK SITE, page 2 of 2
		Area A	**Area B**	**Area C**	**Area D**	**Area E**	**Area F**	**Area G**
Salvia lyrata	Sage	0	0	0	1	0	0	0
Solarium	Nightshade	0	0	0	1	0	0	0
	Clammyweed	0	0	0	1	0	0	0
Ruppia maritima	Widgeongrass	0	0	0	2	0	0	0
Quercus	Oak	0	0	0	1	0	0	0
Phleum pratense	Timothy	0	0	0	1	0	0	0
Galium asprellum	Bedstraw	0	0	0	1	0	0	0
	Scurf Pea	0	0	0	1	0	0	0
	Grey Feather	0	0	0	1	0	0	0
Galium aparine	Goosegrass	0	0	0	6	0	0	0
Phasectus meticalfi	Wild Bean	0	0	0	1	0	0	0
Phytolacca americana	Pokeberry	0	0	0	2	0	0	0
Myrica pennsylvanica	Bayberry	0	0	0	0	0	1	0
	Nut Fragments	0	0	0	0	0	0	0

PUNCHEON RUN SITE, page 1 of 1

Berger Group, Inc. (Charles LeeDecker, John Bedell, Robert Jacoby, and Stuart Fiedel).
Archaeology of the Puncheon Run Site. Volume I and II. 2005.
www.deldot.gov/archaeology/puncheon_run… July 13, 2013.

TOTAL SITE SOIL SAMPLE VOLUME, 249.5 LITERS
TOTAL SITE CHARCOAL, N=4563, WEIGHING 44.93 GRAMS

CARBONIZED WOOD (Pieces)					
Acer	Maple	11	*Acer/Betula*	Maple/Birch	8
Carya	Hickory	99	*Castanea dentata*	American Chestnut	10
Cornus florida	Flowering Dogwood	1	*Diospyros virginiana*	Persimmon	5
Fraxinus	Ash	2	*Ilex opaca*	American Holly	7
Juglans nigra	Black Walnut	8	*Liquidambar styracif.*	Sweetgum	40
Liriodendron tulipifera	Tulip Poplar	4	*Morus ruba*	Red Mulberry	2
Pinus	Pine (Group)	5	*Prunus serotina*	Black Cherry	1
Quercus	Oak (Red Group)	40	*Quercus*	Oak (White Group)	290
Quercus	Unspec.	85	*Robinia pseudoacacia*	Black Locust	4
Sassafras albidum	Sassafras	2	NA	Diffuse Porous	5
NA	Ring Porous	83	NA	Coniferous Taxa	1
NA	Deciduous Taxa	248	NA	Unidentifiable	257
CARBONIZED NUT REMAINS, N=157, WEIGHING 2.22 GRAMS					
Quercus	Acorn	2	*Carya*	Thick-walled Hickory	155
CARBONIZED SEEDS, N=85, WEIGHING 0.14 GRAMS					
Acalypha virginica	Copperleaf	1	*Chenopodium*	Goosefoot	47
Nelumbo lutea (poss.)	American Lotus (poss.)	1	*Phytolacca americana*	Poke	2
Polygonum	Knotweed	2	*Rumex*	Dock	1
Stellaria media	Chickweed	1	*GRAMINEAE*		5
NA	Unident. Seed Frag.	1	NA	Unident. Eroded Seed	17
NA	Unident. Large Seed	6	NA	Unknown Seed	1
NON-CARBONIZED SEED REMAINS, N=1082, WEIGHING 0.35 GRAMS					
Amaranthus	Pigweed	50	*Ambrosia artemisiifolia*	Common Ragweed	1
Crotolaria sagittalis	Rattlebox	1	*Euphorbia*	Spurge	17
Frageria	Strawberry	5	*Mollugo verticillata*	Carpetweed	769
Myrica	Bayberry?	1	*Oxalis stricta*	Wood Sorrel	30
Panicum	Panic Grass	6	*Phytolacca americana*	Poke	0
Polygonum pensylvan.	Knotweed	2	*Polygonum*	Knotweed	49
Prunus serotina	Black Cherry	3	*Rubus*	Raspberry/Blackberry	1
Solanum rostratum	Buffalobur	1	*Stellaria media*	Chickweed	69
Trifolium	Clover	6	*Vicia*	Vetch	1
Vitis	Grape	1	*AMARANTHACEAE*	Pigweed (Family)	62
LEGUMINOSAE	Bean (Family)	1	*POACEAE*	Grass (Family)	4
NA	Unid. Seed Coat Frag.	1	Presence/Absence	Phase II Analysis	50/91
OTHER PLANT REMAINS, N=356, WEIGHING 2.8 GRAMS					
NA	Amorphous Carbon	307	NA	Monocot Stem Frag.	3
NA	Unident. Charcoal	5	NA	Coniferous Bud Frag.	1
NA	Unident. Bud Frag.	3	NA	Unident. Rind Frag.	20
NA	Unident. Plant Frag.	8	NA	Unid. Spherical Spec.	1
NA	Fungal Fructification	1	NA	Woody Bud Frag.	3
NA	Hull Frag.	2	NA	Peduncle Frag.	1

RONALD MCDONALD SITE, page 1 of 1
Skelly and Loy, Inc. (Barbara J. Gundy, Ph.D., R.P.A., Kenneth W. Mohney, Ph.D., Christopher T. Espenshade, Albert T. Vish, and Margaret G. Sams, C.P.S.S.). A Few Hours in the Piedmont: Archaeological Investigations of Site 7NC-B-54 (Ronald McDonald House), Blue Ball Area Transportation Improvements, Brandywine Hundred, New Castle County, Delaware. 2008. www.deldot.gov/archaeology/blue_ball/piedmont… July 3, 2013.
We were unable to find where the above report described a soil flotation program for the purpose of recovering archaeobotanical evidence.

Versar, Inc. American Indians in the Delmarva Uplands: Archaeology at the Sandom Branch Site Complex (7NC-J-227, 7NC-J-228), New Castle County, Delaware. May, 2011.
www.deldot.gov/archaeology/sandom_branch… July 3, 2013.

CARBONIZED ARCHAEOBOTANICALS FROM SITE 7NC-J-227		
LEUCOBALANUS group Quercus	White Oak	Wood
ERYTHROBALANUS group Quercus	Red Oak	Wood
Quercus	Oak	Wood
Liquidambar styraciflua	Sweetgum	Wood
Acer	Maple	Wood
Liriodendron tulipifera	Yellow Poplar	Wood
Fraxinus	Ash	Wood
Juglans nigra	Black Walnut	(Tentative identification) Wood
Carya	Nut shell	Wood
Quercus	Acorn	Wood
POACEAE family	Grass	Seed
NON-CARBONIZED ARCHAEOBOTANICALS FROM SITE 7NC-J-227		
Euphorbia	Spurge	Seed
Vitis	Grape	Seed
POLYGONACEAE family	Knotweed	Seed
CARBONIZED ARCHAEOBOTANICALS FROM SITE 7NC-J-228		
Acer	Maple	Wood
Quercus	White group	Wood
NA	NA	Ring Porous Wood
NA	NA	Deciduous Taxa Wood
NA	NA	Unidentifiable Wood
NON-CARBONIZED ARCHAEOBOTANICALS FROM SITE 7NC-J-228		
Chenopodium	Goosefoot	Seed
Euphorbia	Spurge	Seed
Oxalis stricta	Sheep Sorrel	Seed
Panicum	Panic Grass	Seed
Polygonum/Rumex	Knotweed, Dock	Seed
Rubus	Raspberry/Blackberry	Seed
Trifolium	Clover	Seed

UDCAR, (Jay F. Custer and Barbara Hsiao Silber).
Final Archaeological Investigations at the Snapp Prehistoric Site (7NC-G-101), State Route 1 Corridor, Chesapeake and Delaware Canal Section, New Castle County, Delaware. 199
www.deldot.gov/archaeology/snap_prehis_site... July 7, 2013.

EXAMPLES OF SEED TYPES IN VARIOUS FEATURES

CARBONIZED ARCHAEOBOTANICALS FROM FEATURE 33		
Acalypha	Copperleaf	2 Seeds
Amaranthus	Pigweed	3 Seeds
Euphorbia	Spurge	1 Seed
	Lamb's Quarter	1 Seed
Rubus occidentalis	Raspberry	1 Seed
CARBONIZED ARCHAEOBOTANICALS FROM FEATURE 153		
	Thimbleberry	3 seeds
	Greenbrier	1 Seed
Chenopodium	Chenopodium	3 Seeds
Morella	Bayberry	1 Seed
Persicaria	Smartweed	1 Seed
Commelina	Dayflower	1 Seed
	Eastern Buminbush	1 Seed
CARBONIZED ARCHAEOBOTANICALS FROM FEATURE 230		
Ambrosia	Ragweed	2 Seeds
Cuscuta	Smartweed	1 Seed

Berger & Associates, (Charles H. LeeDecker, Brad Koldehoff, and Cheryl A. Holt).
Excavation of the Two Guys Site (7S-F-68), Sussex County, Delaware. 1996.
www.deldot.gov/archaeology/two_guys… July 3, 2013.

ARCHAEOBOTANICAL PERCENTAGES RECOVERED FROM A TOTAL OF FIFTY SOIL FLOTATION SAMPLES

NA	Carpetweed	Carpetweed Seeds Found in 63% of Flotation Samples (0 Carbonized)
NA	Purslane	Purslane Seeds Found in 2% of Flotation Samples (0 Carbonized)
NA	Chickweed	Chickweed Seeds Found in 3% of Flotation Samples (0 Carbonized)
NA	Oxalis	Oxalis Seeds Found in 2% of Flotation Samples (0 Carbonized)
NA	Knawel	Knawel Seeds Found in 39% of Flotation Samples (0 Carbonized)
NA	Thistle	Thistle Seeds Found in 2% of Flotation Samples (0 Carbonized)
NA	Chenopodium	Chenopodium Seeds Found in 19% of Flotation Samples (0 Carbonized)
NA	Amaranthus	Amaranthus Seeds Found in 3% of Flotation Samples (0 Carbonized)
NA	Knotweed	Knotweed Seeds Found in 3% of Flotation Samples (0 Carbonized)
NA	Pokeweed	Pokeweed Seeds Found in 5% of Flotation Samples (0 Carbonized)
NA	Sedge	Sedge Seeds Found in 22% of Flotation Samples (0 Carbonized)
NA	Chufa	Chufa Seeds Found in 3% of Flotation Samples (0 Carbonized)
NA	Flatsedge	Flatsedge Seeds Found in 44% of Flotation Samples (0 Carbonized)
NA	Grass	Grass Seeds Found in 58% of Flotation Samples (0 Carbonized)
NA	Spurge	Spurge Seeds Found in 3% of Flotation Samples (0 Carbonized)
NA	Blackberry	Blackberry Seeds Found in 3% of Flotation Samples (0 Carbonized)
NA	Deerberry	Deerberry Seeds Found in 3% of Flotation Samples (0 Carbonized)
NA	Paspalum	Paspalum Seeds Found in 5% of Flotation Samples (0 Carbonized)
NA	Doveweed	Doveweed Seeds Found in 7% of Flotation Samples (0 Carbonized)
NA	Cress	Cress Seeds Found in 3% of Flotation Samples (0 Carbonized)
NA	Chokecherry	Chokecherry Seeds Found in 3% of Flotation Samples (0 Carbonized)
NA	Dodder	Dodder Seeds Found in 2% of Flotation Samples (0 Carbonized)
NA	Woodbine	Woodbine Seeds Found in 5% of Flotation Samples (Carbonized example(s) Found in 1 Sample)
NA	Sumac	Sumac Seeds Found in 3% of Flotation Samples (Carbonized example(s) Found in 2 Samples)
NA	Sumpweed	Sumpweed Seeds Found in 7% of Flotation Samples (Carbonized example(s) Found in 4 Samples)
NA	NA	Wood Carbon Found in 75% of Flotation Samples (Carbonized example(s) Found in 35 Samples)

		WHITBY BRANCH SITE, page 1 of 1
Berger & Associates, (Robert M. Jacoby, Charles H. LeeDecker, Richard J. Dent, and John C. Bedell). Excavation of the Whitby Branch Site (7NC-G-151) State Route 1 Corridor, Odessa Segment New Castle County, Delaware. 2001. www.deldot.gov/archaeology/whitby_branch... July 3, 2013.		
CARBONIZED ARCHAEOBOTANICALS		
JUGLANDACEAE	Walnut	Nut Fragments, Found in Features 3, 4, 5, 6, 7, 8, 11, 12, 13, 15, 16, 18, 19, 20, 21, and 22.
Carya	Hickory	Nut Fragments, Found in Features 3, 4, 5, 6, 7, 8, 11, 12, 13, 15, 16, 18, 19, 20, 21, and 22.
NA	NA	Seed, Unidentifiable. Found in Feature 11.
Chenopodium		Seed Found in Off-site Sample No. 4.
Quercus	Oak	Wood, Carbon
Carya	Hickory	Wood, Carbon
Fraxinus americana	White Ash	Wood, Carbon

WRANGLE HILL SITE, page 1 of 1

UDCAR, (Jay F. Custer, Douglass Kellogg, Barbara Hsiao Silber, and Robert Varisco).
Final Archaeological Investigations at the Wrangle Hill Prehistoric Site (7NC-G-105) State Route 1 Corridor, Chesapeake and Delaware Canal Section, New Castle County, Delaware. 1995.
www.deldot.gov/archaeology/wrangle_hill... July 7, 2013.

CARBONIZED ARCHAEOBOTANICALS FROM 16 FEATURES

Chenopodium album	Lamb's Quarter	
Tragia urens	Noseburn	
Portulaca oleracea	Purslane	European
Polygonatum commutatum	Solomon's Seal	
Euphorbia	Spurge	European
Crataegus	Possoin Haw	
Ruppia maritima	Widgeongrass	
Myrica pennsylvanica	Bayberry	
Viburnum	Viburnum	
Ambrosia	Ragweed	
Rhus radicans	Poison Ivy	
Descurainia pinnata manziesii	Tansy Mustard	
Scutellaria galericulata	Skullcap	
Panicum	Panicum	European
Gilia	Gilia	
Hibiscus palustris	Swamp Rose Mallow	
Rumex acetosella	Sheep Sorrel	European
Rhamnus	Buckthorn	
	Blue-eyed Grass	
Scirpus	Bulrush	
Linum	Flax	
NA	NA	Nut Fragments, 6 Unidentifiable

ADVENTIVE PLANTS in DELAWARE, WILLIAM A. MCAVOY, DELAWARE DIVISION of FISH & WILDLIFE, JULY, 2013

SCIENTIFIC NAME	COMMON NAME	FAMILY SCIENTIFIC NAME	LIFE FORM	DURATION	FLOWERING PERIOD	PHYSIOGRA. PROVINCE	HABITAT	NORTH AMERICAN DISTRIBUTION
Acer nigrum	black maple	Sapindaceae	Tree (deciduous)	Perennial	Spring	Piedmont	Cultivated and a rare escape from cultivation to disturbed ground	A northern and Midwestern species
Agastache foeniculum	blue giant-hyssop	Lamiaceae	Herb	Perennial	Summer-Fall	Piedmont	Rare escape to disturbed ground	Native to prairies and plains of the western U.S.
Amaranthus albus	white pigweed amaranth	Amaranthaceae	Herb	Annual	Summer	Piedmont-Coastal Plain	Disturbed areas, edges, fields, roadsides	Native to prairies and plains of the Midwest
Amaranthus blitoides	prostrate amaranth	Amaranthaceae	Herb	Annual	Summer	Piedmont	Rare introduction to disturbed areas	Native in the western states
Amaranthus palmeri	Palmer's amaranth	Amaranthaceae	Herb	Annual	Summer	Coastal Plain	A weed of agricultural fields and edges	Native to the Southwestern states
Amaranthus tuberculatus	tall amaranth	Amaranthaceae	Herb	Annual	Summer	Piedmont	Rare introduction on disturbed soils	Native in the Midwestern states
Ampelopsis cordata	raccoon grape	Vitaceae	Vine (woody)	Perennial	Summer	Coastal Plain	Cultivated and a rare escape to edges and thickets	A northern and western species
Amsonia tabernaemontana	blue-star	Apocynaceae	Herb	Perennial	Spring-Summer	Piedmont	Cultivated and occasionally escaping to disturbed areas	Native in the southern states
Artemisia biennis	biennial wormwood	Asteraceae	Herb	Annual	Summer-Fall	Piedmont-Coastal Plain	Rare introduction to disturbed areas	Native to the western portions of the U.S.
Artemisia ludoviciana	sagebrush wormwood	Asteraceae	Herb	Perennial	Summer-Fall	Piedmont-Coastal Plain	Disturbed areas, edges, fields, roadsides	Native in the western states and northern Mexico
Azolla caroliniana	Eastern mosquito-fern	Azollaceae	Fern (aquatic, free-floating)	Perennial	Summer	Piedmont-Coastal Plain	Floating on the waters surface, in mill ponds and farm ponds, impoundments, slow moving streams and rivers; primarily of the Coastal Plain, rare in the Piedmont	Native to the southeast, likely introduced through commercial crayfish farming
Bidens polylepis	tick-seed sunflower	Asteraceae	Herb	Annual	Summer-Fall	Piedmont-Coastal Plain	Marshes, wet meadows, depressions, ditches, fields	Native in the Midwestern states
Cabomba caroliniana	Carolina fanwort	Cabombaceae	Herb (aquatic, submersed)	Perennial	Summer	Coastal Plain	Ponds and quiet waters	Native in the Midwestern states
Calycanthus floridus var. *floridus*	hairy sweet-shrub	Calycanthaceae	Shrub (deciduous)	Perennial	Summer	Coastal Plain	Cultivated and occasionally escaping to natural areas	Native to the south
Calycanthus floridus var. *glaucus*	smooth sweet-shrub	Calycanthaceae	Shrub (deciduous)	Perennial	Summer	Piedmont	Cultivated and occasionally escaping to natural areas	Native to the south
Cardamine diphylla	pepper-root bittercress	Brassicaceae	Herb	Perennial	Spring	Piedmont	Intentionally planted to natural areas and persisting	Native to the eastern mountains, Quebec to North Carolina

Carex oklahomensis	Oklahoma sedge	Cyperaceae	Sedge	Perennial	Spring-Summer	Coastal Plain	Disturbed poorly drained soils, ditches	Native to southeast Missouri, west to Kansas, Oklahoma, northeast Texas, Arkansas, Louisiana
Carex shortiana	Short's sedge	Cyperaceae	Sedge	Perennial	Spring-Summer	Piedmont	Rare introduction in hay fields	Native from south-central and southwestern Pennsylvania to the Midwestern states
Carex texensis	sedge	Cyperaceae	Sedge	Perennial	Spring-Summer	Piedmont	Rare in meadows, edges, grassy areas	Native to the southeast and Midwest
Catalpa bignonioides	Southern catalpa	Bignoniaceae	Tree (deciduous)	Perennial	Summer	Piedmont-Coastal Plain	Cultivated and escaping to woodlands and edges	Native in the southern states
Cenchrus spinifex	field sandbur	Poaceae	Grass	Annual	Summer-Fall	Coastal Plain	Sandy roadsides and fields	Native in the southeastern states
Chaerophyllum tainturieri	Tainturier's chervil	Apiaceae	Herb	Annual	Spring	Coastal Plain	Infrequent on disturbed soils, road banks	Native to the southern states
Chloris verticillata	tumble windmill grass	Poaceae	Grass	Perennial	Summer-Fall	Coastal Plain	Infrequent in disturbed areas, edges, fields, roadsides	Native to the Midwestern states
Coreopsis lanceolata	lance-leaf coreopsis	Asteraceae	Herb	Perennial	Summer	Coastal Plain	Cultivated and occasionally escaping to roadsides and often seeded in meadows	Native in the western regions of the U.S.
Coreopsis tinctoria var. *tinctoria*	golden tickseed	Asteraceae	Herb	Annual	Summer	Piedmont-Coastal Plain	Cultivated and occasionally escaping to disturbed areas	Native to the central and southern Great Plains
Crataegus phaenopyrum	Washington hawthorn	Rosaceae	Tree (deciduous)	Perennial	Spring	Piedmont	Fields, edges, thin canopy woods	A species with a southern distribution, naturalized and cultivated northward
Croton capitatus	woolly croton	Euphorbiaceae	Herb	Annual	Summer	Coastal Plain	Rare on disturbed soils	Native farther west of Delaware
Croton texensis	Texas croton	Euphorbiaceae	Herb	Annual	Summer	Coastal Plain	Rare introduction on disturbed ground	Native in the mid and southwestern states
Cynanchum laeve	sandvine	Apocynaceae	Vine (herbaceous)	Perennial	Summer	Piedmont-Coastal Plain	Fields, edges, early successional habitats	Native to the southern states
Cyperus compressus	poorland flatsedge	Cyperaceae	Sedge	Annual	Summer	Coastal Plain	Disturbed soils	Native to the southeast and Tropical America
Cyrilla racemiflora	swamp cyrilla	Cyrillaceae	Shrub (evergreen)	Perennial	Summer	Coastal Plain	Intentionally planted to natural areas and persisting	A southeastern species, north to Virginia
Cystopteris tennesseensis	Tennessee bladderfern	Woodsiaceae	Fern	Perennial	Summer	Piedmont	Rare on limestone masonry of stone walls	Native to the western states on calcareous substrates
Datura stramonium	jimsonweed	Solanaceae	Herb	Annual	Summer	Piedmont-Coastal Plain	Disturbed areas, fields, roadsides	Introduced from farther west of Delaware
Dracocephalum parviflorum	American dragonhead	Lamiaceae	Herb	Annual	Summer	Piedmont	Cultivated and a rare escape to disturbed areas	Native in Canada to Alaska and south to New Jersey

Eragrostis mexicana	Mexican lovegrass	Poaceae	Grass	Annual	Summer-Fall	Piedmont	Disturbed areas, edges, fields, roadsides	Native to western North America and Mexico
Eryngium prostratum	prostrate eryngo	Apiaceae	Herb	Perennial	Summer	Coastal Plain	Moist swales, depressions, sandpits	Native from Florida to southeast Virginia
Eschscholzia californica	California poppy	Papaveraceae	Herb	Annual	Summer	Coastal Plain	Rare garden escape to disturbed ground	Native to western North America
Euphorbia hexagona	six-angle spurge	Euphorbiaceae	Herb	Annual	Summer	Piedmont	Rare introduction on disturbed soils	Native in the western states
Froelichia floridana	Florida cottonweed	Amaranthaceae	Herb	Annual	Summer	Coastal Plain	Dry sandy soils, roadsides, power-lines, fields, edges	Native to the southeast
Froelichia gracilis	slender cottonweed	Amaranthaceae	Herb	Annual	Summer	Coastal Plain	Dry sandy soils, roadsides, power-lines, fields, edges	Native in the Midwestern states
Gaillardia pulchella var. *pulchella*	fire-wheel blanket-flower	Asteraceae	Herb	Annual	Summer	Coastal Plain	Cultivated and occasionally escaping to roadsides	Native in the west and along the coast to Virginia
Geranium robertianum	Robert's crane's-bill	Geraniaceae	Herb	Annual	Spring	Piedmont	Occasional garden escape to moist rich woods	Distributed more to the north in Piedmont and Mountain provinces
Geum vernum	spring avens	Rosaceae	Herb	Perennial	Spring	Piedmont	Moist woods and clearings	Adventive from the west
Gleditsia triacanthos	honey-locust	Fabaceae	Tree (deciduous)	Perennial	Spring-Summer	Piedmont-Coastal Plain	Cultivated and occasionally escaping to woodlands	Native to the central U.S.
Grindelia squarrosa var. *squarrosa*	broadleaf gumweed	Asteraceae	Herb	Biennial	Summer-Fall	Coastal Plain	Cultivated and occasionally escaping to disturbed areas	Native in the Midwestern states
Helianthus annuus	domesticated sunflower	Asteraceae	Herb	Annual	Summer-Fall	Piedmont-Coastal Plain	Cultivated and occasionally escaping to disturbed areas	Native to the western plains
Helianthus grosseserratus	sawtooth sunflower	Asteraceae	Herb	Perennial	Summer-Fall	Piedmont-Coastal Plain	Rare along roadsides and in fields	Native of the western prairies
Helianthus tuberosus	Jerusalem artichoke	Asteraceae	Herb	Perennial	Fall	Piedmont-Coastal Plain	Roadsides, fields	Native to the Midwest, cultivated in the east
Heliotropium curassavicum	seaside heliotrope	Heliotropaceae	Herb	Perennial	Spring-Summer	Coastal Plain	Rare introduction to coastal sands	Native to Tropical America and the southeastern U.S.
Hordeum brachyantherum subsp. *brachyantherum*	meadow barley	Poaceae	Grass	Perennial	Spring-Summer	Coastal Plain	Rare introduction to disturbed areas	Native to the western states
Hordeum jubatum	foxtail barley	Poaceae	Grass	Perennial	Spring-Summer	Piedmont-Coastal Plain	Disturbed areas, edges, fields, roadsides, salt meadows	Native to the western states
Houstonia pusilla	tiny bluet	Rubiaceae	Herb	Annual	Spring	Coastal Plain	Roadside banks and mossy lawns	Native from Virginia south and in the Midwest
Ipomopsis rubra	red standing-cypress	Polemoniaceae	Herb	Biennial	Summer	Coastal Plain	Cultivated and a rare escape to disturbed areas	Native to the southeastern U.S., north to North Carolina

Juncus brachycarpus	short-fruited rush	Juncaceae	Rush	Perennial	Summer	Coastal Plain	Roadside drainage ditches	Native of the southeastern and Midwestern states
Juncus diffusissimus	diffuse rush	Juncaceae	Rush	Perennial	Summer	Coastal Plain	Rare on disturbed ground and in ditches	Native in the south-central states
Juncus scirpoides var. *compositus*	lobulate round-head rush	Juncaceae	Rush	Perennial	Summer	Coastal Plain	Roadside drainage ditches	Native to the southeastern Coastal Plain
Juncus torreyi	Torrey's rush	Juncaceae	Rush	Perennial	Summer	Coastal Plain	Disturbed poorly drained soils, ditches and roadsides	Its native distribution is primarily western in North America
Juncus validus var. *validus*	vigorous rush	Juncaceae	Rush	Perennial	Summer	Coastal Plain	Roadside drainage ditches	Native from North Carolina to Florida, west to Texas
Juniperus communis	ground juniper	Cupressaceae	Shrub (evergreen, needle-leaf)	Perennial	Spring	Piedmont	Cultivated and a rare escape to disturbed areas	In North America, this specie is primarily northern and in the mountains
Justicia americana	American water-willow	Acanthaceae	Herb	Perennial	Summer	Coastal Plain	A waif along the banks of the C & D Canal	Native to the eastern shore of Maryland in tidal systems, but historical from artificial habitat (C&D Canal) in Delaware
Koeleria macrantha	prairie Junegrass	Poaceae	Grass	Perennial	Spring-Summer	Piedmont	Rare introduction to fields	Native in the western U.S.
Lepidium densiflorum	dense-flower pepper-grass	Brassicaceae	Herb	Annual	Spring-Summer	Piedmont-Coastal Plain	Disturbed areas, edges, fields, roadsides	Native farther west of Delaware
Leucothoe axillaris	coastal doghobble	Ericaceae	Shrub (evergreen)	Perennial	Spring	Coastal Plain	Cultivated and escaping to moist woods	Native from Florida to southeast Virginia
Liatris cylindracea	slender blazingstar	Asteraceae	Herb	Perennial	Summer-Fall	Coastal Plain	Cultivated and a rare escape to disturbed areas	Native more to the west of Delaware, often on calcareous soils
Ludwigia leptocarpa	water-willow seedbox	Onagraceae	Herb	Annual	Summer-Fall	Coastal Plain	Waterfowl impoundments	Native in the southern states and Tropical America
Ludwigia peploides subsp. *glabrescens*	floating seedbox	Onagraceae	Herb	Perennial	Summer-Fall	Piedmont-Coastal Plain	Ponds, slow shallow streams, impoundments, ditches	Native to the Midwest and Texas, north to the Carolina's
Maclura pomifera	osage orange	Moraceae	Tree (deciduous)	Perennial	Spring	Piedmont-Coastal Plain	Hedge rows	Native to Arkansas, Oklahoma and Texas, planted in the east
Magnolia tripetala	umbrella tree	Magnoliaceae	Tree (deciduous)	Perennial	Spring	Piedmont	Cultivated and escaping to woodland edges and canopy gaps	Native in the southern states
Mahonia repens	creeping hollygrape	Berberidaceae	Shrub (evergreen)	Perennial	Spring-Summer	Piedmont	A rare escape from cultivation to natural areas	Native to the western U.S.
Matricaria discoidea	pineapple-weed	Asteraceae	Herb	Annual	Summer	Piedmont-Coastal Plain	Disturbed areas, roadsides	Native to western North America

Matteuccia struthiopteris var. *pensylvanica*	ostrich fern	Onocleaceae	Fern	Perennial	Summer	Piedmont	A rare escape from cultivation to natural areas	Native much farther north and west of Delaware, but native south in the mountains to Virginia
Melothria pendula var. *pendula*	creeping cucumber	Cucurbitaceae	Vine (herbaceous)	Perennial	Spring-Summer	Coastal Plain	Disturbed areas	Native to the southern U.S.
Mirabilis nyctaginea	heart-leaved umbrella-wort	Nyctaginaceae	Herb	Perennial	Spring-Summer	Piedmont-Coastal Plain	Disturbed areas, edges and roadsides	Native in the Midwestern states
Modiola caroliniana	bristly-fruited mallow	Malvaceae	Herb	Annual	Summer	Coastal Plain	Rare introduction on disturbed ground	Native to Tropical America north to South Carolina
Monarda didyma	Oswego-tea beebalm	Lamiaceae	Herb	Perennial	Summer	Piedmont	Cultivated and a rare escape to disturbed areas	Native farther north and south of Delaware in the mountains
Myosurus minimus	Eastern mousetail	Ranunculaceae	Herb	Annual	Spring	Coastal Plain	Rare introduction in wet ditches	Native in the western states
Parietaria floridana	Florida pellitory	Urticaceae	Herb	Annual	Summer	Piedmont	Rare introduction in city sidewalk cracks, likely not persisting	Native in the southeast, west to Texas
Parthenium hysterophorus	Santa Maria feverfew	Asteraceae	Herb	Annual	Summer-Fall	Coastal Plain	Rare occurrence on waste ground	Native to Tropical America and the southeastern U.S.
Paspalum pubiflorum var. *glabrum*	hairyseed paspalum	Poaceae	Grass	Perennial	Summer-Fall	Piedmont	Roadsides	Native in the Midwestern states
Passiflora incarnata	purple passion-flower	Passifloraceae	Vine (herbaceous)	Perennial	Summer	Coastal Plain	Cultivated and infrequently escaping to roadsides, clearings and thickets	Native in the south, north to southeast Virginia
Pellaea atropurpurea	purple-stem cliff-brake	Pteridaceae	Fern	Perennial	Summer	Piedmont	Crevices of stone walls with limestone masonry	A species of limestone outcrops and other calcareous rock; with us on artificial substrates containing limestone
Phalaris arundinacea	reed canary grass	Poaceae	Grass	Perennial	Spring-Summer	Piedmont-Coastal Plain	Fresh and brackish, tidal and non-tidal marshes and streams	Native to the northwest
Phlox divaricata var. *divaricata*	blue phlox	Polemoniaceae	Herb	Perennial	Spring	Piedmont	Cultivated and escaping to roadsides and edges	Native in the eastern U.S., but only introduced populations are known in Delaware
Phlox paniculata	fall phlox	Polemoniaceae	Herb	Perennial	Spring	Piedmont-Coastal Plain	Cultivated and escaping to roadsides and edges	Native in the eastern U.S., but only introduced populations are known in Delaware
Physalis angulata var. *angulata*	cutleaf ground-cherry	Solanaceae	Herb	Annual	Summer	Coastal Plain	Uncommon on disturbed sandy soils	Adventive from the south
Physostegia virginiana subsp. *virginiana*	false dragonhead	Lamiaceae	Herb	Perennial	Summer-Fall	Piedmont-Coastal Plain	Cultivated and occasionally escaping to poorly drained disturbed areas	Native farther north, west and south of Delaware, rarely near the coast

Picea rubens	red spruce	Pinaceae	Tree (evergreen, needle-leaf)	Perennial	Spring	Piedmont-Coastal Plain	Cultivated and often planted in natural areas and persisting, also found around old home sites	Native in Canada and New England, south in the mountains to North Carolina
Pieris floribunda	evergreen mountain fetterbush	Ericaceae	Shrub (evergreen)	Perennial	Spring	Coastal Plain	Cultivated and a rare escape to woodland edges	A southern Appalachian Mountain endemic
Pinus strobus	Eastern white pine	Pinaceae	Tree (evergreen, needle-leaf)	Perennial	Spring	Piedmont-Coastal Plain	Cultivated and occasionally escapes to woodlands	Native to the north and south in the Mountains
Planodes virginicum	Virginia-cress	Brassicaceae	Herb	Annual	Spring	Coastal Plain	Rare along edges and roadsides	Native farther south
Plantago aristata	large-bract plantain	Plantaginaceae	Herb	Annual	Summer	Coastal Plain	Disturbed sand soils and dunes	Native farther west of Delaware
Plantago heterophylla	slender plantain	Plantaginaceae	Herb	Annual	Summer	Coastal Plain	Rare introduction on disturbed ground	Native in the southeast, north to Virginia
Plantago pusilla	dwarf plantain	Plantaginaceae	Herb	Annual	Summer	Piedmont-Coastal Plain	Fields and roadsides	Native in the western states
Poa chapmaniana	Chapman's bluegrass	Poaceae	Grass	Annual	Spring-Summer	Coastal Plain	Rare introduction on open sandy soils	Native to the central Great Plains
Poa palustris	fowl bluegrass	Poaceae	Grass	Perennial	Spring-Summer	Piedmont-Coastal Plain	Wet meadows, thickets, fields, lawns, disturbed soils	Native to the northern climates of North America and Eurasia
Populus balsamifera	balsam cottonwood	Salicaceae	Tree (deciduous)	Perennial	Spring	Piedmont	Cultivated and rarely escaping to disturbed areas	A species native to the northern latitudes, Maine to Alaska
Populus deltoides var. *deltoides*	Eastern cottonwood	Salicaceae	Tree (deciduous)	Perennial	Spring	Piedmont-Coastal Plain	Cultivated as an ornamental and occasionally escaping to natural areas	A northern and western species, generally west of the mountains
Populus tremuloides	quaking aspen cottonwood	Salicaceae	Tree (deciduous)	Perennial	Spring	Piedmont	Cultivated and a rare escape to disturbed areas	A northern species and irregularly south to New Jersey and Virginia
Prunus angustifolia var. *angustifolia*	Chickasaw plum	Rosaceae	Shrub (deciduous)	Perennial	Spring	Piedmont-Coastal Plain	Sandy soils, open woods, thickets, around old home sites	Native in the south, planted and escaping in Delaware
Ptelea trifoliata	hoptree	Rutaceae	Shrub (deciduous)	Perennial	Spring-Summer	Piedmont	Cultivated and occasionally escaping to thickets and edges	Native to the west and south
Quercus imbricaria	shingle oak	Fagaceae	Tree (deciduous)	Perennial	Spring	Piedmont	Cultivated and escaping to fields	Native in the Piedmont and Mountains from Pennsylvania south, planted and escaping in Delaware
Quercus macrocarpa	bur oak	Fagaceae	Tree (deciduous)	Perennial	Spring	Piedmont	Cultivated and escaping to fields	Native in Canada and south to Virginia, planted and escaping in Delaware
Ratibida columnifera	columnar prairie coneflower	Asteraceae	Herb	Perennial	Summer	Piedmont	Rare escape to roadsides	Native to the Midwestern prairies

Rhododendron maximum	great rhododendron	Ericaceae	Shrub (evergreen)	Perennial	Spring-Summer	Piedmont-Coastal Plain	Planted and escaped from cultivation to moist woodlands of the Piedmont	Native in the mountains from Nova Scotia to Georgia
Rhynchospora inexpansa	nodding beakrush	Cyperaceae	Sedge	Perennial	Summer	Coastal Plain	Power-line swales and wet roadsides and ditches	Native to the southeastern Coastal Plain
Robinia hispida var. *hispida*	bristly locust	Fabaceae	Tree (deciduous)	Perennial	Spring-Summer	Piedmont-Coastal Plain	Cultivated and escaping to edges and thickets	Native in the mountains from Virginia south
Robinia pseudoacacia	black locust	Fabaceae	Tree (deciduous)	Perennial	Spring-Summer	Piedmont-Coastal Plain	Fields, roadsides, edges, often planted	Native in the mountains from Maryland south, extending west to Oklahoma
Rorippa palustris var. *hispida*	hairy bog yellowcress	Brassicaceae	Herb	Annual	Summer	Piedmont-Coastal Plain	Poorly drained disturbed soils	Native more to the north of Delaware
Rorippa palustris var. *palustris*	bog yellowcress	Brassicaceae	Herb	Annual	Summer	Piedmont-Coastal Plain	Poorly drained disturbed soils	Native more to the north of Delaware
Rosa setigera	prairie rose	Rosaceae	Shrub (deciduous)	Perennial	Summer	Coastal Plain	Meadows, fields, thickets, edges	Native to the Midwest and south
Rudbeckia fulgida var. *speciosa*	orange coneflower	Asteraceae	Herb	Perennial	Summer-Fall	Coastal Plain	Open woodlands	Native to the Midwestern states
Rudbeckia hirta var. *pulcherrima*	black-eyed-Susan	Asteraceae	Herb	Perennial	Summer	Piedmont-Coastal Plain	Fields, roadsides and edges	Native to the Midwest
Rudbeckia triloba	brown-eyed Susan	Asteraceae	Herb	Perennial	Summer-Fall	Piedmont-Coastal Plain	Cultivated and escaping to meadows and fields	Native more to the north of Delaware, frequently planted and escaping in the state
Silphium perfoliatum	cup-plant	Asteraceae	Herb	Perennial	Summer-Fall	Coastal Plain	Cultivated and escaping to disturbed areas	Native to the Midwest and the southern states
Solanum carolinense var. *carolinense*	Carolina nightshade	Solanaceae	Herb	Perennial	Summer	Piedmont-Coastal Plain	Disturbed areas, edges, fields, roadsides	Native to the southeast, north to Virginia
Solanum citrullifolium	watermelon nightshade	Solanaceae	Herb	Annual	Summer	Piedmont	Rare introduction on disturbed ground	Adventive from the central U.S.
Solanum rostratum	buffalo bur nightshade	Solanaceae	Herb	Annual	Summer	Piedmont	Rare introduction on disturbed ground	Native to western North America
Stellaria corei	Tennessee starwort	Caryophyllaceae	Herb	Perennial	Spring-Summer	Piedmont	Rare garden escape to rich wooded slopes	Native in high to moderate elevations in the north and south
Stylophorum diphyllum	celandine poppy	Papaveraceae	Herb	Perennial	Summer	Piedmont	Cultivated and occasionally escaping to disturbed areas	A species native to the Midwestern and southern states
Symphoricarpos albus var. *laevigatus*	white coral-berry	Caprifoliaceae	Shrub (deciduous)	Perennial	Summer	Piedmont	Cultivated and escaping to meadows and fields	Native to the western U.S.
Symphoricarpos orbiculatus	coral-berry	Caprifoliaceae	Shrub (deciduous)	Perennial	Summer	Piedmont-Coastal Plain	Cultivated and escaping to thickets, edges and meadows	Native from Connecticut to North Carolina and west, escaping from cultivation in Delaware

Taxodium ascendens	pond cypress	Cupressaceae	Tree (deciduous, needle-leaf)	Perennial	Spring	Coastal Plain	Intentionally planted to natural areas and persisting	Native to the southeastern Coastal Plain to North Carolina
Tradescantia ohiensis	Ohio spiderwort	Commelinaceae	Herb	Perennial	Spring	Coastal Plain	Cultivated and a rare escape to disturbed areas	Most common in the Midwest
Trifolium carolinianum	Carolina clover	Fabaceae	Herb	Annual	Summer	Coastal Plain	Rare on dry, open sandy soils	Native to the southeastern and south-central U.S.
Trillium grandiflorum	great white trillium	Trilliaceae	Herb	Perennial	Spring	Piedmont	Cultivated and escaping to rich woodlands of the Brandywine Valley	Native in the Mountains and Piedmont to the north and south
Tripsacum dactyloides var. *dactyloides*	gamagrass	Poaceae	Grass	Perennial	Summer-Fall	Coastal Plain	Brackish ditches and wet roadsides	A wetland plant native to the Great Plains of the Midwest
Uniola paniculata	sea oats	Poaceae	Grass	Perennial	Summer-Fall	Coastal Plain	Intentionally planted on coastal dunes and persisting	Native to the southeastern Coastal Plain
Urochloa texana	Texas signalgrass	Poaceae	Grass	Annual	Summer	Coastal Plain	A weed of agricultural fields and edges	Native to Texas
Verbena stricta	hoary vervain	Verbenaceae	Herb	Perennial	Summer	Piedmont-Coastal Plain	Disturbed areas, edges, fields, roadsides	Native to the Midwestern prairies
Wisteria frutescens	American wisteria	Fabaceae	Vine (woody)	Perennial	Spring	Coastal Plain	Cultivated and occasionally escaping to open woods and thickets, occasionally found around abandoned home sites and gardens	Native from Florida, north to Virginia

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A TREE CIRCLE CLUSTER IN LEWES, DELAWARE: SYCAMOREHENGE?

Glen Mellin and Lenny Truitt
September 2013

ABOUT THE SITE

In August 2013, Tim Mancl (John Milner and Associates), alerted us to the presence of a circular arrangement of large, living Sycamore trees near the town of Lewes, Delaware. The cluster is currently protected in a vestige woodlot in an active agricultural field about four hundred feet east of the Theodore C. Freeman Highway and about four hundred feet south of the abandoned Breakwater railroad track. This location appears near the southeastern corner of the USGS Lewes quadrangle (see location map).

The woodlot appears as a roundish, forested area, about three hundred feet in diameter, perched on a slight knoll in an active agricultural field. In alphabetical order, Red Mulberry, *Morus rubra*, Sycamore, *Platanus* sp., and Wild Black Cherry, *Prunus serotina*, make up the mature tree species in the woodlot. Of the larger trees; Black Cherries in excess of fifty centimeters in diameter, and Sycamores in excess of sixty centimeters in diameter—measured chest high. We found no dead trees with larger girth than the living. Assuming the trees got their start in the pre-existing agricultural field, with non-restricted sunlight, we estimate the age of these trees to be at least eighty years old, or around the timeframe of the beginning of the Great Depression.

THE SYCAMORE CLUSTER

We identified and GPS mapped a cluster of twenty-four Sycamore trees (see cluster detail map). Be advised our GPS mapping unit, a Garmin Etrex 10 handheld unit, typically has a potential error of one to three meters. Therefore, any individual tree may be mis-located by up to three meters, or about one quarter of an inch on our detailed cluster map. The trees that are present appear to be the remains of an inner circular and an outer circular ring of trees. There are treeless spaces, where no trees exist, that would necessarily be filled in order to facilitate complete inner and outer circles. However, there is no evidence of dead trees where these suggested gaps exist. This means that any trees that may have once been in the gaps did not die recently.

SYCAMORE

From a distance, the Sycamore, *Platanus occidentalis*, native to Delaware, and *P. orientalis* (aka. London plane) may be difficult to distinguish. The native tree, however, is noticeably susceptible to attacks of a defoliating cankering fungus where the Asian variety is less susceptible. The native tree typically exhibits one, sometimes two seed balls, and the Asian variety typically exhibits two, sometimes three seed balls. Both species are widely planted in Delaware for ornament and shade. During the Great Depression, government programs supported the nursery growth of Sycamore and the Civilian Conservation Corps frequently planted these trees along highways and in other public spaces. Sycamore is intolerant of shade, and when planted, large open spaces are usually selected to accommodate this large, attractive, and quick growing tree.

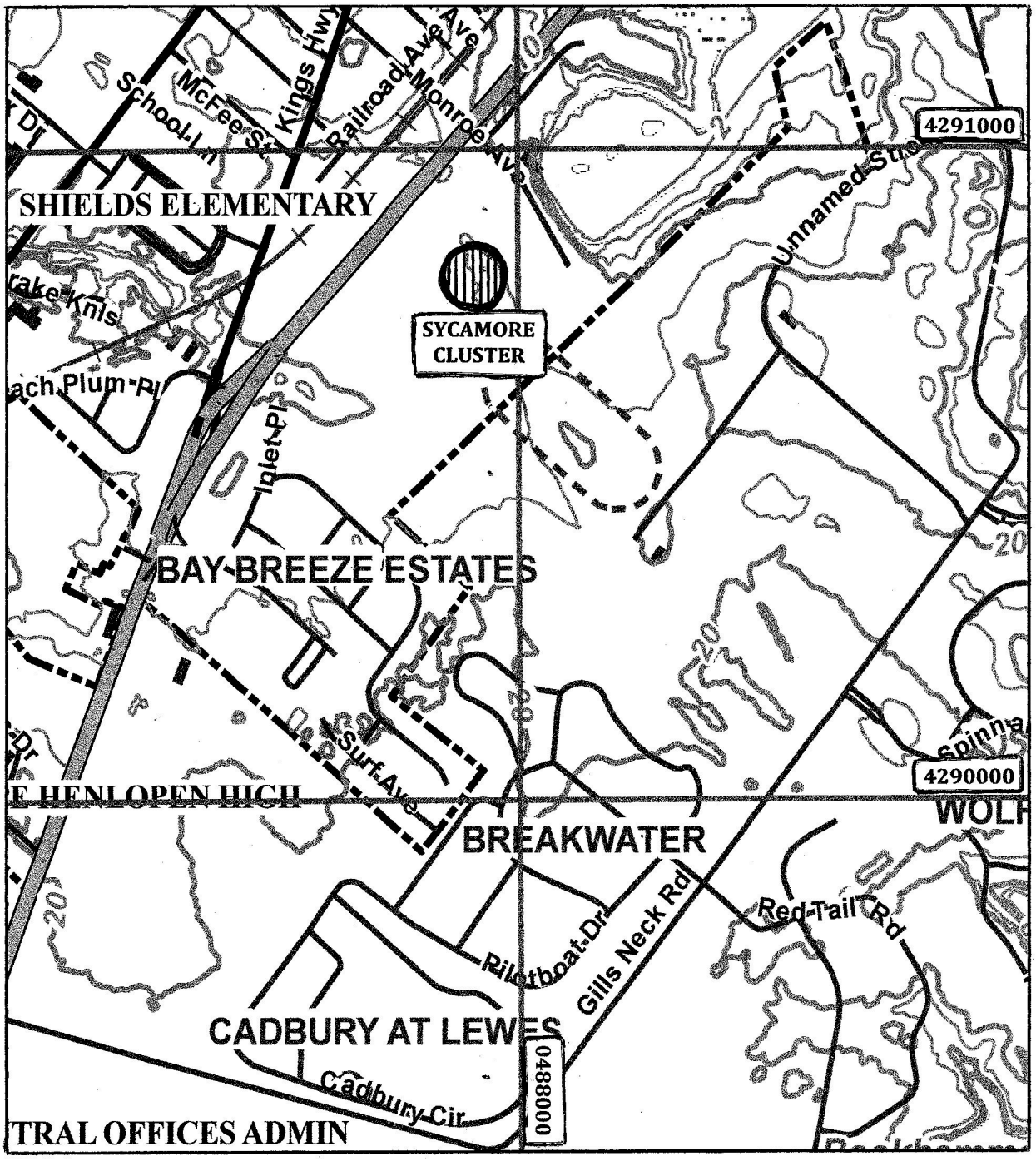
INTERPRETATIONS

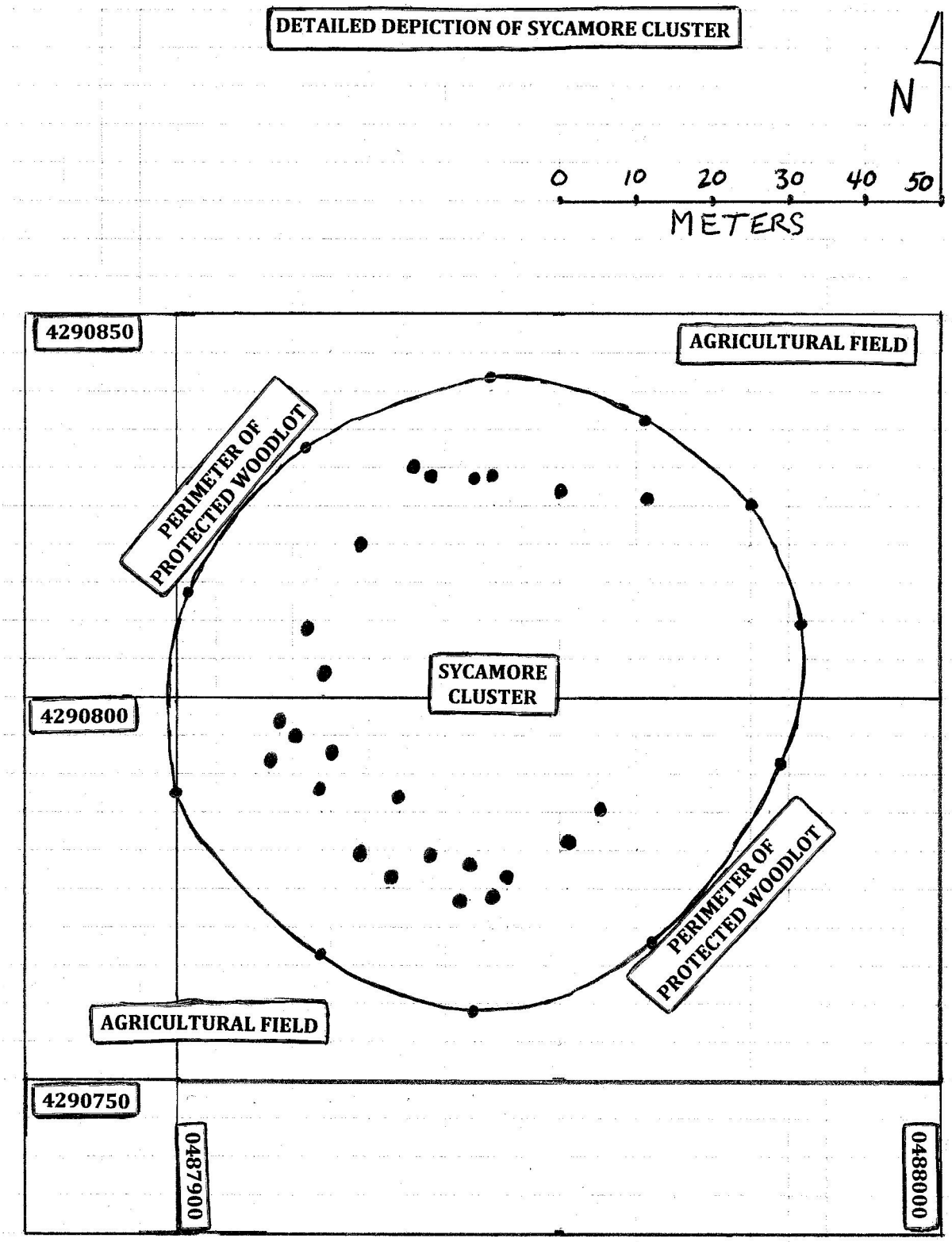
We have twenty-four large Sycamore trees that appear to be about eighty years old. Today, these trees form semi-circular portions of imagined inner and outer circles. What is, or was, going on here?

1) What is real is that a person, or people, planted an undetermined quantity of Sycamore trees at this location approximately eighty years ago. These trees, forming a cluster, were appreciated to the extent that over the ensuing years they have been protected in a woodlot, isolated from the surrounding agricultural activities. What do the remaining twenty-four trees represent: were other trees removed from a nursery to form the suggested circular cluster, or did someone intend for them to appear as two circles, one within another, thus forming an art object, like a "Sycamorehenge"?

2) Sycamore was a much-loved genus in the first quarter of the twentieth century. They were very popular in commercial tree nurseries. Religious organizations planted them on their properties and elsewhere, especially as religious revival and/or religious retreat curricula. During the Great Depression, growing, distributing, and transplanting Sycamore trees was one of the Civilian Conservation Corps most beloved projects. These possible explanations would fit into Recreational, or Ceremonial, or Religious contexts.

HISTORIC SYCAMORE CLUSTER IN LEWES, DELAWARE
PORTION OF LEWES QUADRANGLE
SEPTEMBER 6, 2013.




DETAILED DEPICTION OF SYCAMORE CLUSTER
N
0 10 20 30 40 50
METERS
4290850
AGRICULTURAL FIELD
PERIMETER OF PROTECTED WOODLOT
SYCAMORE CLUSTER
4290800
PERIMETER OF PROTECTED WOODLOT
AGRICULTURAL FIELD
4290750
0487900
0488000

DATA LOG FOR SYCAMORE CLUSTER, September 6, 2013

GPS UTM 18S DATUM		DESCRIPTION
E0487961	S4290826	Living Sycamore Tree
E0487950	S4290827	Living Sycamore Tree
E0487942	S4290829	Living Sycamore Tree
E0487939	S4290828	Living Sycamore Tree
E0487933	S4290829	Living Sycamore Tree
E0487931	S4290830	Living Sycamore Tree
E0487924	S4290820	Living Sycamore Tree
E0487917	S4290808	Living Sycamore Tree
E0487919	S4290803	Living Sycamore Tree
E0487913	S4290796	Living Sycamore Tree
E0487915	S4290795	Living Sycamore Tree
E0487912	S4290791	Living Sycamore Tree
E0487920	S4290793	Living Sycamore Tree
E0487918	S4290788	Living Sycamore Tree
E0487929	S4290786	Living Sycamore Tree
E0487924	S4290779	Living Sycamore Tree
E0487927	S4290776	Living Sycamore Tree
E0487933	S4290779	Living Sycamore Tree
E0487936	S4290773	Living Sycamore Tree
E0487938	S4290777	Living Sycamore Tree
E0487941	S4290774	Living Sycamore Tree
E0487943	S4290776	Living Sycamore Tree
E0487951	S4290781	Living Sycamore Tree
E0487955	S4290785	Living Sycamore Tree
E0487975	S4290825	Perimeter Point of Preserved Woodlot
E0487981	S4290809	Perimeter Point of Preserved Woodlot
E0487978	S4290791	Perimeter Point of Preserved Woodlot
E0487962	S4290767	Perimeter Point of Preserved Woodlot
E0487938	S4290759	Perimeter Point of Preserved Woodlot
E0487918	S4290766	Perimeter Point of Preserved Woodlot
E0487900	S4290787	Perimeter Point of Preserved Woodlot
E0487902	S4290814	Perimeter Point of Preserved Woodlot
E0487917	S4290833	Perimeter Point of Preserved Woodlot
E0487941	S4290842	Perimeter Point of Preserved Woodlot
E0487961	S4290836	Perimeter Point of Preserved Woodlot

HELL ISLAND BOTANICAL SURVEY

Glen Mellin and Lenny Truitt
September 2013

ABOUT HELL ISLAND

Hell Island contains approximately thirty acres of forested upland. It is noted for being the only substantial island located in the brackish, tidal region of the Appoquinimink River west of State Routes 1 and 13. As the Appoquinimink River flows east, it merges with Drawers Creek east of Odessa, Delaware. As these waters continue, they meander through extensive tidal marshes scared by myriad remnant outflows into the upper Delaware Bay.

The geography surrounding the island is characterized as slightly rolling mostly eroded hilltops, with some deeply incised valleys, and sometimes gorge-like smaller stream confluences. These characteristics are typical for these surface soils in Delaware's Upper Coastal Plain. The island itself, exhibits steep shoreline slopes tapering to a less elevated northeastern tip where the island offers a suitable boat-landing location.

FIELD NARRATIVE

On a late fall day, John and Sue Ferenbach, of Odessa, DE. escorted us to Hell Island aboard their motorized workboat. We landed and tied up at the northeastern tip of the island, a location of former, extensive archaeological excavations, which lead to initial, yet evolving descriptions of the Hell Island Ceramic Series (liberally ca.500ce to 1000ce.). We surveyed the entire island. The northeastern tip of the island exhibited a dense cluster of low, bushy evergreens, specifically Rhododendrons (*Rhododendron spp*.) and Mountain Laurel (*Kalmia latifolia*). This bushy botanical cluster covered the northern portion of the known Native American site on the island (c.p. E0442220 S4365750), yet examples of these species are occasionally and sparingly noted at various locations on the island. The mast species on the island are overwhelmingly dominated by deciduous Beech (*Fagus grandifolia*), Yellow Poplar (*Liriodendron tulipifera*), and to a lesser degree various oaks (*Quercus spp*.), being entirely consistent with this geographic location.

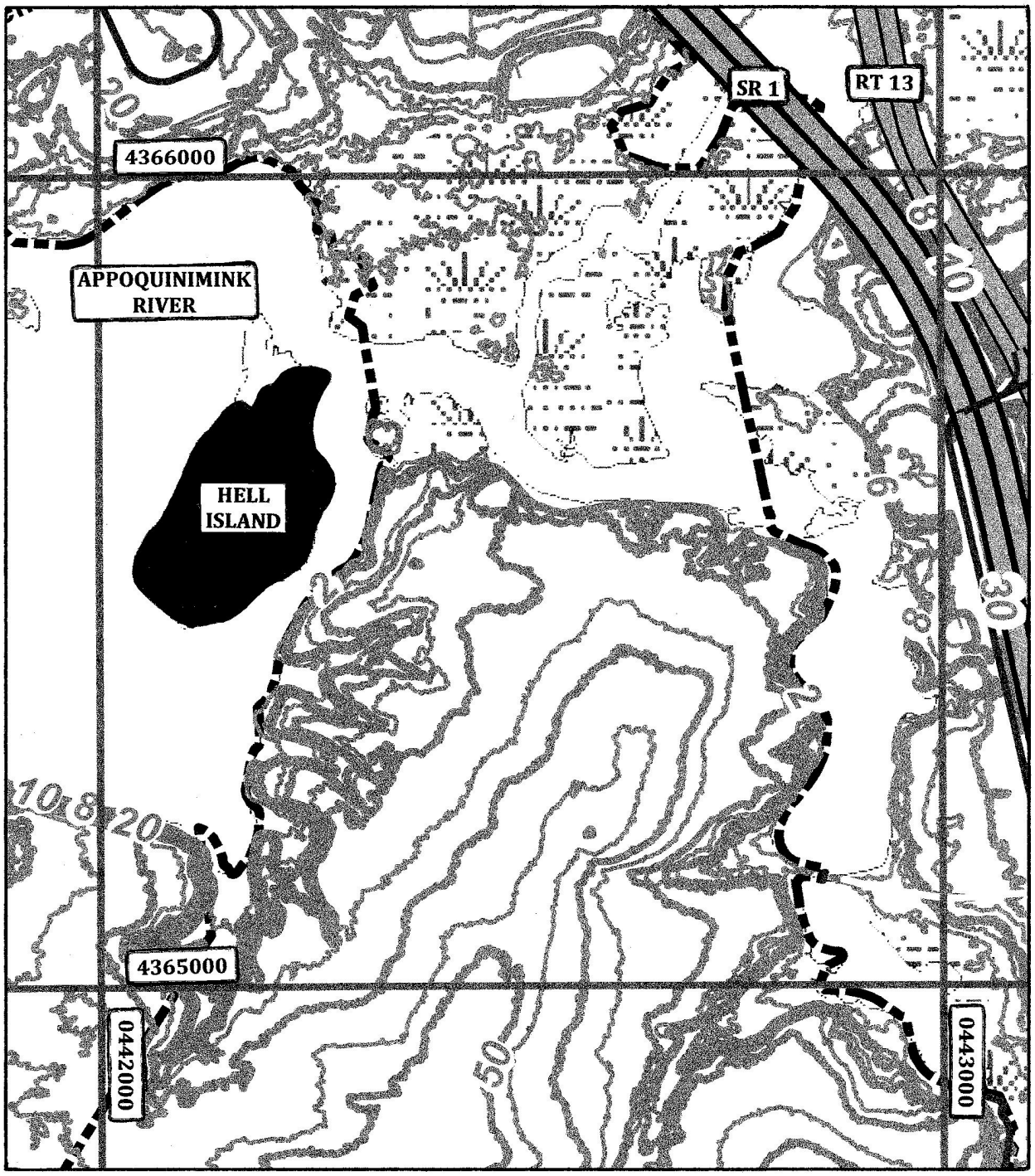
INTERPRETATION

Our geologic assessment is that all elevated portions of the island, including the steep slopes, exhibit extensive weathering. Columbia Series sub-soils are likely at or very near the surface over the vast majority of the island. However, the approximately three-acre portion leading to the northeastern tip of the island—including a portion of the area of previous archaeological excavations, and where the cluster of evergreen shrubbery is found, likely retain a more fertile and deeper soil development. It is possible, if not likely, we have a situation of net soil loss and soil gain—deflating soil profiles at this location are gradually replaced with soils from further up the slope, offering the impression of net soil stability.

Such locations, offering both soil fertility and stability at accessible locations, are viewed as incentive factors, or beneficial natural elements, which typically attract human curiosity. Human activities at such locations are likely to enhance the existing beneficial biota, and also introduce other beneficial biota that were naturally lacking at the location. We view the cluster of various Rhododendrons and the Mountain Laurel identified on Hell Island as perfect examples. These plants, we believe, are presently growing in the ancestral Native American activity area on the island. We consider this botanical cluster to be a candidate worthy of consideration because its position in time and space is likely due to ancestral Native American activities.

It is difficult to determine what interests Native Americans may have had in supporting this cluster of plants. However, these plants do have documented uses that would be considered beneficial from a Native American worldview. The Rhododendrons and Mountain Laurels are reported to be toxic. Ingestion can cause convulsion and coma. Nevertheless, documentation shows very small doses have been ingested to treat fevers and heart conditions. Native Americans are known to have boiled the leaves of these plants into a tea, which was applied topically to relieve muscle pain, headaches, rheumatism, and insect bites. Mountain Laurel is a preferred species for fashioning durable wooden handles, shafts, batons, and smoking pipes.

HELL ISLAND BOTANICAL SURVEY
MIDDLETOWN, DE. QUADRANGLE



LUMS POND BOTANICAL SURVEY

Glen Mellin and Lenny Truitt
September 2013

ABOUT LUMS POND

Lums Pond State Park is a one thousand, seven hundred and ninety acre consolidation of former farms, wooded uplands, stream systems, and bay-basins. Today, the centerpiece feature is the two hundred acre water impoundment, or freshwater pond. The State Park was dedicated in 1963 and it has a Bear, Delaware postal address.

According to the www.destateparks.com/park/lums-pond website, "Before the pond existed, St. Georges Creek flowed through the hardwood forest and was the site of several Native American hunting camps. The creek was dammed in the early 1800's when the C & D canal was built. Water from the pond was used to fill the locks of the canal and power a small mill."

Lums Pond State Park abuts the northern berm of the present day C & D canal. It also abuts the east side of the State Route 896/71 highway north of Summit Bridge, a four-lane steel arched bridge over the canal. Legend has it that Summit Bridge and the decayed village of Summit is situated on the east/west peninsula divide. Thus, land west of Summit drains into the upper Chesapeake Bay and land east of Summit drains into the upper Delaware Bay. At any rate, the Lums Pond area may be referred to as a poorly drained upland in the mid-peninsular drainage divide. This is also an area of the state peppered with roundish, internally drained, seasonally flooded, bay-basin landscape features. These unique characteristics produce a varied landscape including desiccated, elevated hilltops, nearby swamps with non-tidal runoff and seepage streams, and seasonally flooded bay-basin features.

Even though this landscape occasionally exhibits extensive ancestral Native American archaeological sites, these sites are suggested to portray the accumulation of thousands of years of limited, yet specific processing and procurement efforts instead of portraying shorter periods of intensive occupation. We tend to view the available resources in the poorly drained uplands to be different from the available resources in the mid-drainage, tidal riverine zone, and different again in available resources in the coastal marsh zone. Difference does not preclude a value judgment. Actually, in the former St. Georges Creek, widely varied resources were available from the Delaware Bay to the mid-peninsular drainage divide (Lums Pond) within a distance of only nine miles.

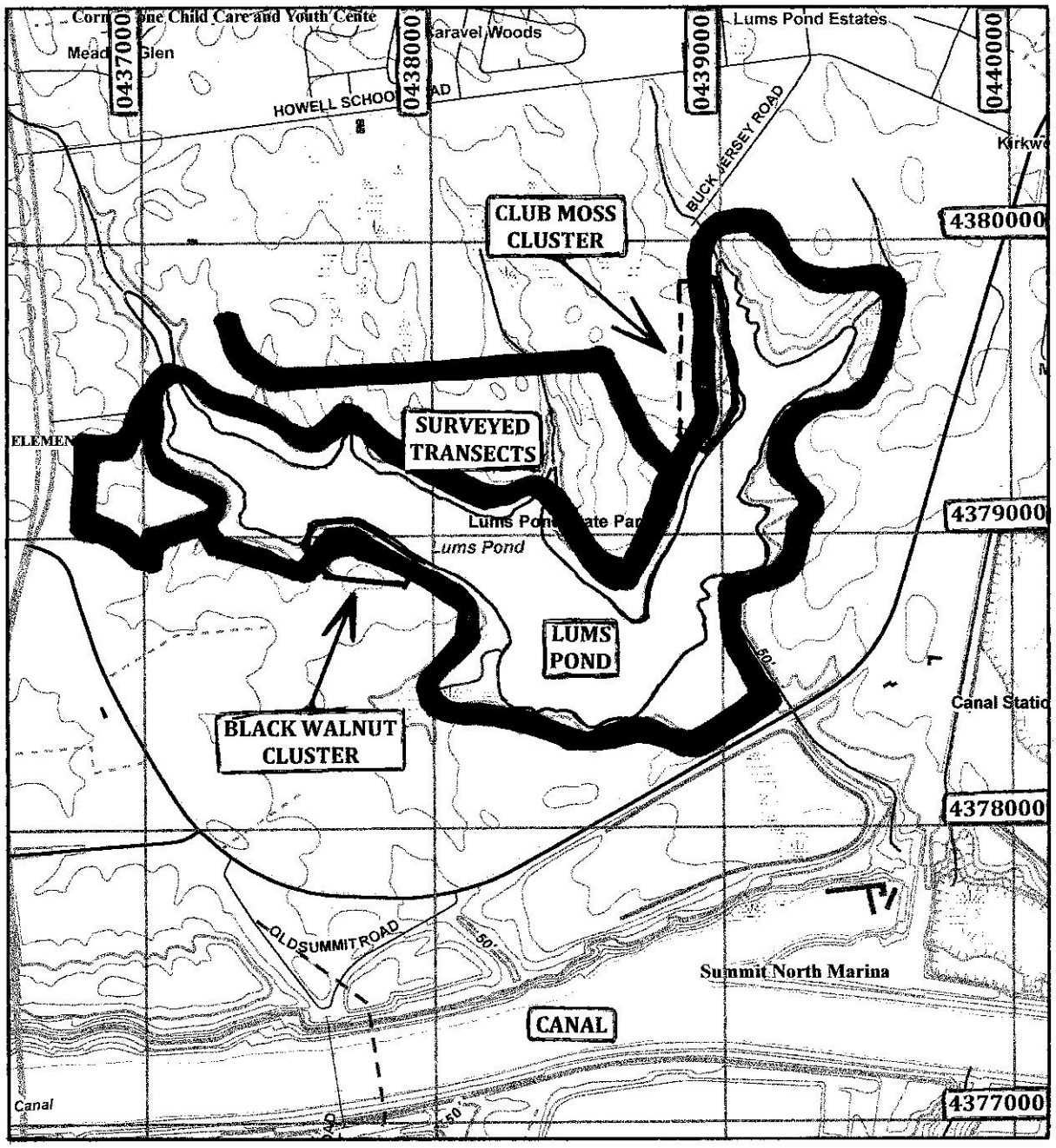
FIELD NARRATIVE

Lums Pond State Park supports a network of hiking, biking, and equestrian trails. These trails are well established, maintained, and marked. Different trails are designed to offer different out-of-doors experiences. We were searching for plants and plant clusters that may be remnant clusters, whose presence may be attributable to ancestral Native American activities. Since our Lums Pond botanical survey is our first survey in Delaware's mid-peninsula drainage divide region, we were excited to see what interesting plant species might be in association with the park's known Native American archaeological sites.

We parked in a parking lot known as Area 1 (GPS UTM E0438800 S4379200) and we hiked in a westerly direction along the Swamp Forest Trail (6.4 miles in length). This trail meanders along the natural slopes between the pond and the uplands. We also walked small portions of the Little Jersey Trail to inspect specific locations in the forested uplands (see map).

In general, we identified stands of Yellow Poplar, Hickories, and Gums. To a lesser degree, we found various Maples, Oaks, Beech, and sporadically, we found Black Cherry, Pines and Holly. Bushy growth was abundant, especially represented by the *Viburnum* genus. All of the above plants were found in expected locations and at expected frequencies. The natural slopes in the vicinity of GPS UTM E0438100 S4379400 supported a few old growth oak trees, or big trees, greater than four feet in diameter.

LUMS POND BOTANICAL SURVEY
SAINT GEORGES, DE. QUADRANGLE



Vast sections of the uplands were former agricultural fields. Some upper slope regions exhibit berms, piles of field rocks, and some hedgerow lines of Osage orange, *Maclura pomifera*, indicating the perimeters of former agricultural fields. Most former agricultural fields within the park are currently either reforested with probably forty-year-old tree growth, or maintained in meadow grasses.

INTERESTING DISCOVERIES

We identified four plant species that peaked our interest. We found and recorded the location of one small Pawpaw tree and three examples of American Wild Crab Apple. These finds appear to be random isolates, they do not appear to form any recognizable, or remnant cluster. See descriptions below, as well as the data log for specific locations.

More importantly however, we found and recorded the locations of a huge Black Walnut cluster and a huge Club Moss cluster (see map). We think the size, density, and location of these two clusters are well beyond what would normally be expected to occur within this environment without human assistance. We think that makes these clusters statistically significant. Therefore, we strongly suggest these clusters are good candidates as remnant Native American husbanded clusters. See descriptions below, as well as the data log for specific locations. All four species' descriptions and locations are found below in alphabetical order.

SPECIES DESCRIPTION

AMERICAN WILD CRAB APPLE

We identified three random examples of American Wild Crab Apple, *Malus coronaria*, along the slopes of Lums Pond (GPS UTM E0438018 S4379170, E0438113 S4379102, and E0439212 S4379111). As we were driving along the park roads in the uplands, we identified perhaps three more examples growing naturally in wooded, upland environments. All of these Crab Apple trees appeared to be isolates and did not appear in cluster form.

American Wild Crab Apple is native to Delaware. However, this species is only locally present in New Castle County, rare in Kent County, and not found at all in Sussex County. The species prefers cool, moist slopes near streams. With abundant sunshine, the species is a prolific fruit producer. Crab Apple fruits are available in October, but ripen on the tree into the winter months. The fruit of this species would have been a benefit to Native Americans living in Delaware, especially for those living in New Castle County. Thickets and clusters of this species existed in the Colonial Period, but aggressive attention paid to commercial, and hybrid apple production have displaced many former Crab Apple groves. We tasted some of the immature fruit on September 17. Reddish examples measuring three quarters of an inch were crisp and slightly bitter, but they did, enjoyably, taste like apple.

BLACK WALNUT

We encountered a huge cluster of Black Walnut, *Juglans nigra*, along the south, central slope to Lums Pond. We counted a minimum of thirty-four mature trees in the cluster, many exhibited fruit. The west end of the cluster beings at GPS UTM E0437611 S4379012 and the east end of the cluster stops at GPS UTM E0437905 S4378945. Measurements indicate this cluster is currently map-able for nearly one thousand feet along the southern slope to Lums Pond. In our experience, random, naturally occurring Black Walnut trees are found in quantities of one to five trees, and at historical sites—from three to ten trees. Our accounting of a minimum of thirty-four trees in one cluster is viewed as being a remnant of human manipulation.

Black Walnut is native to Delaware and is common in all three counties. The species prefers deep, moist soils, but does not tolerate shade. The species, given adequate sunlight, is a prolific nut producer. Walnuts are highly nutritious. Carbonized nut hull fragments as well as carbonized wood fragments have been recovered from Native American archaeological site contexts.

CLUB MOSS

We encountered a huge cluster of Club Moss, *Diphasiastrum digitatum*, along the northeastern slope to Lums Pond. The cluster began at a deeply incised feeder stream at GPS UTM E0438984 S4379790, and ended at another deeply incised feeder stream at GPS UTM E0438898 S4379278. This moss cluster measures about one thousand six-hundred feet (north/south) and at its widest about five hundred feet (east/west).

This species, native to Delaware, is evergreen and grows to a height of about four inches. The plant produces spores, but typically uses root extension migrating through the root mat of the forest floor to sprout new clones. The species prefers to grow on acidic, well-drained, sandy or rocky soils. Club Moss does not tolerate clayey soils, but it is shade tolerant. Furthermore, Club Moss grows best on disturbed soils in coniferous and oak, or mixed forests.

Native Americans boiled Club Moss to make a tea, taken internally, treats fevers, pains, and weakness. The spores may be used to treat diarrhea, stomach and intestinal ailments, and rheumatism. Externally, the spores may be used to treat baby chafing and dermatitis.

PAWPAW

We encountered one small Pawpaw, *Asimina triloba*, tree along the northwest slope to Lums Pond at GPS UTM E0437485 S4379270. This occurrence is likely to be a random find—no clustering or "patch" was noted. This tree is not mature and it did not exhibit fruit.

Pawpaw is native to Delaware and is found in all three counties, but nowhere is it found in abundance. The species prefers protected moist locations along stream banks and swamps, and is tolerant of shade. Mature trees and bushes produce sausage shaped fruits in September. Fruits may be referred to as custard apple, false banana, and papaw. The genus, *Asimina*, is Latinized from the Indian name Asmin.

INTERPRETATIONS

As mentioned above, our Lums Pond botanical survey is our first survey in the poorly drained uplands of the mid-peninsula drainage divide. We identified many of the tree species we expected to find. It was nice to see a Pawpaw, and super nice to see mature, fruiting examples of the American Wild Crab Apple. These Delaware native tree species occur naturally and randomly in this locale, but the seeds can be planted wherever and whenever one desires to start and maintain a patch or grove of these beneficial fruits.

The icing on the cake from our Lums Pond botanical survey is the identification of two huge botanical clusters; Black Walnut and Club Moss. The Black Walnut cluster is massive—the largest one we have ever seen. We think the origin of any walnut cluster of this size must be truly ancient. It is very likely that ancestral Native Americans maintained this remnant walnut cluster as a nut grove. It would be interesting to determine the spatial relationships between this nut grove and the locations of nearby Native American archaeological sites.

Identifying the huge cluster of Club Moss is similar to the above walnut situation. This cluster of Club Moss is the largest one we have ever seen. It is growing in its preferred environment; dry, acidic, sandy soils on an east-facing slope. It seems to have advanced westward into an area of forty-year-old Yellow Poplar trees (probably the location of a former agricultural field, or an area clear-cut about the time the park was dedicated). We find the preference of Club Moss to grow on disturbed soil profiles intriguing, and we wonder if this location is also the location of a Native American archaeological site.

LUMS POND BOTANICAL SURVEY DATA LOG SHEET

PAWPAW ISOLATE

GPS UTM 18S DATUM		DESCRIPTION
E0437485	S4379270	One Immature Pawpaw Tree, 10 Feet High, No Fruit.

AMERICAN WILD CRAB APPLE ISOLATES

GPS UTM 18S DATUM		DESCRIPTION
E0438018	S4379170	One Mature Crab Apple Tree With Fruit.
E0438113	S4379102	One Mature Crab Apple Tree With Fruit.
E0439212	S4379111	One Mature Crab Apple Tree With Fruit.

BLACK WALNUT CLUSTER

GPS UTM 18S DATUM		DESCRIPTION
E0437611	S4379012	West End Of Black Walnut Tree Cluster.
E0437691	S4379054	Station Point, 8 Black Walnut Trees Observed.
E0437642	S4379040	Station Point, 7 Black Walnut Trees Observed.
E0437795	S4379023	Station Point, 10 Black Walnut Trees Observed.
E0437905	S4378945	Station Point, 9 Black Walnut Trees Observed.
E0437950	S4378945	East End Of Black Walnut Tree Cluster.

CLUB MOSS CLUSTER

GPS UTM 18S DATUM		DESCRIPTION
E0438984	S4379790	North End Of Club Moss Cluster.
E0438999	S4379632	Station Point, Thick Club Moss Cluster.
E0438959	S4379496	Station Point, Thick Club Moss Cluster.
E0439035	S4379439	Station Point, Thick Club Moss Cluster.
E0438898	S4379278	South End Of Club Moss Cluster.
E0438898	S4379278	Shoreline Strip of Club Moss
E0438865	S4379184	Club Moss Tapers To Zero At Pond Edge.

PAWPAW CLUSTERS EVALUATED IN ALAPOCAS RUN AND BRANDYWINE CREEK STATE PARKS

Glen Mellin and Lenny Truitt
October 2013

ALAPOCAS RUN STATE PARK

Alapocas Run is a small tributary of Brandywine Creek. This location skirts the northwestern limit of the city of Wilmington, Delaware, which is found on the USGS Wilmington, DE. Quadrangle. The geographic province is Piedmont. The state park offers a range of protected forested land, open meadows, historic sites including standing structures, and recreational areas. Some of these lands are accessible by motor vehicle, but more importantly, a network of established pedestrian trails offer a wide range of vantage points. There are 1.4 miles of local trails, in addition to sections of the Northern Delaware Greenway Trail as well as the East Coast Greenway. We were particularly intrigued by a small (0.3 mile), local trail named "Pawpaw Loop".

FIELD NARRATIVE

We parked at the old Bancroft Mill complex and walked to the footbridge over Brandywine Creek. At this location, the creek has an elevation of approximately 50 feet. We explored around the floodplain at that location and immediately found thickets of Pawpaw. We walked westward, along the north side of Brandywine Creek. These trails were rocky, up and down trails--mostly up, finally reaching the area of the Pawpaw Loop Trail. This loop trail has an average elevation above 250 feet, and the entire south-facing hillside, overlooking Brandywine Creek, was covered with Pawpaw. The loop, which was not all that easy to find, has a west trailhead at E0451639 S4402647 and an east trailhead at E0451708 S4402646. We noted at various locations within the loop, Pawpaw was the dominant species. We noted Pawpaw was the dominant species at other locations, for examples, E0451884 S4402427, and E0452167 S4402467, elevation at 250+ feet. Combining these GPS references, we walked through a minimum of 15 acres of dense Pawpaw cluster.

We found an interesting patch of Mountain Laurel on top of the hill, just east of the Pawpaw Loop. This laurel cluster has a western limit at E0451791 S4402470 and an eastern limit of E0451846 S4402420, elevations above 250 feet. These laurels are sparsely placed and the cluster may be in a state of decline. We observed individual bushes separated by 50 feet, or more, of open space. In a healthy laurel cluster, the bushes are so close they generally touch each other. In addition, we observed each laurel bush had only about half the number of leaves as on healthy plants.

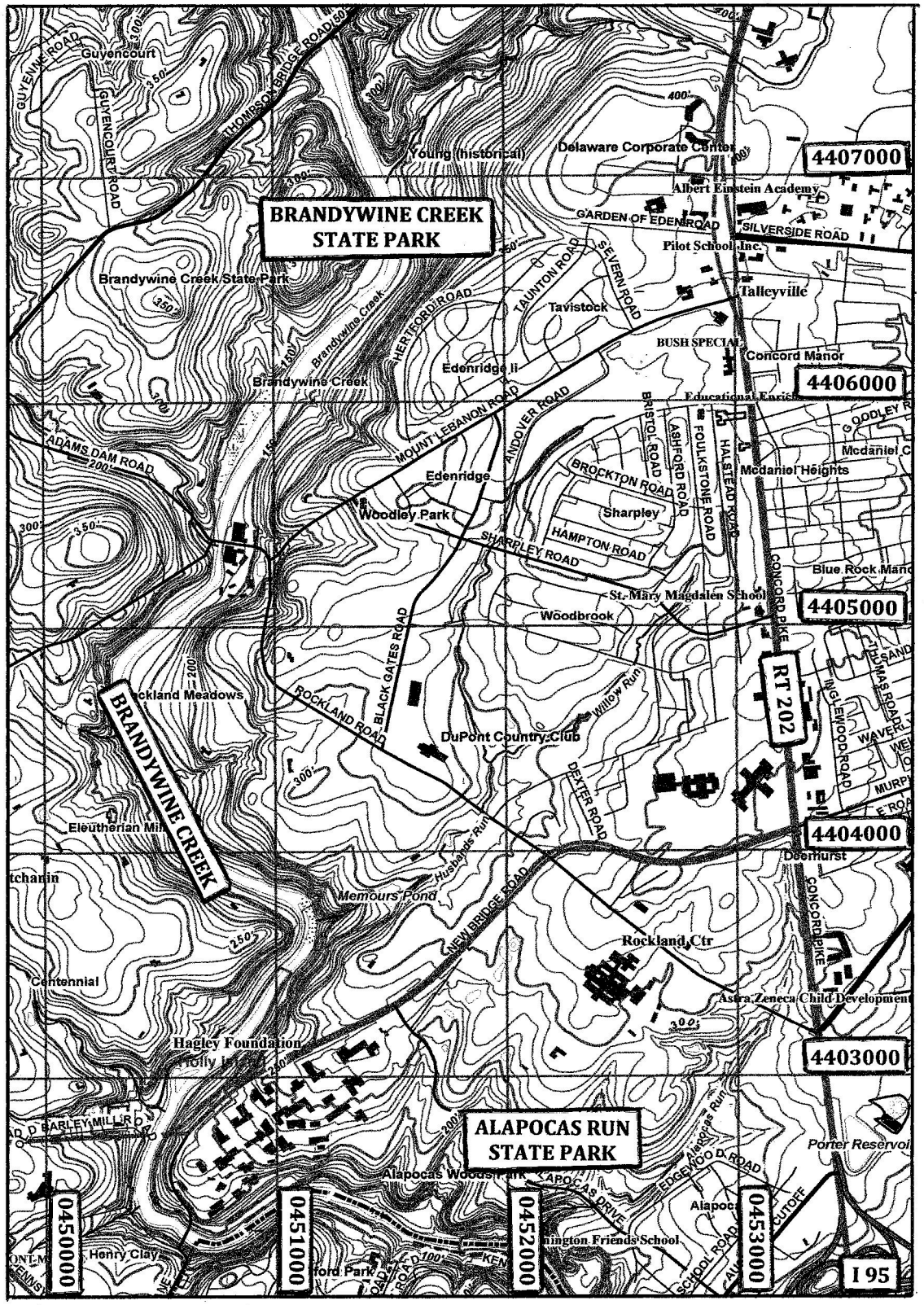
We arrived back at the Bancroft Mill footbridge. We located the Greenway trail, which meanders up the west bank of Alapocas Run. Following that trail in a northern direction, we quickly ran out of Pawpaw trees. The last Pawpaw of the gigantic Brandywine Creek cluster, as we worked our way up Alapocas Run--away from the Brandywine, was at E0452331 S4402536. Further east of that point, we began to see a few Mountain Laurels, perhaps 20 individuals with a center point location of E0452502 S4402592. These laurels seemed to have wide spaces between plants and only about half the foliage expected for healthy laurels.

Finally, when we got a point about 100 feet short of where the forest meets the meadow, at E0452965 S4402920, we identified a small cluster of 6 Pawpaw trees. The forest meets the meadow at E0452995 S4402932 with an elevation 246 feet. After walking these trails for two hours and having traveled 1.5 miles, we were surprised to find a sign warning about the dangers of the poisonous, Alapocas Run Copperhead snake--nice!

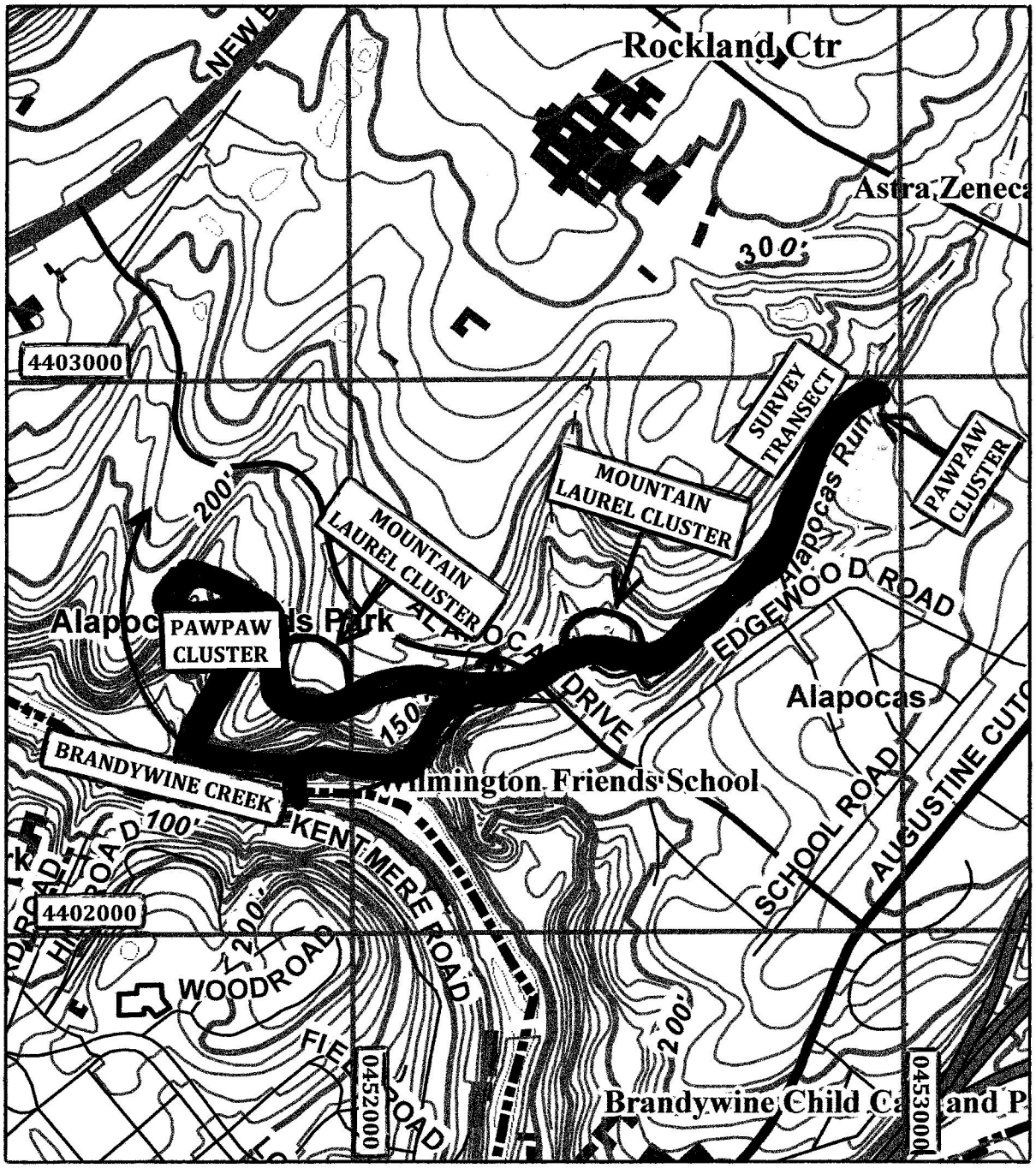
BRANDYWINE CREEK STATE PARK

The headwaters of Brandywine Creek drain a section of southeastern Pennsylvania, flowing south into northern Delaware. A number of other streams and creeks increase the volume of Brandywine Creek as it flows through Wilmington, Delaware, turning east at the base of the Piedmont's fall line, and exits into the west shoreline of the Delaware River at the Port of Wilmington.

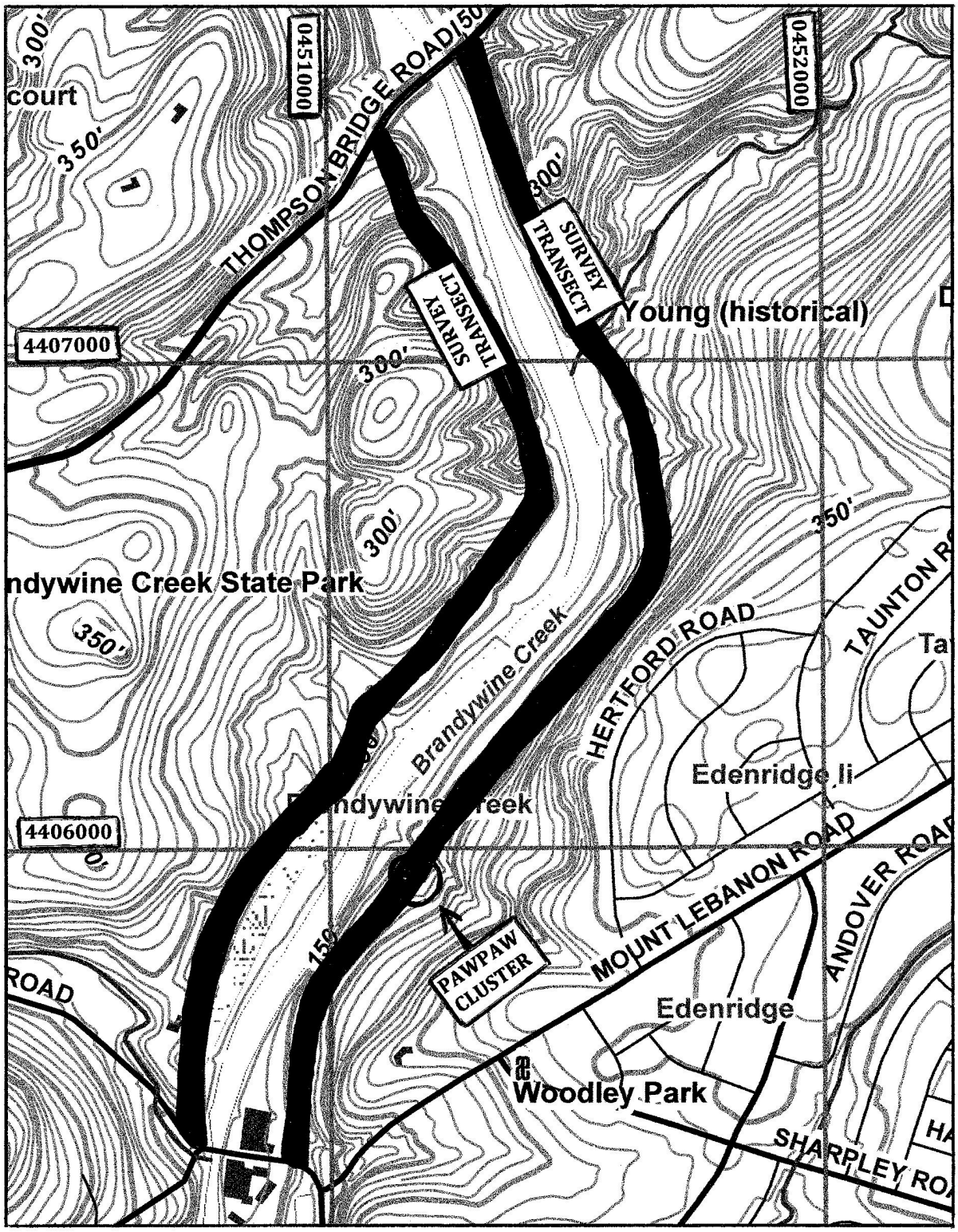
ALAPOCAS AND BRANDYWINE STATE PARKS
WILMINGTON, DE. QUADRANGLE



BOTANICAL SURVEY OF ALAPOCAS STATE PARK



BOTANICAL SURVEY OF BRANDYWINE STATE PARK



This 933 acre state park offers a range of protected forested land, open meadows, historic sites including standing structures, and recreational areas including fishing and boating. Some of these lands are accessible by motor vehicle. A network of established pedestrian trails offer a wide range of vantage points. As the non-tidal creek flows through Brandywine Creek State Park, it maintains streambed of approximately 400 feet wide and 3 feet deep. The park supports seven local trails in addition to a section of the Northern Delaware Greenway totaling 14 miles. These trails range from being very well maintained to being marginally maintained and less frequented. The land had been a former du Pont family property and a historic dairy farm. The State of Delaware purchased the property in 1965 using the newly created Land and Water Conservation Fund.

FIELD NARRATIVE

We parked in a small parking lot in a housing development, just east of Brandywine Creek, and north of Rockland Road. The trail on the east side of the creek is elevated some 30 to 80 feet above Brandywine Creek, which has an approximate elevation of 120 feet at this location. Essentially, the east side trail, also known as the Northern Delaware Greenway Trail runs from Rockland Road upstream 1.5 miles to Thomson's Bridge. Conversely, the west side Brandywine Creek trail winds along the creek at floodplain elevations, 1.5 miles downstream back down to Rockland Road.

Trekking up the east side trail, we discovered a very small cluster of five Pawpaw trees at center point GSP E0451195 S4405940. This cluster is perched on an elevated, flattish area at the confluence of an unnamed stream and Brandywine Creek.

Trekking down the west side trail, we were well aware of the extensive floodplain sandy silt soils associated with the evolving floodplain. We looked for specie examples that might fit our botanical criteria, but we did not expect to find specie clusters that qualified as ancestral clusters. On the floodplain, we did note some trees, for example, a couple of 100 year old yellow poplars, a variety of Black Walnut saplings, and one immature American Wild Crab Apple producing a limited amount of fruit. Nevertheless, we made the effort to document the following examples. We found 2 Black Walnuts growing to a height of 14 meters at E0451445 S4406878, and another similar example at E0451486 S4406761. We found 8 Walnut saplings at E0450926 S4405845, 2 more, larger examples growing to a height of 11 meters at E0450888 S4405780, and 9 more Walnut saplings in the vicinity of E0450842 S4405722. We also discovered 2 Elderberry bushes with fruit at E0450755 S4405501.

Our assessment is that some vegetation has grown in somewhat stable locations on the floodplain for 100 years or more. Closer to the actual creek bed, where we assume less stable conditions, we observed less diversity of vegetation and rarely did that vegetation appear to be greater than 50 to 75 years old. Nevertheless, one example of Sycamore, currently in danger of falling into the creek, appeared to be greater than 200 years old.

Our impression is that present day species that might be beneficial to humans, while growing on the present day floodplain, have a reduced probability of being candidates for ancestral botanical clusters. The seeds of the plants we discovered and documented, growing in the floodplain, while they are consistent with typical vegetation in the local Piedmont region, likely originated in locations further upstream.

Floodplains are environmentally active locations. Some floodplain deposits may be very recent and some deposits may have been stable for thousands of years. Floodplain soils are usually very fertile, and can be particularly attractive locations for horticultural activities. We suggest any analysis or documentation of any plant or plant cluster found within a floodplain requires a multifaceted, detailed understanding of the dynamics of the specific location within the floodplain.

SPECIES DISCUSSED

AMERICAN WILD CRAB APPLE

American Wild Crab Apple, *Mauls coronaria*, is a 30 feet tall, edible fruit-producing tree, native to Delaware. This species is local in New Castle, rare in Kent, and not found in Sussex County, Delaware. Not yet identified as an Archaeobotanical.

BLACK WALNUT
Black Walnut, *Juglans nigra*, is a 60 to 80 feet tall, edible nut-producing tree, native to Delaware. Previously identified as an Archaeobotanical.

ELDERBERRY
Elderberry, *Sambucus canadensis*, is a 10 feet tall, edible berry-producing shrub, native to Delaware. Previously identified as an Archaeobotanical.

MOUNTAIN LAUREL
Mountain laurel, *Kalmia latifolia*, is a 30 feet tall bush and sometimes tree, native to Delaware. Not yet identified as an Archaeobotanical.

PAWPAW
Pawpaw, *Asimina triloba*, is a 40 feet tall, fruit-producing tree, native to Delaware. Not yet identified as an Archaeobotanical.

SYCAMORE
Sycamore, *Platanus occidentalis*, is a 70 to 125 feet tall tree, native to Delaware. Previously identified as an Archaeobotanical.

YELLOW POPLAR
Yellow Poplar, *Liriodendron tulipifera*, is a 50 to 70 feet tall tree, native to Delaware. Previously identified as an Archaeobotanical.

INTERPRETATION
The website, www.destateparks.com/park/alapocas-run/, indicates a large population of Pawpaw can be seen along the Pawpaw Loop Trail in Delaware's Alapocas Run State Park on the east bank of Brandywine Creek. We wanted to make a day of it, so we planned on walking the Alapocas trails and the Brandywine Creek trails, for comparison. Brandywine Creek park is about two miles upstream from Alapocas Run park. Brandywine Creek has an elevation of about 50 feet at the Alapocas park and about 120 feet at the Brandywine park. The east shoreline of Brandywine Creek at both locations rises quickly to elevations of 300 feet. Large bare rocks, rock faces, and rock quarries are typical features of the landscape. The west side of the Brandywine Creek shoreline exhibits various natural and some altered floodplain deposits at both locations.

At Alapocas, we found a very large, perhaps 15 acre, Pawpaw thicket along the east bank of Brandywine Creek. The Pawpaw thicket, for all intents and purposes, did not continue up the Alapocas Run drainage. By comparison, at Brandywine, we found only one tiny cluster of Pawpaw at the confluence of an unnamed stream to the Brandywine. We think it is very strange to observe such a huge difference in quantity of Pawpaw in such a similar environment. Our recommendation is that the Alapocas Run Pawpaw cluster is likely the remains of an ancestral Native American Pawpaw orchard. No Pawpaw fruit was observed at the time of our survey.

Two small clusters of Mountain Laurel were observed in Alapocas Run State Park. Both laurel clusters were observed at the fringes of the Pawpaw cluster. These two laurel clusters are candidates for having ancestral Native American involvement.

We observed a variety of beneficial plant species growing on the Brandywine Creek floodplain. We compared species count and plant size between the floodplain and the sloped environments. We also observed a protected area of freshwater swamp, which is probably a silted-in, Brandywine Creek remnant channel. Taking into consideration the effects of harvesting forest products and relative forest stability in the (seemingly) more protected, former du Pont property, we made our best guess. Based on our observations, we could not determine any locales in the Brandywine Creek floodplain that obviously predate the Colonial Period. Coring, radiocarbon dating, and archaeology might be the next, necessary steps in evaluating the ages of these floodplain sediments.

ALAPOCAS RUN STATE PARK AND BRANDYWINE CREEK STATE PARK
BOTANICAL SURVEYS, DATA LOG

ALAPOCAS RUN STATE PARK BOTANICAL SURVEY

MOUNTAIN LAUREL (CLUSTER 1)

GPS UTM 18S DATUM		DESCRIPTION
E0451791	S4402470	West End of Mountain Laurel Cluster 1.
E0451846	S4402420	East End of Mountain Laurel Cluster 1.

MOUNTAIN LAUREL (CLUSTER 2)

GPS UTM 18S DATUM		DESCRIPTION
E0452502	S4402592	Center Point of Mountain Laurel Cluster 2.

PAWPAW (CLUSTER 1)

GPS UTM 18S DATUM		DESCRIPTION
E0451528	S4402531	West End of Pawpaw Cluster 1.
E0452331	S4402536	East End of Pawpaw Cluster 1.

PAWPAW (CLUSTER 2)

GPS UTM 18S DATUM		DESCRIPTION
E0452965	S4402920	Center Point of Small Cluster of Six Pawpaws, Pawpaw Cluster 2.

BRANDYWINE CREEK STATE PARK BOTANICAL SURVEY

PAWPAW CLUSTER

GPS UTM 18S DATUM		DESCRIPTION
E0451188	S4405937	Center Point of Small Cluster of Five Pawpaws.

INTERESTING SPECIES FOUND IN BRANDYWINE FLOODPLAIN

GPS UTM 18S DATUM		DESCRIPTION
E0451134	S4407510	One American Wild Crab Apple with Fruit.
E0451445	S4406878	Two Black Walnut Trees.
E0451486	S4406761	One Black Walnut Tree.
E0450926	S4405845	Eight Young Black Walnut Trees.
E0450888	S4405780	Two Black Walnut Trees.
E0450842	S4405722	Nine Black Walnut Trees.
E0450755	S4405501	Two Elderberry Bushes.

SUPER PLANTS FIGHT SUPER BUGS

Glen Mellin and Lenny Truitt
February, 2014

The following is a condensation of Stephen Buhner's 2012 book, Herbal Antibiotics: Natural Alternatives for Treating Drug-resistant Bacteria. We found two things very important. 1) Buhner presents a short list of plants containing effective and useful antibiotics that have not been "outwitted" by drug-resistant bacteria. 2) Some of these plants are commonly available; currently found growing in Delaware, and very likely would have been available to ancestral Native Americans.

Buhner's approach in identifying herbal protection from the serious consequences of super bugs is through three contexts. SYSTEMICS are bacterial infections that spread throughout the human body via the bloodstream (Buhner 2012:87—156). LOCALIZED NONSYSTEMICS are bacterial infections that generally do not spread through the bloodstream, but are localized, for examples, the GI tract, the Urinary tract, or skin infection (Buhner, 2012:157—206). SYNERGISTS are combinations of compounds found in different herbs that produce an effect greater than the sum of their individual parts (Buhner, 2012:207—246).

Section 1 (pages 1-4) is a condensation of Buhner's global presentation of bacterial infection and herbal treatment. We provide this section for proper context, but if you choose, skip this and go to Section 3 (pages 8-9) for a shortlist of these superplants that are found in Delaware.

Section 2 (pages 5-7) is an alphabetical list of superplants discussed in Buhner's global search. We provide this section for proper context, but if you choose, skip this and go to Section 3 (pages 8-9) for a shortlist of these superplants that are found in Delaware.

Section 3 (pages 8-9) is a shortlist of Buhner's superplants that are found in Delaware. We have included some plants found in Delaware that contain Buhner's identified antibacterial compounds, but are actually of a different species and in some cases a different genus than what Buhner discusses. For example, (and this is important) – Buhner identifies *Ceanothus* spp. or Red roots, as containing very specific, beneficial antibacterial compounds. New Castle County, Delaware hosts the *C. americanus*, which is very rare, but is very potent. The same, specific antibacterial compounds are found in Pokeweed (*Phytolacca americana*) (commonly found in Delaware) and in the Cleavers (*Galium* spp.) (commonly found in Delaware) at different quantities, therefore; different preparations and dosages are warranted to achieve the desire treatment (see below).

We address these plants and their antibacterial compounds within the context of availability to ancestral Native Americans living in what is now Delaware. This information is applicable to our study of archaeobotanical and enthobotanical medicinal plants in Delaware. We make neither recommendations nor prescriptions of any plants discussed, nor the concoctions and dosages outlined in Buhner's book.

SECTION 1: DISEASE AND HERBAL TREATMENT (A GLOBAL STUDY)

SYSTEMICS: bacterial infections that spread throughout the human body via the bloodstream (Buhner 2012:87—156).

Gram-Positive Bacteria

Clostridium difficile (A severe form of diarrhea usually contracted in hospitals. See also, *C. botulinum*—a food poisoning, *C. perfringens*—a food poisoning, and *C. tetani*—tetnanus. Treat with Berberine plants, Cryptolepis, Isatis, Usnea, Lomatium, Licorice, and Echniacea [see p.48]).

Enterococcus spp. (*E. faecalis, E. faecium*) (Related illness include urinary tract infection, bacteremia, bacterial endocarditis, diverticulitis, and meningitis. Treat with Sida, Alchornea, Cryptolepis, Bidens, Giner, Echinacea, Juniper, Usnea, *Artemisia annua*, Honey, Licorice, Oregano oil, and *Acacia aroma* [see p.49]).

Mycobacterium tuberculosis (Tuberculosis, now includes forms of MDR-TB and XDR-TB. Treat with Cryptolepis, Sida, Bidens, Piperine, *Artemisia annua*, Berberine plants, Juniper, Usnea, Lomatium, Licorice, Echinacea, and Rhodiola [see p.50]).

Staphylococcus aureus (Now includes MRSA. Treat with Cryptolepis, Sida, Alchornea, Bidens, Black Pepper, the Berberines, Usnea, Juniper, Isatis, Licorice, Ginger, Ashwagandha, Echinacea, Red Root, Reishi, Honey, and *Artemisia annua* [see p.52]).

Streptococcus spp. (*S. pyogenes, S. pneumoniae*) (Includes various form of flesh-eating strep. Treat with Cryptolepis, Sida, Alchornea, Bidens (though you'll need to use larger doses, for longer), the Berberine plants, Juniper, Usnea, Lomatium, Honey, Echinacea, Licorice, Ginger, and Red Root [see p.52]).

Gram-Negative Bacteria

Acinetobacter baumannii (Now includes MDRAB, usually contracted in hospitals through open wounds, catheters, and injection sites. Treat with Alchornea, Cryptolepis, Sida, Juniper, Isatis, Ginger, Lomatium, Honey, Oregano essential oil, Epigallocatechin, Acacia aroma, Zuccagnia punctata, and Sechium edule fluid extract [see p.55]).

Campylobacter jejuni (An enteritis with flu-like symptoms. Treat with Cryptolepis (strongly), Sida, Ginger, and the Berberines [see p.56]).

Enterohemorrhagic E. coli (*E. coli* O157, *E. coli* O157:HM, *E. coli* O157:H7). (Contaminated food or water--can destroy red blood cells and result in kidney failure. Treat with Berberines, Cryptolepis, Sida, Alchornea, Bidens, nearly all Artemisias, Juniper, Honey, Usnea, Lomatium, Isatis, Licorice, Ginger, Ashwagandha, and Reishi. All Oak species (*Quercus*) and Pomegranite (*Punica granatum*) fruit rind or tree bark are also highly effective against the E. Coli O157:H7 strains. [see p.57]).

Haemophilus influenzae (Can proceed into pneumonia and meningitis. Treat with Ginger, Licorice, Isatis, Lomatium, Honey, Eucalyptus essential oil, Eucalyptus leaf, and Basil essential oil. "Unfortunately, Cryptolepis, Sida, and Alchornea have not been tested against the organism. However, I believe that, due to their activity against similar Gram-negative bacteria, they are useable for *Haemophilus* infections, especially Sida, given its strong protective effects on red blood cells." [see p.60]).

Klebsiella pneumoniae (Now includes ESBL and CRKP, usually contracted in hospitals. Treat with Cryptolepis, Alchornea, Bidens, Black Pepper, Juniper, the Berberine plants, *Acacia*, *Artemisia annua*, Reishi, Licorice, and Honey [see p.62]).

Neisseria gonorrhoeae (Gonorrhea, usually transmitted as an STD. Treat with Cryptolepis and Sida [see p.63]).

Proteus spp. (*P. vulgaris*, *P. mirabilis*) (UTI, septicemia, and pneumonia, usually contracted in hospitals. Treat with Cryptolepis, Sida, Alchornea, *Artemisia annua*, Juniper, Usnea, *Acacia aroma*, Lomatium, Ginger, and Honey [see p.64]).

Pseudomonas aeruginosas (UTI, septicemia, and pneumonia, usually contracted in hospitals. Treat with Isatis, Alchornea, Bidens, Cryptolepis, Sida, Black Pepper, *Artemisia annua*, the Berberines, Juniper, Ginger, *Acacia aroma*, Honey, Lomantium, Ashwagandha, Echinacea, and Reishi [see p.65]).

Salmonella spp. (*S. typhi*, S. enteritidis, *S. typhimurium*) (Contaminated food or water, can destroy red blood cells and result in kidney failure. Treat with Cryptolepis, Sida, Alchornea, Bidens, the Berberines, Juniper, Honey, Licorice, Lomatium, and Ginger [see p.67]).

Serratia marcescens (UTI, septicemia, conjunctivitis, and pneumonia, usually contracted in hospitals. Treat with Juniper, Bidens, Licorice, Lomatium, *Coptis chinensis*, Honey, Oregano oil, *Tribulus terrestris*, and *Emblica*

officinalis. Also active are *Trichosanthes cucumerina*, *Cassia didymobotrya*, *Blumea lacera*, *Moringa oleifera*, *Isodon* spp. *Dendropht falcata*, *Zaccagnia punctata*, and *Phrygilanthus acutifolius* [see p.68]).

Shigella spp. (*S. dysentariae*, *S. flexneri*, *S. sonnei*) (Contaminated food or water, can destroy red blood cells and result in kidney failure. Treat with Cryptolepis, Sida, Alchornea, Bidens, the Berberins, Juniper, Honey, Licorice, Lomantium, and Ginger [see p.71]).

Stenotrophomonas maltophilia (UTI, septicemia, and pneumonia, usually contracted in hospitals. Treat with *Berberis* spp., Alchornea, Boneset, Honey, Epigallocatechin (green tea constituent), *Scorzonera sandrasica* (aerial parts), Eucalyptus essential oil, Eucalyptus leaf tincture, Thyme essential oil, Oregano essential oil, *Acacia aroma*, *Zuccagnia punctata*, *Sechium edule* fluid extract, *Salvia* spp. *Menyanthes trifoliate*, *Artemisia drcunculas*, *Mammea americana*, *Oedogonium capillare*, *Centaurea cariensis*, *Artemisia arborescens*, *Artemisia afra*, Rosemary, Garlic, and Devil's Claw (*Harpagophytum procumbens* [see p.71]).

Vibrio cholerae (Cholera, contracted from contaminated food or water, results in severe dehydration and electrolyte imbalance. Treat with Berberines, Cryptolepis, Licorice, Ginger, *Geranium mexicanum* (or any of the geranium species' roots), *Psidium guajava* (guava) leaf and bark tea or ethanol extract, and *Punica granatum* (pomegranate) fruit peel or bark as tea or ethanol extract. Basil (Ocimum basilicum), Nopal cactus (*Opuntia ficus-indica*), *Acacia famesiana*, and *Artemisia ludoviciana* are also very active against cholera organisms [see p.73]).

Nonbacterial
Candidas (Yeast infections, UTI and mouth. Treat with Sida, Alchornea, Bidens, Cryptolepis, *Artemisia annua*, Berberines, Juniper, Honey, Usnea, Black Pepper, Lomatium, Isatis, Licorice, Red Root flowers, Reishi, Echinacea, Chaparro amargosa (*Castela emoryi*), and Desert Willow (*Chilopsis linearis*) [see p.74]).

Malaria (*Plasmodium* spp.) (Various parasites of the liver and blood. Treat with Cryptolepis, Sida, Alchornea, Bidens, *Artemisia annua*, Juniper, Isatis, and Licorice [see p.75]).

Aspergillus mold (May result in bronchopulmonary infection and chronic sinusitis. Treat with Sida, Alchornea, Crytolepis, Juniper, Lomatium, Isatis, Ginger, Honey, *Artemisia giraldii*, and *Sechium edule* fluid extract [see p.76]).

Herbs for Treating Non-bacterials
Cryptolepis spp. (*sanguinolenta*, *triangularis*, *buchanani*, *hypoglauca*, and *obtuse* have clinical records.) Commonly called Ghanian quinine. (Tropical--Asia, Africa, and South Pacific).

Sida spp. (*acuta*, *rhombifolia*, *cordifolia*, *tiagii*, and *spinosa* have clinical records). Commonly called the fanpetals. (Tropical and temporate).

Alchornea spp. (cordifolia, and laxiflora have clinical records). Commonly called Christmas bush. (Tropical and temporate).

Bidens spp. (*pilosa*, *frondosa*, *tripartitus*, *ferulaedolia*, *alba*, *maximovicziana*, *pinnata*, and *campylotheca* have clinical records). (Grows almost anywhere, known locally as Spanish needles). Fresh, green leaves are the most potent.

Artemisia spp. (*A. annua* is the most potent). Known as Sweet Annie and Sweet Wormwood. Prepare leaves and flowers for treatment of GI, Urinary, and some Blood parasites like Malaria. Toxicity associated with long term, high doses.

LOCALIZED NONSYSTEMICS: bacterial infections that generally do not spread through the bloodstream, but are localized, for examples, the GI tract, the Urinary tract, or skin infection (Buhner, 2012:157—206).

These nine plants contain Berberine compounds:
Hydrastis canadensis, American goldenseal, roots are best.
Mahonia aquifolium, Oregon grape, roots are best. Also known as *Berberis aquifolium*.
Berberis vulgaris, Barberries, roots are best.
Coptis chinensis, Goldthread, roots are best.
Phellodendron amurense, bark is best.
Tinospora cordifolia, bark is best.
Corydalis spp. (*chaerophylla*, *yanhusuo*, and *longipes*). A poppy with analgesic properties.
Argemone mexicana, Mexican poppy, leaves are best.
Nandina domestica, a Barberry shrub, lower leaves and roots are best.

Juniper: *Juniperus* spp. (Berries are best, needles, bark, roots are all antibiotic. Young trees are best, with more abundant monoterpenes.

Honey: wild, organic honey is used topically and internally as an antibiotic. Best for treating colds, flus, and respiratory infections.

Usnea: *Usnea* spp. (Old man's beard and references to beard or hair). A lichen. Contains usnic acid. In vitro, recently shown to interrupt breast, colorectal, and pancreatic cancer cell formation. Treatment for topical wounds and UTI.

SYNERGISTS: combinations of compounds found in different herbs that produce an effect greater than the sum of their individual parts (Buhner, 2012:207—246). Synergists help in two ways; 1) Slows the efficiency of a bacterium's efflux elimination process, and 2) aids in moving chemical compounds across the intestinal wall and into the circulatory system.

Glycyrrhiza lepidota (American licorice) continues to be used by Native Americans. Also *G. glabra* (European), *G. uralensis* (Chinese), and *G. echinata* (Russian) are widely used in their respective areas. (Roots are best).

Zingiber spp. and *Alpinia* spp. are in the Ginger family, *Zingiberaceae*. Fresh root is best, oil is OK, dried root is practically useless.

Piper spp. Black pepper, Peperine is the active compound extracted from peppercorns.

Herbs for Supporting a Healthy Immune System
Ashwagandha. Family *Solanaceae*, Genus *Withania* spp. Middle East and India. Roots are best.

Astragalus. Family Leguminosae, Genus Astragalus spp. Chinese species have clinical records, others do not.

Boneset. *Eupatorium perfoliatum* used by Native Americans. Leaves are best in tea.

Echinacea. *Echinacea* spp. Extensively used by Native Americans. Leaves and flower buds are best in tea.

Eleuthero. *Eleutherococcus* spp. Devil's shrub. Roots are best after maturity at 4 years. (Taken internally, slowly builds to maximum effectiveness in 6 months).

Red Root. *Ceanothus* spp. (All species apparently have identical medicinal value). Root and inner bark are best. Poke root (*Phytolacca*) is a good alternative, but use only 1/3 dosage. Cleavers (*Galium*) is another alternative, but use at 4 times dosage.

Reishi. *Ganoderma* spp. Asian mushroom.

Rhodiola spp. Grows in circumpolar, subarctic climate. Roots are best.

SECTION 2: ALPHABETICAL ORGANIZATION OF SUPER PLANTS
Acacia aroma (Aromita*), and A. famesiana*, native to South American. Not found in Delaware.

Alchornea spp. (Christmas bush) (*A. cordifolia*, and *A. laxiflora* have clinical records). Native to tropical and temporate Africa. Not found in Delaware.

Allium sativum (Garlic), native in central Asia westward to the Mediterranean. *A. canadense* (Meadow onion) is native and common in Delaware, and *A. tricoccum* (Ramp) is uncommonly found in the Piedmont of Delaware.

Artemisia spp. (Sweet Annie, or Sweet Wormwood) *A. annua* is the most potent. *A. drcunculas*, *A. arborescens*, *A. afra*, *A. ludoviciana* are also very active against cholera organisms. *A. biennis* (Biennial wormwood) Adventive in New Castle County and *A. ludoviciana* (Sagebrush wormwood) Adventive in all three counties of Delaware. Found native west of the Mississippi.

Astragalus spp. (na), vine-like vetch, temporate, some Asian species have clinical records. Not found in Delaware.

Berberine plants--These plants contain Berberines:
Argemone mexicana, (Mexican poppy), native to Mexico. Not found in Delaware.
Berberis vulgaris (Barberries) native to southern Europe, Africa, Mid-east. Not found in Delaware.
Coptis chinensis (Goldthread), native to China. Not found in Delaware.
Corydalis spp. (Poppy), *Corydalis flavula* native, but rare in Delaware's Piedmont.
Hydrastis canadensis (American goldenseal), listed as uncommon in New Castle County, Delaware.
Mahonia aquifolium (Oregon grape), sometimes listed as *Berberis aquifolium* (Oregon grape) native to western North America. *Mahonia repens* (Creeping Hollygrape) is Adventive in Delaware's Piedmont.
Nandina domestica, (Nandina, or Barberry) native to eastern Asia. Not found in Delaware.
Phellodendron amurense, (Amur Cork Tree) native to Asia. Not found in Delaware.
Tinospora cordifolia (Guduchi), native to India. Not found in Delaware.

Bidens spp. (Tick-seeds). (*B. pilosa*, *B. frondosa*, *B. tripartitus*, *B. ferulaedolia*, *B. alba*, *B. maximovicziana*, *B. pinnata*, and *B. campylotheca* have clinical records). Locally known as Spanish needles, there are 12 species in Delaware.

Blumea lacera (na.), native to India and Asia. Not found in Delaware.

Cassia didymobotrya, (Candelabra tree), native to Africa. Not found in Delaware.

Castela emoryi (Crucifixion thorn) and *Chaparro amargosa* (Goat bush) native to northern Mexico. Not found in Delaware.

Ceanothus spp. (All species apparently have identical medicinal value). *Ceanothus americanus* (Red root) very rare, found on dry soils in New Castle County in both the Piedmont and Coastal Plain. *Phytolacca americana* (Pokeweed) is a good alternative, commonly found in all three counties of Delaware. (*Galium spp.* are the Bedstraws, or Cleavers) and are good alternatives. There are 13 species of Bedstraw growing in Delaware—some are at their northern range and others are at their southern range. Two species (*G. boreale* and *G. hispidulum*) are Historic introductions.

Centaurea cariensis, (na), native to Turkey. Not found in Delaware.

Chilopsis linearis (Desert Willow), native to American southwest and Mexico. Not found in Delaware.

Coptis chinensis, (Goldthread), native to China. Not found in Delaware.

Cryptolepis spp. (Ghanian quinine) (*C. sanguinolenta*, *C. triangularis*, *C. buchanani*, *C. hypoglauca*, and *C. obtuse* have clinical records.) Native to tropical Africa, Asia, and South Pacific. Not found in Delaware.

Dendrophthoe falcata, (Honey Suckled Mistletoe), native to Africa, Asia, and Australia. Not found in Delaware.

Echinacea spp. (Echinacea). *Echinacea purpurea* (Purple coneflower) is native to eastern North America, but is listed as not yet identified in Delaware. Known to be extensively used by ancestral Native Americans.

Eleutherococcus spp. (Eleuthero, Siberian ginseng, or Devil's shrub). Native to eastern Asia. Not found in Delaware.

Epigallocatechin gallate, (Green tea), native to Asia. Gallate compounds are found in St. John's Wart. *Hypericum* spp. (St. John's Wart) has 19 species in Delaware (1 extirpated, 8 rare, 3 uncommon, 6 common, and 1 historic).

Eucalyptus spp.(Eucalyptus or Sweetgum), notably Australia. Not found in Delaware.

Eupatorium perfoliatum (Boneset, or Perfoliate thoroughwort), used by ancestral Native Americans. Native and common in Delaware. There are 15 species of Thoroughworts known in Delaware, although 1 species is thought to be extirpated.

Ganoderma spp. (*Ganoderma lucidum*, Reishi), an Asian mushroom. Not found in Delaware.

Geranium mexicanum (Geranium), two species are found native and common in Delaware, *G. carolinianum*, *G. maculatum*, and *G.robertianum* is likely an escaped Adventive.

Glycyrrhiza glabra (Licorice), *G. glabra* (European), *G. uralensis* (Chinese), and *G. echinata* (Russian) are widely used in their respective areas. *G. lepidota* (American licorice) continues to be used by Native Americans, but is listed as not yet identified in Delaware.

Harpagophytum procumbens (Devil's Claw), native to southern Africa. Not found in Delaware.

Honey: wild, organic honey produced by honeybees (*Apis* spp). No *Apis* species (honeybees) existed in the New World during the Holocene before the introduction of the dark honeybee, *Apis mellifera* in the Chesapeake region in 1622, followed later by the Italian strain *Apis mellifera* var. *ligustica* and others. There were, however, other native bee species kept and traded by ancestral Native Americans.

Isatis tinctoria (Isatis, or Dyer's woad), native to the Caucasus to western Asia. Not found in Delaware.

Isodon spp. (Isodon), *Isodon rubescens* is a basil-like herb native to China. Not found in Delaware.

Juniperus spp. (Juniper, Red Cedar) *Juniperus virginiana* is native to Delaware.

Lomatium dissectum (Lomatium or Biscut root), native to the Pacific Northwest. Not found in Delaware.

Mammea americana (Mammea), a South American apricot, tropical. Not found in Delaware.

Menyanthes trifoliate (Bog buckbean) now extirpated in Delaware, a monotypic, was found in Fen-like swamps on Coastal Plain in New Castle County, Delaware.

Moringa oleifera (Moringa) native to semi-arid, tropical and sub-tropical India and Asia. Not found in Delaware.

Ocimum basilicum (Basil, or St. Joseph's Wart), native to southeast Asia, naturalized in Europe. Not found in Delaware.

Oedogonium capillare, (Capillare) a hair-like freshwater algae found in New Zealand and Australia. Not found in Delaware.

Opuntia ficus-indica (Nopal cactus also called Prickly pear cactus), originated in Mexico. *Opuntia humifusa* var. *humifusa* listed native in Delaware, found in Sussex and Kent Counties.

Origanum vulgare (Oregano), Mediterranen, Not found in Delaware.

Phrygilanthus acutifolius (Acutifolius). Native to Argentina. Not found in Delaware.

Phyllanthus emblica officinalis (Gooseberry), native to India and Asia (not the gooseberries native to Delaware, which are *Ribes* spp.) Not found in Delaware.

Piper spp. (Black pepper), Peperine is the active compound, extracted from peppercorns. Tropical, found in both hemispheres. Not found in Delaware.

Psidium guajava (Guava) a tropical plant in the Myrtle family native to Mexico, central and South America and the Caribbean region. Not found in Delaware.

Punica granatum (Pomegranate) is native from southern Europe to India and Asia. Not found in Delaware.

Rhodiola spp., *R. rosea* (Golden root) grows in cold and treeless climates. Identified at extreme locations in North Carolina. Not found in Delaware.

Rosmarinus officinalis (Rosemary) native to the Mediterranean. Not found in Delaware.

Salvia spp., *S. lyrata,* (Lyre-leaf sage) commonly found in all three counties of Delaware typically in old fields.

Scorzonera sandrasica (Scorzonera), native to Turkey and Mediterranean. Not found in Delaware.

Sechium edule (Chayote), a summer squash native to Mexico and Central America. Not found in Delaware.

Sida spp. (Fanpetals), (*S. acuta*, *S. rhombifolia*, *S.cordifolia*, *S. tiagii*, and *S. spinosa* have clinical records). These are tropical and temporate plants within the Mallow family. Not found in Delaware.

Thymus vulgaris (Thyme) is a European and north African herb. Not found in Delaware.

Tribulus terrestris (Bullhead or Devil's thorn) is indigenous to Southern Europe, Africa, Asia, and Australia. Not found in Delaware.

Trichosanthes cucumerina (Snake gourd) is a tropical and sub-tropical vine. Fruit used to make didgeridoos. Not found in Delaware.

Usnea spp. (Old man's beard) is a mushroom found in both hemispheres. Not found in Delaware.

Withania spp. (Ashwagandha), native to Middle East and India. Not found in Delaware.

Zingiber spp. and *Alpinia* spp. are in the Ginger family, *Zingiberaceae*. (Ginger) is native to south Asia, later East Africa and the Caribbean. Not found in Delaware.

Zuccagnia punctata (Zuccagnia) is a monotypic bushy plant native only to alpine regions of central Argentina and Chile. Not found in Delaware.

SECTION 3: A SHORT LIST OF SUPER PLANTS (RELATING TO DELAWARE)

The following table is a short-list of Super Plants, plants that contain special antibacterial compounds (Buhner 2012), which either are or should be found in Delaware. Examples of *Galium*, *Hypericum*, *Juniperus*, *Phytolacca*, and *Salvia* already have been identified in (pre-contact) archaeological contexts as recovered archaeobotanical specimens (Mellin and Truitt 2013:Appendix 1 and 2).

LIST OF SUPERPLANTS FOUND IN DELAWARE. THESE SPECIES CONTAIN COMPLEX ANTIBACTERIAL COMPOUNDS, WHICH ARE NOT OUTWITTED BY DRUG-RESISTANT BACTERIA (BUHNER 2012, MELLIN AND TRUITT 2013).

Genus	Species	Common name	Status	County / Piedment and Coastal Plain
Allium spp.	*canadense*	Meadow onion	Common	All P+CP
	tricoccum	Ramp	Uncommon	NC P
Artemisia spp.	*biennis*	Biennial wormwood	Adventive	NC P+CP
	ludoviciana	Sagebrush wormwood	Adventive	All P+CP
Bidens spp.	*bidentoides*	Estuary tick-seed	Historical	NC CP
	bipinnata	Spanish-needle tick-seed	Common	All P+CP
	cernua	Nodding tick-seed	Common	All P+CP
	comosa	Three-lobe tick-seed	Common	All P+CP
	connata	Purple-stem tick-seed	Status Uncertain	All P+CP
	discoidea	Swamp tick-seed	Common	All CP
	frondosa	Devil's tick-seed	Common	All P+CP
	laevis	Smooth tick-seed	Common	All CP
	mitis	Small-fruited tick-seed	Rare	S CP
	polylepis	Tick-seed sunflower	Adventive	All P+CP
	trichosperma	Northern tick-seed sunflower	Uncommon	All CP
	vulgata	Tall tick-seed	Uncommon	NC P+CP
Ceanothus	*americanus*	Red root	Rare	NC P+CP
Corydalis	*flavula*	Yellow corydalis, Poppy	Rare	NC P
Eupatorium spp.	*album album*	White thoroughwort	Common	K-S CP
	album subvenosum	3-nerved basal thoroughwort	Status Uncertain	K-S CP
	album vaseyi	Vasey's white thoroughtort	Uncommon	K CP
	altissimum	Tall thoroughwort	Status Uncertain	NC CP
	capillifolium	Dog-fennel thoroughwort	Common	All P+CP
	hyssopifolium	Hyssop-leaf thoroughwort	Common	All P+CP
	leucolepis	White-bract thoroughwort	Uncommon	K-S CP
	ferfoliatum	Perfoliate thoroughwort	Common	All P+CP
	pilosum	Ragged thoroughwort	Common	All CP
	resinosum	Pine barren boneset	Extirpated	S CP
	rotundifolium ovatum	Hairy thoroughwort	Common	All P+CP
	rotundifolium rotu.	Roundleaf thoroughwort	Common	All P+CP
	serotinum	Late-flowering thoroughwort	Uncommon	All CP
	sessilifolium sess.	Sessile-leaf thoroughwort	Rare	NC-K P+CP
	torreyanum	Torrey's eupatorium	Status Uncertain	NC CP
Galium spp.	*aparine*	Catchweed bedstraw	Common	All P+CP
	asprellum	Rough bedstraw	Rare	NC P
	boreale	Northern bedstraw	Historical	NC P
	ciraezans circaezans	Southern forest bedstraw	Common	All P+CP
	ciraezans hypomalacum	Northern forest bedstraw	Common	All P+CP
	hispidulum	Coast bedstraw	Historical	S CP
	lanceolatum	Lance-leaf bedstraw	Uncommon	NC P
	obtusum filifolium	Narrowleaf blunt-leaf bedstraw	Common	All CP
	obtusum obtusum	Blunt-leaf bedstraw	Common	All P+CP
	pilosum pilosum	Hairy bedstraw	Common	All P+CP

	pilosum puncticulosum	Hairy punctate bedstraw	Common	All P+CP
	tinctorium	Stiff marsh bedstraw	Common	All P+CP
	triflorum	Sweet-scent bedstraw	Common	NC-K P+CP
Geranium spp.	*carolinianum*	Carolina crane's-bill	Common	All P+CP
	maculatum	Wild geranium	Common	All P+CP
	robertianum	Robert's crane's-bill	Adventive	NC P
Hydrastis	*canadensis*	American goldenseal	Uncommon	NC P+CP
Hypericum spp.	*adpressum*	Creeping St. John's-wort	Rare	S CP
	boreale	Northern St. John's-wort	Rare	S CP
	canadense	Canadian St. John's-wort	Common	All P+CP
	crux-andreae	St. Peter's-wort	Uncommon	All CP
	densiflorum densi.	Bushy St. John's-wort	Rare	NC-S CP
	denticulatum	Coppery St. John's-wort	Rare	S CP
	drummondii	Drummond's St. John's-wort	Rare	NC CP
	ellipticum	Pale St. John's-wort	Historical	NC CP
	fraseri	Northern marsh St. John's-wort	Rare	NC CP
	gentianoides	Orange-grass St. John's-wort	Common	All P+CP
	gymnanthum	Clasping-leaved St. John's-wort	Uncommon	All CP
	hypericoides	Erect St. Andrew's cross	Uncommon	All CP
	majus	Larger Canadian St. John's-wort	Extirpated	NC P
	mutilum mutilum	Slender St. John's-wort	Common	All P+CP
	prolificum	Shrubby St. John's-wort	Rare	NC P
	punctatum	Dotted St. John's-wort	Common	All P+CP
	stragulum	Decumbent St. Andrew's cross	Common	All P+CP
	virginicum	Marsh St. John's-wort	Common	All P+CP
	walteri	Walter's St. John's-wort	Common	All CP
Juniperus	*communis*	Ground juniper	Adventive	NC P
	virginiana	Eastern red-cedar	Common	All P+CP
Mahonia	*repens*	Creeping hollygrape	Adventive	NC P
Menyanthes	*trifoliate*	Bog buckbean	Extirpated	NC CP
Opuntia	*humifusa*	Prickly pear	Common	K-S CP
Phytolacca	*americana*	Pokeweed	Common	All P+CP
Salvia	*lyrata*	Lyre-leaf sage	Common	All P+CP

LIST OF SUPERPLANTS NOT YET FOUND IN DELAWARE. THESE SPECIES CONTAIN COMPLEX ANTIBACTERIAL COMPOUNDS, WHICH ARE NOT OUTWITTED BY DRUG- RESISTANT BACTERIA (BUHNER 2012, MELLIN AND TRUITT 2013).

Genus	Species	Common name	Status	County / Piedment and Coastal Plain
Echinacea	*purpurea*	Purple coneflower	Not listed	
Glycrrhiza	*lepidota*	American licorice	Not listed	

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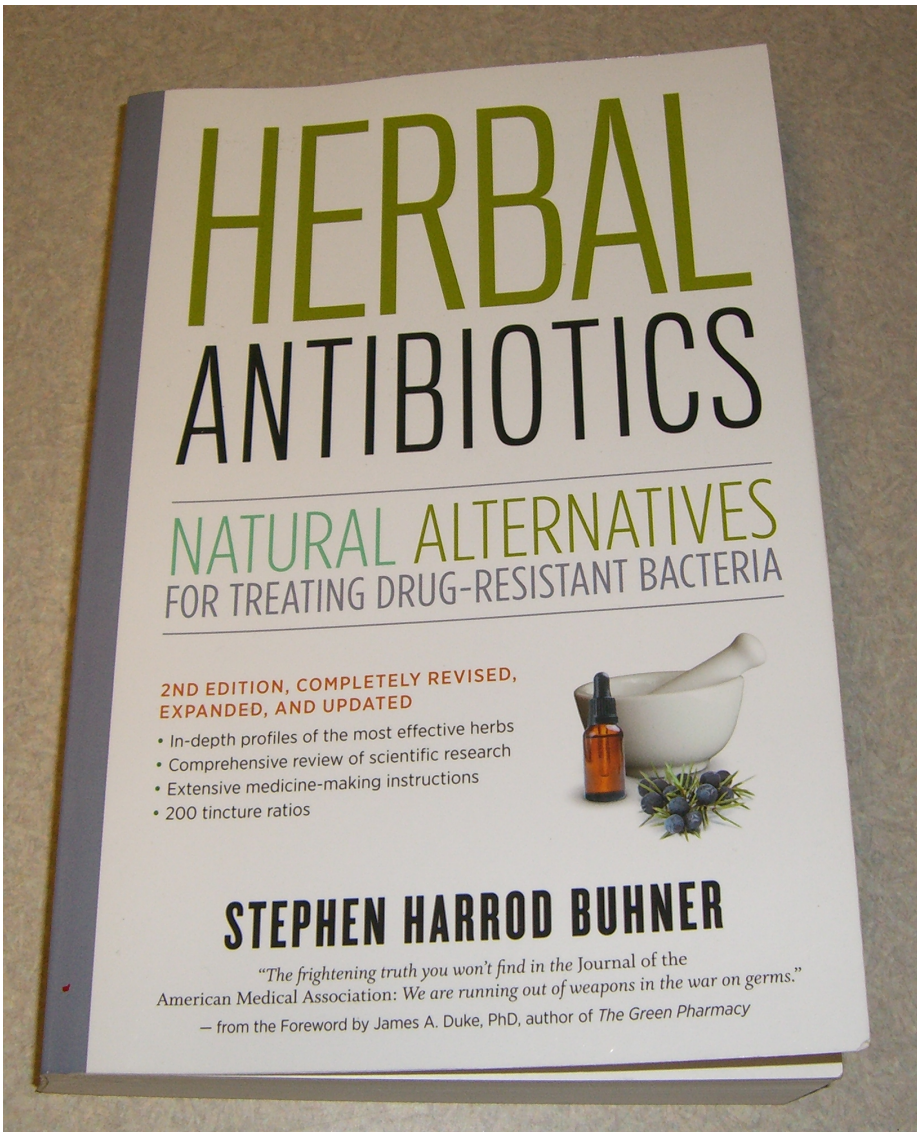
PHOTO OF BUHNER, 2012



APPROACHING UNITY AS AN ACTIVELY DYNAMIC CULTURAL LANDSCAPE

Glen Mellin
Lenny Truitt

March 2014

BACKGROUND

Native Americans have occupied the Mid-Atlantic Region of the United States for about twelve thousand years. Spanning that timeframe, archaeological explanation has identified Native American cultural expressions that support a wide range of interdisciplinary interests. Whether we group these cultural expressions together, or split them up, we have relied on interpretations within systemic models based on an organizational framework called Cultural Ecology. These systemic models attempt to organize a range of broadly defined tangible concepts, such as initial peopling the hemisphere, migration, mobility, and sedentism. The models also attempt to explain more refined societal concepts, such as technology, economy, trade and exchange, as well as degrees of social change and cohesiveness.

Most notably, through climate change, the Ice Age is accepted responsible for producing a land bridge for pedestrian access to the hemisphere and how Holocene sea level rise has submerged lower elevation landscapes. More subtly, however, explanations through Cultural Ecology have largely addressed the complex interplay (in non-determinist ways) of cultural variability as a function of adaptation to the natural environment. Consequently, less attention has been paid to how the natural environment, or available landscape, has responded to the effects of cultural activities. Assuming remnants of these culturally altered landscapes, or cultural landscapes, exist, our challenge has been to quantify how, when, where, and why various aspects of the landscape have been shaped by culture.

The concept of cultural landscape seeks to comingle a range of opportunities and challenges presented in the natural environment with how people might have altered their environment to make their surroundings more beneficial. Addressing past cultural behavior through the lens of cultural landscape offers a more realistic view of the great benefits realized through problem solving. By addressing problem solving, we can achieve a clearer view of past worldviews and in turn, achieve a clearer view of our worldviews. This work is intended to research and describe the past, to evaluate our present situation, and to shape or design our future. It is important to remember that past cultures were fashioned by an inestimably long list of very intelligent and courageous people. For the ones that have passed, and to their living descendents, you rightfully deserve our honor, respect, and curiosity.

INTRODUCTION

This essay illustrates newly organized information, which allows us to speak about how ancestral Native Americans behaved not only within North American and hemispherical contexts, but how their actions are relevant in a global context. To illustrate this point, we offer the following three factors, which unify ancestral Native American behavior with every other human who lived on the planet. These factors have everything to do with cultural landscapes, but very little to do with climate itself. We address: 1) effects of volcanic eruption as the major impetus for human migration, 2) landscape management, creating a physical construct (developing of a sense of place), and 3) intense plant management (creating an actively dynamic landscape).

VOLCANIC ERUPTION AND HUMAN MIGRATION

In a global sense, we have witnessed over one thousand volcanic eruptions during the Holocene. The magnitudes of these eruptions are rated on the Volcanic Explosivity Index (VEI), an exponential scale from 0 to 10 (0 being the smallest and 10 being the largest). Although there has been no VEI 8, 9, or 10 eruptions during the Holocene, we are aware there have been forty-eight VEI 6 and eight VEI 7 eruptions while ancestral Native Americans occupied the Western Hemisphere. Ejected gases from these significant volcanic events, or singularities, permeated the stratosphere and circled the earth for a number of years. When suspended in earth's stratosphere, rock, ash, and glass particles, known as tephra, may reduce or block sunlight from reaching the earth's surface. A blanket of these materials, usually red or gray in color, results in a cooling effect

or even a volcanic winter. Aerosol sulfur compounds, like sulfur oxide and sulfur dioxide cause a yellowish haze of frozen sulfuric acid. A sulfuric haze reflects sunlight and causes significant cooling. Water vapor, carbon dioxide, hydrocloric acids (HCLs), and chlorofluorocarbons (CFCs) absorb heat radiation and hold the heat in the atmosphere. Blankets of these aerosols may appear as a frozen white haze. These compounds cause the surface of the earth to heat up.

All Eight Holocene Eruptions Measuring VEI 7		
Volcano	**Location**	**Age or Date**
Kurile Lake	Kamchatka (Russia)	6440 BCE ± 25 years
Crater Lake	Oregon (USA)	5677 BCE ± 150 years
Kikai	Ryukyu Islands (Japan)	4350 BCE
Santorini	Greece	1640 BCE ± 12
Taupo	New Zealand	180 CE
Krakatau	Indonesia	535 CE
Baitoushan	Eastern China	1000 CE
Tambora	Indonesia	1815 CE
Sources: Newhall and Self (1982), Simkin and Sierbet (1994).		

- The Kurile Lake eruption (ca. 6440 BCE) may be associated with people leaving the Ridge and Valley regions and relocating to the Coastal Plain where the LeCroy tool kit became pervasive.

- The Crater Lake eruption (ca. 5677 BCE) may be associated with people leaving the southern New England region relocating to the Coastal Plain where the Bare and Poplar Island toolkits became pervasive.

- The Kikai eruption (ca. 4350 BCE) may be associated with a Mid-Atlantic regional fusion while the "Broadpoint Industry" became the defining material cultural character.

- The Santorini eruption (ca. 1640 BCE) seems to be associated with the swift decline of the Broadpoint Industry and the innovative development of the steatite bowl.

- The Taupo eruption (ca. 180 CE) seems to occur while many people developed a dependency on estuarine shellfish. We also see the ubiquitous use of Mockley related shell-tempered ceramics (at least in the Chesapeake Region), with interesting additions to the material culture, such as the Fox Creek type bifacial tool.

- The Krakatau eruption (ca. 535 CE) may be associated with people moving from western New York and relocating to the Delmarva Peninsula (and elsewhere, but basically from north to south—an Algonquian expansion). These people bring with them elements of trade and exchange with mid-western groups and the Ohio Valley together with elements of the Jack's Reef style tool kit, and a quartz tempered ceramic tradition.

- The Baitoushan eruption (ca. 1000 CE) is likely associated with new groups of people sweeping across the Chesapeake Bay to dominate the majority of the Delmarva Peninsula. This is noted as a Rappahannock expansion moving into a less populated and less socially organized territory.

- The consequence of the Tambora eruption (ca. 1815 CE) is well documented in historic literature. Researchers need to be discerning, however, in separating out the economic consequences of the War of 1812 (Mellin and Oshima, 2007).

To put this in perspective, a maximum VEI 7 eruption in Indonesia would cause several years of catastrophic weather conditions in the Mid-Atlantic Region. For examples, a significantly hot singularity would have put the Appalachian forests in danger of burning, and a significantly cold singularity would have put flowering plants in danger of freezing, thus failing to produce fruit. Realistically, VEI 6 singularities have caused significant environmental disruption, and VEI 7 singularities have caused widespread environmental disaster. What do these VEI 7 singularities have to do with human migration in the Mid-Atlantic Region? What cultural events might be linked to these dates in Delaware?

Pairing the above human migrations and changes in material cultural with the dates of the above eight documented VEI 7 volcanic singularities offers new insight to cultural landscapes on a macro scale. We are not saying these volcanic eruptions caused people to move, but we are saying that the physical consequences of these eruptions likely dramatically magnified, or diminished existing opportunities, or constraints in the pre-eruption environment. In the future, we may find further definition linked with the forty-eight documented VEI 6 volcanic singularities during the Holocene. Detailing the mobility and cultural changes in the Mid-Atlantic Region on a more localized scale requires us to dig deeper.

LANDSCAPE MANAGEMENT AS A PHYSICAL CONSTRUCT

At about the time of the Kikai eruption, ca. 4350 BCE, we begin to see very interesting changes in archaeological sites and the material cultures present. Most notably, the proliferation of storage pits at repeatedly inhabited locations give rise to a sense of place. A basal worldview, from which frequently venturing out and then returning to the base seems to exhibit a heightened level of economic and social benefit.

Material cultures associated with this basal worldview are new developments too. Long, narrow stem points with either contracting or expanding hafting bases became widespread. Local varieties developed. Some trade and exchange systems developed. Increased hoarding or caching of goods, and likely regulated distribution is suggestive of more complex economic and social systems. Eventually, the development of the Broadpoint Industry (an apparent emergence of specialists engaged in material crafts or trades) allowed forest management tools, at least in mental template, or quarry-blank form to be "communicated" in an area from Georgia to Maine, quite ironically, throughout the area of the eventual English Colonies. This pattern of home base, accumulation, and distribution would continue until the Santorini eruption (ca. 1640 BCE), where we suggest the next global economic catastrophe occurred.

Archaeological sites that span the period between 4350 BCE and 1640 BCE often exhibit very intriguing soil profiles. In some instances, there is evidence of soil deflation or mass wasting, while other soil profiles exhibit soil accretion, sand sheets, even subtle dune building. Contrary to popular interpretations, we think climate change is likely less responsible and culture is likely more responsible for producing these various localized landscapes. From a cultural landscape context, these localized landscapes were probably being managed as physical constructs. Groups of people, perhaps landscape specialists, were actively altering the physical, local environment making it more economically efficient. On the one hand, creating broad open spaces would be one mechanism allowing these surface soils to move. On the other hand, localized loosened and shifting surface soils would be an indication of substantial forest clearing. What might be the economic advantage in all of these organized and perhaps, ritualized landscaping activities?

Essentially, eliminating undesirable species, such as pine, and encouraging desirable species, such as acorn, apple, grape and berry, nut, and persimmon varieties changes the make-up and quantities of beneficial resources. Management programs like burning and coppicing invigorates growth, as well as reducing the elevation of edible materials making them immediately available and easier to harvest. Creating these broad open spaces—places resembling browse lots would be one mechanism that allowed surface soils to become unstable.

We recently, exhaustively addressed the topics of manufacturing and maintaining white-tailed deer browse lots and the economic advantages in maintaining fringe environments. We forecast the primary reason for doing so was twofold: 1) concentrate and accumulate beneficial animals like white-tailed deer, turkeys, rabbits, and squirrels, and 2) concentrate, accumulate, and the translocation of beneficial, edible, and medicinal plant species. Additionally, we developed population analysis of white-tailed deer management models for both

carnivorous husbandry and dairy husbandry. That's right, thinking of a soapstone bowl as a deer milking pan or yogurt making appliance suggests we need to take a step back, and re-think the range of possibilities (Mellin, 2009).

This idea of raising white-tailed deer and growing beneficial plants at the same time does not necessarily cancel each other out. A deer family (mother and yearling offspring) typically occupies a home-range of less than one hundred acres. Multiple deer families often occupy the same home-range. Well-maintained deer browse lots can support two deer per acre. A minimum of twenty adult female deer is needed to maintain a durable, healthy herd. This thinking would suggest that a well-maintained and economically efficient browse lot needs to be (at minimum) a patchwork of between fifteen and thirty acres in size.

Coeval with the Santorini eruption (ca. 1640 BCE) is the proliferation of soapstone bowls and the demise of the Broadpoint Industry. Obviously something dramatic occurred to economic systems and the overall cultural landscape. It is possible this represents a shift from white-tailed deer carnivorous husbandry to dairy husbandry. Nevertheless, this may be the beginning of an era of increased plant translocation, an era of staking-out dedicated berry patches, fruit orchards, nut groves, and medicinal gardens. In addition, we see some rapid in situ progressions in ceramic technology. We also see some people owning enough excess resources to invest in collecting antiquities, trading for copper implements and jewelry, and developing fairly elaborate mortuary programs.

PLANT MANAGEMENT AS AN ACTIVELY DYNAMIC LANDSCAPE

In 2013, we conducted ten botanical surveys in Delaware (Mellin and Truitt, 2013). We identified and recorded a number of plant clusters, which we felt are candidate, remnant Native American botanical clusters representing identifiable berry patches, fruit orchards, nut groves, medicinal gardens, and fiber stocks. We found and recorded plant clusters of various species, for examples, American Chestnut, American Wild Crab Apple, Black Walnut, Box Huckleberry, Catalpa, Chinquapin, Club Moss, Elderberry, Ironwood, Mountain-laurel, Pawpaw, Prickly Pear, Red Mulberry, Rhododendrons, and Yucca. The interesting thing about these candidate remnant clusters was that we found them growing along riverine, foot trail locations spaced adjacent to or between known Native American archaeological sites. Europeans often use the Latin phrase, *frux civilas*, or civic fruit to explain this phenomenon. Perhaps ancestral Native American transportation corridors were lined with civic fruit as well.

Ancestral Native American plant resource management is increasingly recognized. In fact, this course of thinking is very well researched and highly published in South America and Mesoamerica, yet there are only small pockets of researchers across North America interested in investigating such cultural landscapes. Turner and Brown (2014:1) recognize that North American researchers are "…building a convincing case of widespread and long-standing human assisted plant dissemination including across major geographic regions."

SUMMARY

In the Mid-Atlantic Region of the United States, ancestral Native Americans established a diverse history of being both mobile and sedentary. As we attempt to record and describe cultural activity within the context of the landscapes in which those activities occurred, we need to be aware of the full diversity of potential social, cultural, and economic reactions to various environmental obstacles and opportunities. The implication is that we need to see this as a very busy, two way street—this is after all, the original definition of Cultural Ecology. A more salient way to state this, and a way in which the idea of worldview becomes alive, as Nieves (2014 personal communication) pointed out, is to view a people's problem solving activities as the defining characteristic of their actively dynamic cultural landscape.

When a cultural landscape ceases to function in a predictable, reliable way, economic catastrophe is the outcome. As we have shown, the pairing of VEI 7 volcanic eruptions with ancestral Native American migrations support new understanding for human mobility in a macro view. Native Americans shared the consequences of these catastrophic VEI 7 singularities with every other human on the planet!

In the micro view, cultural landscapes may appear as systems, or a series of fractals of varying degrees of proportion. For example, one family's physical construct supports groups of family's physical constructs, and in

turn, these organized social groups support cultural territories of like-minded people. Within a cultural territory, we need to include the uses and contents of the varied spaces between identified archaeological sites. These spaces were not simply unused spaces—these spaces were being managed as integral and essential parts of the overall physical cultural constructs—as actively dynamic cultural landscapes. We need to document often neglected instances of ethnobiological manipulation and intensive ethnobotanical management as two more ways to enhance the framework of our growing micro views of what Cultural Ecology actually has to offer. If we teach ourselves to evaluate a people's ingenious efforts toward problem solving, the existing environment, space, and time, with equal footing, we will be in a much better position to approach unity as an actively dynamic cultural landscape.

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INVESTIGATING POTENTIAL NATIVE AMERICAN BOTANICAL CLUSTERS AROUND DELAWARE'S INLAND BAYS: PINEY NECK, FRESH POND, AND THOMPSON ISLAND

Glen Mellin
Lenny Truitt

April 2014

BACKGROUND

Delaware's Sussex County inland bays are a unique and fragile landscape. Atlantic Ocean tidal waters inundated the Assawoman, the Indian River, and the Rehoboth Bays over the past five thousand years. These bays, as well as their former fresh water river valleys, drained the eastern and southeastern portion of Sussex County.

The inland bay area continues to witness increasing residential, recreational, and retail developmental pressures. Nevertheless, we have managed to preserve and protect a patchwork of undeveloped parcels. In general, the protection of these parcels originated from public/private partnerships designed to secure portions of these increasingly limited open spaces—all the better if these parcels held significant cultural and/or natural resources.

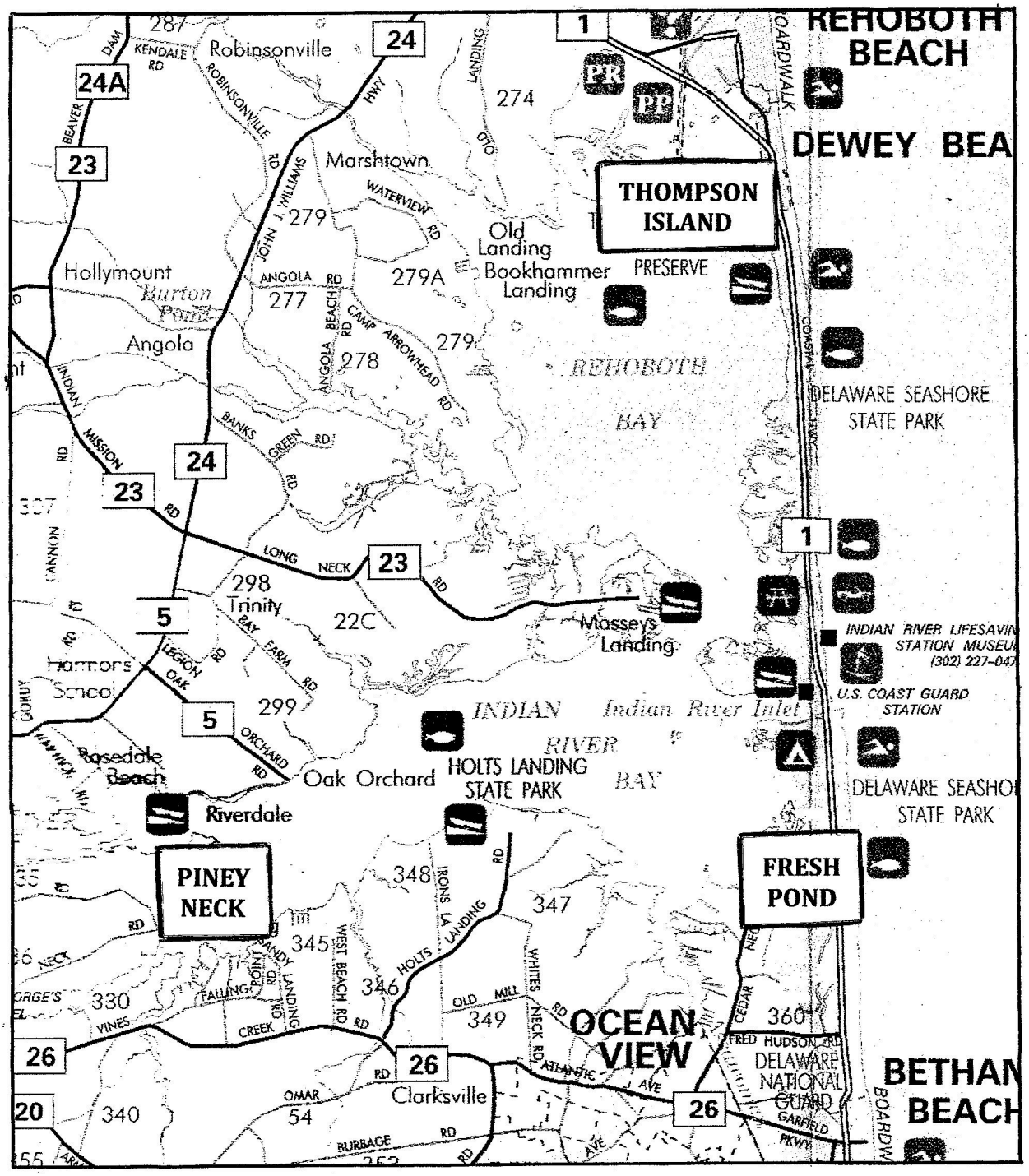
Most areas within these protected parcels were impacted by ancestral Native American activities, historic and commercial logging efforts, agricultural complexes, private residences and by private and public transportation, and public park infrastructure. Additionally, these inland bay areas experience shoreline erosion, are impacted by invasive plant species, and probably contain some forms of precipitate contamination related to a nearby coal-fired electric plant. Nevertheless, some remaining plant species on these parcels are of special interest and are worthy of investigation. Thus, we designed this botanical survey to view the various remaining botanical species and document the ones we felt were potentially translocated or curated through ancestral Native American activities.

We selected the following three locations around the Inland Bay area to conduct our botanical surveys. The first location was an area along the western Indian River Bay, also known as Piney Neck. The second location was an area along the southern Indian River Bay, also known as Fresh Pond. The third location was an area along the northern Rehoboth Bay, also known as Thompson Island. All three locations are currently owned and managed by the State of Delaware (see map on page 2). All three of these primary survey locations are directly associated with previously identified ancestral Native American archaeological sites.

During our three Inland Bay botanical surveys, we found some expected botanical species, but we also found an absence of some expected botanicals. The Piney Neck survey exhibited interesting examples of Bayberry, Prickly Pear Cactus, and Yucca. The Fresh Pond survey exhibited interesting examples of Bayberry, Prickly Pear Cactus, and Yucca. The Thompson Island survey exhibited an absence of Prickly Pear Cactus, but we did record Bayberry, Fringe Tree, Highbush Blueberry, and Mullein. Each of the three areas surveyed, together with our findings, maps, and data logs are discussed below. Lastly, we discuss the curious situation of the differences in proportion of Prickly Pear Cactus in Delaware's Inland Bay region.

STATE OF DELAWARE ROAD MAP

DETAIL OF INLAND BAY AREA



EPISODE ONE--PINEY NECK BOTANICAL SURVEY

FIELD NARRATIVE

At the east end of Piney Neck Road, three miles northeast of Dagsboro, Delaware, the State of Delaware has acquired about one square mile of forested fast-land and tidal cripple. This parcel is known as Piney Neck Preserve (PNP) and is managed by Fish and Wildlife Division of the Department of Natural Resources. PNP is at the confluence of Indian River to the north and Pepper Creek to the south. Indian River Bay begins at the east end of PNP. We also surveyed a nine-acre parcel, which is slated for a future subdivision known as Piney Creek, along the north shore of Pepper Creek. Our pedestrian survey focused on the land east and south of Bunting Road (see map on page 4 and data log on page 5).

We parked at the PNP deer stand parking lot GPS 0482986—4269450. We walked various trails and woods roads until we arrived at the east end of the landmass. We also walked from the parking lot westward to Wingate Cove and surveyed the proposed development called Piney Creek.

We identified interesting clusters of Bayberry, Cactus, and Yucca, which may owe their presence and position in time and space to ancestral Native American activities. We identified two historic archaeological sites. The first is a 19th and early 20th century tenant site at GPS 0483166—4269633, the second is a 19th century agricultural complex at GPS 0483700—4269950. We identified Native American flakes and clamshell at GPS 0483700—4269950, and 0483791—4269980, and flakes, clamshell, and Townsend ceramics at GPS 0483744—4270412.

BAYBERRY

On the north side of the woods road, at GPS 0483120—4269640, we found a multi-species patch of *Morella*. The genus of the Bayberries, in Delaware, is *Morella*, where we have three species. The first species, *Morella caroliniensis* (aka *Myrica heterophylla*), an evergreen, is locally called Evergreen Bayberry. A State Rare species found only in Sussex County, is dioecious (McAvoy 2013b). This species is <u>not listed</u> as a Native American medicinal plant (Moerman 2009). The second species, *Morella cerifera* (aka *Myrica cerifera* and *Myrica pusilla*), an evergreen, is locally called Southern Bayberry. This species is commonly found in all three counties, is dioecious (McAvoy 2013b), and is listed as a Native American medicinal plant (Moerman 2009). The third species, *Morella pensylvanica* (aka *Myrica pensylvanica*), a semi-evergreen, is locally called Northern Bayberry. This species is commonly found in all three counties, is dioecious (McAvoy 2013b), and is <u>not listed</u> as a Native American medicinal plant (Moerman 2009).

On April 5, 2014, we observed at least two very distinct types of *Morella* within this multi-species patch of bayberries. One species was four meters tall with weathered and wilted-looking dark green with red-toned leaves. The other species was two meters high with very bright, light green leaves. We were undecided in making positive species identification, although it is likely we found an example of *M. caroliniensis*, a rare and supposedly native plant, but one that might need to be addressed as a translocated, or adventive species.

Moerman (2009) says the *Myrica cerifera* is used as a Native American medicinal. Bayberries possess antibacterial properties, they are edible, and they are coated with a harvestable wax. McAvoy (2013b) says *Morella caroliniensis* is a State Rare species and only found in Sussex County, the northern limit of its current range (which we think raises questions about whether this plant is actually an adventive or translocated species of Native American origin).

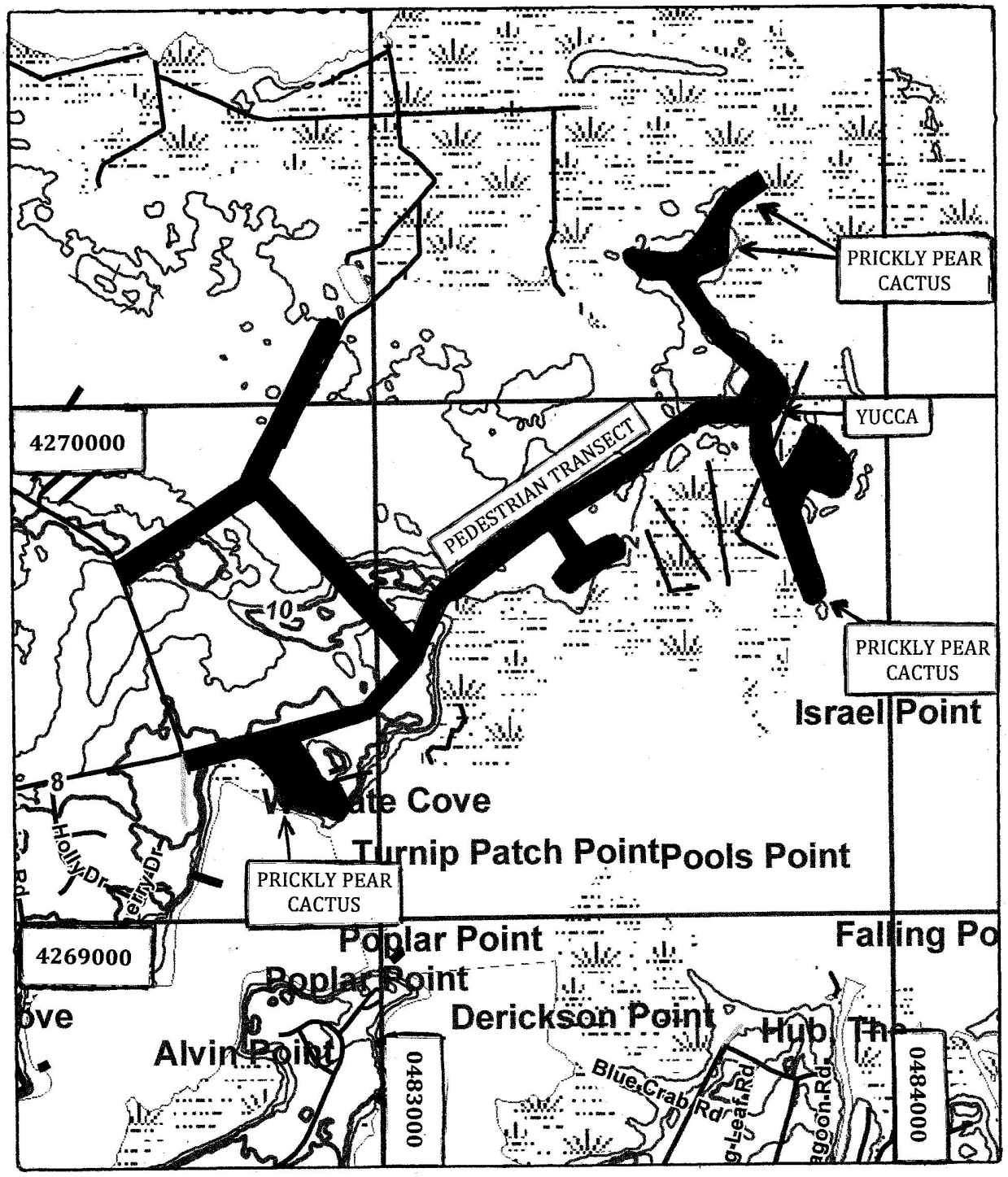
CACTUS

We found five patches of Prickly Pear Cactus on the extreme eastern end of Piney Neck where known ancestral Native American archaeological sites are located. We also found a large spread of Prickly Pear Cactus clusters at a known ancestral Native American archaeological site in the proposed Piney Creek development (see map and data log).

The cactus found here is the Prickly Pear Cactus, *Opuntia humifusa* var. *humifusa*, commonly found in Kent and Sussex Counties (McAvoy 2013b), and is listed as a Native American medicinal plant (Moerman 2009). The plant typically appears as a flattish, rounded assemblage, or cladode of greenish, spiny cactus paddles,

A BOTANICAL SURVEY ON PINEY NECK IN SUSSEX COUNTY

DETAIL OF USGS FRANKFORD QUADRANGLE, DELAWARE



BOTANICAL SURVEY OF PINEY NECK (DATA LOG)		
Piney Neck Preserve (State Land)		
GPS UTM Grid point		**Description**
0482986	4269450	Transect waypoint (Parking lot)
0482986	4269450	Transect waypoint (Historic tenant site found)
0483315	4269772	Transect waypoint
0483508	4269856	Transect waypoint
0483708	4269979	Transect waypoint
0483782	4269985	Transect waypoint (Shell and flakes found)
0483781	4270046	Transect waypoint
0483682	4270100	Transect waypoint
0483623	4270219	Transect waypoint
0483646	4270302	Transect waypoint
0483705	4270382	Transect waypoint
0483744	4270412	Transect waypoint (Flakes and Townsend ceramics found)
0483798	4269784	Transect waypoint
0483772	4269835	Transect waypoint
0483686	4269958	Transect waypoint
Piney Neck Preserve Botanicals (State Land)		
GPS UTM Grid point		**Description**
0483120	4269640	Bayberry patch (Two different species)
0483791	4269980	Yucca
0483645	4270305	Prickly Pear Cactus patch (4m x 4m)
0483672	4270292	Prickly Pear Cactus patch (4m x 4m)
0483703	4270382	Prickly Pear Cactus patch (2m x 2m)
0483745	4270419	Prickly Pear Cactus patch (1m x 1m)
0483859	4269628	Prickly Pear Cactus patch (33m x 12m)
Piney Creek Botanicals (Private Development)		
GPS UTM Grid point		**Description**
0483691	4269963	Prickly Pear Cactus field (Perimeter) (Flakes found)
0482920	4269208	Prickly Pear Cactus field (Perimeter) (Flakes found)
0482873	4269227	Prickly Pear Cactus field (Perimeter)
0482807	4269290	Prickly Pear Cactus field (Perimeter)
0482828	4269355	Prickly Pear Cactus field (Perimeter)
0482853	4269325	Prickly Pear Cactus field (Perimeter)

which may attain 50 cm. in diameter, and 40 cm. in height. Prickly Pear plants are usually found in clusters where sandy, xeric soils (may) have experienced some degree of natural or cultural disturbance. This plant is edible and contains medicinal properties.

YUCCA

We found one Yucca plant growing on the eroding bluff edge on Piney Neck at GPS 0483791—4269980. This bluff edge is only 1 to 2 meters above the tidal salt marsh, thus, this single plant is the only remaining plant of this species at this location. Its proximity to the eroding edge is an indication it will fall into the marsh within a period of fifty years. Yucca, or Adam's Needles (*Yucca filamentosa*) is commonly found in Kent and Sussex Counties (McAvoy 2013b) and is listed as a Native American medicinal plant (Moerman 2009). This plant forms a low rosette of lance-shaped leaves native to Delaware. This species produces a flower stalk, which

may reach up to 9 feet high. Native Americans processed the leaves to make cordage and salves for topical treatments.

EPISODE TWO—FRESH POND BOTANICAL SURVEY

FIELD NARRATIVE

If you drive north on Cedar Neck Road and turn east on to Hickman Road, you will enter into a parking lot for the Fresh Pond Preserve, a State owned, preserved parcel, which was formerly a nineteenth and twentieth century private agricultural complex. In pre-colonial times, this parcel has a long history of being an ancestral Native American activity area. The area we surveyed on April 8, 2014 was roughly two miles long and one half mile wide, confined by Sloughs Gut on the west, Fresh Pond on the east, and Indian River Bay on the north (see map on page 7 and data log on page 8). We parked at the seasonal pay parking lot at GPS 0493671—4268365. The former agricultural fields have been repopulated with mostly loblolly pine within the past thirty years or so. Our plan was to walk along or as close to the habitable land edges as we could and try to observe and document any clusters that might be candidate clusters of ancestral Native American origin. The State of Delaware is currently maintaining a series of foot trails in locations that fit well with our objectives. The primary foot trail is called Prickly Pear Trail—giving us an indication that Prickly Pear Cactus was present.

BAYBERRY

Bayberry (*Morella* sp.) is found in abundance. At the time of our survey, in April, some of the plants appeared to have few leaves, and some of the plants appeared to retain most of their leaves. At any rate, all of these plants were about four meters tall with weathered and wilted-looking dark green with red-toned leaves. Due to the vagaries of exposure to wind, soil moisture, and available sunlight, we could not reliably decide between examples of the Southern and the Northern species.

The *Morella cerifera* (aka *Myrica cerifera* and *Myrica pusilla*), locally called Southern Bayberry, is considered an evergreen. This species is commonly found in all three counties, is dioecious (McAvoy 2013b), and <u>is listed</u> as a Native American medicinal plant (Moerman 2009). The other species, *Morella pensylvanica* (aka *Myrica pensylvanica*), locally called Northern Bayberry, is a semi-evergreen. This species is commonly found in all three counties, is dioecious (McAvoy 2013b), and is <u>not listed</u> as a Native American medicinal plant (Moerman 2009).

CACTUS

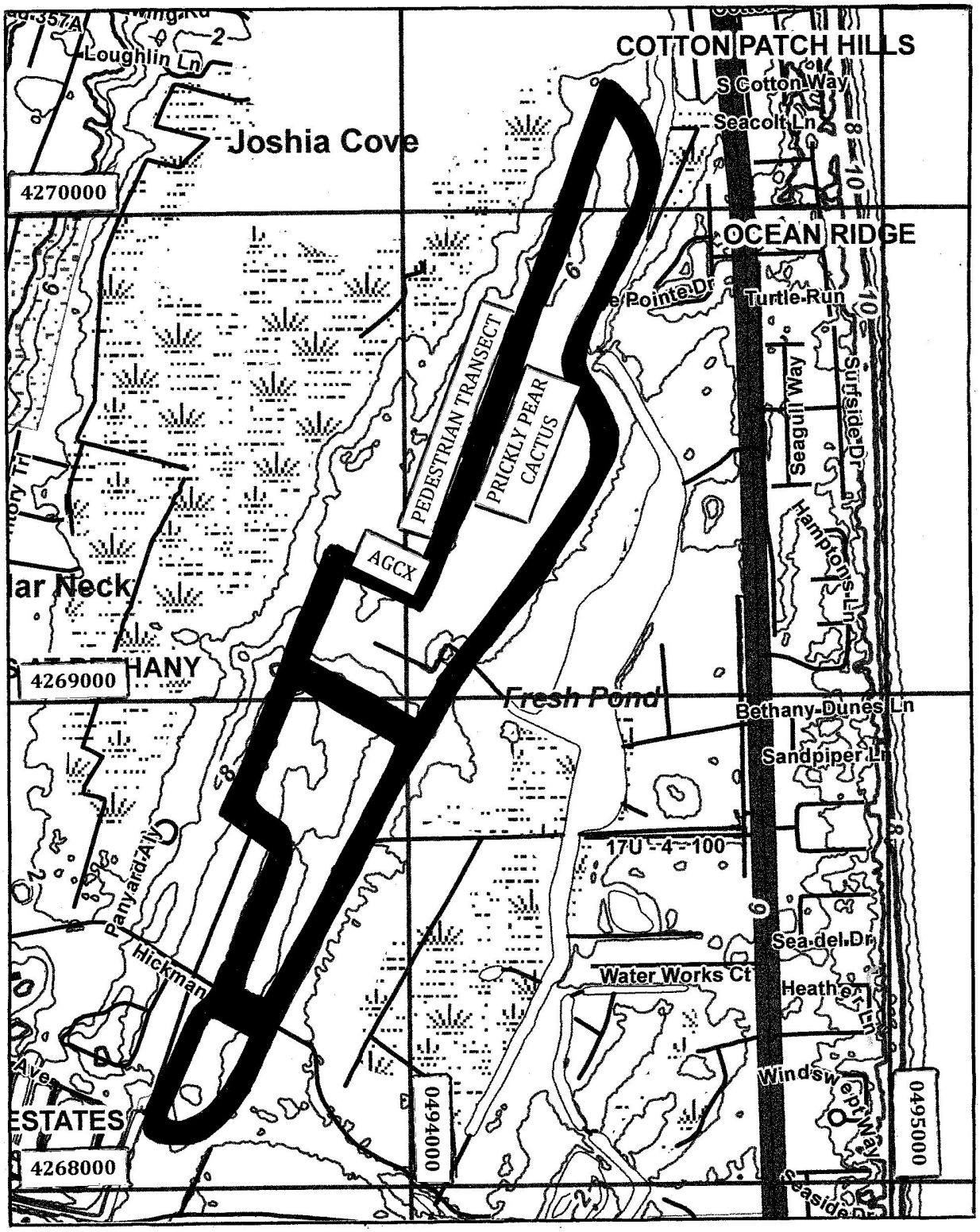
The cactus found here is the Prickly Pear Cactus (*Opuntia humifusa* var. *humifusa*) commonly found in Kent and Sussex Counties (McAvoy 2013b) and is listed as a Native American medicinal plant (Moerman 2009). Indeed, we found a very limited amount of cactus from GPS N4268269 up to about N4268900. We found a moderate amount of cactus, some associated with clam shell, from GPS N4268900 up to about N4269100. And, we found a large amount of cactus, some associated with clam shell from GPS N4269100 up to about N4270200, or the north end of the neck of land. At the north end of the neck we observed shell, shell-tempered ceramics, lithics, and a notched jasper bifacial tool. Essentially, the north half of this survey area is loaded with cactus and clam shell, while the south half of this survey area has little cactus and no clamshell. Thus, our impression of what we observed, is that the cactus we found is in the same spatial association as with the ancestral Native American clam shell scatters.

AGCX

We visited the location of the known historic agricultural complex. The residence has fallen and we took a reading on the southwest corner of the foundation, GPS 0493948—4269231. From that spot, we observed the standing brick chimney, and a standing barn-like structure to the west. As far as those plants go, we observed daffodils, red cedars, cactus, yuccas, and some old black cherry trees. I was somewhat surprised that there is no indication these former historic residents aspired to collecting European and Asian varieties readily available in the second half of the nineteenth century. We searched for, but failed to find even one black walnut.

A BOTANICAL SURVEY OF FRESH POND IN SUSSEX COUNTY

DETAIL OF USGS BETHANY BEACH QUADRANGLE, DELAWARE



BOTANICAL SURVEY OF FRESH POND (DATA LOG)		
Fresh Pond Preserve (State Land)		
GPS UTM Grid point		Description
0493529	4268269	Prickly Pear Cactus patch (2m x 2m)
0493560	4268269	Prickly Pear Cactus patch (2m x 2m)
0493650	4268422	Prickly Pear Cactus patch (2m x 2m)
0493671	4268365	Preserve Parking Lot
0493680	4268862	Prickly Pear Cactus patch (2m x 2m)
0493799	4269268	Prickly Pear Cactus patch (2m x 2m)
0493877	4268999	Prickly Pear Cactus patch (2m x 2m) and Clam Shell
0493948	4269231	AGCX (cactus, daffodil, red cedar, and yucca)
0493981	4268941	Prickly Pear Cactus patch (2m x 2m)
0494014	4268965	Prickly Pear Cactus patch (2m x 2m)
0494132	4269564	Prickly Pear Cactus patch (2m x 2m)
0494190	4269703	Prickly Pear Cactus patch (2m x 2m) and Clam Shell
0494336	4270045	Prickly Pear Cactus patch (2m x 2m) and Clam Shell
0494394	4269891	Prickly Pear Cactus patch (2m x 2m) and Clam Shell
0494400	4270250	(End of Land) Prickly Pear Cactus patch (2m x 2m), shell, ceramics, lithics
0494475	4270200	Prickly Pear Cactus patch (2m x 2m) and Clam Shell

EPISODE THREE—THOMPSON ISLAND BOTANICAL SURVEY

FIELD NARRATIVE

While driving south on State Route 1 in Rehoboth, just south of the canal bridge, turn west on Bay Road and drive to the Thompson Island preserve parking lot. We parked at GPS 0492193—4283866. Follow the crushed stone foot path southward through some extensive holly patches. The path leads through a five-acre grove of old trees, perhaps a remnant native landscape with two hundred and fifty year old oaks. We walked past the wooden observation platform (GPS 0491859—4283056) where we had our initial view of Thompson Island, the extensive salt marsh, and the Lewes Canal (Intracoastal Waterway). Continue southward on a non-maintained foot trail along the east side of the canal. Thompson Island is an elevated island covered primarily with Loblolly Pine. Its south shoreline is eroding. Walk along the island loop trail. A signed (keep out) wooden and barbed wire fence protects significant natural and cultural resources in the interior, elevated portion of the island. This ancestral Native American location is sequestered under State of Delaware regulations.

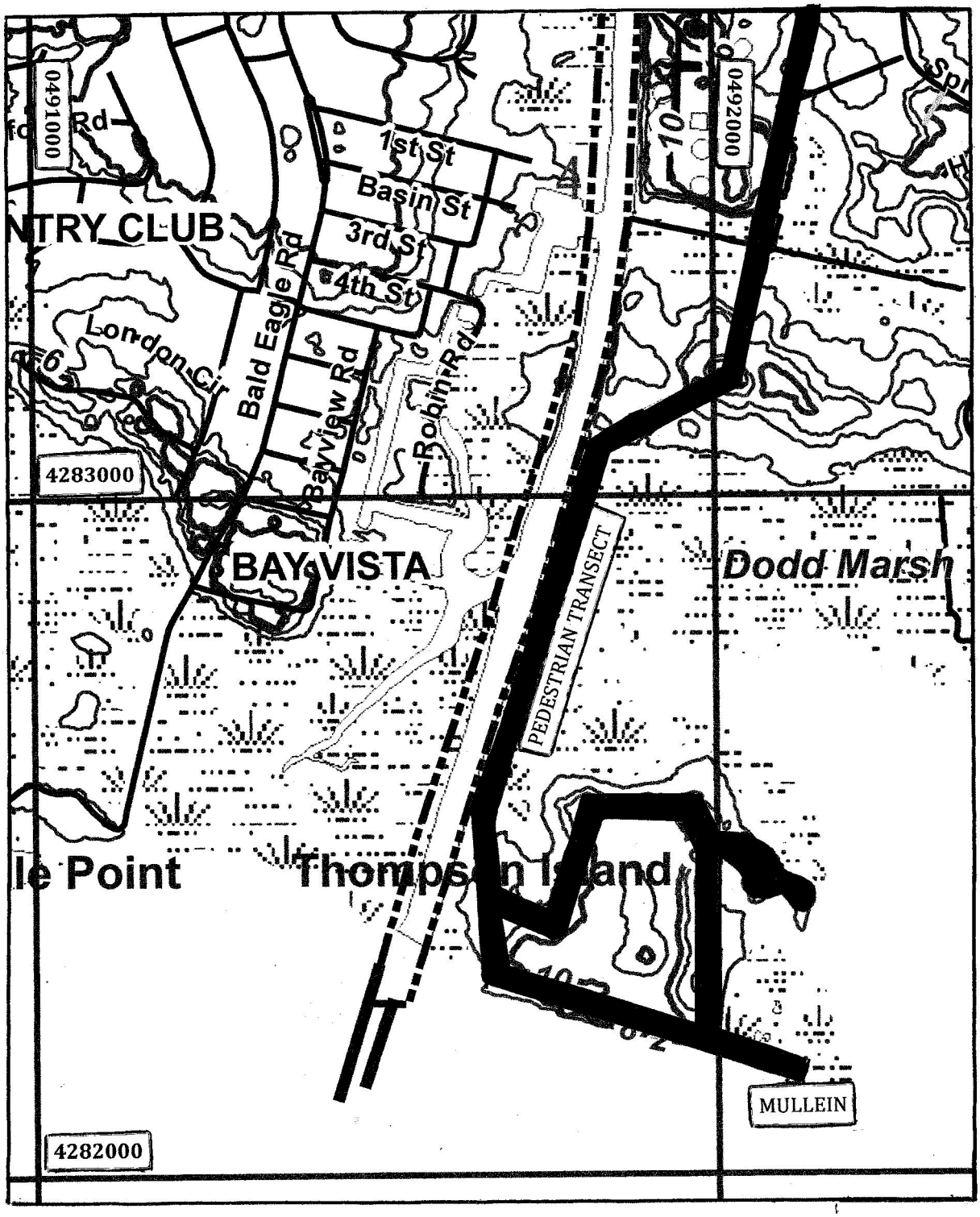
The east end of Thompson Island is reported to support a cluster of Holy Grass (*Hierochloe odorata*), known to be an ancestral Native American ceremonial plant species (McAvoy 2000, McAvoy 2013a, McAvoy 2013b, McKnight 2013, and Mellin and Truitt 2013:10). On April 9, 2014, while surveying only along the designated trails, we failed to locate any specimens of Holy Grass. Therefore, we were not able to confirm its continued existence, or provide an accurate GPS location. Nevertheless, we found other plant species, which may be of interest. We identified Bayberry, Fringe Tree, Highbush Blueberry, and Mullein (see map on page 9 and data log on page 10).

BAYBERRY

Bayberry (*Morella* sp.) is found in abundance. At the time of our survey, in April, some of the plants appeared to have few leaves, and some of the plants appeared to retain most of their leaves. At any rate, all of these plants were about four meters tall with weathered and wilted-looking dark green with red-toned leaves. Due to the vagaries of exposure to wind, soil moisture, and available sunlight, we could not reliably decide between examples of the Southern and the Northern species.

A BOTANICAL SURVEY OF THOMPSON ISLAND IN SUSSEX COUNTY

DETAIL OF USGS REHOBOTH BEACH QUADRANGLE, DELAWARE



BOTANICAL SURVEY OF THOMPSON ISLAND (DATA LOG)		
Thompson Island Preserve (State Land)		
GPS UTM Grid point		Description
0492193	4283866	Parking lot (No charge)
0491859	4283056	Observation Platform
0491674	4282472	Pedestrian Entrance to Thompson Island
0491693	4282282	Fringe Tree
0492095	4282142	Mullein patch (5m x 5m) Clam Shell and Townsend Ceramics

The *Morella cerifera* (aka *Myrica cerifera* and *Myrica pusilla*), locally called Southern Bayberry, is considered an evergreen. This species is commonly found in all three counties, is dioecious (McAvoy 2013), and is listed as a Native American medicinal plant (Moerman 2009). The other species, *Morella pensylvanica* (aka *Myrica pensylvanica*), locally called Northern Bayberry, is a semi-evergreen. This species is commonly found in all three counties, is dioecious (McAvoy 2013), and is not listed as a Native American medicinal plant (Moerman 2009).

FRINGE TREE
We identified one very large Fringe Tree (*Chionanthus virginicus*) commonly found in all three counties, and is a dioecious plant (McAvoy 2013b). This species is listed as a Native American medicinal plant (Moerman 2009). It is located near the southern bluff edge of the island at GPS 0491693—4282282.

HIGHBUSH BLUEBERRY
The eastern and northern perimeter of Thompson Island supports a dense population of mature Highbush Blueberry (*Vaccinium corymbosum*). This species is commonly found in all three counties (McAvoy 2013b). Although other species of blueberry are medicinal, *V. corymbosum* is not listed as a Native American medicinal (Moerman 2009).

MULLEIN
We found a cluster of Mullein (*Verbascum thapsus*) on the extreme eastern landform at GPS 0492095—4282142. The Mullein patch was growing in an exposed scatter of old clam shells, which also contained some very late shell-tempered Native American ceramic shards. *V. thapsus* likely had a very early introduction from Europe where it is widely recognized as being a very beneficial edible and medicinal plant. Today, we assume it is common in all three counties, but we could not find it listed as *Verbascum* in Delaware (McAvoy 2013b). Nevertheless, this species is listed as a Native American medicinal plant with post-introduction use (Moerman 2009).

RESULTS OF THE THREE AREAS IN THE INLAND BAY BOTANICAL SURVEY

This essay incorporates three botanical surveys—Piney Neck, Fresh Pond, and Thompson Island into a comparative Inland Bay botanical survey. All three of these similar landforms are contained within an eight mile-wide circle. We chose these "undeveloped" locations because we thought they would contain less disturbed examples of remaining ancestral Native American cultural landscapes with potentially less disturbed examples of any remaining ancestral Native American botanical clusters. While analyzing the many similarities of the three locations, we found a significant difference in proportion of Prickly Pear Cactus. Our results were unexpected—leaving us with the question of why were our results unexpected?

The Piney Neck survey is along the western Indian River Bay area. Archaeological sites exhibit some shellfish refuse and some ceramic shards of the Woodland Periods (ca. 2000BCE—1500CE). These types and quantities of artifacts probably indicate activities at these locations were oriented toward processing and procurement of local resources. Scattered Prickly Pear Cactus is currently documented growing in and around these scatters of artifacts.

The Fresh Pond survey is along the southeastern Indian River Bay area. These extensive archaeological sites exhibit extensive shellfish refuse—shell middens in some areas, together with extensive concentrations of ceramic shards and lithic debitage. These types and quantities of artifacts probably indicate activities at these various locations were oriented toward seasonal base camps of the Woodland Period (ca. 2000BCE—1500CE) and perhaps even year-round bases in the Late Woodland II Period (ca.1200CE—1650CE). A huge amount of Prickly Pear Cactus is currently growing in and around these concentrations of artifacts. On April 8, 2014, the date of our survey, we estimated we could have scooped-up at least one pick-up truckload of cactus per acre in the most intense part of the cactus field (an area estimated to be no less than twelve acres). Less dense cactus patches generally followed the meandering shellfish refuse scatters over an additional estimated area of thirty acres. Overall, where we found shellfish refuse—we found cactus.

The Thompson Island survey is along the northern Rehoboth Bay area. This extensive archaeological site contains a protected holy place. The holy place portion of the island is marked and protected from trespass by a series of posted, no access orders and a substantial wood rail fence and wire barrier. This ceremonial location should be respected—please keep out! We restricted our botanical survey to the access trail, where, we failed to find any trace of the previously reported Holy Grass. Although we did observe a shellfish refuse location, which did contain Late Woodland II Period ceramic shards and Mullein, on the eastern-most spit of land. Overall, we failed to find any trace of Prickly Pear Cactus. The absence of Prickly Pear Cactus was a shocking discovery!

Since the scope of our botanical surveys is limited to documenting existing botanical data, we are currently not in a position to have a detailed discussion of each of these archaeological sites. Nevertheless, we are aware the Delaware Historic Preservation Office has a documentation file on each of these sites. Additionally, each one of these sites has been addressed in at least one archaeological publication. Our impression of what we found is that: Piney Neck offers a series of Native American processing and procurement locations that exhibit light scatterings of Prickly Pear Cactus patches. Fresh Pond offers a large seasonal base camp cluster and perhaps a temporally late, year-round camp that exhibits a very large and dense field of Prickly Pear Cactus. Thompson Island offers (at minimum) a ceremonial/holy place complex that exhibits no Prickly Pear Cactus at all.

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CHINQUAPIN CLUSTER IDENTIFIED IN RIVERS END ON DEEP CREEK, A TRIBUTARY OF THE NANTICOKE RIVER, SUSSEX COUNTY, DELAWARE

Glen Mellin
Lenny Truitt

May 2014

BACKGROUND

In the fall of 2013, Mr. Kenna Nethken informed us that he had observed Chinquapin trees in the eastern portion of Rivers End, a residential subdivision currently under construction east of Seaford, Delaware. We designed a pedestrian botanical survey to investigate this new discovery. Indeed, we found a large and discreet Chinquapin cluster along the north riverbank uplands of Deep Creek near the east end of the subdivision. This essay describes our botanical survey, details what we found, and provides some updated interpretations on these very rare and unusual nut producing tree clusters.

FIELD NARRATIVE

The Rivers End residential subdivision is situated along the north shoreline of Deep Creek between the Nanticoke River and the village of Concord in Sussex County, Delaware. Our botanical survey started at the confluence of Deep Creek and the Nanticoke River and ended at the east end of Rivers End, a distance of over two miles (see map on page 2 and data log on page 3). We easily accessed the area through a network of macadam residential roadways. Although various buildable lots are already developed in the majority of this survey, the Chinquapin cluster is identified growing on a number of un-built forested lots, along the roadside of Rivers End Drive, Deep Creek Drive, Otter Run Court, and on the slopes of several ephemeral streams.

Our scouting survey occurred on April 20, 2014, and we returned on May 9 to record our GPS readings. We recorded the GPS location on thirty-nine living Chinquapin trees, one dead Chinquapin tree, and two small Prickly Pear Cactus patches (see data log on page 3). Only botanical specimens that were easily accessible from the road were documented. We assumed there were many more living specimens available within the overall cluster, but we did not pursue them. The cluster measures approximately 440 meters East/West (GPS 0451098—0451538) and 186 meters North/South (GPS 4277567—4277753).

THE RIVERS END CHINQUAPIN CLUSTER

The Rivers End Chinquapin cluster (*Castanea pumila pumila*) illustrated in this paper covers about six hectares or about eight acres. Although these trees are found dense in some places and sparse in others, the overall cluster suffers from the Asian bark disease and from currently growing in an inhospitable environment characterized as a triple canopy forest on the Lower Coastal Plain. This Chinquapin cluster is of undetermined age, however; we are inclined to believe this cluster is a remnant ancestral Native American nut grove.

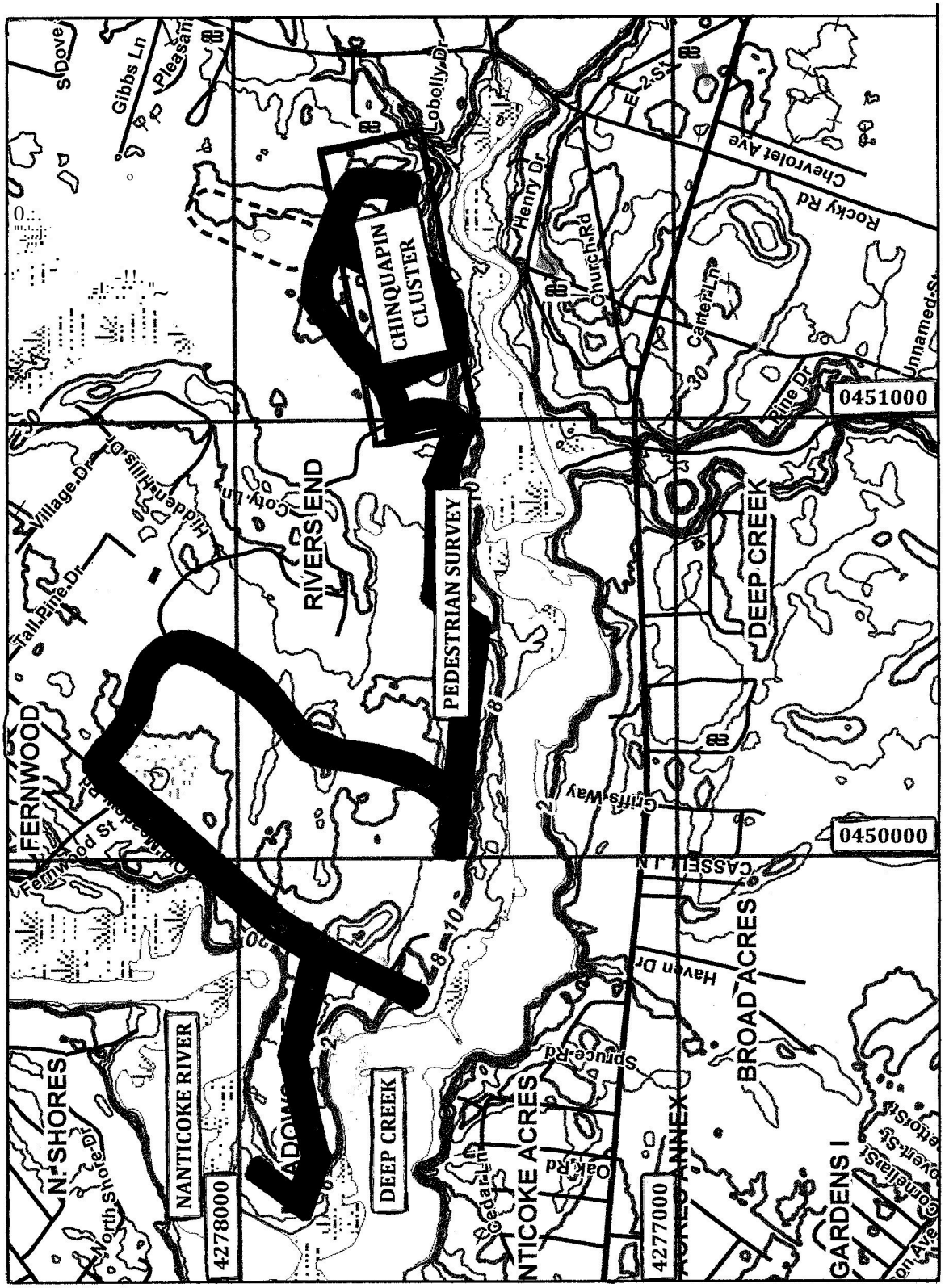
Overall, individual specimens of Chinquapin within this cluster suffer for two reasons. First, all specimens observed are perpetually stunted, or knocked back, by the effects of the Asian bark fungus. Second, most of these specimens suffer from lack of direct sunlight due to the overbearing canopy of oaks, hickories, and pines (the typical tri-dominant spices in this terrain). A few Chinquapins growing along side Deep Creek Drive and Otter Run Court were receiving some afternoon direct sunlight and we did see a few pubescent catkins on those plants. Overall, the color of the leaves (maximum three inches long on May 9) seemed pale green, probably due to stress and/or lack of nutrients and sunlight. The takeaway is—all observed plants suffer, or are barely surviving, trying to make a living in this type of environment (see Mellin and Truitt, 2013a:3-4; and Taber, 2012:99). See interpretations where we compare the six known Chinquapin clusters thus far detailed in Delaware.

PRICKLY PEAR CACTUS

During the Rivers End botanical survey, we found two patches of Prickly Pear Cactus, both within the Chinquapin cluster. As noted above, the Prickly Pear Cactus finds and the Chinquapin cluster are

RIVERS END BOTANICAL SURVEY

DETAIL OF USGS SEAFORD EAST QUADRANGLE, DELAWARE



RIVERS END BOTANICAL SURVEY (DATA LOG)		
GPS UTM EAST	**GPS UTM SOUTH**	**DESCRIPTION**
0451098	4277578	Chinquapin Tree
0451102	4277602	Chinquapin Tree
0451108	4277580	Chinquapin Tree
0451108	4277594	Chinquapin Tree
0451110	4277581	Chinquapin Tree
0451112	4277580	Chinquapin Tree
0451112	4277581	Chinquapin Tree
0451113	4277582	Chinquapin Tree
0451115	4277583	Chinquapin Tree
0451115	4277586	Chinquapin Tree
0451351	4277567	Chinquapin Tree
0451390	4277740	Chinquapin Tree
0451403	4277749	Chinquapin Tree
0451404	4277750	Chinquapin Tree
0451404	4277752	Chinquapin Tree
0451405	4277749	Chinquapin Tree
0451407	4277752	Chinquapin Tree
0451408	4277752	Chinquapin Tree
0451419	4277753	Chinquapin Tree
0451433	4277748	Chinquapin Tree
0451455	4277751	Chinquapin Tree
0451457	4277749	Chinquapin Tree
0451460	4277751	Chinquapin Tree
0451470	4277749	Chinquapin Tree
0451471	4277748	Chinquapin Tree
0451477	4277749	Chinquapin Tree
0451479	4277641	Chinquapin Tree
0451489	4277634	Chinquapin Tree
0451490	4277637	Chinquapin Tree
0451495	4277741	Chinquapin Tree
0451505	4277640	Chinquapin Tree
0451511	4277636	Chinquapin Tree
0451514	4277635	Chinquapin Tree
0451515	4277633	Chinquapin Tree
0451515	4277635	Chinquapin Tree
0451519	4277636	Chinquapin Tree
0451521	4277635	Chinquapin Tree
0451527	4277634	Chinquapin Tree
0451536	4277646	Chinquapin Tree
0451538	4277651	Chinquapin Tree (Dead)
0451014	4277518	Prickly Pear Cactus (Small Patch)
0451215	4277479	Prickly Pear Cactus (Small Patch)

geographically associated with a known ancestral Native American archaeological site(s) (see map on page 2 and data log on page 3).

The cactus found here is the Prickly Pear Cactus, *Opuntia humifusa* var. *humifusa*, commonly found in Kent and Sussex Counties (McAvoy 2013), and is listed as a Native American medicinal plant (Moerman 2009). The plant typically appears as a flattish, rounded assemblage, or cladode of greenish, spiny cactus paddles, which may attain 50 cm. in diameter, and 40 cm. in height. Prickly Pear plants are usually found in clusters where sandy, xeric soils (may) have experienced some degree of natural or cultural disturbance. This plant is edible

and contains medicinal properties. The juice of this plant is particularly effective in treating urinary tract infection.

DISCUSSION

The discovery of the Rivers End Chinquapin cluster in western Sussex County, Delaware offers new insights to the presence and geographical distribution of this unique plant species. The addition of this newly defined cluster now gives us a total of six detailed clusters (Mellin and Truitt, 2013a; 2013b; 2013c). Furthermore, these results offer an opportunity to compare and contrast these detailed Chinquapin clusters located at Raccoon Pond (Broad Creek), Trap Pond (Broad Creek), Concord Pond (Deep Creek), Middleford Pond (Nanticoke River), and the two clusters at Killen Pond (Murderkill River). We see a developing pattern.

The eighteenth century millpond dams were constructed at locations where the water was shallow enough that a person could wade across the tidal river without swimming. Dams at these locations are less expensive to build, and cargo shallops could navigate to the mills without grounding. Additionally, each of these Chinquapin clusters is found within 1,000 feet of the eighteenth century dam locations, or at ancestral Native American river wading/crossing locations. We provide a map (see page 5) that exhibits the exact proximity of two Chinquapin clusters geographically associated with two eighteenth century dams, east of Seaford, Delaware.

In the past, we have somewhat jokingly said, there are no bronze plaques in the woods that inform us of the location of any ancestral Native American botanical clusters. However, with six known Chinquapin clusters being located in very close proximity to six eighteenth century dams (technically—first water of wading depth), we strongly suggest these six found Chinquapin clusters are actually six elements of a readable, ancestral Native American roadmap. In addition, the Mellin and Truitt Chinquapin cluster is found on the southeast edge of Jackson's 1682 patent called "Venture". The 1682 King's Road from Milford to Seaford bisects the Mellin and Truitt Chinquapin cluster at the north edge of the Middleford eighteenth century dam. So, we very strongly suggest the King's Road from Milford to Seaford followed an ancient Native American foot trail or transportation corridor with this Chinquapin cluster growing at the last, safe wading on the Nanticoke River. And finally, on page 6, we have included a June 2013 photograph of Lenny Truitt standing next to one of our Chinquapin trees (with catkins in decline) on the shoulder of the old King's Road at GPS 0450833—4280241.

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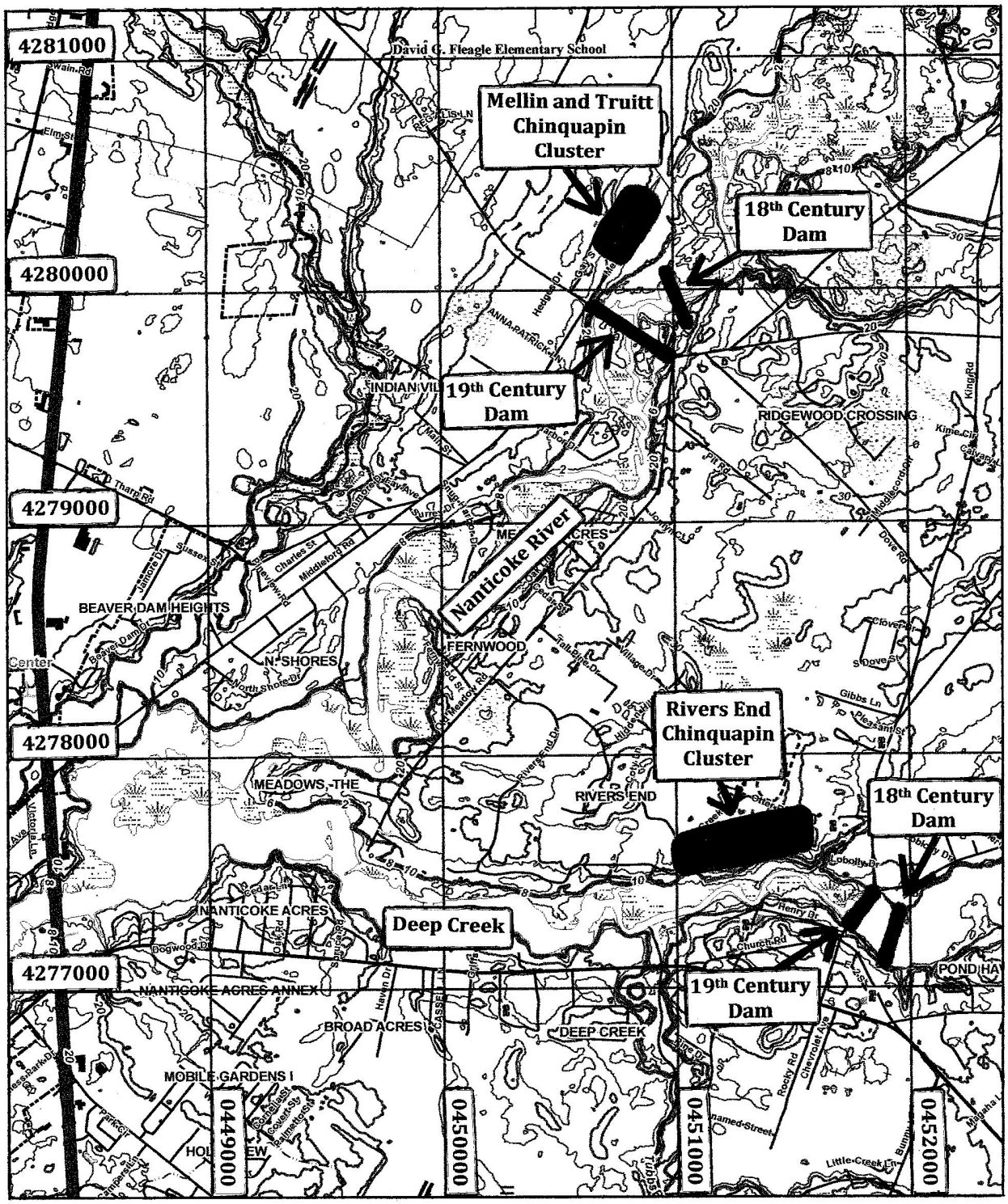
TWO DOCUMENTED CHINQUAPIN CLUSTERS EAST OF SEAFORD

DETAIL OF USGS SEAFORD EAST QUADRANGLE, DELAWARE



THE APPALACHIAN TRAIL: WILDERNESS OBSTACLE, OR A NATIVE AMERICAN TRUCK ROUTE?

Glen Mellin
Lenny Truitt

June 2014

INTRODUCTION

This essay explains why we think the Appalachian Trail was originally laid out by Paleoindians and continued to serve as a Native American footpath throughout history. We think this arterial footpath is both the oldest and the longest footpath in the eastern portion of the United States. After plotting most of the major lithic quarries in the eastern Appalachians in close proximity to this ancient footpath, we suggest the original purpose of the footpath was for "interstate" transportation and for trucking goods and services to and fro—basically from quarry site to quarry site, up and down the trail, from Maine to Georgia.

Additionally, we realize a long history of quarried lithic materials having been placed and found hundreds of miles adjacent to the Appalachian Trail. We suggest these artifacts were trucked laterally from the Trail down footpaths of lesser importance. A wide variety of topics fit well into this network of transportation features. Topics such as access to quarry sites, direct procurement, trade and exchange, preferred lithic types by cultural contexts, etc. are all tied to footpaths, or pedestrian routes, ancestral trails leading from one place to another place.

Recently, there has been a concerted effort to look into these ideas of place and transportation in ancestral Native American worldviews. What might be the relationship between transportation and place, mobility and base; and why should we even care? May we suggest that just as artifacts are imbedded in sites, sites are imbedded in landscapes, and landscapes are imbedded in worldviews. We need to understand these spaces between sites, including transportation corridors, before we can even attempt to understand ancestral Native American worldviews.

MOVING THE SCIENCE FORWARD

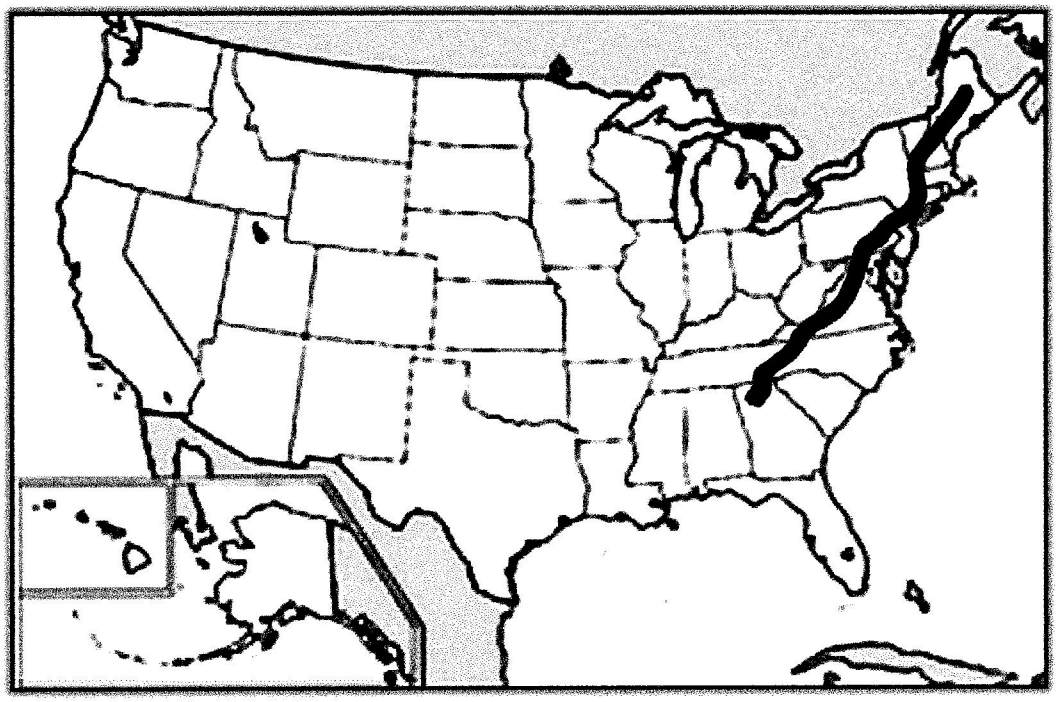
A lot of time and effort has been spent identifying the sources of quarried lithics used by ancestral Native Americans. Recently, the use of the handheld X-Ray Florescence spectrometer (XRF) has allowed researchers to document the specific ratio of chemical elements in individual artifacts. With these new forms of information, not only have individual "parental" lithic quarry sites been identified—specific sections of individual quarries may be identified!

Clearly, the use of XRF is a huge move forward. But still, the use of XRF is limited to deciphering a correlation between chemical content and source location, and does not explain under what circumstances specific lithics moved from, say, point A to point B. For example, through the use of XRF, it is now possible to link a rhyolite tool found on a site to its original quarry source some 200 miles distant. Furthermore, if this rhyolite tool happens to be a "Susquehanna Broadpoint", we can narrow the time frame down to specific cultural contexts.

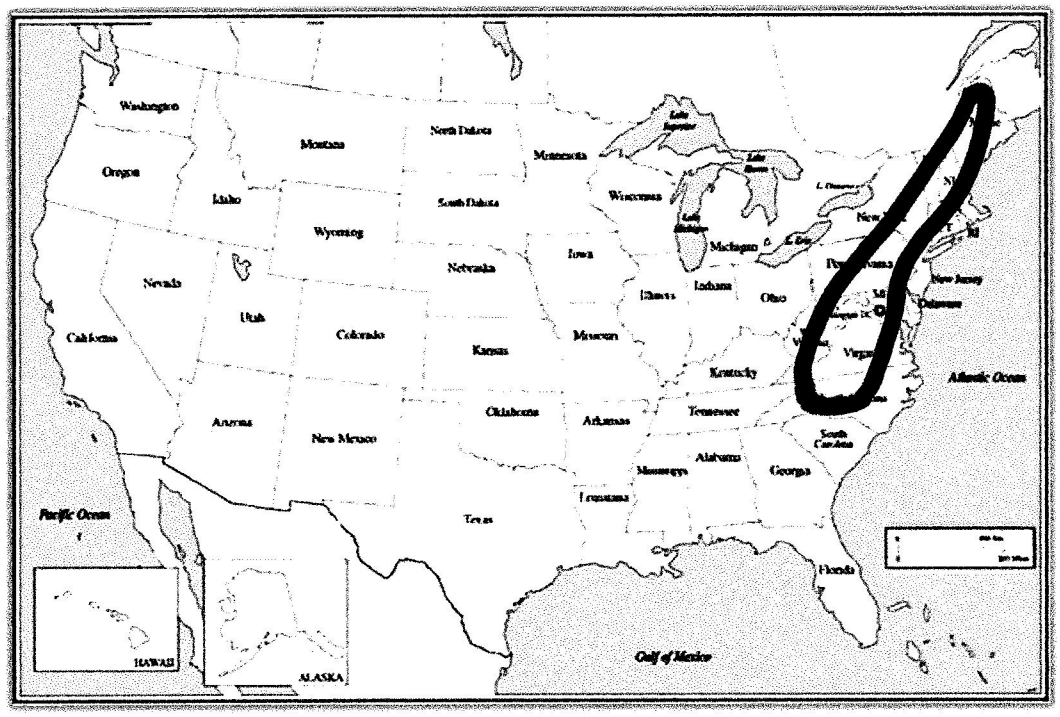
Lacking in these hypothetical explanations are the circumstances of mobility. We now can figure out how far the artifacts moved across the landscape, but, did the people also move with the artifacts? How did the artifact get from the quarry to the site of discovery? Do these circumstances suggest direct procurement—trade and exchange—overland or by water? Are we looking at egalitarian access to source material with random individuals flint knapping, or are we looking at controlled access to source material with quarry specialists as a division of social hierarchy? Even though these questions are very important, they stubbornly refuse credible explanation. Our next step in trying to answer these transportation questions is to try to identify the routes these artifacts took to get from point A to point B. In this essay, our approach involves looking at the special relationships of known quarry sites and the Appalachian Trail (see Figure 1).

Figure 1

Appalachian Trail



Appalachian Shales Zone



Primary Source: www.google.com/search?q=APPALACHIAN+MOUNTAIN+QUARRIES.
Secondary Source: en.wikipedia.org/wiki/Appalachian_Trail. Retrieved June 6, 2014.

Figure 1 consists of two maps. The upper map, labeled Appalachian Trail, is a map of the United States with the location of the Appalachian Trail indicated by a thick black line. The lower map, labeled Appalachian Shales Zone, is a map of the United States with the location of the Appalachian Shales Zone indicated by a thick black line. The Trail tracks through the Shales Zone except for the extreme southern portion. This southern portion of the Trail transitions out of the eastern shale deposits and into Georgia's limestone and sandstone substrata.

The Appalachian Shales Zone contains important sedimentary deposits, which over time, have developed into various shale, slate, siliceous, chalky, cherty, and other cryptocrystalline formations. Igneous flows occurred in some locations, while Moosehead Lake, in Maine, is actually a dormant caldera. Appalachian mountain building forces rippled, folded, and metamorphosed some of these deposits, including various deposits of quartzite. Additionally, glacial forces exposed, eroded, and also pushed some of these upper level deposits from their original locations.

CULTURAL RESOURCE OVERVIEW AND ASSESSMENT

OFFICIAL HISTORY OF THE APPALACHIAN TRAIL

Recognized by many, the official origin of the Appalachian Trail is tied to MacKaye's (1921) publication "An Appalachian Trail: A Project in Regional Planning" published in the *Journal of the American Institute of Architects*. The proposal was to formalize a trail linking work, study, and farming camps along the Appalachian ridges from Mt. Washington in New Hampshire to Mt. Mitchell in North Carolina. These ideas were shaped more by the philosophy of Henry Thoreau (separation of man and nature) than by recreational pursuits like camping, hiking or sightseeing. William Welch is credited with transforming the project into a Maine to Georgia trackway. In 1937, the trail was widely recognized as a 2,000 mile, marked (blazed) wilderness footpath leading from Mt. Katahdin in Maine to Mt. Oglethorpe in Georgia. The National Trails System Act of 1968 continues to offer the Appalachian Trial federal definition, as well as federal protection (Appalachiantrail.org, nd.:1).

Although various state, federal, and non-governmental organizations (NGOs) have cultural resource management programs for areas containing sections of the Appalachian National Scenic Trail (ANST), according to Grumet (2002:III-8), there is neither a comprehensive list of cultural resources, nor an overall management plan addressing known and possible resources. Nevertheless, Grumet (2002:II-68) addresses archaeology in the following statement:

> An "archaeological overview and assessment" describes known and potential archaeological resources for a park. Documentation of known and expected cultural resource properties along the Appalachian Trail – at least to the extent that it is available to the Appalachian Trail Park Office and Appalachian Trail Conservancy – is fragmentary and incomplete. In fact, overview and assessment studies have been completed for the Appalachian Trail in only two states: Pennsylvania (1999) and Connecticut (2004).

The following block quote is Grumet's (2002:II-69 through II-72) actual description, state by state, for known and potential resources within the ANST:

> **Maine:** The Maine Appalachian Trail Club and the University of Maine conducted a secondary-reference inventory of cultural resources in 1986. Although never finalized, the draft inventory contains an extensive list of historically occupied sites and features along the Trail in Maine.
>
> **New Hampshire:** The White Mountain National Forest has an extensive record of archaeological and historical research for lands under its administration. However, no studies specific to Appalachian Trail lands administered by the Forest have been conducted in New Hampshire.
>
> **Vermont:** Surveys conducted by Green Mountain National Forest cultural resource personnel indicate that low elevations, gaps, and saddles along the Trail route in Vermont have the highest archeological potential. Some balds and mountain tops are reported to have sacred or traditional significance to Native Americans. Plans are currently being developed to interpret the archeological remains of the now abandoned Aldrichville townsite. Forest Archeologist David Lacey has identified seven additional cultural resource sites within the Appalachian

Trail corridor on U.S. Forest Service lands in Vermont. These include one extensive prehistoric quartzite quarry stretching along a one kilometer stretch of the Trail, two quartzite flake scatters, a quartzite knife find spot, several stone cairns, and three places regarded as traditional cultural properties by Abenaki people. None of these locales have been subjected to intensive testing, and none are presently known to possess diagnostic artifacts or organic remains associated with human occupation.

Massachusetts: No comprehensive studies of cultural resources along the Appalachian Trail lands have been conducted in Massachusetts. In 2005, the NPS Omsted Center for Landscape Preservation began work on a methodology for conducting cultural landscape inventories along the length of the Appalachian Trail. This methodology, which is expected to be finished in 2009, will include a pilot study of the Appalachian Trail in Massachusetts.

Connecticut: In 2004, the Connecticut State Archaeologist and a subcontractor completed a comprehensive cultural resource overview and assessment project of the 52-mile section of the Appalachian Trail in Connecticut under a cooperative agreement with the Appalachian Trail Conservancy. This survey, which took three years to complete, identified 382 cultural resources along the Trail in that state and provided detailed ASMIS information, GPS coordinates, and management recommendations for all of the sites. This survey represents the most thorough assessment of cultural resources on the Appalachian Trail to date.

New York: No comprehensive studies of Appalachian Trail lands have been conducted in New York.

New Jersey: The Appalachian Trail Park Office and the Appalachian Trail Conservancy are exploring the potential for conducting a cultural resource inventory and overview for Appalachian Trail lands in New Jersey. This study would use State Historic Preservation Office files and other cultural resource management documentation to build upon Ronald J. Dupont, Jrs.' *Hiking With History: Heritage on the Appalachian Trail in New Jersey* (Dupont 1994), which documents and describes more than 20 culturally important sites along the Trail in New Jersey.

Pennsylvania: A cultural landscape survey of Trail lands in the Cumberland Valley of Pennsylvania completed in 1998 documented a number of point features, such as stone wall steps, ponds, buildings, garden sites, a cemetery, and a large "resting tree" preserved to shade farmers while working; cluster features, such as farmsteads, farm fields, pastures, stone wall intersections, and hedgerow intersections; and linear features, such as stone walls, hedgerows, fence lines, abandoned farm roads, roads, and bridges. This survey included the following nine individually named cultural resources: Scott Farmstead, Bernhisel Bridge, Rutter House, White Oak Resting Tree, the US 11 Footbridge, Chambers Family Cemetery, Hertzler Farmstead, Boiling Springs Village, and the Sunday Farmstead.

In 1999, the Department of Anthropology of the Pennsylvania State University conducted a literature search of previously reported archeological resources along the Trail corridor in Pennsylvania under a cooperative agreement with the Appalachian Trail Park Office and Appalachian Trail Conservancy. The study identified 55 cultural resource sites or features, including one frontier fort (Fort Dietrich Snyder), four iron furnaces, numerous charcoal hearths, and one coal mining estate (the Stony Creek Coal Estate, also known as Saint Anthony's Wilderness, a broad area between the Susquehanna and Schuylkill rivers encompassing Rausch Gap and Yellow Springs). Researchers further identified fourteen previously recorded prehistoric resources (none presently known to contain diagnostic artifacts within intact features or deposits) and twenty-five areas (most coinciding with road, canal, or rail alignments) possessing potential to contain significant cultural resources. Additional field research by an extraordinary volunteer, an intern, and a National Park Service archaeologist in 2001 and 2002 provided additional documentation and field verification of the 55 sites identified in the report, as well as preliminary data for an additional 21 sites.

Maryland: In 1998, the Appalachian Trail Park Office, the Appalachian Trail Conservancy, the Potomac Appalachian Trail Club, and the Central Maryland Heritage League entered into a Memorandum of Understanding to develop a long-term management plan to survey and interpret the South Mountain Battlefield in Washington and Frederick Counties, Maryland.

In 2004, Indiana University of Pennsylvania completed a detailed archaeological survey and management plan for the Fox's Gap site of the Battle of South Mountain under a contract with the Appalachian Trail Conservancy, with additional guidance and direction provided by the Appalachian Trail Park Office, the Maryland Department of Natural Resources, the Potomac Appalachian Trail Club, and the Central Maryland Heritage League.

Portions of the B & O Railroad Potomac River Crossing and the Harper's Ferry Historic District in Maryland and the Washington Monument, the first memorial to the nation's first president, are currently the only properties on

the Appalachian Trail in Maryland listed in the National Register of Historic Places. Studies are currently underway to determine the potential eligibility of South Mountain battle sites at Crampton Gap, Fox's Gap, and Turner's Gap for listing in the National Register of Historic Places.

West Virginia: No comprehensive studies of Appalachian Trail lands have been conducted in West Virginia. Harpers Ferry National Historical Park has an extensive cultural resource management program. Forty years of archaeology in the Park have generated more than 50 reports and 500,000 objects. The Park's List of Classified Structures, updated in 1991, contains 157 structures. Two landscape plans were prepared between 1990 and 1992.

Virginia: In northern Virginia, Shenandoah National Park's List of Classified Structures lists twenty-eight properties, broken down into five property types, within Appalachian Trail corridor lands in park boundaries. Built or modified for park use by the Civilian Conservation Corps during the 1930s, these properties include the Appalachian Trail itself, fourteen cabins and shelters (including one National Register property), three stone walls, five fire pits and hearths, and five springs and springhouses.

George Washington and Jefferson National Forests archeologist Mike Barber reported in 2002 that 25 archeological sites had been identified within the Appalachian Trail corridor on U.S. Forest Service lands in Virginia. Two of these sites preserve remains of historic farmsteads. Diagnostic artifacts associated with particular time periods in prehistory have been recovered at six locales; scattered stone chips identified as debris left over from quarrying, tool manufacture, or resharpening activities, have been primarily found on the surface of the remaining 17 sites. In 2001, Forest Service staff assisted the Appalachian Trail Park Office in recording and stabilizing the Catawba Crest Archaeological Site.

Also in Virginia, the Blue Ridge Parkway maintains several historic structures within the immediate vicinity of the Appalachian Trail near Humpback Rocks, as well as extensive records of archaeological sites in the vicinity of the Trail.

Tennessee: No data are currently available for Tennessee.

North Carolina: The National Forests of North Carolina have surveyed only a small fraction of the 230 miles of Appalachian Trail under U.S. Forest Service jurisdiction. Archaeologist Rodney Snedecker reported identification of 46 prehistoric sites, 7 historic archeological sites, and 3 historic Trails (the Over Mountain Victory, Trail of Tears, and Bartram Trails). He further reported that some sites have only surface components; others have subsurface and intact deposits and features. An unspecified number of cultural resources possessing intact subsurface deposits have been determined eligible for listing in the National Register of Historic Places. Several sacred sites and traditional gathering areas, and other traditional cultural properties are also reported on U.S. Forest Service Trail lands in North Carolina (Rodney Snedecker 2002: personal communication).

Georgia: No comprehensive studies of Appalachian Trail lands have been conducted in Georgia.

JUSTIFYING THE ANST DATA

The above ANST archaeological overview and assessment context is both enlightening and disappointing. Clearly, a wealth of cultural resources representing approximately 13,000 years of landscape use has been documented and (at least) addressed in various preliminary resource management plans. Connecticut and Pennsylvania lead the pack. However, some large areas of the ANST have no reliable cultural resource documentation at all. A review of the above, state by state, overview and assessment of the ANST illustrates how discovery, recording, and documentation processes are further challenged (while likely hundreds of interested volunteers, private land owners, local organizations, various county and state agencies, and the multiple owner/supervisory Federal agencies—including battlefield monuments—have been involved) in ANST's management.

From these files, we cannot identify the evidence we need. At the very least, large-scale incompleteness seems to be the curiously convincing lead found here. Grumet (2002) briefly identified the ANST cut through a Native American lithic quarry in Vermont (II-69), and yet another instance in Virginia (II-71). More detailed description of specific sites and site complexes along the ANST would be of benefit. We must look elsewhere to answer our research question: is the Appalachian Trail a wilderness obstacle or a Native American truck route?

THE ANST GOES THROUGH NATIVE AMERICAN LITHIC QUARRIES?
Yes, the ANST goes through a lot of Native American lithic quarries, including most of the major Native American lithic quarries located in the eastern Appalachian mountain range. Now, that is interesting! We downloaded the AT-Strip-Map @ www.nps.gov/appa/index and made five splice sections to achieve five separate pages of readable scale. When we plotted a variety of known Native American lithic quarries onto the strip map sections, we found a strong correlation where the ANST crosses most of the known quarries with the shortest direct traversable route. The lithic quarries we searched from north to south are found on Table 1.

Because the ANST runs through so many Native American lithic quarries, we will provide a brief description of the cultural resources identified from each quarry. This essay is about identifying Native American foot trails, not archaeological sites, nevertheless; we feel it is appropriate to briefly qualify these cultural highlights along the trail, firstly, to support our case, and secondly, to provide relevant research avenues for others who wish to follow.

TABLE 1: LITHIC QUARRIES SEARCHED

STATE	LITHIC TYPE	LOCAL NAME OF QUARRY OR FORMATION
Maine	Chert	Munsungun Lake Formation
Maine	Rhyolite	Kineo Rhyolite Formation (Moosehead Lake Caldera)
New Hampshire	Rhyolite	Mount Jasper Rhyolite Formation
Vermont	Quartzite	Cheshire Quartzite Formation
New York	Cherts	Normanskill Assoc. (Coxsacki, Esopus, Normanskill, and Snake Hill)
Pennsylvania*	Argillite	Lockatong Formation (*See also New Jersey)
Pennsylvania	Jasper	Reading Prong Formation (King's Hill, Macungie, and Vera Cruz)
Delaware	Jasper	Iron Hill Formation
Pennsylvania	Jasper	Branch Road/Houserville Formation
Pennsylvania**	Rhyolite	South Mountain Formation (**See also Maryland)
Virginia	Jasper	Flint Run Formation
Virginia	Jasper	Brook Run Formation
Virginia	Jasper	Rockbridge Formation
Virginia***	Rhyolite	Mount Rogers Formation (***See also North Carolina and Tennessee)
North Carolina	Rhyolite	Carolina Slate Belt Formation
North Carolina****	Soapstone	Blue Rock Formation (****See also Tennessee)

DESCRIPTION AND LOCATION OF NATIVE AMERICAN LITHIC QUARRIES

MUNSUNGUN CHERT
The Munsungun Lake chert formation is located near Norway Bluff, north of Baxter State Park in the State of Maine. A recent study by Adrian Burke of the University of Montreal (nd. page 5) shows that Munsungun chert tools and debitage have a long distance distribution. For example, one hundred percent of the lithics found at the Vail Kill site (Maine), located 220 kilometers from the Munsungun quarries are actually Munsungun chert. Additionally, fifty eight percent of the lithics found at the Bull Brook I site (Massachusetts), located 440 kilometers from the Munsungun quarries, are actually Munsungun chert. This formation is very large and extensively exploited, therefore: it is of regional significance. The Munsungun formation is identified in Figure 2 on page 10.

KINEO RHYOLITE
The Kineo rhyolite formation is located in and around the Moosehead Lake caldera in the State of Maine, as well as in glacial till fields scattered to the Atlantic Ocean. A wide range of Kineo lithic cultural material

distribution is evident. For example, Toney and Crock (nd. page 1) report from the Arbor Gardens Site in northwestern Vermont, "The recovery of exotic raw materials including highly weathered examples of Mt. Jasper rhyolite (New Hampshire), Mt. Kineo rhyolite (Maine), and Onondaga chert (New York), the form and type of lithic tools recovered, the high proportion of artifacts recovered from deep contexts within the non-depositional soil profile, and the site's geographical location, all suggest that the Arbor Gardens site dates to the early Holocene epoch." This formation is very large and extensively exploited, therefore: it is of regional significance. The Kineo formation is identified in Figure 2 on page 10.

MOUNT JASPER RHYOLITE

The Mount Jasper rhyolite formation (aka. Jefferson formation) is found in the White Mountain State Park in the State of New Hampshire. "Artifacts of spherulitic rhyolite derived from two locations in northern New Hampshire are significant to minor components of numerous Paleoindian, Archaic and Woodland archaeological sites in Maine, New Hampshire, Massachusetts, Vermont and easternmost Quebec. The two known sources of are a dike near the city of Berlin, New Hampshire, and blocks-in-till near the village of Jefferson, New Hampshire" (jackcrafty 2013:1). This formation is large and extensively exploited, therefore: it is of regional significance. The Mount Jasper rhyolite formation is identified in Figure 2 on page 10.

CHESHIRE QUARTZITE

The Cheshire quartzite formation is found in the vicinity of Bennington in the State of Vermont. Crock and Robinson (2012:70) said, "Vermont quartzite also has been found in Paleoindian contexts outside Vermont, notably in the form of fluted points at the Whipple site in New Hampshire (Curran 1984) and scrapers at Paleoindian sites in Maine (Spiess et al. 1998)." This formation is very large and extensively exploited, therefore: it is of regional significance. The Cheshire quartzite formation is identified in Figure 3 on page 11.

NORMANSKILL CHERT

The Normanskill chert association is exposed in the lower Hudson Valley of the State of New York. This massive association is expressed in various derivatives, such as, Coxsacki, Esopus, Normanskill, Snake Hill, and others. Although this formation of cherts may be one of the largest chert formations in the eastern Appalachians, qualities vary greatly and glacial till fields extend to the Atlantic Ocean. We offer a single example, a beautiful Clovis point made from an exceptionally nice piece of Normanskill chert, which was surface collected near Easton, Pennsylvania, very close to the Appalachian Trail. This point is 2 ¾ inches long and exhibits one flute on the obverse and three flute scars on the reverse (Website 1:1). This formation is very large and extensively exploited, therefore: it is of regional significance. The Normanskill chert formation is identified in Figure 3 on page 11.

LOCKATONG ARGILLITE

The Lockatong argillite formation is exposed along the Delaware River valley in Pennsylvania and New Jersey. Originally described by Henry Mercer at Point Pleasant, Pennsylvania. A wide range of bifaces, cores, and debitage of this lithic material has been recovered from Connecticut, Delaware, Maryland, New Jersey, New York, Pennsylvania, and Virginia. This formation is very large and extensively exploited, therefore: it is of regional significance. The Lockatong argillite formation is identified in Figure 3 on page 11.

READING PRONG JASPER

The Reading Prong jasper formation is found near the Lehigh Gap in eastern Pennsylvania. This formation is divided into basically three types: King's Hill, Macungie, and Vera Cruz. Lothrop and Bradley (2012:15) discuss the movement of Reading Prong or Hardyston jasper:

> In eastern Pennsylvania, jasper in the Hardyston Formation was mined by Native Americans throughout prehistory (Hatch 1994). Paleoindians appear to have transported this toolstone from quarries in Berks, Lehigh, and Bucks counties to sites in the Susquehanna and Delaware drainages of Pennsylvania (Carr and Adovasio 2002:21-23; Carr and McLearen 2005; Fogelman and Lantz 2006; Hatch and Maxham 1995; Lothrop et al. 2008). The likely additional presence of eastern Pennsylvania jasper in Paleoindian site collections in the upper Susquehanna and Hudson valleys of New York strongly suggests that Paleoindians imported this toolstone to the region during seasonal travels (Funk 1993:174, 2004; Ritchie 1957; Whitney 1977). This notion is consistent with sourcing analysis that links jasper at the Bull Brook Paleoindian site in Massachusetts to eastern Pennsylvania sources (Robinson et al. 2009).

This formation is very large and extensively exploited, therefore: it is of regional significance. The Reading Prong jasper formation is identified in Figure 4 on page 12.

IRON HILL JASPER

The Iron Hill formation is found in various qualities in northwestern Delaware extending briefly into Maryland. Compared to other, larger jasper sources such as the Reading Prong, Iron Hill jasper experienced somewhat limited distribution. Artifacts made of Iron Hill jaspers are commonly found in the counties surrounding Iron Hill, however; quantities diminish quickly with distance from the quarry source. Although locally important, this formation is not regionally significant. The Iron Hill jasper formation is identified in Figure 4 on page 12.

BRANCH ROAD JASPER

The Branch Road/Houserville formation is exposed north of Altoona in central Pennsylvania. This jasper has been referred to as Bald Eagle jasper, also Hatch jasper. This small outcropping is a point source of limited size although diagnostic artifacts show at least 8,000 years of use. Artifacts produced from this quarry appear to have disputed distribution distances and patterns. Although locally important, this formation is not regionally significant. The Branch Road jasper formation is identified in Figure 4 on page 12.

SOUTH MOUNTAIN RHYOLITE

The South Mountain rhyolite formation is massively exposed in the Caledonia State Park in south central Pennsylvania. The formation intermittently outcrops southward through Maryland and into northern Virginia. Artifacts fashioned from this rhyolite formation are found at least from up the Susquehanna River in New York, down the Susquehanna River and Chesapeake Bay and surrounding areas. This formation is very large and extensively exploited, therefore: it is of regional significance. The South Mountain rhyolite formation is identified in Figure 4 on page 12.

FLINT RUN JASPER

The Flint Run jasper formation is exposed in the vicinity of Front Royal in northern Virginia. According to one website, "Artifacts from this jasper are distributed throughout the northern Shenandoah Valley, particular on its eastern side along the South Fork of the Shenandoah River" (Website 2:1). This formation is large and extensively exploited, therefore: it is of regional significance. The Flint Run jasper formation is identified in Figure 4 on page 12 and Figure 5 on page 13.

BROOK RUN JASPER

The Brook Run jasper formation is exposed in the vicinity of Richmond, Virginia. According to one website, "Although the Brook Run jasper is distinctive from other sources of jasper, its cultural distribution is unknown. There are only a few known sites in the region with evidence of jasper" (Website 3:1). Although locally important, this formation is not regionally significant. The Brook Run jasper formation is identified in Figure 5 on page 13.

ROCKBRIDGE JASPER

The Rockbridge jasper formation is exposed in the vicinity of Peaks of Otter, Virginia. According to a website, "Although widely used in Rockbridge County, the distribution of this material is unknown" (Website 4:1). Although locally important, this formation is not regionally significant. The Rockbridge jasper formation is identified in Figure 5 on page 13.

MOUNT ROGERS RHYOLITE

The Mount Rogers rhyolite formation is exposed in the vicinity of Mount Rogers, Virginia and extends into North Carolina and Tennessee. According to a website, "Mount Rogers rhyolite does not appear to have traveled far from its source in Grayson County, Virginia" (Website 5:1). Although locally important, this formation is not regionally significant. The Mount Rogers rhyolite formation is identified in Figure 5 on page 13.

CAROLINA SLATE BELT RHYOLITE

The Carolina Slate Belt rhyolite formation is variously exposed north and south of Charlotte, North Carolina. Elements of this formation are locally referred to as Morrow Mountain or Uwharrie Mountains Rhyolite. According to a website, "…Uwharrie rhyolite is distributed widely across the piedmont of North Carolina and down into South Carolina" (Website 6:1). This formation is very large and extensively exploited, therefore: it is of regional significance. The Carolina Slate Belt rhyolite formation is identified in Figure 6 on page 14

BLUE ROCK SOAPSTONE

The Blue Rock soapstone formation is exposed in the vicinity of Spivey Gap on the North Carolina and Tennessee borders. The main quarry exhibits many bowl cavities, bowl pedestals, and quarry tools. However, distribution of the quarried materials is not well understood. Although locally important, this formation is not regionally significant. The Blue Rock soapstone formation is identified in Figure 6 on page 14.

PLOTTING THESE QUARRIES

We have included the following five sections of the Appalachian Trail Strip map (Appalachian Trail Map, 2014) with the above, identified lithic quarries plotted on those map sections. Figure 2 page 10 is Section 1: Mt. Katahdin, Maine south to Hanover, New Hampshire. Figure 3 page 11 is Section 2: Hanover, New Hampshire south to Stroudsburg, Pennsylvania. Figure 4 page 12 is Section 3: Stroudsburg, Pennsylvania south to Front Royal, Virginia. Figure 5 page 13 is Section 4: Front Royal, Virginia south to Mt. Rogers, Virginia. And finally, Figure 6 page 14 is Section 5: Mt. Rogers, Virginia south to Springer Mountain, Georgia.

THE APPALACHIAN TRAIL AS A TRUCK ROUTE

In this essay, we highlight the Appalachian Trail as likely the earliest and longest Native American arterial trucking route in the eastern United States. Surely, lateral secondary trails, such as the trucking routes up and down the Hudson, Delaware, Susquehanna, and Potomac Rivers were equally important, and perhaps more frequently traveled. But clearly, the ancient road that leads from one Paleoindian quarry to the next Paleoindian quarry, just as the local transit system stops at each station, should at the very least, inspire us to think that their world view was quarry-centric.

In researching each of the quarries, as well as lithic distribution from their sources, we actually developed a feeling for regional distinctions—not necessarily differences, but distinctions. We felt that from the earliest use of these quarries, the Northeast region (north of the Berkshires) was slightly different from use in the Mid-Atlantic region (north of Roanoke, Virginia), and likewise, different in use in the Southeast region (south of Roanoke).

The Appalachian Trail traverses through three very similarly distinguished gross drainage patterns. In the northeast, rivers drain both to the Atlantic and to the Saint Lawrence. In the Mid-Atlantic, rivers drain to the Atlantic, and Delaware and Chesapeake Bays. In the Southeast, most rivers drain to the Atlantic. Other areas, along the Appalachian Trail, west and south of Asheville, North Carolina for example, drain southeast into the Savanna, southwest into the Alabama, and westward into the Tennessee Rivers, respectively.

Lithic materials are perceived to stay (most often) within their own regional drainage pattern (distribution), while the idea of what a lithic tool is and what it is used for (form and function) seems to jump well beyond their perceived drainage limitations. This is indeed a curious dilemma! How are we supposed to respond to a Koens—Crispin biface, made out of Lockatong argillite, being recovered along the Appalachian Trail in the state of Maine? What is the idea behind a Savanna River biface, made out of an undiagnosed rhyolite, being recovered along the Appalachian Trail north of Trenton, New Jersey, 500 miles away from home?

Some people may be thinking our idea of the Appalachian Trail—being an ancestral Native American truck route—is an obtuse approach to ancestral Native American behavior. But if we are going to address prehistory in a holistic context, where artifacts are imbedded in sites, sites are imbedded in landscapes, and landscapes are imbedded in worldviews, then we affirm the Appalachian Trail is indeed the oldest and longest ancestral Native American transportation feature in the eastern United States.

Figure 2

Appalachian Trail Map Section 1: Mt. Katahdin, Maine south to Hanover, New Hampshire, Internet Source: www.nps.gov/appa/index (A-T-Strip-Map.pdf) June 3, 2014.

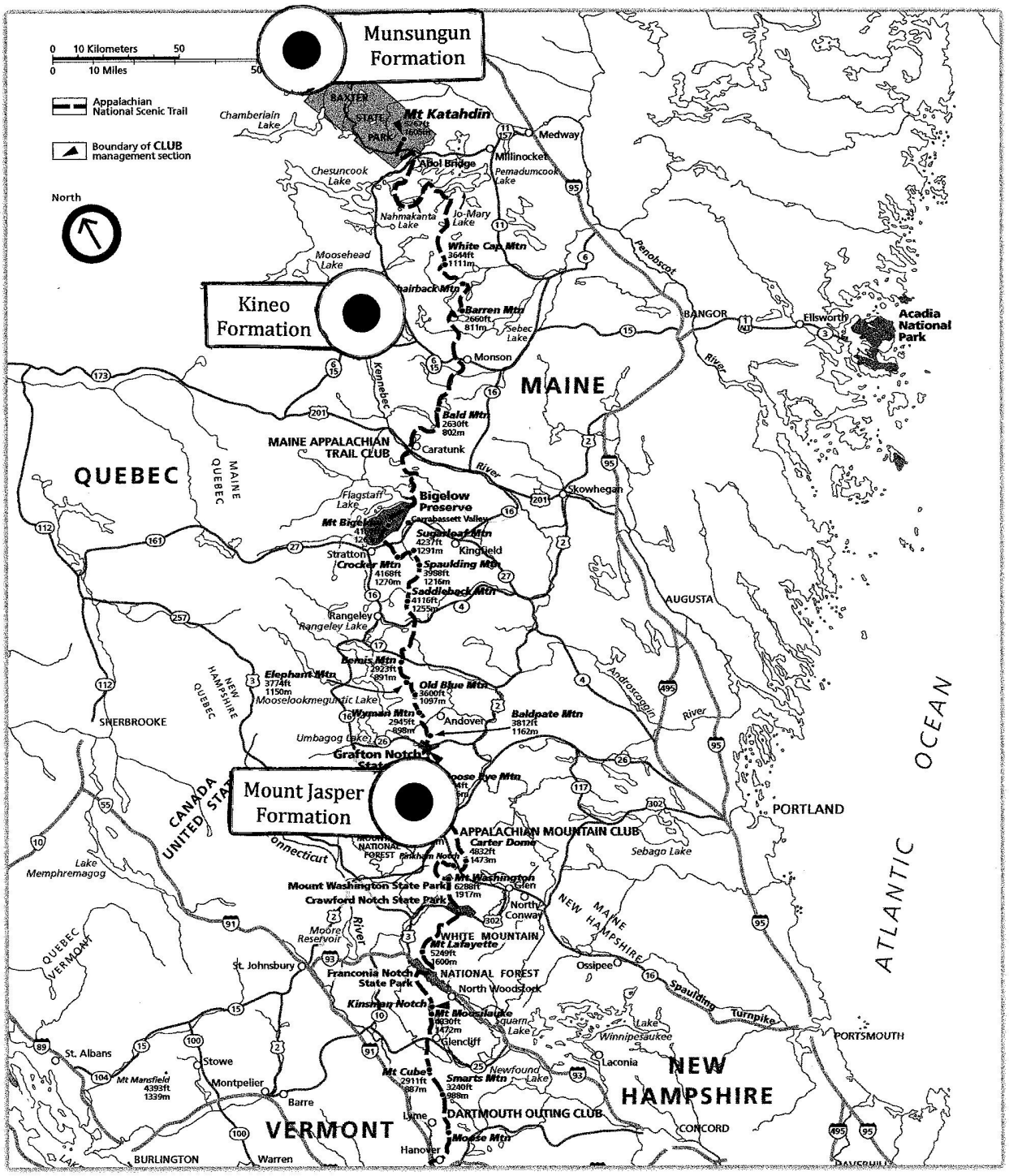


Figure 3

Appalachian Trail Map Section 2: Hanover, New Hampshire south to Stroudsburg, Pennsylvania, Internet Source: www.nps.gov/appa/index (A-T-Strip-Map.pdf) June 3, 2014.

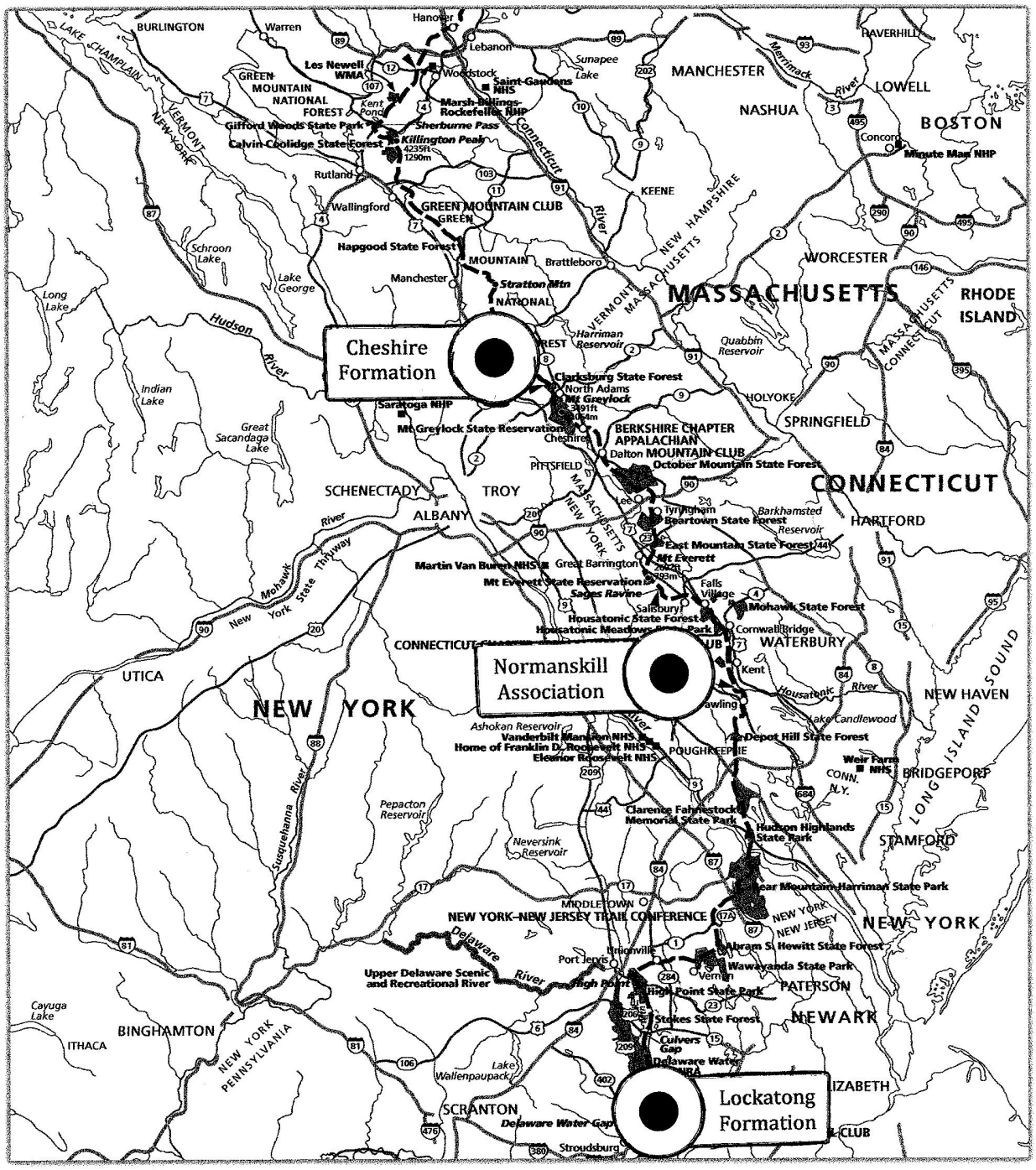


Figure 4

Appalachian Trail Map Section 3: Stroudsburg, Pennsylvania south to Front Royal, Virginia, Internet Source: www.nps.gov/appa/index (A-T-Strip-Map.pdf) June 3, 2014.

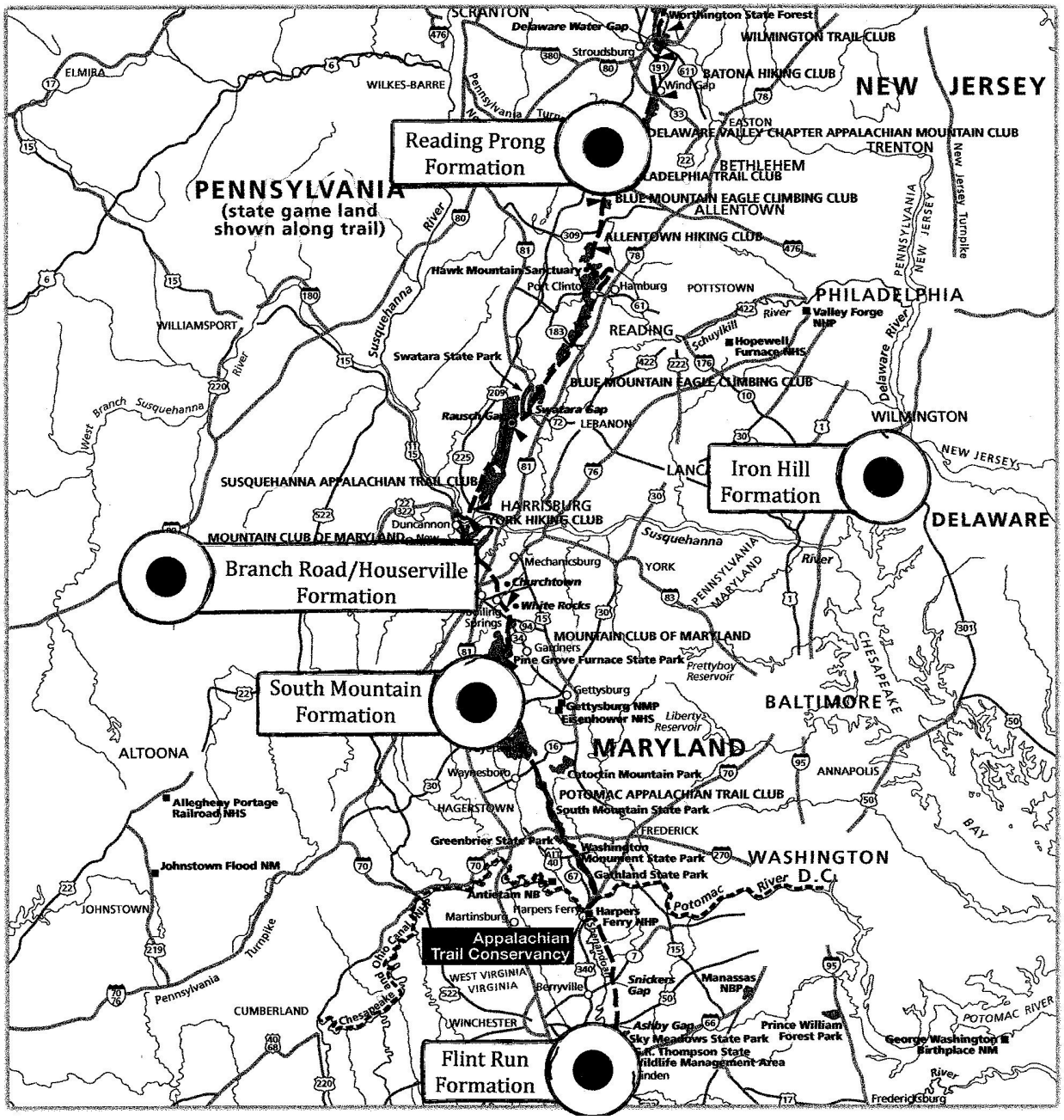


Figure 5

Appalachian Trail Map Section 4: Front Royal, Virginia south to Mt. Rogers, Virginia, Internet Source: www.nps.gov/appa/index (A-T-Strip-Map.pdf) June 3, 2014.

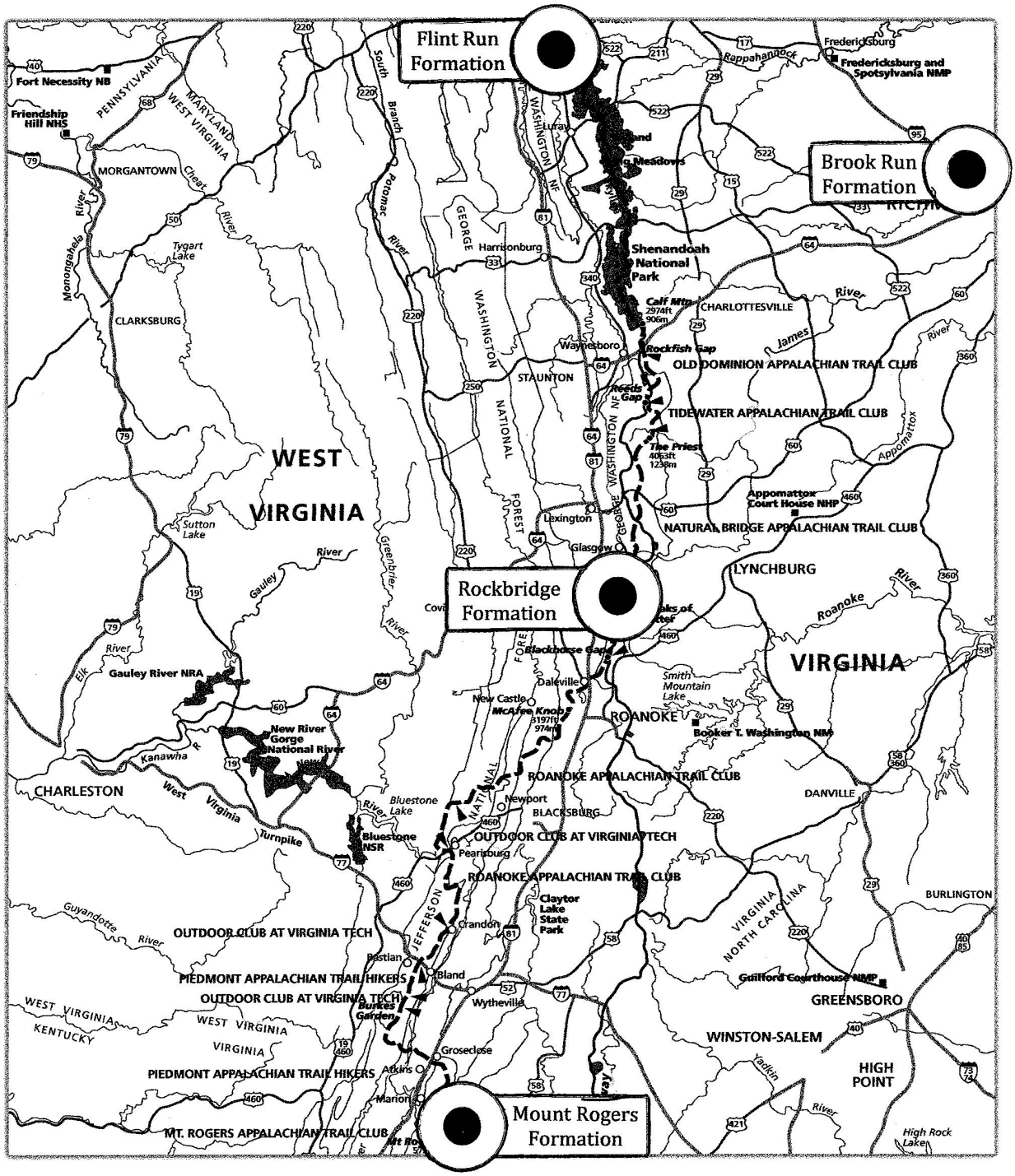
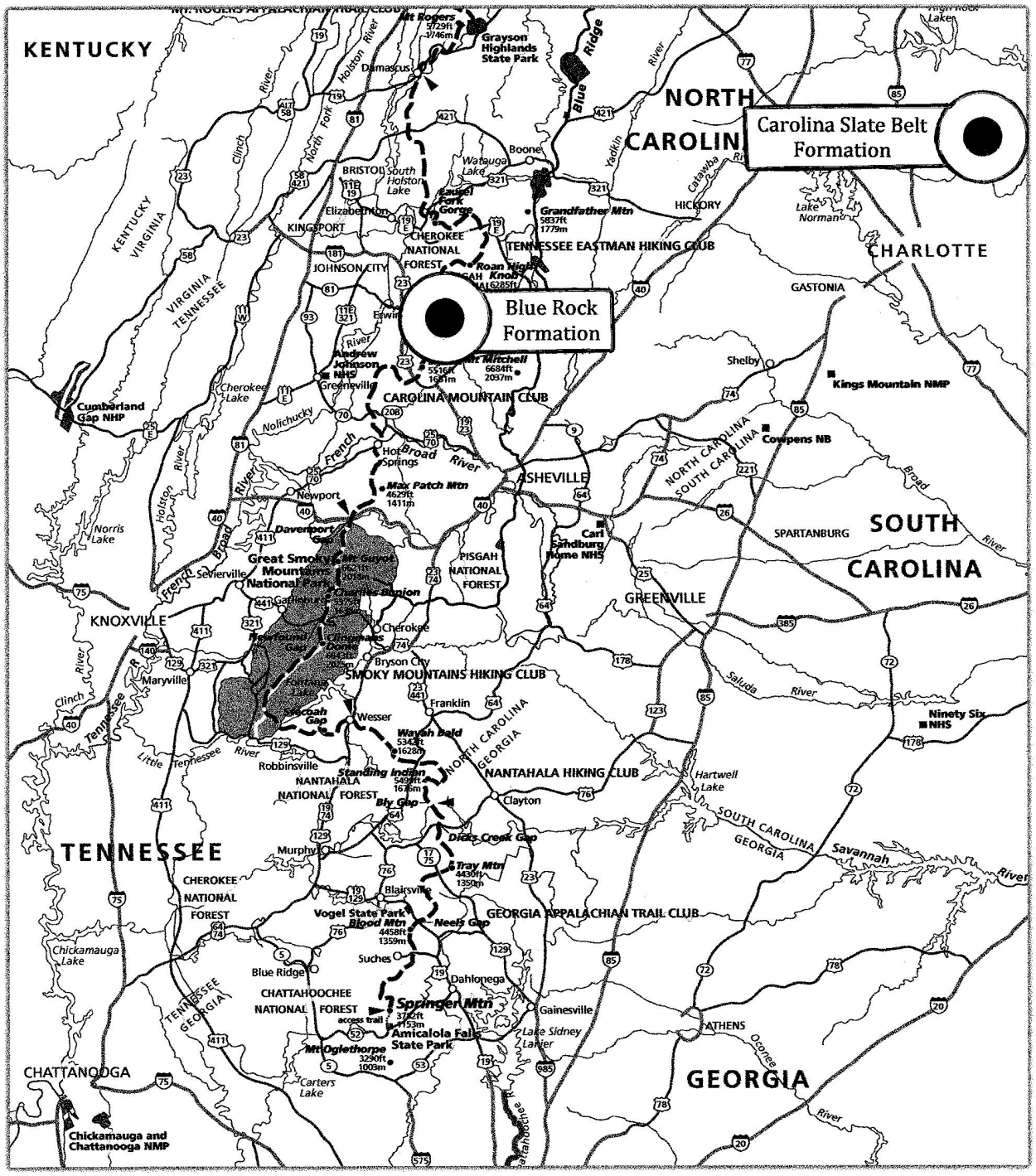


Figure 6

Appalachian Trail Map Section 5: Mt. Rogers, Virginia south to Springer Mountain, Georgia, Internet Source: www.nps.gov/appa/index (A-T-Strip-Map.pdf) June 3, 2014.



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WATER HAZARDS AND CULTURAL RESOURCE VULNERABILITIES ON DELAWARE'S LOWER COASTAL PLAIN

Glen Mellin
Lenny Truitt

July 2014

"If it keep on rainin', the levee gonna break
Some people still sleepin', some people are wide awake" – Bob Dylan

INTRODUCTION

This essay addresses the potential for sea level rise from global warming affecting cultural resources in Delaware's Lower Coastal Plain. Following an official organizational format developed in other risk management assessments (largely prepared for the Delaware Emergency Management Agency, or DEMA), this independent essay adds sea level rise to previously assessed risk management studies concerning the impact of water hazards in Delaware's Lower Coastal Plain, while identifying cultural resource vulnerabilities within existing preservation frameworks.

To date, any detailed, or even preliminary studies of Delaware's cultural resource vulnerabilities to water hazards have not yet materialized. Yet, some of us realize there is an urgent need to get this topic organized—before we have a large-scale unaccountable loss of the very cultural resources we are ascribed to identify and defend. Dylan said it best, in 2006, "some people still sleepin', some people are wide awake."

In our opinion, the best existing water hazard studies (flooding and inundation) for Delaware's Lower Coastal Plain are Ratledge and Laznik's (1998a and 1998b) assessments for Kent and Sussex Counties, Delaware. We should not have to "re-invent" a sea level rise organizational wheel if we view our sea level rise predictive model through the lens of their existing and accepted water hazard model. Essentially, for our sea level rise model, we recommend using the Ratledge and Laznik (1998) flooding and inundation models while adding two feet of sea level rise hazard for the twenty-first century and an additional four feet of sea level rise hazard for the twenty-second century.

WATER HAZARDS

For the Lower Coastal Plain of Delaware, Ratledge and Laznik (1998a and 1998b) identified flooding and inundation as their two predictable water hazards. Flooding is a **temporary surface phenomenon**, typically a result of heavy rainfall. Inundation is a **temporary surface phenomenon**, typically a result of wind driven overwash, or storm surge, coupled to a lesser degree by low barometric pressure. Hurricane force winds can produce significant storm surges. Although the magnitude of a surge is shaped by the contour of land, the force generating the surge is mathematically predictable—as wind speeds square, wind forces cube.

Sea level rise due to global warming, however, is not yet an exact science. It is forecast to occur differentially around the Earth. Since sea level rise is considered to be a **permanent submergence phenomenon**, various geologic considerations need to be taken into account when measuring its potential affect. Soil compression, density, friability, liquefaction, permeability, and repose are some stability considerations needed to calculate the effects of sea level rise on specific locales. For example, some researchers have speculated that one third of the Jamestown Fort, Virginia (ca. 1607) has been lost due to: 1) tidal and wave erosion, and 2) a two foot rise in sea level, due to global warming, since the fort's construction.

Tides caused by lunar and solar phases, and other atmospheric considerations such as dew point, freeze-thaw cycles, wind chill, hail, snow pack, terrestrial ice, and sea ice are not specifically identified as water hazards. Additionally, wave action and littoral drift (as in lateral movement), are ongoing phenomenon associated with erosion. Even though these actions can be very detrimental to the preservation of cultural resources, they are not specifically identified as water hazards.

VULNERABILITIES

For the purpose of this essay, vulnerabilities are defined as **all cultural resources**, or historic properties, as defined in the State of Delaware Division of Historic and Cultural Affairs website: (history.delaware.gov/preservation/protection/sec106.shtml), summarized here as any thing possessing or exhibiting a cultural value, while being at least 50 years old. For most of us reading this essay, we are talking about things like archaeological sites, cemeteries, historic structures, our built infrastructure, as well as Native American and Historical botanical arrangements. Through evaluating the integrity and significance of each of these cultural resources; individual items, sets, complexes, and districts may then be ranked with an appropriate level of desired protection. Ultimately, the Delaware State Historic Preservation Office is the State Agency, which has the privilege and responsibility to implement and regulate these public processes. Private processes remain free to do as they wish, providing they operate within existing Delaware Code.

Water Hazards are the floods, hurricane storm surges, and sea level rise that may damage or destroy these cultural resources. The following graphic shows just how much of the Delmarva Peninsula has been lost due to sea level rise during the past 9000 years (see Figure 1).

Figure 1
Reconstruction of Delmarva's Ancestral Shorelines (ca. 7000 bce)

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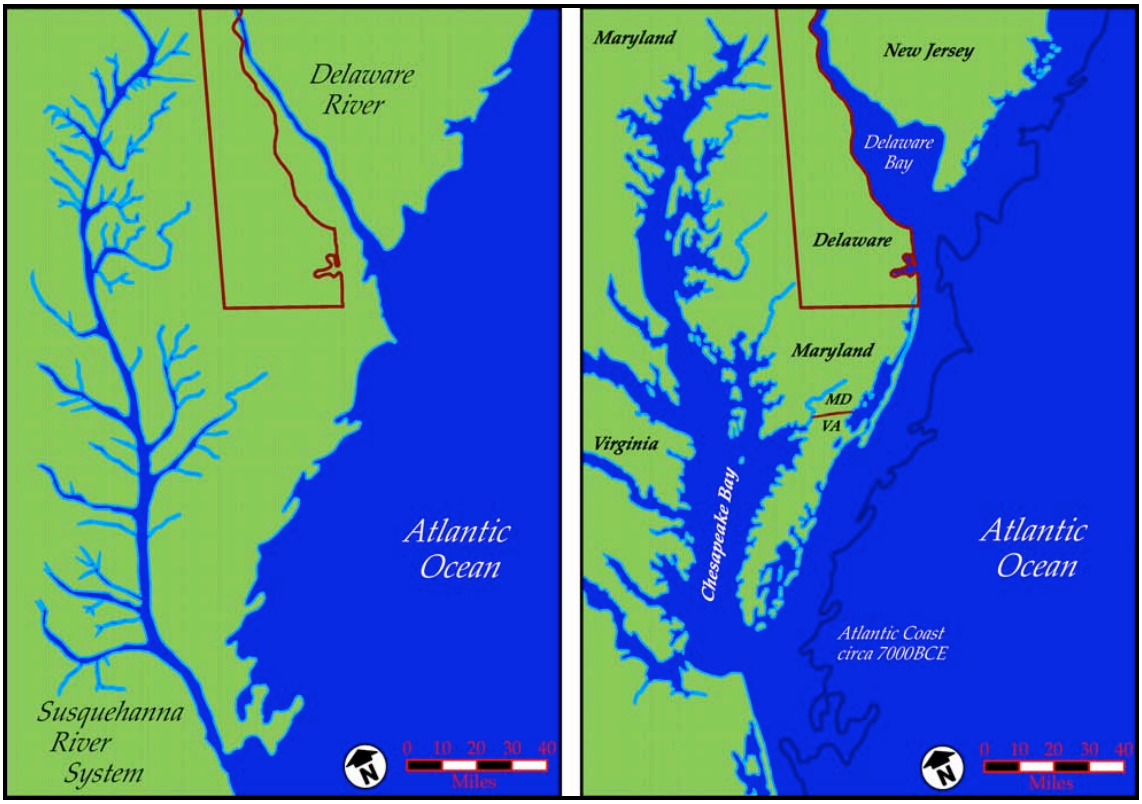
Sources: "A Report of Archaeological Investigations at the Cemetery Hill Site" by Craig Rose and Glen Mellin representing Heite Consulting, Inc. (2008, Figure 2.1, page 9). Prepared for Carl M. Freeman Communities, LLC, Selbyville, Delaware 19975. (Adapted from Steve Wilke and Gail Thompson (1977), "Prehistoric Archaeological Resources in the Maryland Coastal Zone", Maryland Department of Natural Resources.



SEA LEVEL RISE

In the above figure, all of the land area painted green on the Delmarva Peninsula (in the left image), which is now submerged due to sea level rise during the past 9000 years (in the right image), had been available for ancestral Native American activities. Additional cultural resources appearing in the present-day tidal zone will soon be submerged. And as the sea level continues to rise, some lower elevation terrestrial cultural resources will eventually become submerged.

FOR THE RECORD

For the record, DEMA collects previous and existing environmental data in an effort to forecast what is likely to happen in the future. DEMA's water hazard data sets and predictive models currently focus on: 1), the **100-year flood** scenario, and 2), the **category 1, 2, and 3 Hurricane** scenarios. This essay introduces **sea level rise** as a complimentary, third water hazard data set for Kent and Sussex Counties in Delaware's Lower Coastal Plain (see maps below—Figures 2 through 5).

As stated earlier, we feel comfortable with sea level rise adding two feet of water in the twenty-first century and perhaps an additional four feet of water in the twenty-second century. We propose adding our sea level rise projections into the existing DEMA map series. We offer the following compromise: in preparing water hazard and vulnerabilities models for the next two centuries, we should consider moving the existing DEMA "coastal influenced" high water elevation marks another five feet higher. Essentially, our sea level rise proposal is not significantly different than what an existing category 4 Hurricane model would look like for coastal locales. We feel that the interior, or non-tidal areas (Zone A) of the two counties largely affected by a rainfall induced 100-year flood, would not have to be adjusted higher than the corresponding sea level rise affected tidal zones (Zones AE and VE), currently located in the mid to lower reaches of each estuary.

DEMA DATA SETS

We have included four DEMA data set maps (see below). The first set is the predicted 100-year flood mapping, Kent County (Figure 2, page 4) and Sussex County (Figure 3, page 5). The second set is the predicted category 1, 2, and 3 Hurricane overwash mapping, Kent County (Figure 4, page 6) and Sussex County (Figure 5, page 7).

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Figure 2
100-Year Flood Plain Forecast, Map of Kent County, Delaware

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Source: This graphic is a portion of Figure 2.4 (page 19) of a published, public document; "Hazard Vulnerability Assessment: Kent County, DE—1998" by Edward C. Ratledge and John Laznik at the Center for Applied Demography & Survey Research (CADSR), College of Human Resources, Education and Public Policy, University of Delaware, Newark, Delaware 19716, and was prepared for the Delaware Emergency Management Agency (1998). The original digital document is known as (knthazvul12.pdf) and can be accessed on the Internet in its entirety at: (udspace.udel.edu/handle/19716/763).

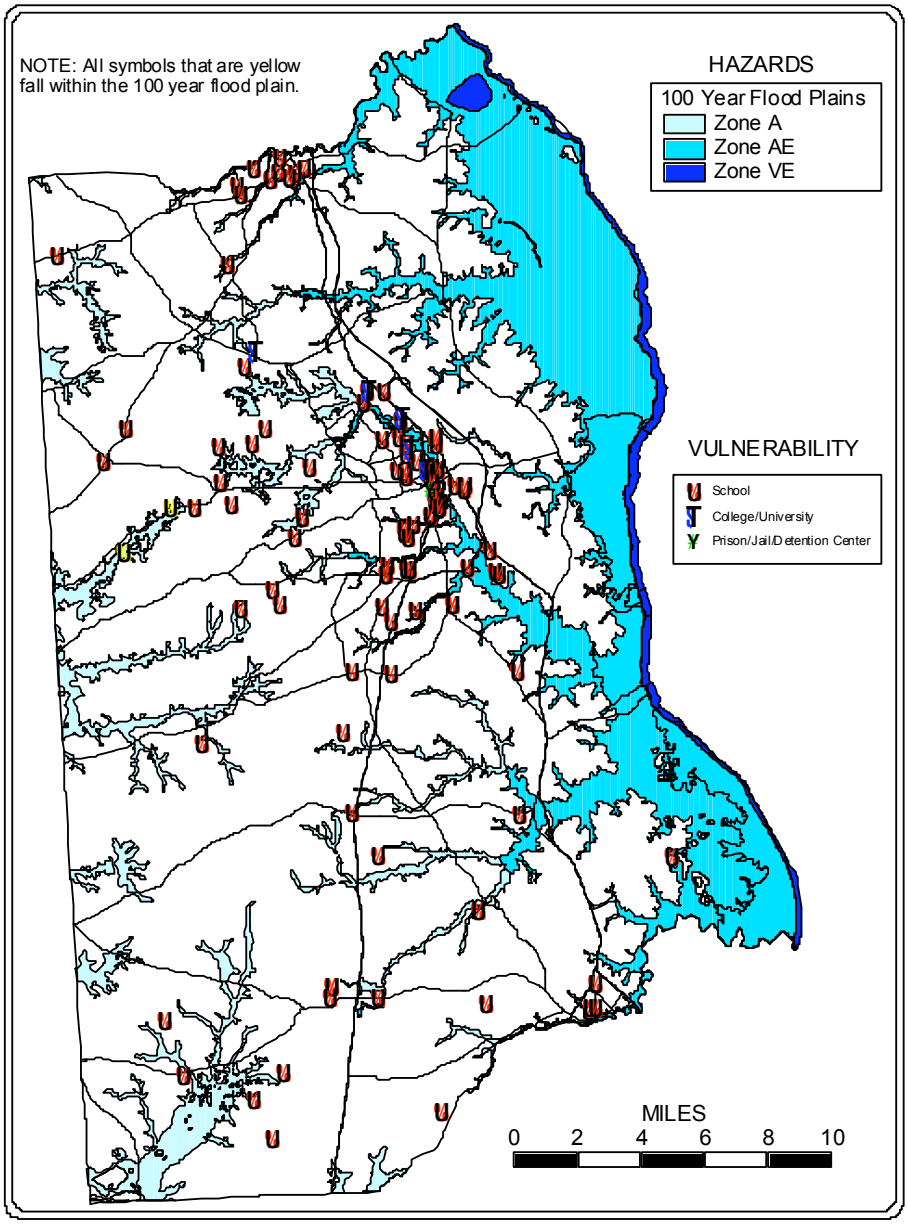

Figure 3
100-Year Flood Plain Forecast, Map of Sussex County, Delaware

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Source: The following graphic is a portion of Figure 2.4 (page 19) of a published, public document; "Hazard Vulnerability Assessment: Sussex County, DE—1998" by Edward C. Ratledge and John Laznik at the Center for Applied Demography & Survey Research (CADSR), College of Human Resources, Education and Public Policy, University of Delaware, Newark, Delaware 19716, and was prepared for the Delaware Emergency Management Agency (1998). The original digital document is known as (suxhazvu12.pdf) and can be accessed in its entirety on the Internet at: (udspace.udel.edu/handle/19716/764).

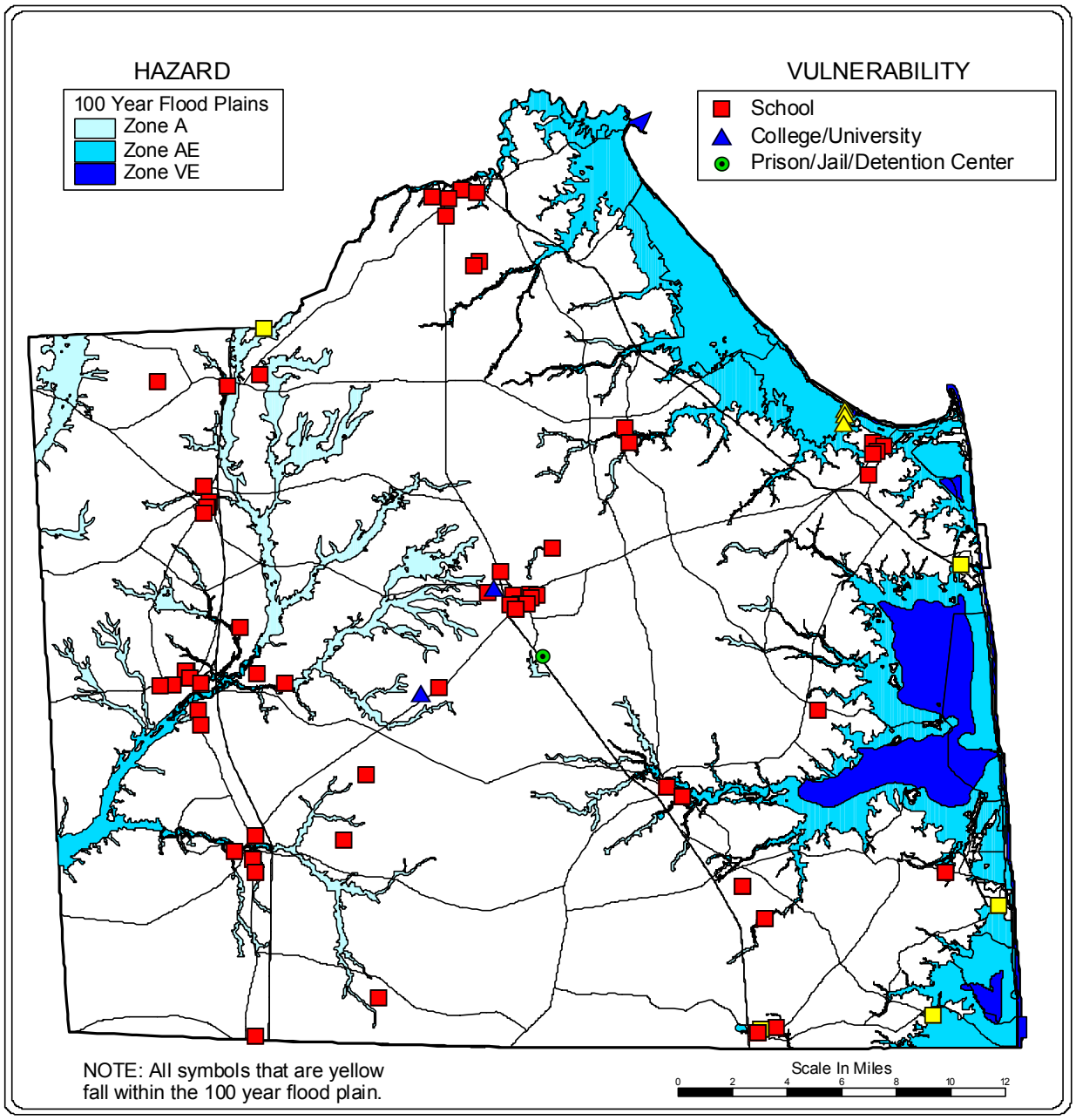

Figure 4
Hurricane Inundation Forecast, Map of Kent County, Delaware

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Source: This graphic is a portion of Figure 3.4 (page 32) of a published, public document; "Hazard Vulnerability Assessment: Kent County, DE—1998" by Edward C. Ratledge and John Laznik at the Center for Applied Demography & Survey Research (CADSR), College of Human Resources, Education and Public Policy, University of Delaware, Newark, Delaware 19716, and was prepared for the Delaware Emergency Management Agency (1998). The original digital document is known as (knthazvul12.pdf) and can be accessed on the Internet in its entirety at: (udspace.udel.edu/handle/19716/764).

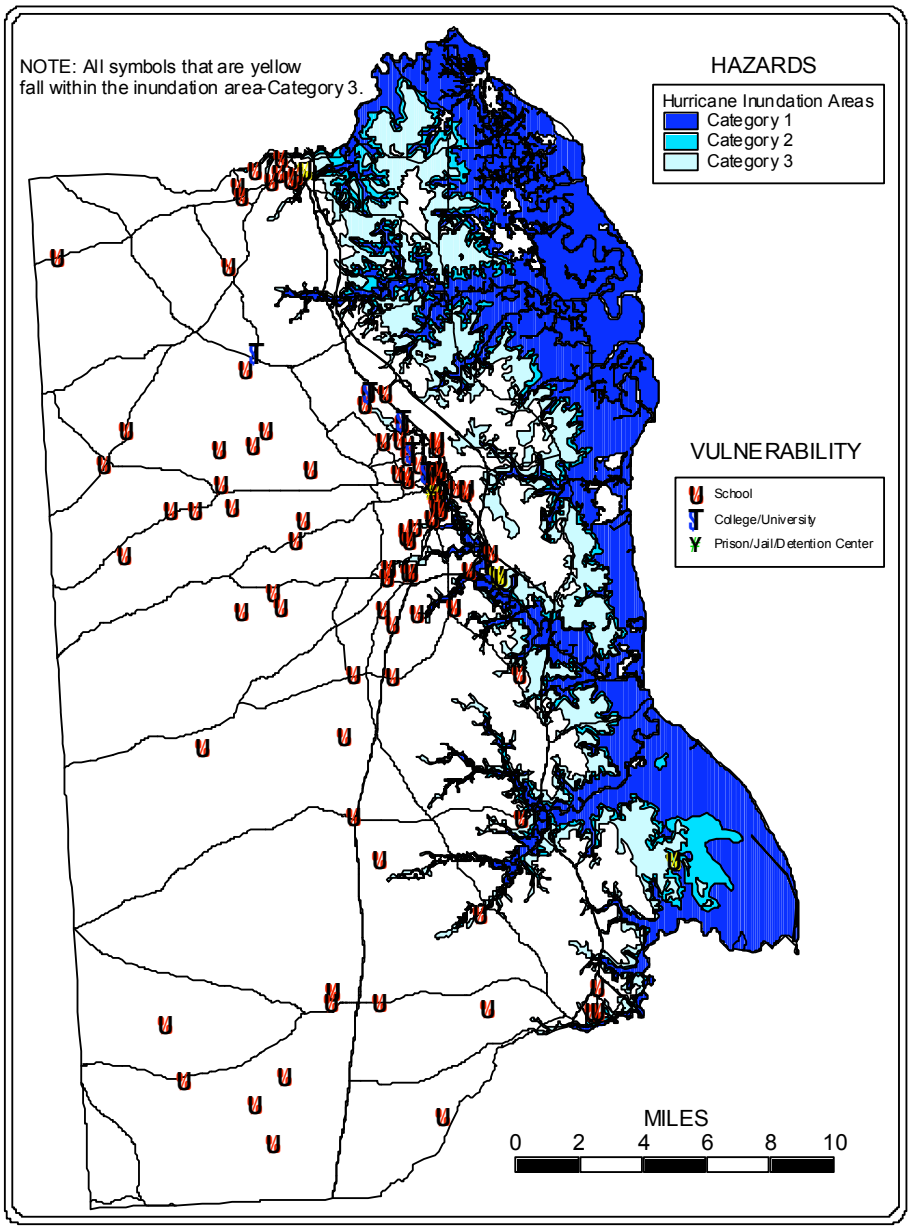

Figure 5
Hurricane Inundation Forecast, Map of Sussex County, Delaware

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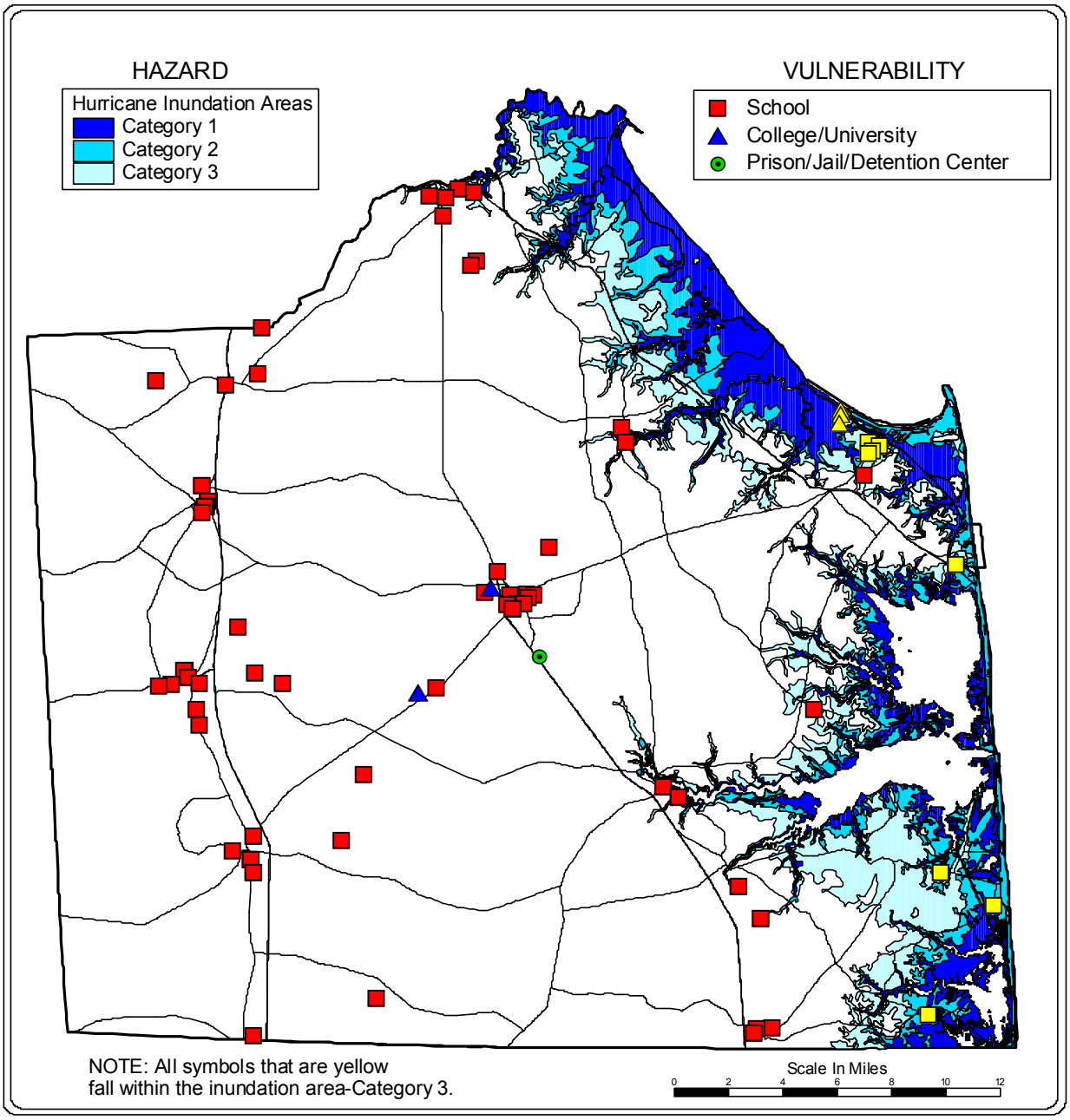
Source: This graphic is a portion of Figure 3.4 (page 31) of a published, public document; "Hazard Vulnerability Assessment: Sussex County, DE—1998" by Edward C. Ratledge and John Laznik at the Center for Applied Demography & Survey Research (CADSR), College of Human Resources, Education and Public Policy, University of Delaware, Newark, Delaware 19716, and was prepared for the Delaware Emergency Management Agency (1998). The original digital document is known as (suxhazvu12.pdf) and can be accessed on the Internet in its entirety at: (udspace.udel.edu/handle/19716/764).



The Clam Gardens on Pot Hook Creek
(South of Cape Henlopen, Delaware)

Glen Mellin
Lenny Truitt

December 2014

The dimming of the light makes the picture clearer
Its just an old photograph, theres nothing to hide
When the world was just beginning. (Brian Eno and David Byrne, 2008)

INTRODUCTION

This essay is the result of our Ethnoecological survey of a portion of the Pot Hook Creek drainage located southeast of Lewes, Delaware. During the fall of 2014, we assessed the environs about Pot Hook Creek in order to identify, record, and better understand the immediately available species of plants and animals, which may have contributed to the benefit of various ancestral Native Americans who resided at two associated National Register sites. Both of these National Register sites exhibit extensive shell-middens, which accumulated as food processing debris from about 600bce through about 1650ce.

Our overall interpretation in this Ethnoecological assessment is the illumination of the former clam gardens on Pot Hook Creek as a fully developed food production system. This system supported large human populations through at least seasonal cycles, in this tidal, brackish water, back-bay locale. When these clam gardens are viewed through social and cultural lenses, we see very highly developed economic systems. From planning through harvest, their cultivation likely included physical divisions of labor in marking parameters, cleaning, suppression of predators, selective harvesting, reseeding, and storing preserved meats. We also envision advanced community organization tactics through ownership, defense, and planned generational inheritance of the clam garden food production system.

At this Pot Hook Creek locale in eastern Sussex County, we view these clam gardens as cultural keystone economic properties. They were likely the focus of integrated and durable economic, social, spiritual, and ceremonial processions that continued for over two thousand years. These clam gardens seem to have been inherited through time by definable and successive populations. We think the yield of this durable economic program supported successive ceramic technologies, from Wolfe Neck to Coulbourne to Mockley, through a series of changing techno-environmental landscapes.

The storable yield of these clam gardens on Pot Hook Creek probably offered enough spare time for communities to engage in elaborate trade and exchange systems resulting in local cultural manifestations often referred to as "Delmarva Adena". Additionally, our research indicates periods of definable social friction. While the above populations likely owned and inherited the clam gardens, an immigrant ethnic group who made Hell Island ceramics, did not have access to these clam gardens. And finally, another likely immigrant group who made Rappahannock series ceramics seems to have taken over, or seized and supervised the clam gardens on Pot Hook Creek until the unsettlement associated with European contact.

For a half-century, we have seen the bright light of archaeology having a laser focus on the remaining terrestrial shell-middens and trash heaps on Pot Hook Creek, obviously important physical features that demand both preservation and refined explanation. But, just as Eno and Byrne suggested in their song, "Home"; by dimming the light, we see a clam garden food production system on Pot Hook Creek becoming visible—appearing out of the cultural ecological shadows. Clam gardening is an Ethnoecological explanation. We propose that in seizing control, owning, and improving specific aspects of their local environment, specific ethnic groups of ancestral Native Americans were able to design, improve, and manage resources according to their worldview. Clearly, people who owned and managed this clam garden economic system on Pot Hook Creek were not only able to defend their territory they were able to define their neighbors. In this essay, we make a strong argument that the clam gardens and the clam garden economic program on Pot Hook Creek is certainly worthy of recognition and protection as Delaware's first Traditional Land and Resource Management area.

BACKGROUND INFORMATION

We conducted our Ethnoecological survey of the Pot Hook Creek area on three different days—September 22 and 23, and on November 2, 2014. Examples of candidate Ethnoecological species were observed, recorded, and assessed. In particular, our assessment involved where and how plants and animals were clustered, and if those clusters might have been originated or managed by the ancestral Native Americans living in the immediate area. Evidence of ancestral Native American use of the immediate area is well documented in The Townsend Site National Register listing and the Wolfe's Neck Site National Register listing.

The Townsend Site (7S-G-2) is located on the west side (Thomas, et al. 1974), and the Wolfe's Neck Site (7S-D-10) is located on the east side (Thomas, et al. 1976) of Pot Hook Creek (see Maps 1 and 2). Our survey identified four species that we determined to be significant to the cultures who lived at the above sites as follows: 1) A botanical cluster of Jimson Weed (*Datura stramonium*); 2) Botanical clusters of non-native (historic) Wineberry (*Rubus phoenicolasius*); 3) Extensive botanical clusters of Skunk Cabbage (*Symplocarpus foetidus*); and 4) Extensive cultural shellfish debris indicating previous clusters of clam (*Mercenaria mercenaria*). Each of these resource clusters will be addressed. Each of the species and the location of each clusters present opportunities for new and significant Ethnoecological interpretations.

What is not of general public knowledge is a Phase II survey of The Townsend Site's "rectangle" conducted in 2004 by Heite Consulting. In that survey, Heite conducted a shovel test pit program in the wooded "far east" portion of The Townsend Site rectangle in the vicinity of 0488745—4288759. That survey identified a massive clamshell scatter associated with likely Mockley ceramics. Heite also conducted a shovel test pit program in the wooded "far west" portion of the rectangle in the vicinity of 0487856—4288988. That survey identified a clamshell scatter associated with likely Coulbourne ceramics.

RESULTS OF OUR ETHNOECOLOGICAL SURVEY

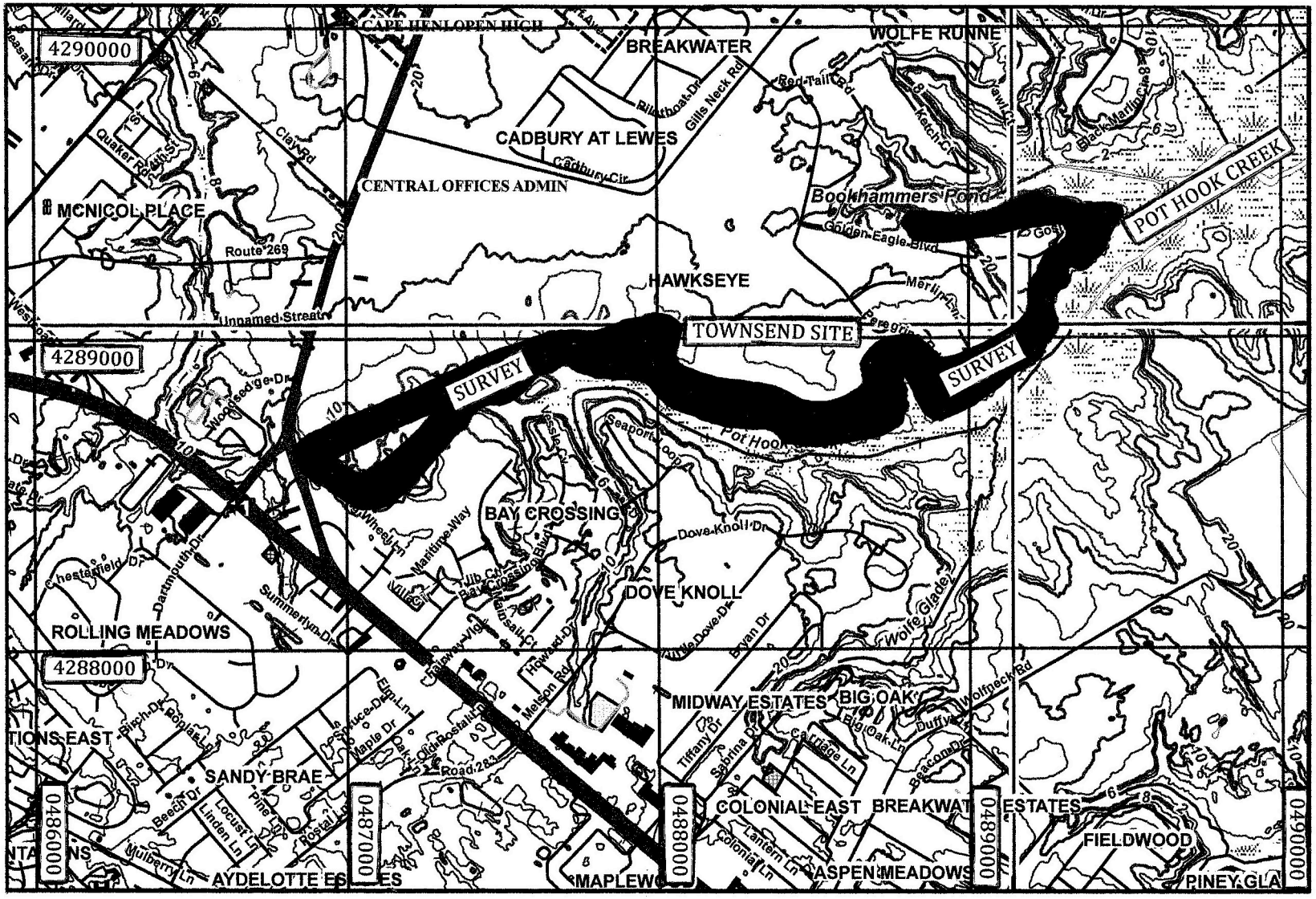
Our Pot Hook Creek survey produced a wide range of interesting and significant results. We identified a number of plant and one animal species. Many of these species have been documented elsewhere as having been ecological assets to ancestral Native Americans. These assets range from fuel, raw materials for tool and craft construction, of spiritual and ceremonial focus, foodstuffs and/or medicines.

Many examples of these identified species along Pot Hook Creek seem to appear randomly, to varying degrees, in the immediate locale. However, we found four species occurring in dense clusters, which we determined significant not only to our survey, but significant to the people who used this locale as their home. Focusing on these clusters allowed us to offer new and interesting interpretations of the everyday activities of the Colonials and the ancestral Native Americans who resided and prospered on these lands and waters. It is our hope the living descendents of these former residents will appreciate the efforts and extraordinary accomplishments their ancestors made for themselves and to the human species.

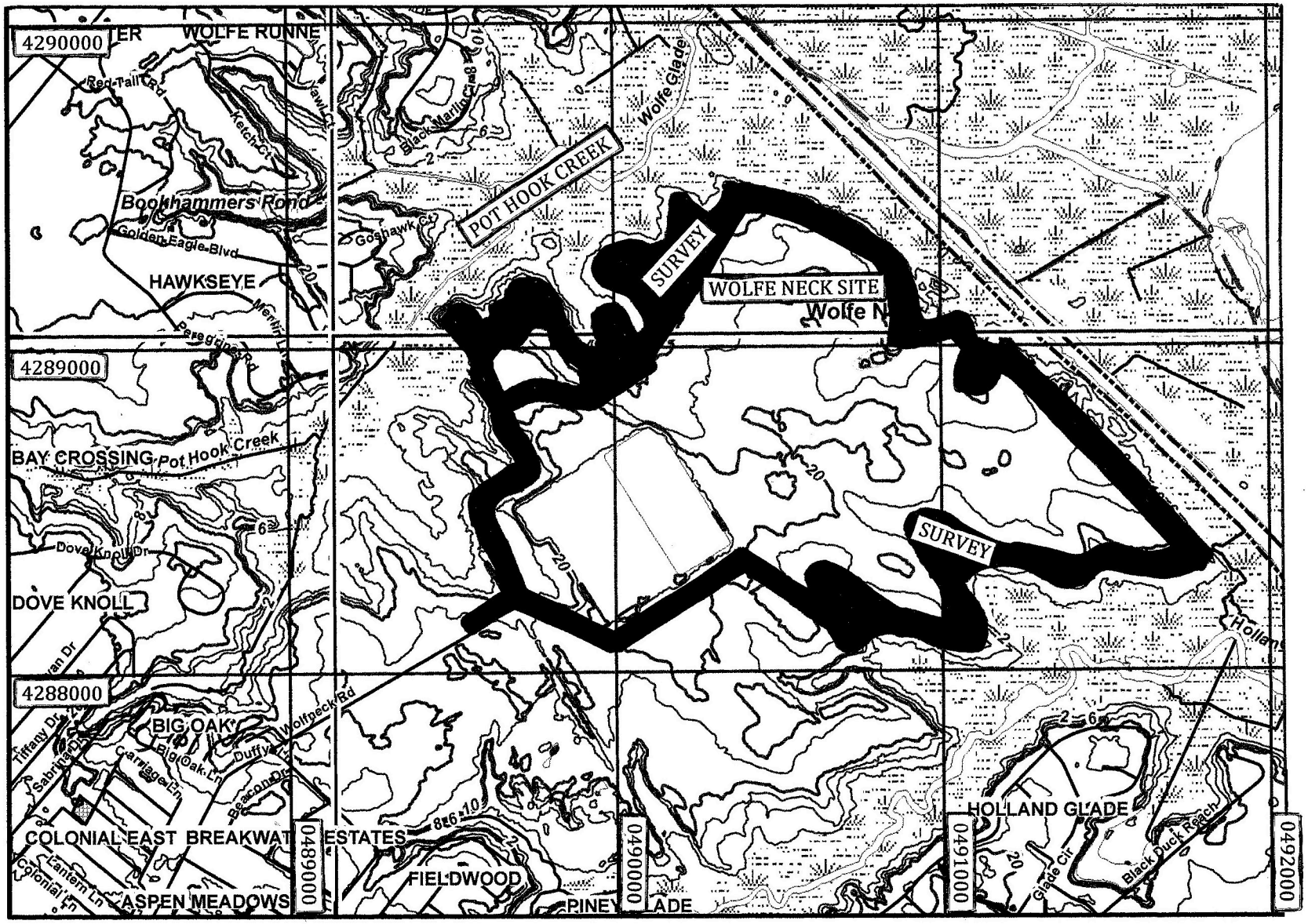
A wealth of documentation exists for individual species itemized in this essay. For Delaware, we suggest referring to Mellin and Truitt (2014a), our spreadsheet showing Moerman's (2009) medicinal plants used by Native Americans cross-referenced with McAvoy's (2013) list of plants found in Delaware. Additionally, one may use our Archaeobotanical (archaeologically recovered) synthesis for Delaware (Mellin and Truitt 2013). The above synthesis may also be viewed on the Delaware Department of Transportation website at (http://www.deldot.gov/public.ejs?command=PublicArchaeologySearch).

As stated earlier, we offer interpretations based on the plants and an animal found during our survey of the Pot Hook Creek locale. We organized the species we found into groups following long-standing, professional management models, such as the methods used in the Ethnoecological subsets; Ethnobotany and Ethnobiology, which are regarded as the living elements of the ecological landscape that ancestral Native Americans lived in, and manipulated for their benefit.

MAP 1: POT HOOK CREEK (WEST SIDE), SITES AND SURVEY, PORTION OF LEWES QUADRANGLE



MAP 2: POT HOOK CREEK (EAST SIDE), SITES AND SURVEY, PORTION OF CAPE HENLOPEN QUADRANGLE



IDENTIFYING PLANTS OF INTEREST

The ancestral Pot Hook Creek was likely a mosaic of wetlands and drains with an ocean formed dune field separating it from the Atlantic Ocean. Three thousand years ago, the Pot Hook Creek estuary likely resembled a recently drowned stream channel and flood plain system feeding the newly formed, shallow back-bay lagoon located west of the northward migrating Cape Henlopen.

Today, one ubiquitous estuary plant is Phragmites (*Phragmites* ssp.); an invasive plant that is known to delineate a transition zone where freshwater mixes with brackish water. Currently, this delineation in Pot Hook Creek is located where open marsh transitions to wooded canopy cover, or about GPS 0488707—4288682. This location also appears to be the limit of daily tidal influence. We could characterize the current upstream portion of Pot Hook Creek as a freshwater, wooded swamp in a generally deeply incised stream valley fed by various landscape runoff traces, in addition to multiple slope seeps. The downstream portion of Pot Hook Creek is currently brackish water and salt marsh—a likely result of recent and Historic siltation.

Excluding the ferns, we found higher frequency of all the plants listed in Table 1 and Table 2 upstream from this brackish/fresh transition zone. Several things could be in play here: on the one hand—is this an indication that the persistence of these plants is inhibited by brackish water, or, on the other hand—are we witnessing the remains of cultural botanical arrangements that have escaped their cultural location? A third possibility is that these examples of these culturally beneficial plants as found, simply cannot be meaningfully interpreted.

Let's use the ferns we found as an additional example. The varieties of ferns found appear nearly everywhere there is shaded moist soil. The quantity of ferns observed increased and diminished with no discernable regularity. We could have been observing the escaped remains of cultural fern gardens, whose limits have decayed beyond spatial recognition, or, this seemingly random fern pattern may simply be just that—a random pattern.

Table 1 (below) is a list of interesting plants of cultural benefit we found in our survey of the greater Pot Hook Creek area. Examples of each of these species were found in varying populations at varying habitat locations. It is very likely that local sea level rise has had a dramatic effect on salinity regimes in this shallow, back-bay locale. This rise in sea level would have resulted in a net movement, or transgressive relocation of the brackish/fresh transition zone moving up the Pot Hook Creek valley. Currently, extensive areas of salt marsh are indicators that these ancestral tidal back-bay locales have accumulated extensive silt deposits. All of these changes have produced the mosaic tidal stream—salt marsh complex we see today.

Table 1: Identified Plants of Interest

Common Name	Scientific Name	Status	Medicinal	Edible
Bracken Fern	*Pteridium aquilinum*	Common	Yes	Yes
Broad-leaved Arrowhead	*Sagittaria latifolia*	Common	No	Yes
Catalpa	*Catalpa* spp.	Adventive	No	No
Crested Wood-Fern	*Dryopteris cristata*	Common	Yes	Yes
Fern (Unidentifed)	*Dryopteris spp.*	?	?	?
Mint	*Mentha* spp. (*canadensis?)*	Uncertain	Yes	Yes
Persimmon	*Diospyros virginiana*	Common	Yes	Yes
Raspberry	*Rubus* spp.	Rare-Uncommon	Yes	Yes
Red Mulberry	*Morus rubra*	Uncommon	Yes	Yes
Trillium	*Trillium* spp.	Rare-Uncommon	Yes	Yes
Wild Calla or Water-Arum	*Calla palustris*	Uncertain	Yes	Yes
Wild Strawberry	*Fragaria virginiana*	Common	Yes	Yes

SIGNIFICANT ANIMAL AND PLANTS FOUND IN CLUSTERS

Our Pot Hook Creek survey produced four species that we determined to be significant in relation to the two known archaeological site complexes, The Townsend Site and the Wolfe's Neck Site. The four species we found are listed alphabetically in Table 2 (below). We will discuss these species individually, in two sets: The first set is Jimson Weed and Japanese Wineberry. These species are addressed in this essay as physical living indicators of human activity or identifying the location of Culturally Modified Soils (CMSs). The second set is Skunk Cabbage and Clam. These species are addressed in this essay as descriptor species of ancestral Native American economic importance.

Table 2: Significant Animal and Plants Found in Clusters

Common Name	Scientific Name	Status	Medicinal	Edible
Clam (Quahog)	*Mercenaria mercenaria*	Common	No	Yes
Japanese Wineberry	*Rubus phoenicolasius*	Non-Native	No	Yes
Jimson weed	*Datura stramonium*	Adventive	Yes	Yes
Skunk Cabbage	*Symplocarpus foetidus*	Common	Yes	Yes

Plants listed in Table 1, together with GPS locations of specific examples are listed in the Field Narrative attached as Appendix 1. Jimson Weed, Japanese Wineberry, Skunk Cabbage, and Clam clusters are itemized below, found on Maps 3 and 4, as well as documented with GPS readings in the Field Narrative attached as Appendix 1.

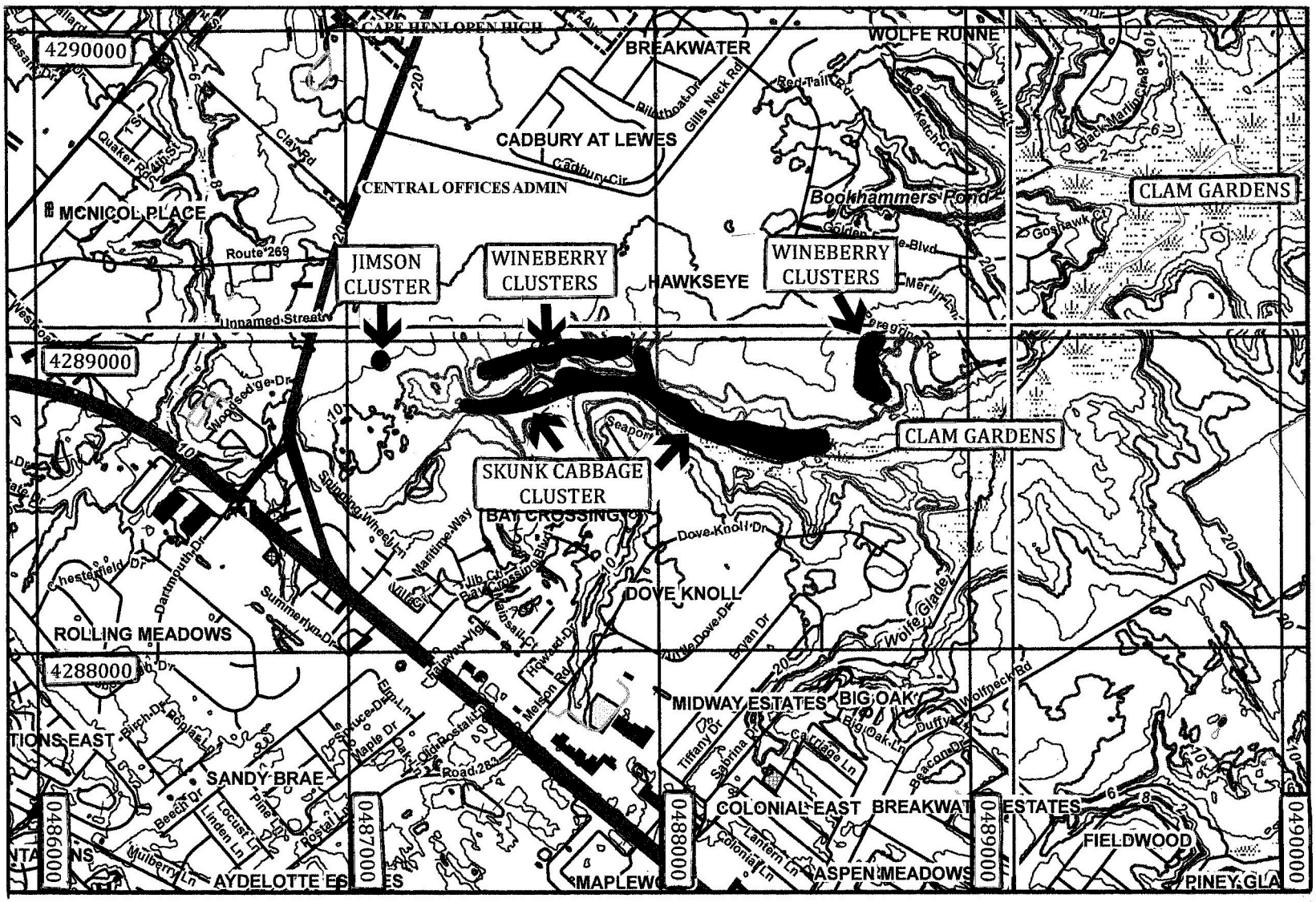
Set One: Jimson Weed and Japanese Wineberry

Jimson Weed (See Map 3)
In Delaware, Jimson Weed is listed as an Adventive species (McAvoy 2013), thought to have arrived here within the past 5000 years—likely a direct result of ancestral Native American efforts. Moerman (2009) discusses various Native American usage of Jimson Weed as having medicinal and ceremonial importance and is an edible herb. It is noted that Jimson Weed prefers to grow in full light on well drained, sandy soils that have experienced intense cultural activity. We view Jimson Weed as a cultural keystone plant in Delaware.

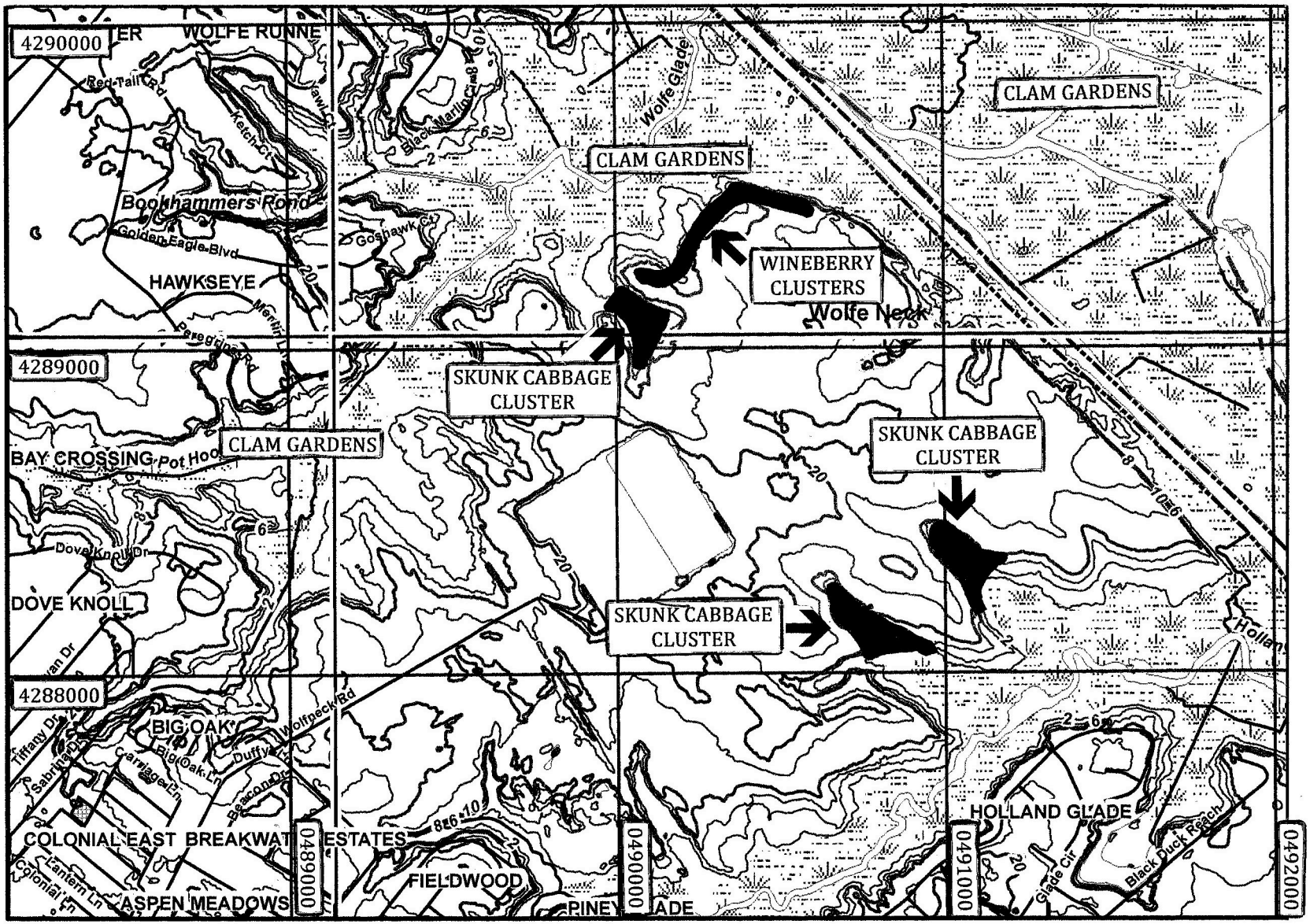
During our Ethnoecological survey, we observed a large patch of Jimson Weed (*Datura stramonium*) growing in the Lima bean field immediately north of where the flattish agricultural field begins its slope down to the Pot Hook Creek floodplain. About 200 Jimson Weeds comprise this dense cluster, which measured about 150 feet N/S and about 200 feet E/W with a center point of GPS 0487111—4288958 (see Map 3). The surface soil at this location is noticeably darker than the surrounding soils. We deduced some sort of intense cultural activity at this location had formed this soil—cultural activity that would have been much more intensive than simply the surrounding soils which are a product of mechanized agriculture. This location is likely to be a historic site location of the Colonial Period.

Japanese Wineberry (See Maps 3 and 4)
Japanese Wineberry is not listed on McAvoy's (2013) list of plants found in Delaware. Nevertheless, Wineberry is described elsewhere as having been introduced to Delaware early in the twentieth century in an attempt to hybridize varieties of Raspberry. Apparently, these attempts at crossbreeding Wineberry did not work out as expected. Wineberry has since escaped and may be found growing along field edges at various locations in Sussex County, Delaware. Wineberry thrives in loosened sandy, and windblown soils along the edges of agricultural fields.

MAP 3: POT HOOK CREEK (WEST SIDE), SURVEY RESULTS, PORTION OF LEWES QUADRANGLE



MAP 4: POT HOOK CREEK (EAST SIDE), SURVEY RESULTS, PORTION OF CAPE HENLOPEN QUADRANGLE



Our Ethnoecological survey discovered three dense clusters of Japanese Wineberry (*Rubus phoenicolasius*), two growing on the west side of Pot Hook Creek and one growing on the east side of Pot Hook Creek (see Maps 3 and 4). These three large clusters of Wineberry are found growing in sheltered areas within fully canopied woodlots, which are very odd locations for any members of the Rubus genus to thrive.

On the west side of Pot Hook Creek, flanking the agricultural field area of The Townsend Site are two large wooded areas (see Map 3). A large Wineberry cluster is found in each of these mature wooded parcels. The measured limits of the western Wineberry cluster are GPS 0487438—4288872 to the west and 0487934—4289031 to the east. The measured limits of the eastern Wineberry cluster are GPS 0488664—4288841 to the west and 0488750—4288793 to the east.

An unpublished archaeological survey of these wooded parcels (Heite 2004) discusses culturally modified soils, Mockley ceramics, and clamshells identified in the eastern woodlot, and culturally modified soils, Coulbourne ceramics, and clamshells identified in the western woodlot. Our survey found a large Wineberry cluster growing in each of these wooded areas on these previously identified Native American Culturally Modified Soils.

On the east side of Pot Hook Creek, flanking the agricultural field area of the Wolfe's Neck Site, we identified a large Wineberry cluster growing in the western and northern wooded slope areas and along the eastern bluff edge of the previously recorded Wolfe's Neck Site area (see Map 4). We documented this current western limit of this Wineberry cluster at GPS 0490068—4289293. Close by, an overturned tree stump exhibited some cultural shellfish debris at GPS 0490072—4289298. Alternately, the DESHPO Wolfe's Neck Site National Register nomination form (Thomas et. al., 1976:5) pinpoints the southwestern site limit (Point A) at GPS 0490100—4289260. We believe these very similar GPS readings are not simply a coincidence. What we have discovered here, at this location, is that this large cluster of Wineberry is growing on these previously documented Culturally Modified Soils, at least as a result of the reduced soil acidity found in the culturally derived shellfish debris deposited there.

The co-occurrence of Wineberry found in cluster form in these wooded environments and Culturally Modified Soils, at all three known wooded site areas, is a profound new realization. Wineberry, it would seem, is able to populate and thrive on these areas of culturally modified soils. As a future indicator of presence or absence of wooded archaeological sites, this Wineberry species is likely a powerful new tool. Further research in the field of Ethnobotany may show that Wineberry is just one species in a suite of species (see our previous discussion on Jimson Weed) capable of showing astute observers where Culturally Modified Soils are located.

Set Two: Skunk Cabbage and Clam

Skunk Cabbage (See Maps 3 and 4)

Skunk Cabbage is listed by McAvoy (2013) as a Common, Native plant in Delaware. Moerman (2009) lists the Skunk Cabbage as having Native American medicinal uses and is reported to be an edible plant, especially in late winter and early spring. Turner (2014) discusses cultural benefits of growing and harvesting Skunk Cabbage, which we will address momentarily in this section. When we do find Skunk Cabbage in Delaware, the plants appear in discrete clusters. These clusters have endpoints that are highly definable and easily mapped using GPS documentation. We do not generally encounter examples of Skunk Cabbage that appear to be randomly or sparsely populated.

Our Ethnoecological survey of Pot Hook Creek identified four substantial clusters of Skunk Cabbage (*Symplocarpus foetidus*). The largest Skunk Cabbage cluster currently occupies the drowned creek valley near The Townsend Site (see Map 3). Three other Skunk Cabbage clusters currently occupy drowned runoff and seepage valleys draining from the Wolfe's Neck peninsula into the surrounding tidal, brackish and salt marsh areas (see Map 4).

In reviewing the four clusters of Skunk Cabbage found during our Pot Hook Creek survey, the first cluster occupies the Pot Hook Creek stream valley (see Map 3) from GPS 0487352—4288826 upstream, to 0488519—4288680 downstream. This cluster is in close spatial proximity to The Townsend Site. The second

cluster occupies a drain and seepage to Pot Hook Creek, or Wolfe Glade (see Map 4) from GPS 0489950—4289100 to 0490050—4288950. The third cluster occupies a drain and seepage to Holland Glade (see Map 4) from GPS 0490950—4288450 to 0491100—4288200. The fourth cluster occupies a drain and seepage to Holland Glade (see Map 4) from GPS 0490600—4288300 to 0490950—4288075.

How is our identification of these Skunk Cabbage clusters, or gardens, significant to this survey? Our Ethnoecological survey was designed to look for remnant "signatures" of plants and animals that may have been of benefit or necessity to the ancestral Native Americans who lived nearby. Such ecological resources are more easily addressed through describing Native American economic programs than by excavation through archaeology. We think Skunk Cabbage played a very important role in the local economy, yet various plant remains, such as Skunk Cabbage rarely, if ever, are preserved in the archaeologically excavated database. Nancy Turner, an archaeologist, ethnoecologist, and ethnographer, has compiled a wealth of information on the value of Skunk Cabbage in the lives of Native Americans.

In her area of expertise, the northwest coastal and mountain zones of North America, Turner (2014, V1:326-7) says, "Skunk-cabbage leaves also seem particularly suited to aiding in food processing and storage, not only because of their large size but also because of the waxy coating on their leaves, their flexibility when warmed, and possibly, too, the raphides of calcium oxalate in their tissues that might deter pests. These leaves were used for multiple purposes: to line cooking pits, or earth ovens; as a surface on which to dry berries; for makeshift drinking cups and berry containers; for covering highbush cranberries, currants, and other berries being stored; and for lining pits and, later, barrels used to make fermented salmon eggs."

Turner (2014, V2:249) relays a Haida and Tlingit story regarding Fog Woman (and her husband, Raven), who taught Raven how to wrap fish and shellfish in Skunk Cabbage leaves; "Fog Woman, who was married to Raven, captured all of the fog in Raven's spruce-root hat. Then she used that same hat to capture all of the different kinds of salmon and showed Raven how to pit-cook salmon, wrapping it in skunk-cabbage leaves, and how to smoke it." Although Skunk Cabbage roots have been used in the Pacific Northwest as halibut bait, it seems the leaves were most often used as lining and wrapping materials. We view Skunk Cabbage as a cultural keystone plant in Delaware.

Clam—Quahog (See Maps 3 and 4)

Much of Delaware's descriptions of ancestral Native American contexts are based on previous archaeology conducted within these shell-middens found at The Townsend Site (Thomas et al. 1974) and the Wolfe's Neck Site (Thomas et al. 1976). However, in our current Ethnoecological approach, we wanted to look at the extensive reliance on Clams (*Mercenaria mercenaria*) from environmental and economical perspectives instead of from the traditional archaeological perspective. In short, we wanted to evaluate how shellfish factored into the ancestral Native American economy at this location—why were these people here, and what were they doing? We identified and will discuss some new solutions to those questions; solutions, which have the potential to significantly improve our understanding of these various Woodland peoples and their economic programs.

From a grand perspective, these accumulations of shellfish debris on Pot Hook Creek appear to be overall, horizontally and frequently vertically stratified. Shell-midden excavation analysis has provided lists of temporally organized, culturally definable contexts. Carbon samples, in association with Native American ceramics and shellfish debris, have produced carbon dates that range from about 600bce to about 1650ce. Given this 2,200-year duration, as some models of projected sea level rise might suggest, the known locations of datable shell debris on Pot Hook Creek does not consistently or evenly, over time, move upstream. Even though there appear to be cultural "hot spots" up and down the stream valley, it seems that all of the cultures represented on the Pot Hook Creek drainage made use of all of the resources, and very likely improved and maintained, and even relocated beneficial resources within this drainage.

The quantity of cultural clamshell debris found on Pot Hook Creek is substantial, perhaps the largest known accumulation of clamshell debris within the State of Delaware. Other, smaller deposits of clamshell are recorded on discrete sites elsewhere along the Coastal Bay and Delaware Bay river systems. However, we recognize the difference in proportion of clamshell debris from location to location as being meaningful.

Measuring Native American clamshell debris can be an obtuse and cumbersome task. In this essay, we measure Native American clamshell debris by the dump truck load, an approximation of twelve cubic yards. We use this method of measurement for overall visual effect, not for its scientific accuracy. Thus, when we speak of small sites with small cultural clamshell deposits, we suggest these deposits are within the range of one to ten dump truck loads. When we speak of cultural clamshell deposits at The Townsend Site and the Wolfe's Neck Site, we are talking about cultural clamshell debris in the range of hundreds of dump truck loads. We therefore view Clam as a cultural keystone animal in Delaware, especially at these significant sites on Pot Hook Creek.

In general, small sites with small cultural clamshell debris fields can be multicultural, but they are rarely sequentially multicultural. We propose a clam foraging economic program at these locations. With The Townsend Site and the Wolfe's Neck Site combined, they offer horizontal and vertical stratification data that exhibits sequential multicultural use. We propose a clam garden economic program at these locations. So, what is a clam garden economic model?

We use the word garden, because it implies the concept of cultivation. As Webster's (1967:202) defines cultivate, as "to prepare or prepare and use for the raising of crops", we suggest our clam garden model contained tidal areas set aside for the cultivation of clams. Today, these proposed clam garden areas along Pot Hook Creek have unfortunately accumulated massive amounts of silt where they have been transformed into salt marshes (see Maps 3 and 4).

INTERPRETATIONS

Obviously, in Delaware, years of future research could be applied to asking questions concerning clams found along Pot Hook Creek, as well as the ancestral Native American contexts in which they are embedded. What do the contents of the various shell-middens and other cultural features tell us about who was doing what through time? What made this particular back-bay location a suitable place for the sustainable production of shellfish?

We should also be asking a wide range of environmental questions, such as; how and when did this back-bay form in relation to the littoral repositioning of Cape Henlopen; what were the effects of past sea level rise; what will happen to this locale if subjected to terrestrial development or additional Army Corp dredging? How will this locale be impacted by projected future sea level rise?

The process of ancestral Native American clam gardening should be addressed wherever we find evidence of huge amounts of cultural shell debris. We need to be judicious in describing evidence of shell debris because the quantity of shellfish debris over time is important. We need to address whether a cultural deposit represents successive cultural inheritance of a managed location, or are we looking at a small deposit representing an isolated, short-term singularity. Turner (2014, V1:212) reminds us, "Clam beds, carefully built up to extend their area and productivity, were created and sustained on many parts of the coast (Fowler and Lepofsky 2011; J. Williams 2006; Recalma-Clutesi 2005). Quantifying successive sustainability is likely the key element that differentiates **clam gardening** from **clam foraging**!

We also think that clam gardening would regulate the division of labor where elders, women, and children (arguably three quarters of the total available population) contributed more directly to food procurement. Turner (2014, V2:55) says, "This may have endowed these groups (elders, women, and children) with higher status and possibly shifted the power relationships within families away from the stronger, more dominant male who hunted in groups with other men and toward a more balanced social standing across gender and age groups." How do these suggestions oppose or agree with previously assumed social strata for these cultures in this locale? Do these suggestions add to or take away from our ideas about material, ceremonial expressions commonly referred to as "Delmarva Adena"?

This clam gardening program, along with berry gardening, maintaining other fruit orchards, and nut groves is perhaps the strongest indication of gender biased, or matrilineal organized economic properties we have thus

far suggested in Delaware. The waste debris found in the shell-middens on Pot Hook Creek is an indicator of what was being processed. Species such as razor clams, conch, scallops, ribbed mussel, etc. were likely cleaned out of the clam beds and probably contributed to edible food stocks. Harvested clams, however, represent a strong bias toward large, adult clams. We can only assume the small and medium sized clams were left behind as breeding stock, as they are woefully under-represented in artifact databases and collections. We think selectively harvesting only **large clams** represents a regulated clam harvest size. This form of garden management would harvest adult clams that will not grow larger and produce ample room for juvenile and small clams to reach maturity. We think this form of management could increase the yield of the clam beds at least fourfold. Such management programs designed to increase sustainable yield are consistent with other examples of matrilineal organized economic properties where reliable, owned, and inherited resource based Traditional Land and Resource Management areas (TLRMs) are organized within larger, territory based TLRMs.

Clam garden management, or shellfish stewardship implies the cultivation of harvestable clams within a storable shellfish economy, promoting enhanced economic predictability with a large degree of permanence, even if permanence is based on a repetitive seasonal basis. Such factors might enrich trade and exchange networks and result in elaborations of ritual, ceremonial, and mortuary practices. Williams (2008:1) said, "The clam gardens were one of the foundation blocks of aboriginal economy for specific coastal peoples. If they are accepted as an essential cultivated and privately owned unit of Native economy, a term like "hunter gatherer", which has been used by social scientists to define Northwest Coast Native society, must be reassessed." This is why we are making a profound distinction between clam foraging and clam gardening. We strongly suggest our idea of clam gardening involves regulated selective harvesting and cultivation. Our Ethnoecological explanation of clam gardening as an anthropogenetic landscape, or TLRM property simply cannot be properly addressed using the moniker "hunter gatherer".

What is the legacy of clam gardening on Pot Hook Creek (ca. 600bce to 1650ce)? The long story is one that requires a great deal more research, but the short story is one where we need to readjust our impressions about who these people were with at least the following three thoughts:

A) The makers of Wolfe Neck, Coulbourne, and Mockley ceramics (including their various derivative and debased forms) built, maintained, owned, and sequentially inherited these clam gardens on Pot Hook Creek. Their material surpluses likely afforded them the opportunity to engage in trade and exchange to acquire goods (and perhaps services) moving east from the Potomac Trail, the Appalachian Trail, and the Delaware Trail (Mellin and Truitt, 2014b), including, but not limited to materials and ceremonies that have previously been referred to as manifestations of "Delmarva Adena", or "Fox Creek", etc. There are no known human burials found from any of these populations (600bce through 1650ce) at the Wolfe's Neck Site. However, there are a number of known cemeteries and ceremonial sites (600bce through 1650ce) for the above populations and other populations (including the Island Field Site) located a few miles to the north.

What does this seeming succession of labeled ceramic types really mean? When viewing our clam garden economic model for Pot Hook Creek, these changes in ceramic labels probably describe a succession of technological developments within a socially stable group rather than a succession of different people or different groups of people.

B) The makers of Hell Island ceramics, a likely immigrant group from western New York State, **did not have** access to the clam gardens on Pot Hook Creek—there are no Hell Island ceramics on Pot Hook Creek! Although there is some evidence that the makers of Hell Island ceramics did forage for small amounts of clams nearby (see the Argo's Corner Site, for example), there are no Hell Island ceramics directly associated with the clam garden shellfish cultural debris on Pot Hook Creek. Overall, the efficiency of clam garden economy on Pot Hook Creek may have diminished while the makers of Hell Island ceramics lived nearby. Certainly, archaeologists have hotly debated how the makers of Mockley (and the derivative Claggett) ceramics and the makers of Hell Island ceramics could have co-existed in seemingly overlapping territories. The main cemetery and ceremonial center for the makers of Hell Island ceramics (ca. 500ce through 1200ce) is located near Bowers Beach.

C) The makers of Rappahannock and later Townsend ceramics, possibly an immigrant lineage with Chesapeake origins, seem to either have inherited and maintained, or seized and supervised the clam gardens on Pot Hook Creek. The focus of their habitation site was situated slightly upstream on Pot Hook Creek for undetermined reasons. We do know the location of the Cape was constantly moving. Tidal and salinity regimes in the back-bay and lagoon areas, and sea level rise may have all contributed to the demise and relocation of some of the previously sustainable clam garden beds. The efficient use of watercraft may have allowed easier access to distant clam beds, across deeper waters. At The Townsend Site, we recognize a number of human burials that were interred there after 1000ce.

INTEGRATING THESE ETHNOECOLOGICAL OBSERVATIONS

Obviously, injecting a clam garden economic program and other Ethnoecological interpretations into ancestral Native American cultural explanations has the potential to add significantly to understanding Delaware's prehistory. Interpreting cultural ecology is at the heart of the issue. We share the desire, and appreciate the overall strategy to identify, analyze, interpret, and protect significant cultural resources. Yet, when we fail to properly identify cultural resources, using these clam gardens on Pot Hook Creek as an example, the rest of the process is pointless.

Under the umbrella of Cultural Resource Management, there are many discussions about organizing cultural traits into various periods of context—as if the label, Context, or the concept of context somehow validates, justifies, or legitimizes our efforts in exploring, organizing, and explaining the activities of individuals, families, and groups of people. We find that the implementation of the context labeling system of ancestral Native American behavior continues to be shaped by Eurocentric ideals, and, in general, continues to dwell on explanations of adult male activities. This needs to change! Our approach to investigating the totality of what qualifies, or what may qualify as a cultural resource strives to examine individual, families, and groups of people within their anthropogenic landscape, the landscape of their creation, not ours. Many elements of these anthropogenic landscapes endure to this day and are appreciated by the few who keep an open mind in knowing what to look for, and take the time to look for them.

It is nearly impossible to neatly fit this clam garden economic system into the existing organizational context system. Actually, some people prefer to organize ancestral Native American behavior through the **techno-temporal Context method** using Early Woodland—Middle Woodland—Late Woodland as definable, non-overlapping Contexts. But this method seems to disallow two different ethnic groups occupying a similar territory. For example, in this essay, we seem to have a group of people, making Mockley ceramics (technically Early Woodland), engaged in a clam garden economic system, while at the same time we have an immigrant group of people living a few miles away making Hell Island ceramics (technically Middle Woodland), apparently engaged in an upland economic system.

Additionally, we have the **environmental Context method** using Woodland I and Woodland II as definable, non-overlapping Contexts. But this method also seems to disallow two different ethnic groups occupying similar territory. For example, in this essay, we seem to have a group of people, continuing to use Hell Island ceramics or derivatives thereof (technically a continuation of Woodland I), while a different ethnic group—a Rappahannock ceramic making immigrant community (technically Woodland II), continuing with a clam garden economic program living at The Townsend Site.

Clearly, we cannot turn one Context off and turn another one on as easily as drawing water from you kitchen faucet. Even trying to apply some sort of transitional apparatuses between Contexts is a sloppy and probably a false assumption because, again, there are different ethnic groups of people together with their different cultural and economic systems moving and repositioning around the landscape.

There has been no evidence concerning the inhabitants discussed in this essay where an immigrant group expediently displaces or annihilates a seated group. Yet, during periods of such "assumed" immigrant positioning, there are indications of economic disruption, or social friction between neighboring groups. These disruptions sometimes lasted for hundreds of years. We do see some indications, however, that after a long time some assimilation, or cultural homogenization did occur, at least until the next immigrant group

appeared. These topics are immensely important to this discussion, but unfortunately, we do not have the time or space in this essay to explore them. We would, however, very much enjoy reading someone else's essays addressing ideas like; "Where is Claggett a derivative of Mockley", or, "Under what circumstances does Hell Island lose its mica temper". We think the keys to answering some of these questions are imbedded in the anthropogenic landscapes—areas much larger than a string of comparative or contrasting archaeological sites.

Why are anthropogenic landscapes, cultural resources—in need of protection? Because they are critical remaining elements to understanding that humans manipulated aspects of their environment to their liking! We found an author new to this area, Dr. Nancy Turner, who addresses that question in her new book; Ancient Pathways, Ancestral Knowledge: Ethnobotany and Ecological Wisdom of Indigenous Peoples of Northwestern North America, a two volume set published in 2014 by McGill-Queen's University Press, Montreal. We very much appreciate Nancy Turner's approach and recommend her new book to everyone interested in her encompassing scope of Cultural Resource Management.

Following this new paradigm, we are persistent in integrating an Ethnoecological approach to identifying and managing our collective cultural resources. It is equally important for archaeologists to have an appreciation for understanding the widest range of possible cultural behavior within all aspects of all anthropogenic landscapes and TLRMs. If this sounds like a monumental task for anyone planning or conducting a cultural resource survey—you're right, it is a monumental task! Turner (2014:165-6) discusses the many reasons why Governments, archaeologists, and other "authorities" are biased and misdirected in believing ancestral Native American territory was not fully occupied, or that an "anthropogenic landscape could encompass a group's total territory."

Turner says, at the very least, we must come to grips with the concept that ancestral Native Americans maintained anthropogenic landscapes that were larger than fifty percent of their total useable territory. Turner (2014:148-9) defines a TLRM as, "The conscious accumulation, application, and adaptation of any combination of techniques and methods drawn from traditional ecological knowledge systems, mediated by particular beliefs and worldviews, that sustain or enhance the availability, abundance, productivity, diversity, and/or quality of a plant or animal population or of an entire resource area or habitat over a period of years or generations (see also M. K. Anderson 2005; Berkes 2012; Deur and Turner 2005; Gadgil and Berkes 1991; and Menzirs 2006b)."

When we understand that ancestral Native Americans enjoyed an indivisible kincentric relationship with their TLRMs, we have to view TLRMs as highly significant cultural resources, even though the cultural resource, or TLRM may not contain any traditionally recognizable artifacts. Some researchers suggest that residual stone, bone, shell, and ceramic, the items we commonly call artifacts, represents 5% to 10% of material culture. The remainder, of course, is either ethnobotanical, ethnobiological, or the TLRMs that contain them. For example, the prospective clam gardens on Pot Hook Creek probably qualify as ethnobiological economic programs contained within a definable TLRM that supported significant numbers of people, spanning successive cultures, for several thousand years. That is an important new idea.

If we connect the gardening of clams on Pot Hook Creek with the leaves of the Skunk Cabbage gardens on Pot Hook Creek as clam smoking and clam storage wrappers, then we have multiple elements within a TLRM working together as a cultural resource economic system. In turn, we could deduce that this system produced the main reliable/storable/edible protein that enabled material and ceremonial embellishments, such as what is known as "Delmarva Adena". In short, if we didn't have these productive clam gardens on Pot Hook Creek, it is very likely we would not have "Delmarva Adena". This is where the new paradigm of TLRMs is able to incorporate these cultural elements into a unified cultural and economic explanation, where the contextual explanation alone has discouraged this sort of thinking. This has been the main reason why some people continue to erroneously support the idea that Delmarva Adena is a complete cultural context independent of all other cultural contexts, and existing without a definable economic program.

Some people may be inclined to quickly point out that a TLRM falls under the old definition of context, but, it does not, and here are some examples why. The largest and most stubborn reason is that TLRMs, or subsets

of anthropogenic landscapes often contain no traditionally recognizable artifacts. An example might be a sandy hill next to a huckleberry swamp. The hill may have served as a very important, even essential berry harvesting and drying camp, occupied by elders, women, and children during specific harvest periods of the seasonal round. Yet, even when a few cultural features are present, if this site contains no temporally diagnostic tools or ceramics, this location would typically not qualify as an interesting cultural resource under the current assumption of Context. This location would most certainly qualify as a TLRM, but because the location might lack a subjective quantity of datable cultural artifacts based principally on "style", these locations are typically ignored after Phase I survey. These very important locations usually fail to receive proper recognition, or assignation of a cultural resource location number.

If we continue to apply these forms of ineffective thinking inherent in Context definition, we will continue to read ineffective explanations, such as: **We think we know where the men were and what they were doing, but we don't know where the elders, the women, and the children were, or what were they doing.** This is why we have to ask, why do we continue to misidentify what three-quarters of the indigenous population were doing, and where they were doing it? Or is it that we don't really care what they were doing?

Nancy Turner experiences similar value judgment difficulties in British Columbia. For example, Turner (2014, V2:401), while speaking about how various value judgments are legislated through the Heritage Conservation Act of British Columbia, or the HCA, supplies the following block quote:

> The HCA appears to accommodate the heritage of First Peoples, but the legislation's criteria of what is worthy of protection were selected through a decidedly European lens, which favors and values the built environment (e.g., monumental structures, works of art, and archaeological sites). Significantly, even an archaeological site can be legally demolished once it has been "scientifically" documented and the artifacts and/or human remains have been excavated. Further, although the HCA protects sites where there is physical evidence of past human use or occupation, this legislation was written at a time before archaeologists and anthropologists recognized the physical evidence of Indigenous-managed root gardens, berry gardens, orchards, and clam gardens.

Lenny and I met Nancy Turner at the International Ethnoecology conference in Cherokee, North Carolina in May 2014. She introduced her new book, which is a must-read for everyone interested in the discipline of Ethnoecology! For those of you who don't have the time to read her one thousand and one hundred pages, and because this is an essay and not a professional paper, we will break some rules and include two massive block quotes from Turner, 2014. The first block quote places the above quotation into her deeper discussion about how we often use Eurocentric value judgments to determine cultural resource significance, from Turner (2014, Volume 2, pages 400-402):

> In the past three decades, the federal government, and later the provincial government as well, entered into treaty negotiations. Until these treaties are concluded, the governments are legally obliged to consult with First Nations before allowing any activity on publicly owned lands within their territories (the majority of lands in British Columbia) that may infringe upon Aboriginal rights arising from original use and occupancy. Although an awkward, and often acrimonious, process for protection, the legal acknowledgment of Aboriginal rights and title has opened up interest in and research on traditional knowledge of plants and animals of First Nations in British Columbia. Some First Nations in the province have opted to exchange their general and undefined Aboriginal rights for a clearly defined set of rights within defined geographical areas through modern-day treaties. These modern treaties, such as the Maa-nulth Final Agreement, provide some examples of how First Nations' traditional plant and animal resources are being managed.
>
> Even without treaties, but backed by Aboriginal rights recognized in the Canadian Constitution and other legal venues, many First Nations throughout British Columbia are initiating their own land use plans that take to heart their needs for plant resources and land bases on which to practise and sustain their cultures. Others have negotiated with provincial and federal governments, and with supportive nongovernmental organizations, to collaborate in the sustainable use of traditional

lands and resources—for example, in the development of marine protected areas and in the co-management and co-governance systems, in establishing laws that effectively protect Indigenous peoples' lands, waters, and resources from overexploitation, and in giving a real voice to Indigenous peoples' needs and perspectives.

As modern treaties are being slowly negotiated, however, there is a policy and legislative gap in providing protection for medicinal plants and other culturally valued species, as well as for culturally important lands. Currently, for example, the Heritage Conservation Act of British Columbia (HCA), despite its stated purpose "to encourage and facilitate the protection and conservation of heritage property in British Columbia" (British Columbia 1996, part 1, 1), is limited in its application and does not explicitly protect medicinal plant populations or, necessarily, their habitats or culturally valued habitats in general—even when such areas are known from oral history to have cultural significance over many generations—unless these have some verifiable associated archaeological feature. Recently, for example, a large patch of obviously very old *q'exmin* ("wild celery," *Lomantium nudicaule*) was destroyed by construction of a new bridge at the Little River ferry terminal near Comox on the east-central coast of Vancouver Island. As the site did not contain physical evidence (in the form of a culturally modified artifact) of past human use, it was not afforded automatic protection under provincial heritage legislation.

The HCA appears to accommodate the heritage of First Peoples, but the legislation's criteria of what is worthy of protection were selected through a decidedly European lens, which favors and values the built environment (e.g., monumental structures, works of art, and archaeological sites). Significantly, even an archaeological site can be legally demolished once it has been "scientifically" documented and the artifacts and/or human remains have been excavated. Further, although the HCA protects sites where there is physical evidence of past human use or occupation, this legislation was written at a time before archaeologists and anthropologists recognized the physical evidence of Indigenous-managed root gardens, berry gardens, orchards, and clam gardens. As a result, there is no explicit policy or practice associated with the HCA to include these unique and highly significant heritage features within the province's heritage site system.

Although there is other provincial and federal legislation in Canada that addresses indigenous plants, as well as threatened species and ecosystems, none explicitly considers the protection of First Nations' cultural keystone species or managed landscapes; thus protection is by accident rather than by purposeful inclusion.

Frustrated by the lack of legislative avenues to protect their traditional food, medicinal, and material plants and unique sites, First Nations have often asserted their Aboriginal rights and title through the courts. Although this action has provided some real success for First Nations, proving they have Aboriginal rights and title to a given area is an expensive, time-consuming, and acrimonious solution of last resort.

Another venue that might help in this endeavour is the United Nations Declaration on the Rights of Indigenous Peoples (United Nations 2007), which Canada and the United States have both endorsed. Along with the United Nations Convention on Biological Diversity (United Nations 1992), to which Canada is a signatory, this agreement requires Canada and the United States to conform to international standards in supporting their Indigenous citizens, including their rights to continue their traditions, languages, and use of their territories and resources.

In the Western world, we have a reservationist's mentality. Creating reservations makes life easy for us when we draw little circles on maps, and put THOSE people inside the circle. We do a similar thing with archaeological sites. But, if we are to respect one another, life should not be that way. The more we limit cultural diversity (and this reflects back on our ability to explain by using only a limited number of "regulator approved" insufficient and ineffective Context categories)—the more we limit biodiversity. We are

collectively supposed to be learning from this process, but what we are doing is creating an easy road to our own extinction. What, if anything, can we learn from coming to grips with this dilemma? What can we learn and how can we learn from the past that may offer solutions to present-day Ethnoecological problems?

Strong, new trends are developing in the use of data gathered from Ethnoecology and archaeology to gain access to, as Turner puts it, these ancient pathways and ancestral knowledge. Traditional Land and Resource Management programs allowed these so-called primitive people to prosper in the so-called New World for over twelve thousand years. They developed suites of cultural solutions that worked! When we compare many of our current environmentally destructive habits to their environmental management programs, many of our habits may exhibit criminal intent. Again, we offer a block quote from Turner's new book (2014, Vol .2, pages 409-411):

> What we have come to understand in recent decades is that there is a vast complexity in the many and varied interactions between the First Peoples of northwestern North America and the biological diversity of this region. In particular, in the case of this study, the role of plants in supporting and sustaining Indigenous cultures and lifeways for countless generations has been immense and diverse. It was not so long ago that those of the dominant Western society, including many academics, understood little about how plants have been fundamentally important to First Nations. Political leaders, educators, policymakers, and bureaucrats often recognized little beyond the importance of salmon, and perhaps deer, as the key resources for Indigenous peoples of this area. Across their traditional territories, "reserves" and "reservations" were designed to accommodate their "needs," but these were generally restricted to immediate village sites and, in some cases, to places used for fishing or hunting. Metaphorically, communities were left without their gardens, their pharmacies, their hardware centers, and their scared places. The reserve and reservation systems in Canada and the United States respectively reflect policies often based on greed, but perhaps more on ignorance, under a philosophy that First Peoples in northwestern North America and elsewhere were not really "using" most of the land they claimed as their territory. Similar notions were taught widely in the public school system as recently as a couple of decades ago.
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> Gradually, this incomplete understanding is changing. Of course, many First Nations individuals, particularly culturally knowledgeable elders, knew that this Western view was deeply flawed, but their voices were seldom heard and usually ignored. At last, however, through their efforts, and through a growing awareness of society in general, this situation is changing. Many recent initiatives at the global, national, and regional levels have focused on the significance of Indigenous peoples' knowledge and on their rights to influence policy formulation and to exert some control over activities occurring within their territories. The imperative for consultation, listening to their perspectives, and respecting their deep knowledge and wisdom has resulted in a change and a growing appreciation of First Peoples' histories, cultures, perspectives, and knowledge.
>
> In these endeavours, knowledge and understandings of plant resources and culturally valued environments have been prominent. However, there is a long way to go. Now as perhaps never before there is pressure for conformity, not only as a community level but also at a global level. Languages are disappearing and cultural distinctions are blurring across the planet as the large multinational companies offer the same products and as media spread the same messages far and wide. People will have to work hard to maintain their cultural distinctiveness in the face of these forces, but diverse knowledge systems and perspectives bring advantages in terms of offering more and potentially better solutions to problems and thus increasing our resilience as humans in these times of great change (W. Davis 2009). By no means do Indigenous peoples have all of the answers for sustaining humans and other life forms over long time periods, but they have had—and still do in some measure—distinctive approaches and different worldviews and related values that might help humanity collectively to find a better and less destructive relationship with our environment.

As a global community, we must come to a better understanding of our collective impacts, both on the environment and on countless local and Indigenous cultural groups in different parts of the world. Not only are these peoples being deprived of their cultural and linguistic heritage, but we are also depriving humanity as a whole of the richness and resilience that biocultural diversity can bring; we are losing a major portion of our combined environmental knowledge, practices, beliefs, and relationships, which are such an integral part of human existence (W. Davis 2009; Hunn 1999). The ability to access, use, care for, and perpetuate the plants, animals, habitats, and landscapes of their own homelands is essential for the continued health and well-being of Indigenous peoples and for the continuation of Indigenous cultures, languages, and identities. These peoples, together with their cultures, languages, stories, and ceremonies, are inextricably linked to their traditional territories and to the other species that dwell there. Consequently, their identity and their ability to maintain and use this environment are critical to their future success and survival as distinct peoples.

Ethnobotany and ethnoecology have finally come into their own in northwestern North America. The recognition that these knowledge systems are vastly more complex and important than was appreciated only a few decades ago is reflected in many ways—not only in publications such as this one (see also Turner and Lepofsky 2013) but also in the very vibrancy of programs being developed by Indigenous communities and their collaborators in schools, in local economic development initiatives, in videos and educational productions shown on television, and in the celebrations of Indigenous foods and feasts that are occurring in many places on Vancouver Island and beyond. The message is now loud and clear; Indigenous peoples in northwestern North America were not just casual wanderers through a bountiful land, hauling salmon from the rivers and perhaps plucking a few clusters of berries as they were encountered. They were active participants in managing their environments and in using their resources sustainably, treating them with care and consideration. This newly recognized paradigm serves as a excellent starting point for all of us to create better, more respectful, more meaningful, and more careful relationships with our local environments, with other species, and with the entire natural world on which we rely.

Helin (2008, 168) writes, "In going forward, Aboriginal people must understand the realities of their ancestors' success and self-reliance over millennia (a foundation of independence, interdependence, self-discipline, ethical leadership, and cultural cooperation)." More than this, *all* of us need to recognize this history of success and self-reliance. Indigenous peoples' knowledge, skills, values, and approaches can contribute substantially to humanity's efforts to achieve the "paradigm shift" that is needed if we are truly to reduce our impacts on the earth and to reverse the tide of global environmental and cultural change and loss. Indigenous perspectives—about the interconnectedness of life, about plants and animals as relations or kin, about the importance of a long-term view of the future, about the linking of human health and well-being to the health of the environment as a whole, and about what is truly important to the human condition—need to be communicated effectively to Western urbanized society so that they can be considered and potentially adopted more widely.

I hope that this synthesis will contribute to the advancement of knowledge and understandings both about cultural adaptations to specific places and environmental situations and about influences of people on these places and ecosystems. Moreover, the inclusion of scales of time and space over which patterns have been identified in this project will hopefully lead to a clearer understanding of humans' capacity for learning, exchanging, retaining, and regenerating knowledge. This understanding is critical to our efforts to reformulate our behaviours in ways that will allow us to live more sustainably in the world we have inherited and to bequeath it to the future in a fully functioning, healthy, vibrant, and diverse state.

We thank Nancy Turner for her insightful and astute contributions. She has an interesting plan and if we follow her advise maybe we can save our species and our planet from self-destruction! In taking all of the above comments into account, what have we learned from our Ethnoecological survey and why do we have an appreciation for the clam gardens on Pot Hook Creek?

SUMMARY

As a result of our Ethnoecological survey on Pot Hook Creek, there are so many new things to talk about we regrettably have to distill this summary down to a simplified list of topics discussed. Our Pot Hook Creek Ethnoecological survey re-located and evaluated two known National Register site complexes; The Townsend Site and the Wolfe's Neck Site. Our survey identified three plant species and one animal species found in cluster forms that we felt were significant to our survey. We found and recorded Ethnoecological clusters of Jimson Weed, Japanese Wineberry, Skunk Cabbage, and Clam. Combining the known archaeology and our identified species clusters allowed us to make a number of meaningful interpretations about past human behavior at this locale that would not have been possible without the results of this survey.

These massive clamshell middens and debris fields on Pot Hook Creek have a date range of 600bce through 1650ce. Horizontal and vertical sequential strata offer many great opportunities to illustrate sequences of who was there and how they lived their lives at this locale. The first grouping is a continuous use involving Wolfe Neck—Coulbourne—Mockley ceramic verities (perhaps 600bce through 1000ce). The second grouping, an absence of use involving Hell Island ceramic verities (perhaps 500ce through 1200ce). The third grouping, a continuous use involving Rappahannock and Townsend series ceramics (perhaps 1000ce through 1650ce). These dates are derived from sites within Delaware, not necessarily from these two sites immediately on Pot Hook Creek. Nevertheless, an increasing number of carbon dates with significant date overlaps, from ceramic type to ceramic type provides an opportunity for new and meaningful explanations in assessing the behavior of immigrant groups and assimilation.

Turner's (2014) concept of Traditional Land and Resource Management areas is an attempt to organize Native American groups on an Ethnoecological basis. The TLRM system supports different ethnic groups simultaneously occupying adjacent and even overlapping territories. This system allows, for example, a coastal group living in close proximity to an upland group and explores the obvious benefits of trade and exchange between the two groups (occupying similar territory, but developing and exploiting different environmental niches and creating different economic systems). These different groups produced and maintained different anthropogenic landscapes, and as we identify and record elements of these different landscapes we are creating a new, more insightful explanation of the lives and times of these ancestral peoples.

We think the clam gardens on Pot Hook Creek produced the required, storable yield that offered some of these people sufficient affluence and spare time to engage in distant trade and exchange. It remains difficult to explain what was traded out of this area, but we do find various groupings of artifacts transported into Delaware that have been referred to as "Delmarva Adena". The presence of these groupings of artifacts, ritually deposited with the deceased, illustrates the maximum kincentric value in any anthropogenic landscape. Certainly, more research is needed on these very interesting topics, and perhaps in the future, a clearer picture of what really happened here on Pot Hook Creek will emerge from these shadows. As Eno and Byrne once said, the dimming of the light makes the picture clearer—it's just an old photograph, there's nothing to hide, when the world was just beginning.

Special thanks go out to ancestral Native Americans and their living descendants for tolerating our efforts, while prying into their ancestral private lives, and for producing a wealth of positive contributions to the human species. Thanks go out to Justine McKnight and William McAvoy, who identified our press-dried specimens of Japanese Wineberry. Thanks go out to Daniel Griffith and Nancy Turner for their archaeological, ethnoecological and ethnograpic contributions. We also recognize the Archaeological Society of Delaware, the Delaware Department of Natural Resources and Environmental Control, the Delaware Department of Transportation, the Delaware State Historic Preservation Office, and the University of Delaware, as well as a plethora of researchers of all capacities for their contributions.

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Ethnoecological Survey of Kuskarawack Towne
on the Nanticoke River, Delaware

Glen Mellin
Lenny Truitt

February 2015

You follow your feelings, you follow your dreams
You follow the leader into the trees
And what's in there waiting, neither one of us knows (Tom Petty, "Wildflowers", 1994)

INTRODUCTION

This essay is the result of our Ethnoecological survey of Kuskarawack Towne, or the Nanticoke Indian King's residence described by Captain John Smith in June 1608. Our Ethnoecological survey was designed to discover, identify, and document plants and animals that may have been of benefit to ancestral Native Americans who lived along the Nanticoke River. We selected a project area of about twenty square miles and devised a simple but thorough investigation strategy (see Map 1). Using a pedestrian survey sampling strategy, we searched for individual(s) and clusters of species that may have been maintained and/or relocated species that appear today as decayed, remnant, or disjunct gardens, orchards, and groves, as well as patches of medicinal or ceremonial resources (see Map 2). In doing so, we were attempting to document possible resource type and location. We were not attempting to document specific human habitation type or location.

The results of our survey provide significant new understandings of a larger framework of the anthropogenic landscapes and Traditional Land and Resource Management Areas that had developed and were largely fixed at the time of the June 1608 John Smith "voyages of discovery" on the Nanticoke River. Firstly, we documented and plotted sixty-four examples of *Castanea* (found in five discreet clusters) on our botanical clusters identified map (see Map 3). These sixty-four examples revealed a surprising semi-circular pattern measuring about 6 miles east/west, with Kuskarawack Towne projected near the center of the semi-circle (see Map 1). After we had completed our survey and plotted all field finds on our survey map, we found that all the likely early culturally important botanical finds were included within our proposed *Castanea* semi-circular pattern (see Maps 1 and 3).

Secondly, we identified an Arrow Arum Starchy Tuber Complex, an Upland Game Complex, an Anadromous Fish Complex, a Highbush Blueberry cluster, the two Prickly Pear clusters, the two Yucca clusters, and a Christmas Fern and Crowsfoot association, all found within the proposed *Castanea* semi-circle. In addition, known, but yet to be observed or plotted Box Huckleberry cluster(s) may all be the remains of cultural arrangements, elements of economic programs, beneficial species that were either proprietary, maintained, or manufactured over a period of thousands of years, with Kuskarawack Towne and its associated Contact Period, Woodland II, and Woodland I archaeological sites being the epicenter of culturally based decision making at this locale (see Map 3).

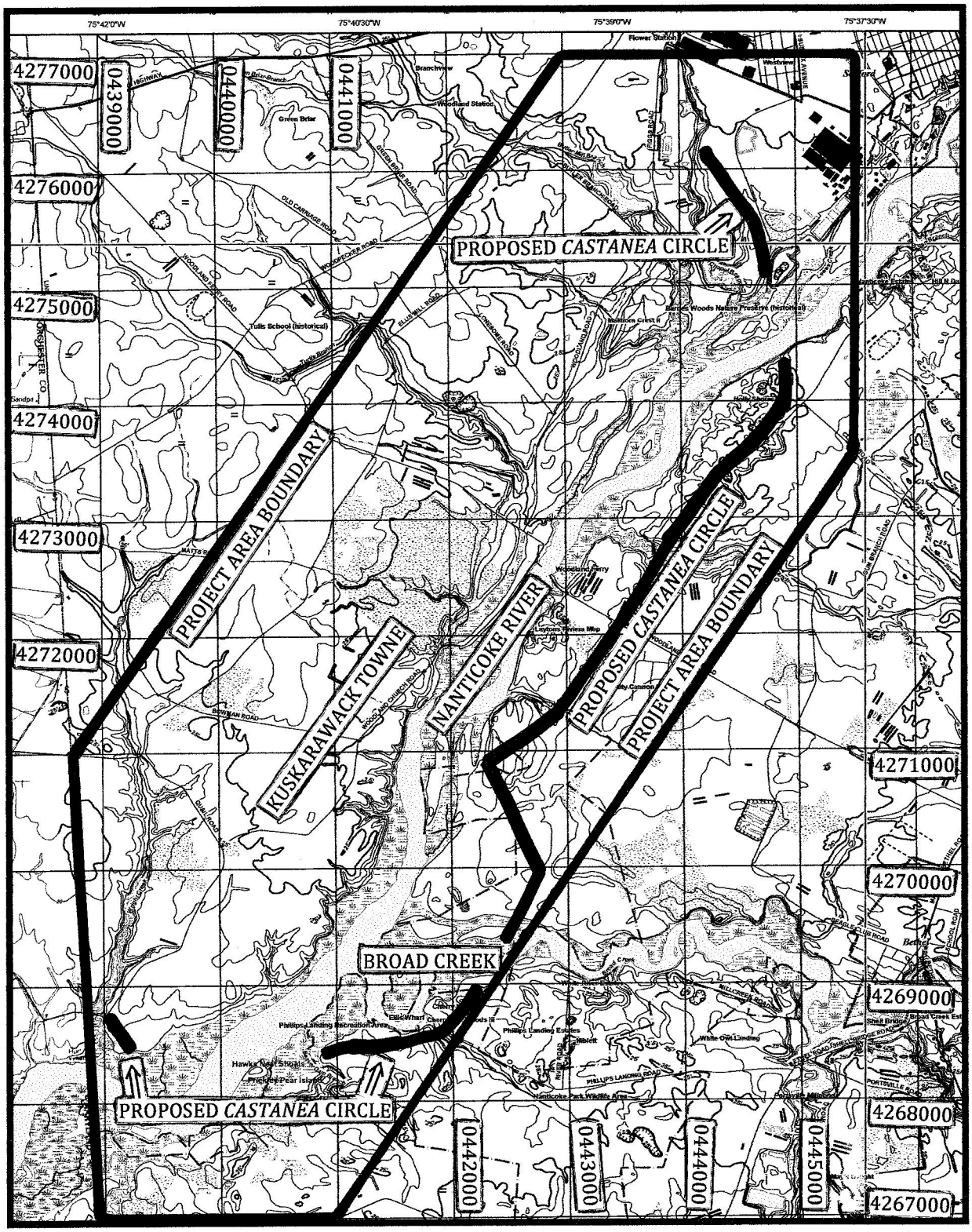
Thirdly, at the end of this essay we discuss a range of cultural implications concerning these new sets of information. These new sets of information will likely significantly improve our understanding of ancestral Native American lifeways and worldviews in the Tidewater Chesapeake Basin.

PREVIOUS RESEARCH

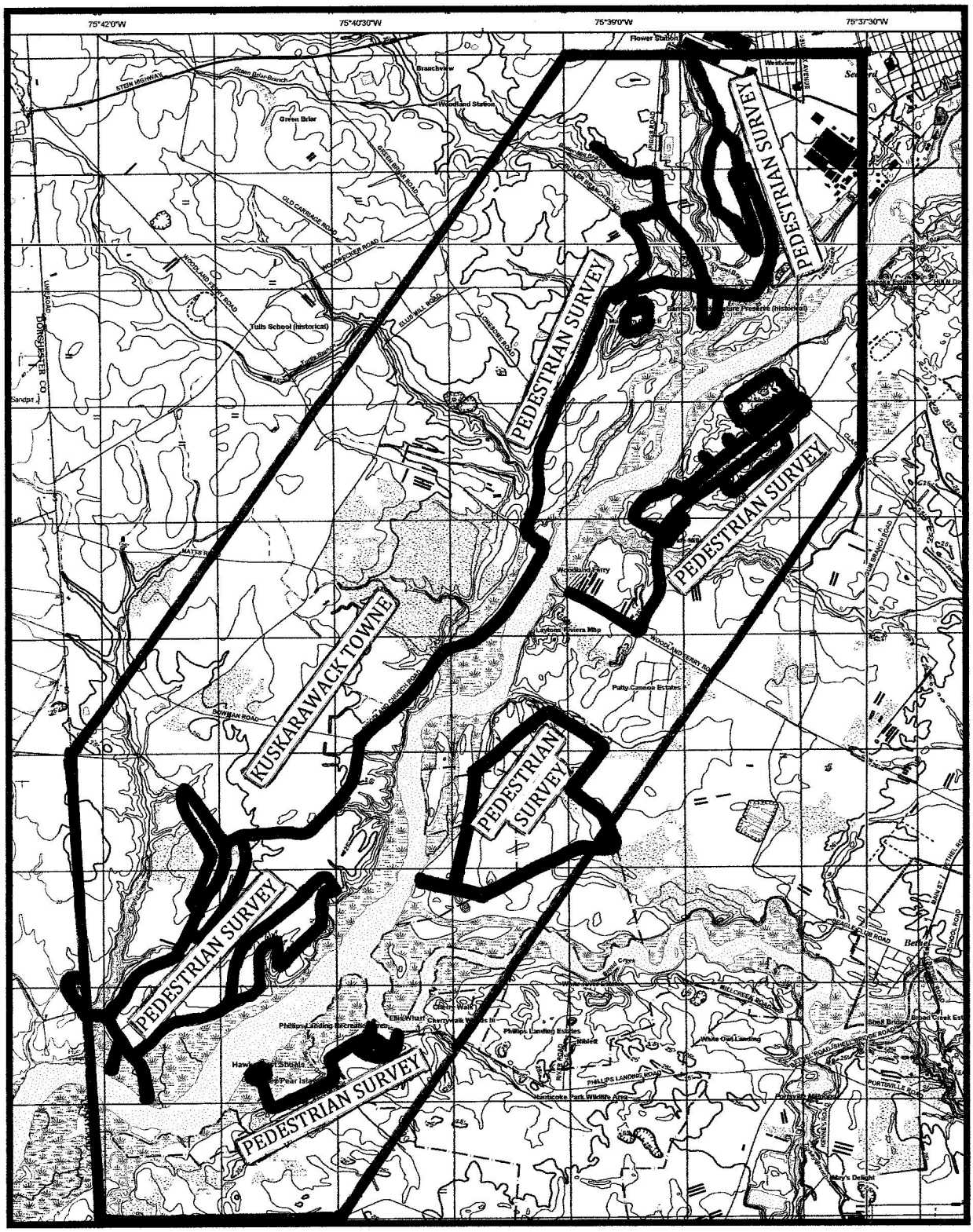
A very useful condensation of the Seventeenth Century natural and cultural histories of the Nanticoke River watershed was developed in Griffith and Busby (2014). They point out Kuskarawack Towne was likely along the northern upland side of the Nanticoke River in what is now Delaware located between Wright Branch and Chapel Branch. Some of that ground next to the Nanticoke River is in excess of twenty-five feet elevation and appears to contain prime locations for ancestral Native American habitation.

Within our project area, much of the landscape is currently protected as individual tracts of land incorporated under the umbrella of The Nanticoke Wildlife Area (DNREC, 2015). Speaking from an archaeological perspective, we believe the primary ancestral Native American residential locations were situated on the high ground, at or above twenty-five feet elevation near the Nanticoke shoreline. Most of this

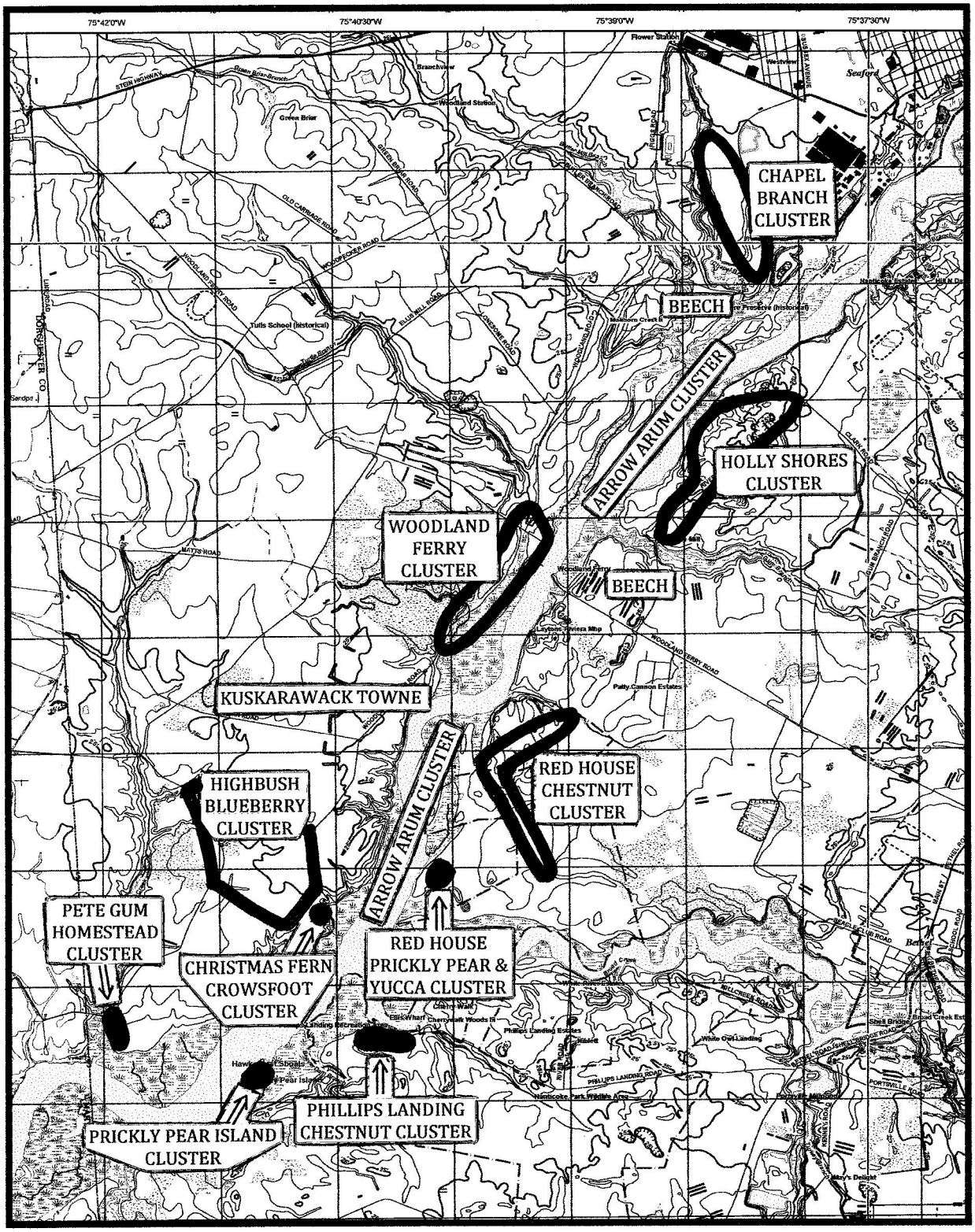
MAP 1, KUSKARAWACK TOWNE PROJECT AREA
PORTION OF SHARPTOWN QUADRANGLE.



MAP 2, PEDESTRIAN TRANSECTS SURVEYED
PORTION OF SHARPTOWN QUADRANGLE.



MAP 3, BOTANICAL CLUSTERS IDENTIFIED
PORTION OF SHARPTOWN QUADRANGLE.



specific high ground remains privately owned and appears today as a series of agricultural complexes where several known Native American archaeological sites have previously been identified.

Robert Gano evaluated the overall Nanticoke Wildlife Area in a report; The Wildlife Management Plan For The Robert L. Graham Nanticoke Wildlife Area (Gano, 1991, Appendix 1, pages 58-64, and in Appendix 2, pages 65-6), where we found lists of various plant and animal species, which we itemized in our following two sections.

WILDLIFE ECOLOGICAL SETTING (Derived from Gano, 1991)
The following is a baseline description of local wildlife ecological setting attributed to and derived from Gano's (1991, 16-7) Wildlife Management Plan For Robert L. Graham Nanticoke Wildlife Area. Upland Oak-Pine forest community species are largely dominated by impressive examples of White Oak (*Quercus alba*), Southern Red Oak (*Quercus falcata*), and Loblolly Pine (*Pinus taeda*), with Virginia Pine (*Pinus virginiana*) and Chestnut Oak (*Quercus prinus*) conspicuous on the most xeric locations. Mature mesic-xeric forests are largely controlled by summertime deciduous and evergreen upper canopy fullness producing park-like appearances. Woods dominated by oak generally support Lowbush Blueberry (*Vaccinium angustifolium*). Heavier soils dominated by Loblolly Pine and Southern Red Oaks generally support Pepperbush (*Clethra alnifolia*).

Wet soils are characterized by the Sweetgum (*Liquidambar styraciflua*), Green Ash (*Fraxinus pennsylvanica*), Blackgum (*Nyssa sylvatica*), Persimmon (*Diospyros virginiana*) grouping. An understory may be composed of Red Maple (*Acer rubrum*), Willow Oak (*Quercus phallos*), Water Oak, (*Quercus nigra*), Black Cherry (*Prunus serotina*), Mockernut Hickory (*Carya tomentosa*), Sassafras (*Sassafras albidum*), and American Holly (*Ilex opaca*). Additional lower level species include Sweetbay Magnolia (*Magnolia virginiana*), Serviceberry (*Amelanchier arborea*), Highbush Blueberry (*Vaccinium corymbosum*), Pepperbush (*Clethra alnifolia*), Rosebay Rhododendron (*Rhododendron maximum*), Poison Ivy (*Toxicodendron radicans*), Green Briar (*Smilax* sp.), and Trumpet-creeper (*Campsis radicans*).

Fresh and brackish tidal zones are highly recognized for supporting extensive fields of Virginia Arrow Arum (*Peltranda virginica*). Additionally, tidal flats support Pickerel Weed (*Pontederia* sp.), Cattail (*Typha* sp.), Wildrice (*Zizania* sp.), Reed grass (*Phragmites communis*), Swamp Rose-mallow (*Malva mushceotus*), and American Bulrush (*Scirpus americanus*).

SPECIES DISCUSSED IN THE NANTICOKE WILDLIFE AREA PLAN (Derived from Gano, 1991)
Species identified in the Nanticoke Wildlife Area Plan are itemized below by common name, however; species likely or probable, but not yet confirmed are itemized by common name followed by "?", and species possible, but not likely are itemized by common name in "italic" (attributed to and derived from Gano, 1991, Appendix 1, pages 58-64 and Appendix 2, pages 65-6) listed as follows:

Amphibians—American Toad?; Bullfrog; *Carpenter Frog*; Cope's Gray Treefrog?; Eastern Mud Salamander?; Eastern Narrowmouthed Toad?; Eastern Spadefoot Toad?; *Eastern Tiger Salamander*; Four-toed Salamander?; Fowler's Toad; Gray Treefrog?; Green Frog?; Green Treefrog?; Marbled Salamander?; New Jersey Chorus Frog?; Northern Cricket Frog?; *Northern Dusky Salamander*; Northern Two-lined Salamander?; Pickerel Frog?; Red-backed Salamander; *Red-spotted Newt*; Southern Leopard Frog; *Spotted Salamander*; Spring Peeper; and *Wood Frog*.

Birds—Acadian Flycatcher; American Bittern; American Black Duck; American Coot; American Crow; American Kestrel; *American Oystercatcher*; American Redstart?; American Robin; American Widgeon; American Woodcock; Atlantic Brant; *Bald Eagle*; Bank Swallow?; Barn Swallow; Barred Owl?; Belted Kingfisher; Black and White Warbler; Black Rail?; Black Scoter; Black Skimmer?; Black Vulture; Black-billed Cuckoo?; Black-crowned Heron; *Black-necked Stilt*; Blue Grosbeak; Blue Jay; Blue-gray Flycatcher; Blue-winged Duck; Blue-winged Warbler?; Boat-tailed Grackle; Bobwhite; *Brown Pelican*; Brown Thrasher; Brown-headed Cowbird; Brown-headed Nuthatch?; Broad-winged Hawk; Bufflehead; Canada Goose; Canvasback; Carolina Chickadee; Carolina Wren; Cedar Waxwing?; Cerulean Warbler?; Chestnut-sided Warbler?; Chimney Swift; Chipping Sparrow; Chuck-will's Widow; *Clapper Rail*; Common Barn Owl?; Common Grackle; Common

Merganser; Common Moorhen?; Common Nighthawk; Common Tern?; Common Yellowthroat; Cooper's Hawk; Downy Woodpecker; Eastern Bluebird; Eastern Kingbird; Eastern Meadowlark; Eastern Phoebe; Eastern Screech Owl; Eastern Wood Pewee; European Starling; Field Sparrow; Fish Crow?; Forster's Tern?; Gadwall; Glossy Ibis; Goldeneye; *Goshawk*; Grasshopper Sparrow?; Gray Catbird; Great Blue Heron; Great Crested Flycatcher; Great Egret; Great Horned Owl; Greater Scaup; Green-backed Heron; Green-winged Duck; Gull-billed Tern?; Hairy Woodpecker; Henslow's Sparrow?; Herring Gull; Hooded Merganser; Hooded Warbler?; Horned Lark; House Finch; House Sparrow; House Wren; Indigo Bunting; *Kentucky Warbler*; Killdeer; King Rail?; Laughing Gull; *Least Bittern*; Least Flycatcher; Least Tern?; Lesser Scaup; Louisana Waterthrush?; Mallard; Marsh Wren?; Merlin; Mourning Dove; Northern Cardinal; Northern Flicker; Northern Harrier; Northern Mockingbird; Northern Orchard; Northern Parula?; Northern Pintail; Northern Rough-winged Swallow?; Northern Waterthrush; *Oldsquaw*; Orchard Oriole?; Osprey; Ovenbird; Peregrin Falcon?; Pied-billed Grebe; Pileated Woodpecker; Pine Warbler?; Piping Plover?; Prairie Warbler?; Prothonotary Warbler; Purple Martin; *Redhead*; Red-bellied Woodpecker; Ring-billed Gull; Red-breasted Merganser; Red-breasted Nuthatch?; Red-eyed Vireo; Red-headed Woodpecker; Red-shouldered Hawk; Red-tailed Hawk; Red-winged Blackbird; Ringneck; *Ring-necked Pheasant*; Rock Dove; Ruby-throat Hummingbird; Ruddy Duck; Rufous-sided Towhee; Scarlet Tanager?; *Seaside Sparrow*; Sedge Wren?; Sharp-shinned Hawk; *Sharp-tailed Sparrow*; Shoveler; Snow Goose; Snowy Egret; Song Sparrow; Sora?; Spotted Sandpiper; Summer Tanager; *Surf Scoter*; Swainson's Warbler?; Swamp Sparrow; Tree Swallow; Tufted Titmouse; Tundra Swan; Turkey Vulture; Veery; Vesper Sparrow?; Virginia Rail; Warbling Vireo?; White-breasted Nuthatch; White-eyed Vireo; *White-winged Scoter*; Whip-poor Will; *Wild Turkey*; *Willet*; Willow Flycatcher?; Wood Duck; Wood Thrush; Worm-eating Warbler?; Yellow Warbler?; Yellow-billed Cuckoo; Yellow-breasted Chat?; Yellow-crowned Heron; Yellow-throated Vireo?; and Yellow-throated Warbler?.

Fish—Alewife; American Brown Lamprey; American Eel; American Shad; Atlantic Croaker; Atlantic Menhaden; Atlantic Needlefish; Atlantic Silverside; Atlantic Sturgeon; Banded Killifish; Banded Sunfish; Bay Anchovy; Black Crappie; Blackbanded Sunfish; Blueback Herring; Bluegill; Bluespotted Sunfish; Brown Bullhead; Carp; Chain Pickerel; Channel Catfish; Creek Chubsucker; Eastern Mudminnow; Gizzard Shad; Golden Shiner; Goldfish; Hickory Shad; Hogchoker; Inland Silverside; Ironcolor Shiner; Largemouth Bass; Longnose Gar; Margined Madtom; Mosquitofish; Mud Sunfish; Mummichog; Pirate Perch; Pumpkinseed; Redbreast Sunfish; Redfin Pickerel; Satinfin Shiner; Sea Lamprey; Shield Darter; Shorthead Redhorse; Silvery Minnow; Spotfin Shiner; Striped Bass; Swallowtail Shiner; Tadpole Madtom; Tesselated Darter; White Catfish; White Perch; Yellow Bullhead; and Yellow Perch.

Mammals—*Beaver*; *Blue Whale*; Cotton Rats; Deer Mouse?; Delmarva Fox Squirrel; Eastern Cottontail; Eastern Mole; *Finback Whale*; Gray Fox?; Gray Squirrel; *Humpback Whale*; Least Weasel?; Masked Shrew; Meadow Vole; Mink?; Muskrat; Opossum; Raccoon; Red Fox; *Red Squirrel*; *Right Whale*; River Otter; *Sei Whale*; Short-tailed Shrew?; Short-tailed Weasel?; Southern Flying Squirrel; *Sperm Whale*; Star-nosed Mole?; Striped Skunk?; White-footed Mouse; White-tailed Deer; *Woodchuck*; and Woodland Jumping Mouse?.

Reptiles—Black Rat Snake; Bog Turtle?; Broad-headed Skink?; Common Snapping Turtle; Corn Snake?; Eastern Box Turtle; Eastern Garter Snake; Eastern Hognose; Eastern Kingsnake?; Eastern Milksnake?; Eastern Mud Turtle?; Eastern Painted Turtle; Eastern Ribbon Snake?; Eastern Smooth Earth Snake?; Eastern Worm Snake?; Five-lined Skink?; *Green Turtle*; *Hawksbill Sea Turtle*; *Kemp's Ridley Sea Turtle*; *Leatherback Sea Turtle*; *Loggerhead Turtle*; Northern Black Racer?; Northern Brown Snake?; Northern Copperhead?; *Northern Diamondback Terrapin*; Northern Fence Lizards; Northern Red-bellied Snake?; Northern Ringneck Snake?; Northern Scarlet Snake?; Northern Water Snake?; Red-bellied Snake?; Rough Green Snake?; Six-lined Racerunner?; Southern Ringneck Snake?; Spotted Turtle?; Stinkpot Turtle?; and Wood Turtle?.

OUR SURVEY THEORY

We consider the above Wildlife Ecological Setting an applicable explanation of the overall protected lands along the Nanticoke River and its tributaries upstream from the Maryland State line and downstream from the town of Seaford. Convenient for our survey, Gano's (1991) descriptions of The Nanticoke Wildlife Area nearly overlay our project area—the primary suspected location and environs of Kuskarawack Towne, as identified by Griffith and Busby (2014).

Since Gano's 1991 compilation, some things have changed. Wild Turkeys, Bald Eagles, Gold Finches, and Beaver, for examples, have repopulated the project area. A very detrimental invasive species, the dreaded Shakehead fish has appeared. And other species that were likely present, or nearby in ancestral Native American times, such as Oysters, Clams, Freshwater Mussels, and Blue Claw Crabs, for examples, are not addressed in Gano's description. These omissions were probably not oversight—they were likely deemed not relevant to his Wildlife Management Study when conducted.

Gano (1991) talks about copious understory shrubs of Pepperbush (*Clethra alnifolia*), an important species in our project area, but we failed to find any examples. There were also supposed to be copious understory examples of Shad Bush (*Amelanchier canadensis*), a species known to be very important in the diet of ancestral Native Americans. Yet, the only example of Shad Bush we could positively identify was located in the Woodland Ferry Botanical Garden. That example literally had an information sign displayed next to it informing the passerby that this bush is an example of the legendary Shad Bush.

It is true that Gano identified extensive tidal and mud flat expanses of starchy tuber producing plants. Specifically, on this portion of the Nanticoke River, Arrow Arum (*Peltandra virginica*) is dominant. Pickerel Weed (*Pontederia* sp.), Arrowhead (*Potamogeton* **s**p.), Water Lily (*Nelumbo* sp.), Wild Calla (*Calla* sp.), Cattail (*Typha* sp.), Wildrice (*Zizania* sp.), Reed grass (*Phragmites communis*), Swamp Rose-mallow (*Malva mushceotus*), and American Bulrush (*Scirpus americanus*) are identified as minority species. We walked along some shoreline and witnessed these expanses of Arrow Arum on a previous survey, but now, it being wintertime and lacking a canoe, we will have to take Gano's word for it that these mentioned species are at least seasonally present. All of the above species were immensely important starchy dietary opportunities for ancestral Native Americans. In fact, all five of the Nanticoke Indian towns that Smith talked about in 1608 (Griffith and Busby, 2014:19) would have had, corresponding to their position in the river system, a different mix of these above starchy or tuberous plants. It is also likely that the residents of each town traded their individual processed starch types up and down the river, contributing meaningfully to a varied diet, and perhaps epitomizing essential elements of social cohesion and cultural sustainability.

So, we suggest a number of resource "programs" that need to be more fully developed before we can fully flesh out more robust ancestral Native American landscape opportunities at this locale. We need to develop an understanding of what a Starch Tuber Complex offered these people. If these people harvested, stored, prepared, and traded these grains, bulbs, and tubers, then they likely owned, maintained, and managed their production.

We need to develop an understanding of what the Anadromous and Residential fish populations offered these people. Likewise, we need to understand the roles that upland game and shellfish played in at least diet and divisions of labor. There is such a great body of work yet to do it makes our efforts to identify and count plant species during the dead of winter look like a very small step forward. Yet, we did step forward, and we got results with the following plant species being identified. We also experienced some unexpected and highly rewarding surprises concerning their quantities and locations.

OUR SURVEY METHOD

Our Ethnoecological survey of Kuskarawack Towne covered a project area of about 20 square miles. We walked nearly 40 miles, spent 60 hours in the woods, with over 12 days of physical investigation. Within that area and timeframe, we investigated areas mostly of public property using both intensive and extensive sampling strategies. We excluded current agricultural fields, two Army Corp dredge spoil locations, a golf course, numerous borrow pits, a "stabilized" toxic coal ash mound encompassing perhaps 50 acres, the manicured lawns within residential housing developments, and of course the flowing waters of the Nanticoke River and its tributaries. We found that every square inch of the entire project area was a series of overlapping and overlaying anthropogenic landscapes—there was not one square inch of landscape left in its natural state. Succinctly put, the big trees were gone—the rivers silted in.

Attention to detail would be a painstaking and challenging task. Finding and sifting out the important data—the early data, from the more modern "cultural noise" would be an utmost priority—otherwise for examples, one could get lost in a pine plantation and see nothing but the pines, or one could focus on the upper canopies

of deciduous species and miss-out on the lower level bushes and ground cover. We were very aware of survey bias, sampling large areas inherently produces biases. We strived to investigate sample areas at different elevations, different soil types, different geographical orientations or aspects, etc. Sometimes we were able to walk on "nature trails" and peer into a relatively open forest two hundred feet on either side. At other times, swampy thickets and brush restricted lateral visibility. We walked straight lines, zigzag lines, concentric circle patterns, radial lines from important finds (implementation of a center point pattern), in addition to occasionally trying to establish negative perimeters in order to "frame" a specie cluster of interest.

Simply put, we did what we could do and we did it as well as we could do it, all the while remaining loyal to our favorite Latin phrases—*Nullius in verba, sapere aude, carpe diem* (See for yourself, dare to know, seize the day).

KUSKARAWACK TOWNE SPECIES IDENTIFIED DURING THIS SURVEY

The following species were either identified as a result of this survey, or were reliably previously identified as a result of our literature search, which was based largely on Gano (1991), Griffith and Busby (2014), Mellin and Truitt (2013 January; 2013 July; and 2013 August). We discuss the following individual species arranged alphabetically.

AMERICAN BEECH

American Beech (*Fagus grandilolia*) is a deciduous blonde hardwood upland tree species that periodically produces small lobed bur-husks that contain two or three small nuts. These nuts are a principle food stock for Turkeys. This species produces a smooth gray bark useful in making crafts and for construction. Beech is very choosy about suitable environmental conditions. It requires both a high water table and well-drained locations. McAvoy (2013) says this species is Common in Delaware. Moerman (2009) lists this species as edible and has Native American medicinal uses.

We found and recorded an area containing an unusually high number of Beech trees. Beech may in fact be the dominant botanical species in this woodlot. Due to residential development and the presence of agricultural fields, the former extent of this Beech cluster cannot be accurately determined. However, we found the west end of this Beech cluster is extant at the intersection of Woodland Ferry Road and River Road at GPS 0443579—4272031. This cluster is very evident walking east on River Road, crossing a well developed unnamed tributary, and significantly decreases at a point where we encountered the western limit of the Holly Shores Chestnut cluster at GPS 0443875—4272917. No specific Beech trees were plotted, and no Table is provided for this Beech woodlot. We also encountered elevated Beech tree occurrences on and around the Barnes Woods property as well as trending up Butler Mill Branch and Chapel Branch.

AMERICAN CHESTNUT

American Chestnut (*Castanea dentata*) is a deciduous nut-producing tree. Typically two, sometimes three nuts are contained in each spinney bur. Burs are induced to open and fall to the ground with the first frost. An Asian bark fungus affecting the *Castanea* Genus was first seen at the Bronx Zoological Park in 1904. In Delaware, this fungus typically kills above ground stems when the stem reaches sexual maturity—thus severely reducing the availability of viable nuts. Very few nut producing trees were seen after mid-century, and today, we consider it a rare opportunity to discover a rejuvenated coppice or stump sprout. We found and recorded two Chinquapin (*Castanea pumilla*), or dwarf Chestnut in the Holly Shores Chestnut cluster and we are listing them here as a subset of American Chestnut for convenience. McAvoy (2013) lists American Chestnut as Common in Delaware, and Moerman (2009) lists this plant as edible and having Native American medicinal properties.

During our survey, we found and recorded approximately sixty-two American Chestnut coppices, two Chinquapin coppices, and two additional Asian Chestnut trees. At the Pete Gum cluster, we counted thirty-two American and those two Asian in a cluster largely west of the fallen homestead with extant brick chimneys. At the Pete Gum cluster, the southern limit of the Chestnut cluster is at GPS 0439054—4268550, and the northern limit of the Chestnut cluster is at GPS 0438980—4268737. These Chestnuts are itemized in Table 2, The Pete Gum Homestead Cluster, and on Map 3.

At the Chapel Branch cluster, we counted nine American Chestnuts. These Chestnut coppices were recorded at GPS 0444243—4276039, GPS 0444534—4275478, GPS 0444532—4275458, GPS 0444519—4275277, GPS 0444178—4276004, GPS 0444200—4276184, GPS 0444692—4275195, GPS 0444600—4275108, and GPS 0444618—4275087. All of these recordings may be viewed in Table 5, The Chapel Branch Cluster, and on Map 3.

At the Holly Shores cluster, we counted nine American Chestnuts and two Chinquapins. These coppice locations were recorded as follows: Chinquapin is at GPS 0444637—4273638, and 0444648—4273605. Chestnut coppices are at GPS 0444892—4273867, GPS 0444390—4273453, GPS 0444354—4273445, GPS 0444312—4273417, GPS 0444213—4273376, GPS 0444047—4273532, GPS 0444176—4273271, GPS 0443880—4272933, and GPS 0443875—4272917. All of these recordings may be viewed in Table 6, The Holly Shores Cluster, and on Map 3.

At the Red House cluster we counted six American Chestnut coppices, which were recorded at GPS 0442654—4269977, GPS 0442246—4270939, GPS 0442227—4270936, GPS 0442634—4271284, GPS 0442627—4271284, and GPS 0442809—4271356. All of these recordings may be viewed in Table 7, The Red House Chestnut Cluster, and on Map 3.

At the Phillips Landing cluster we counted six American Chestnut coppices, which were recorded at GPS 0441263—4268568, GPS 0441282—4268589, GPS 0441302—4268526, GPS 0441315—4268540, GPS 0441379—4268481, and GPS 0441404—4268459. All of these recordings may be viewed in Table 9, The Phillips Landing Cluster, and on Map 3.

ARROW ARUM

Arrow Arum (*Peltandra virginica*), also known as "Tuckahoe" is an emergent flowering perennial aquatic herb, producing many arrowhead-shaped leaves from low oxygen tolerant rhizomes. These rhizomes are typically found in fresh tidal zones and associated mudflats along this portion of the Nanticoke River. This plant may be easily confused with two other common aquatic plants, the Arrowhead and the Pickerelweed, which look similar to Arrow Arum, and the Calla, which has heart-shaped leaves. The plant contains raphides of calcium oxalate (microscopic spinney needles) and must be very well cooked before it is safe to eat. We found a Native American recipe provided by Deane (2015); wash roots well, bury them in a storage pit for some time. Dig them up and steam-roast or boil for one whole day, thoroughly dry before above ground storage, moisten and bake or fry. It is important to render the spinney needles harmless before eating. The same raphides' problem and culinary processing requirements apply to Skunk Cabbage. McAvoy (2013) lists Arrow Arum as Common in Delaware, and Moerman (2009) lists it as edible and having Native American medicinal properties.

We found that within our project area the Arrow Arum (the dominant member of our Starchy Tuber Complex) began on the north shore of Nanticoke River at the Maryland State line at GPS 0438900—4268575, and continued along the north shore to Chapel Branch at GPS 0444450—4274900. Similarly, this complex began on the south shore of the Nanticoke River at the Maryland State line at GPS 0438950—4267450, and continued along the south shore to a point across from Chapel Branch at GPS 0444450—4274200. The most extensive acreage of this complex is currently found at the confluence of Broad Creek and the Nanticoke River, see Table 1, The Arrow Arum Cluster, and Map 3.

BALD CYPRESS

Bald Cypress (*Taxodium distichum*) is a deciduous conifer that grows well in saturated soil. The southern part of Delaware is the northern limit of its natural range. We are including these trees in this essay because McAvoy (2013) lists Bald Cypress as Rare in Delaware. Although the seeds are edible, Moerman (2009) did not list this species for Native American medicinal value.

We identified three Bald Cypress trees in this survey—all three are located along north shore of the Woodland Ferry waterfront. We documented one tree at GPS 0442651—4272508, and two trees at GPS 0442805—4272695. Neither of these trees measures two feet in diameter and it is unlikely these particular

trees participated in any ancestral Native American experience. These Bald Cypresses may be viewed in Table 4, The Woodland Ferry Cluster, and on Map 3.

BOX HUCKLEBERRY

The Box Huckleberry (*Gaylussacia brachycera*) is a globally endangered, edible berry producing plant with a worldwide count of about 100 known specimens. The incredible rarity of this plant is surpassed only by its unique history—having lost its ability to sexually reproduce during the Pleistocene, all Holocene occurrences are self-sterile. Only found in isolated colonies, optimally growing at an overall rate of 15 centimeters per year, the species is only able to sustain itself through cloning in a subsurface process known as root extension (a natural process), or physically transplanting prepared settings through relocation (a cultural process).

Gano, (1991, p.29) reports: "Several box huckleberry sites have been identified on the wildlife area by the Natural Heritage Program. One tract of land - the Good Property was bought by Delaware Wildlands, Inc. to protect the site, then re-sold to the Division. These areas will be given a high priority in keeping with the Division's explicit policy of protecting species viability and ecosystem diversity and stability." We were not able to locate or measure these "several" Box Huckleberry sites during our survey even though we think they are within the project area or within close-range of our project area. However, we consider all occurrences of Box Huckleberry in Delaware to have been at least ceremonial and remain high priority candidates for ancestral Native American cultural manipulation (Mellin and Truitt, 2013 January). McAvoy (2013) lists this specie as Rare in Delaware, and Moerman (2009) does not list this specie as having ancestral Native American medicinal uses. Further research, documentation, and protection are definitely warranted. No Table is provided, and these "several" (unfound) Box Huckleberry clusters do not appear on Map 3.

CHRISTMAS FERN

Christmas Fern (*Polystichum acrostichoides*) is an evergreen fern that often matures into bushy clumps. Typically, frost may "burn" the proximal one third leaving the remaining two thirds unblemished offering easily collected leafy greens all winter long. McAvoy (2013) lists Christmas fern as a Common species in Delaware, and Moerman (2009) lists it as edible with a history of Native American medicinal uses.

We observed at least three types of Ferns during this survey with some species frost burnt, brown and shriveled. The Christmas Fern, however, was obviously the most frequent fern encountered in this survey with some examples found on all but the most xeric soils. Interestingly, we did observe evidence of this proximal frost burning as previously described. We found the densest populations of Christmas Fern along both sides of an unnamed tributary in the vicinity of GPS 0440900—4269570, opposite the confluence of Broad Creek and the Nanticoke River. There is so much of a concentration of Christmas Fern at this location we may actually be observing an ancestral Native American Fern garden that has escaped its cultural limits. No Table is provided for Christmas Fern.

CROWSFOOT

Crowsfoot (*Diphasiastrum digitatum*) is a Fan Clubmoss known in Delaware as Running-pine Clubmoss typically grows to four inches and has a vibrant history of being harvested as Christmas greenery. Prefers to grow on disturbed soils, often associated with coniferous environs. McAvoy (2013) lists Crowsfoot as a Common species in Delaware. Moerman (2009) does not list this species as edible or as having medicinal properties.

We found and noted (see field notes) at least a dozen disjunct patches and running clusters of Crowsfoot during our survey. The vast majority of Crowsfoot was found along the north side of the Nanticoke River. The densest and perhaps the broadest clusters were found in the same place as the densest patches of Christmas Fern (see above) using GPS 0440900—4269570 as a center point. This location is opposite the confluence of Broad Creek and the Nanticoke River. No Table is provided for Crowsfoot.

HIGHBUSH BLUEBERRY

Highbush Blueberry (*Vaccinium corymbosum*) is an edible berry producing bush growing up to twelve feet high and twelve feet wide. This species thrives on moist acidic soils within the pH range of 4.5 to 5.5. McAvoy (2013) lists Highbush Blueberry as a Common species in Delaware, and Moerman (2009) did not list this

species for Native American medicinal value, however; Moerman lists other species of *Vaccinium* as having medicinal uses.

Although there were occasional examples of Highbush Blueberry found on both sides of the Nanticoke River, we found and mapped one very large (estimated to be one square kilometer), and at times very dense Highbush Blueberry cluster near the intersection of Woodland Church Road and Quail Road. The northwestern limit is at GPS 0439700—4270695, the northeastern limit is at GPS 0440745—4270285, the southeast limit is at GPS 0440803—4369698, a southern limit is at GPS 0440821—4269880, a southern limit is at GPS 0440605—4269384, the southwest limit is at GPS 0439873—4269793, and the western limit is at GPS 0439884—4270395. This Highbush Blueberry cluster is listed in Table 3, The Highbush Blueberry Cluster, and on Map 3.

PECAN

Pecan (*Carya illinoinensis*) is a large deciduous tree that produces many thin-shelled nuts. To our knowledge, no evidence of Pecan has been archaeologically recovered from ancestral Native American sites in Delaware. Pecan trees can live and produce fruit for more than three hundred years, but the oldest living Pecan trees in Delaware were likely planted during the Colonial Period. McAvoy (2013) does not include Pecan on his Internet list that we use. So, we do not know whether Pecan is absent, or Native, or Adventive in Delaware before European contact. Pecan is said to be an Algonquian word describing this nut. The ancestral origin of Pecan is thought to be Mexican spreading up through the American southwest and eventually in the southeast. How far up the east coast it spread before the Colonial Period remains a topic of great interest. Moerman (2009) lists Pecan as having Native American edible and medicinal uses.

We identified five living Pecan trees in the yard of an Historic archaeological site known as the Pete Gum Homestead. Each one of these trees measures greater than thirty-six inches in diameter at chest height. Pecan trees can live in excess of three hundred years, so we are thinking these trees were planted during the Colonial Period. We itemized these trees at; GPS 0439085—4268687, GPS 0439100—4268696, GPS 0439110—4268691, GPS 0439110—4268643, and GPS 0439105—4268628. At some point in the twentieth century, several Asian Chestnut trees were added to this cluster (see above). Additionally, this homestead site was likely chosen as a good location due to the American Chestnut cluster that was already there, likely a result of ancestral Native American efforts (see above). These Pecan trees are listed in Table 2, The Pete Gum Homestead Cluster, and on Map 3.

PRICKLY PEAR

Prickly Pear cactus (*Opuntia humifusa*) grows in low, flattish, rounded cladodes on xeric soils. Both the paddle, or tuna, and the pear that develops directly behind the flower are edible, but require special skills to avoid the sharp spines. The ancestral origin of Prickly Pear is thought to be Mexican spreading up through the American southwest and eventually in the southeast making its way to Delaware before the Colonial Period. McAvoy (2013) lists Prickly Pear as Common in Delaware, and Moerman (2009) lists this species as having Native American edible and medicinal value. The Prickly Pear is especially effective as an ingestible alkaline antibiotic for curing Urinary Tract Infection (UTI).

We found one cluster of Prickly Pear cactus growing on an ancestral Native American Clamshell midden at Red House along the south shore of the Nanticoke River. The cluster's northwestern limit is at GPS 0441864—4269877, and the cluster's southeastern limit is at GPS 0441882—4269885. To view this Prickly Pear Cluster together with the Yucca Clusters Nos. 1 and 2, see Table 8, The Red House Prickly Pear and Yucca Clusters, and on Map 3.

We found a number of discrete bunches of Prickly Pear cactus growing on Prickly Pear Island. Some of these bunches were growing within the limits of the ancestral Native American clamshell midden. We had good reason to assume some archaeological materials could be found on the entire island. We listed the exact GPS coordinates of each cactus bunch recorded (see field notes). Here, we provide the recorded GPS limits of the Island itself; the west end Prickly Pear Island is at GPS 0440160—4268210, the north end Prickly Pear Island is at GPS 0440249—4268283, the south end prickly Pear Island is at GPS 0440305—4268216, and the east

end Prickly Pear Island is at GPS 0440361—4268333. To view these examples of Prickly Pear, see Table 10, The Prickly Pear Island Cluster, and on Map 3.

SEASIDE ALDER

Seaside Alder (*Alnus maritima*) is a deciduous coniferous bushy plant that thrives in wet, often tidal locales. Only found in North America, there are three known varieties, one variety in Oklahoma, one in Georgia, and one on the Delmarva Peninsula. The World Conservation Monitoring Center has placed Seaside Alder on the Red List of Threatened Species. McAvoy (2013) lists this species as Uncommon in Delaware, and Moerman (2009) does not list this species for Native American medicinal value.

We found two examples of Seaside Alder in an unnamed stream along the north shore of the Nanticoke River west of Woodland Ferry, one at GPS 0441928—4271914, and one at GPS 0441948—4271920. Additional examples were recorded in the village of Woodland at GPS 0442645—4272926, and GPS 0442696—4272582, and a large, dense cluster being recorded at and west of GPS 0442648—4272876. All of these examples are found listed in Table 4, The Woodland Ferry Cluster, and on Map 3.

SHADBUSH

Shad Bush (*Amelanchier canadensis*), or Serviceberry is found in Delaware and the Tidewater Chesapeake Region in two varieties. According to McAvoy (2013) the var. *canadensis* is Common and the var. *obovalis* is Uncertain in Delaware. Usually a multi-stem bush growing to twenty-five feet found along edges of forested wetlands or stream banks, but can also be found in open wet woods with broken canopy. This species produces round, reddish-purple to black berries similar to huckleberries following five-petaled white flowers. These berries are considered to be delicious with bountiful yields. Even though Moerman (2009) lists most all *Amelanchier* with Native American medicinal value, neither of the above varieties has documented medicinal value.

We were able to find one example of Shad Bush just west of the Woodland Ferry terminal along the north shore of the Nanticoke River at GPS 0442725—4272610. We realized that we are not qualified to identify Shad Bush during the wintertime when neither leaves or berries are available. This example of Shad Bush is listed in Table 4, The Woodland Ferry Cluster, and on Map 3.

YUCCA

Yucca (*Yucca filamentosa*) or Spanish Bayonet is a low growing evergreen with filamentous strappy leaves. Produces clusters of whitish bell-shaped flowers on six foot high stalk. Crushed leaves are used to stun fish and processed leaves are used to make quality twisted cordage. McAvoy (2013) lists this species as Common in Delaware, and Moerman (2009) lists this species as having Native American medicinal value, but not considered edible.

We found two discrete clusters of Yucca at Red House along the south shore of the Nanticoke River. The center point of Yucca Cluster No. 1 is at GPS 0441761—4269918, and the center point of Yucca Cluster No. 2 is at GPS 0441719—4269924. These examples are listed in Table 8, Red House Prickly Pear and Yucca Clusters, and on Map 3.

KUSKARAWACK TOWNE'S BOTANICAL CLUSTERS

Examples of species found during this survey that were likely beneficial to ancestral Native Americans and members of the Colonial Period typically occurred in observable, disjunct clusters. Recording either the GPS location of individual plants or plant cluster boundaries, we constructed a useful and detailed system of descriptive Tables. The data presented in these Tables links a species cluster, or several species in one cluster with their GPS measured location. Future researchers can use this data to actually go afield and view these specimens for themselves. These Tables are numbered for reference (refer to the species descriptions above) and have useful organizational labels describing location found within the project area. The following Tables are organized starting with Arrow Arum in the Nanticoke River at the Maryland State line and from there,

numbered in a clockwise manner (see Map 3) until we end up at Prickly Pear Island on the south shore of the Nanticoke River near the Maryland State line.

TABLE 1, THE ARROW ARUM CLUSTER			
EAST	SOUTH	ITEM	DESCRIPTION
0438900	4268575	ARROW ARUM	NORTH SHORE, MARYLAND LINE
0444450	4274900	ARROW ARUM	NORTH SHORE, CHAPEL BRANCH
0438950	4267450	ARROW ARUM	SOUTH SHORE, MARYLAND LINE
0444450	4274200	ARROW ARUM	SOUTH SHORE, CHAPEL BRANCH

TABLE 2, THE PETE GUM HOMESTEAD CLUSTER			
EAST	SOUTH	ITEM	DESCRIPTION
0439093	4268633	BRICK CHIMNEY (NORTH)	HOUSE, EARLY
0439092	4268627	BRICK CHIMNEY (SOUTH)	HOUSE, EARLY
0439085	4268687	PECAN, LIVING	>36 INCHES DIAMETER
0439100	4268696	PECAN, LIVING	>36 INCHES DIAMETER
0439110	4268691	PECAN, LIVING	>36 INCHES DIAMETER
0439110	4268643	PECAN, LIVING	>36 INCHES DIAMETER
0439105	4268628	PECAN, LIVING	>36 INCHES DIAMETER
0439053	4268550	CHESTNUT CLUSTER	SOUTH END
0438980	4268737	CHESTNUT CLUSTER	NORTH END

TABLE 3, THE HIGHBUSH BLUEBERRY CLUSTER			
EAST	SOUTH	ITEM	DESCRIPTION
0440745	4270285	HIGHBUSH BLUEBERRY	NORTHEAST LIMIT
0440803	4269698	HIGHBUSH BLUEBERRY	SOUTHEAST LIMIT
0440821	4269880	HIGHBUSH BLUEBERRY	SOUTH LIMIT
0440605	4269384	HIGHBUSH BLUEBERRY	SOUTH LIMIT
0439873	4269793	HIGHBUSH BLUEBERRY	SOUTHWEST LIMIT
0439884	4270395	HIGHBUSH BLUEBERRY	WEST LIMIT
0439700	4270695	HIGHBUSH BLUEBERRY	NORTHWEST LIMIT

TABLE 4, THE WOODLAND FERRY CLUSTER			
EAST	SOUTH	ITEM	DESCRIPTION
0441948	4271920	SEASIDE ALDER	INDIVIDUAL
0441928	4271914	SEASIDE ALDER	INDIVIDUAL
0442696	4272582	SEASIDE ALDER	INDIVIDUAL
0442648	4272876	SEASIDE ALDER	DENSE CLUSTER
0442645	4272926	SEASIDE ALDER	INDIVIDUAL
0442651	4272508	BALD CYPRESS	INDIVIDUAL
0442805	4272695	BALD CYPRESS	TWO INDIVIDUALS
0442725	4272610	SHAD BUSH	INDIVIDUAL

TABLE 5, THE CHAPEL BRANCH CLUSTER			
EAST	SOUTH	ITEM	DESCRIPTION
0444243	4276039	CHESTNUT	COPPICE
0444534	4275478	CHESTNUT	COPPICE
0444532	4275458	CHESTNUT	COPPICE
0444519	4275277	CHESTNUT	COPPICE
0444178	4276004	CHESTNUT	COPPICE
0444200	4276184	CHESTNUT	COPPICE
0444692	4275195	CHESTNUT	COPPICE
0444600	4275108	CHESTNUT	COPPICE
0444618	4275087	CHESTNUT	COPPICE

TABLE 6, THE HOLLY SHORES CLUSTER			
EAST	SOUTH	ITEM	DESCRIPTION
0444637	4273638	CHINQUAPIN	COPPICE
0444648	4273605	CHINQUAPIN	COPPICE
0444892	4273867	CHESTNUT	COPPICE
0444390	4273453	CHESTNUT	COPPICE
0444354	4273445	CHESTNUT	COPPICE
0444312	4273417	CHESTNUT	COPPICE
0444213	4273376	CHESTNUT	COPPICE
0444047	4273532	CHESTNUT	COPPICE
0444176	4273271	CHESTNUT	COPPICE
0443880	4272933	CHESTNUT	COPPICE
0443875	4272917	CHESTNUT	COPPICE

TABLE 7, THE RED HOUSE CHESTNUT CLUSTER			
EAST	SOUTH	ITEM	DESCRIPTION
0442654	4269977	CHESTNUT	COPPICE
0442246	4270939	CHESTNUT	COPPICE
0442227	4270936	CHESTNUT	COPPICE
0442634	4271284	CHESTNUT	COPPICE
0442627	4271284	CHESTNUT	COPPICE
0442809	4271356	CHESTNUT	COPPICE

TABLE 8, THE RED HOUSE PRICKLY PEAR AND YUCCA CLUSTERS			
EAST	SOUTH	ITEM	DESCRIPTION
0441864	4269877	PRICKLY PEAR CLUSTER	NORTHWEST LIMIT
0441882	4269885	PRICKLY PEAR CLUSTER	SOUTHEAST LIMIT
0441761	4269918	YUCCA CLUSTER No. 1	24 INDIVIDUALS
0441719	4269924	YUCCA CLUSTER No. 2	14 INDIVIDUALS

TABLE 9, THE PHILLIPS LANDING CLUSTER			
EAST	SOUTH	ITEM	DESCRIPTION
0441263	4268568	CHESTNUT	COPPICE
0441282	4268589	CHESTNUT	COPPICE
0441302	4268526	CHESTNUT	COPPICE
0441315	4268540	CHESTNUT	COPPICE
0441379	4268481	CHESTNUT	COPPICE
0441404	4268459	CHESTNUT	COPPICE

TABLE 10, THE PRICKLY PEAR ISLAND CLUSTER			
EAST	SOUTH	ITEM	DESCRIPTION
0440160	4268210	PRICKLY PEAR	WEST END ISLAND
0440249	4268283	PRICKLY PEAR	NORTH END ISLAND
0440305	4268216	PRICKLY PEAR	SOUTH END ISLAND
0440361	4268333	PRICKLY PEAR	EAST END ISLAND

OUR BIG FIND

We discovered sixty-four examples of *Castanea* (Chestnut and Chinquapin) coppices (please review how and why the Genus *Castanea* is only found in coppice form in Delaware, see American Chestnut on page 6). We noted in the field that many of these coppices appeared to form linear patterns. When we plotted our *Castanea* examples on the project map a surprising semi-circular pattern developed, measuring about 6 miles east/west with Kuskarawack Towne near the center of the semi-circle. After we had completed our survey and plotted all field finds on our survey map, we found that all the likely early culturally important finds were included within the *Castanea* semi-circular pattern, and no likely early culturally important finds were found outside the *Castanea* semi-circular pattern. So, what is the meaning of this apparently semi-circular *Castanea* tree arrangement?

A) If the proposed *Castanea* semi-circular pattern exists as the south half of a full circle, then the northern half of the circle lies north of our surveyed project area.

B) This proposed *Castanea* semi-circle appears to be some sort of early visible, physical, nut-producing boundary that likely predates Smith's voyage of 1608. If this reasoning is to be taken seriously, the cultural implications are profound!

C) This *Castanea* boundary by itself, as well as an Arrow Arum Starchy Tuber Complex, an Upland Game Complex, an Andadromus Fish Complex, a Highbush Blueberry cluster, the two Prickly Pear clusters, the two Yucca clusters, and a Christmas Fern and Crowsfoot association, all found within the proposed semi-circle, in addition to the known, but yet to be plotted Box Huckleberry cluster(s) may be the remains of cultural arrangements or elements of economic programs—beneficial species that were either proprietary, maintained, or manufactured over a period of thousands of years, with Kuskarawack Towne and its associated Contact Period, Woodland II, and Woodland I archaeological site contexts being the epicenter of social and cultural based decision making at this locale.

CONCLUDING REMARKS

First of all, we sincerely thank Daniel Griffith and Virginia Busby (2014), as well as Robert Gano (1991) for putting together excellent sets of documentation with interpretations that allowed us to conceptualize our Ethnoecological survey of Kuskarawack Towne. We also recognize the Delaware Department of Natural Resources and a number of private organizations for having the insight and ability to provide the leadership in attempting to preserve large portions of the current environment at this locale, and to the former owners of those land parcels who obviously suffered financial loss in not developing their properties.

In the recent past, we conducted a couple of dozen Ethnoecological surveys in Delaware. Those surveys consisted of project areas measuring between one and three square miles each, consuming field efforts between one and three days each. We had considered those projects successful because we identified clusters of plants and animals that appeared to have been both beneficial and managed elements of ancestral anthropogenic landscapes. However, we now realize that identifying individual or small groupings of anthropogenic clusters was indeed a myopic view on our part. The results of this survey, Ethnoecological Survey of Kuskarawack Towne, show us that our previous small finds fit into larger, more complex cultural patterns. With these new large-scale discoveries, we can now approach more meaningful understandings of what anthropogenic landscapes and Traditional Land and Resource Management areas look like when we view these environs through multiple sets of macro lenses. This realization really blows the doors off the barn! Our previous research questions were too small, as our individual or repetitively incomplete finds surely exhibit.

As stated earlier, our Ethnoecological survey project area around Kuskarawack Towne was about twenty square miles, and consumed twelve days of field research. But, with the discovery of the proposed *Castanea* semi-circle appearing in the project area, we realized that another ten to fifteen square miles north of our project area would have to be surveyed in order to search for a possible northern portion of a projected *Castanea* circle encompassing Kuskarawack Towne. If that survey were conducted and found to be successful, we would likely try to add a negative perimeter, or frame, around the full *Castanea* circle, requiring an additional twenty square miles of field survey. Adding all of these dimensions together, it would require an astounding fifty square miles of survey sampling project area in order to fully appreciate the decayed remains or remnants of subtle landscape features such as this proposed six-mile wide *Castanea* circle.

Certainly, the results of our Ethnobotanial survey of Kuskarawack Towne have been very rewarding. However, with a survey of this size and this scope, we unfortunately cannot provide the level of detail needed to fully comprehend the possible relationships between clusters found, and the people who may have made them. Our proposed *Castanea* circle needs more explanation—we realize that! What we need to do is enhance and complete our description of the five *Castanea* clusters already found, search for connecter points between clusters, and present that data using a series of much larger scaled maps where we can accurately plot each example found. When we do that, we think our known strings of evenly spaced four, five, or six coppices will appear to look more like sections of tree-lined footpaths rather than the black lines and blobs currently exhibited on our (above) Maps 1 and 3.

As a result of this survey, we now have a strong indication that ancestral Native American *Castanea* were arranged in lines, clusters, and circles—cultural lines, clusters, and circles! So, what meanings can we ascribe to these ancestral Native American planted botanical cultural features? We hope one of our future essays will provide a much better description of these *Castanea* clusters encircling Kuskarawack Towne, and perhaps we may approach larger questions concerning ancestral Native American benefits in managing *Castanea* on the Coastal Plain.

Go back and look at Map 1, are we looking at the decayed remains of one semi-circle or are we looking at two semi-circles? If projected to the north, the smaller, western semi-circle would encircle all of the important beneficial species found in this survey and may actually include the location of the Nanticoke King's house. So, why was the *Castanea* circle apparently extended eastward to incorporate Chapel Branch? Are we looking at previous Woodland I occupations enlarged by Woodland II occupations, or are we simply looking at a prosperous Woodland II people enlarging their defined spatial footprint? Do other Contact Period year-round village sites on the Delmarva Peninsula have *Castanea* circles—whom among us are going to get out there and look for them? And finally, we just cannot help ourselves but to envision these *Castanea* lines and circles as some sort of metaphoric, or symbolic, or even cosmologic stockade devices.

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PLACES in Spacetime

Glen Mellin
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Why do we continue to struggle with the putative abrupt division between Hunter/Gatherer and Horticulture/Agriculture Native American economic programs? Antediluvian definitions ascribed to the catch-as-catch-can Hunter/Gatherer economic program and the genetically modified domesticates Horticulture/Agriculture economic program may provide reason enough to discourage the progressive thinking needed to explore pragmatic concepts like Cultural Landscapes, and more recently, Anthropogenic Landscapes.

Unfortunately, even our national narratives, often written into history and law, describe unoccupied natural landscapes; expanses of forest, unbroken plains and waters, virtually free for the taking! There is little wonder why jingoistic eyes fail to see how Native Americans altered and improved their living environments by employing creative cultural solutions that sustainably transformed few into many. This essay illustrates a sampling of the many ancestral Native American landscapes that were established between the Hunter/Gatherer and Horticulture/Agriculture economic programs.

Making this essay easier for pragmatists to support, we elected not to tinker with the accepted "third rail" definitions of the Hunter/Gatherer and Horticulture/Agriculture economic programs at all—we simply pried those two programs apart and inserted our concept of Public Landscaping—Agroforestry—and Creating Economic Strategies, or **PLACES**, in the following manner:

Hunter/Gatherer ⇒ PLACES ⇒ Horticulture/Agriculture

Further along in this essay we will demonstrate why it is important to view and discuss these PLACES in Spacetime, the necessary fourth dimension for addressing archaeological research questions in the 21st century. But for right now, let's take a look inside PLACES and see how our model identifies and organizes cultural solutions to environmental deficiencies in the following three categories.

1) Public Landscaping—involves the organized manipulation of environmental settings (upland, wetland, tidal, and seascapes) to encourage and maintain desired species of plants and animals and discourage undesired species.

2) Agroforestry—involves selective burning, ringing, and bark stripping to reduce specific species profiles, while planting and transplanting native species and acquiring adventive species that increased desirable species profiles. These manufactured groupings, or clusters of beneficial plants and animals developed local landscapes into an array of concentrated and efficiently retrievable stores. Through the arrangement of nut, fruit, berry, grape, and vegetables as edible gardens; the arrangement of bark, twine fiber, and basket making materials as utility gardens; and the arrangement of wellbeing species like cohosh, jimson weed, and prickly pear as medicinal gardens for examples, these and other prepared landscapes were likely developed as visionary templates of ancestral Native American worldviews.

3) Creating Economic Strategies—involves the conception and manufacture of sustainable beneficial anthropogenic landscapes as economic programs. Briefly, lets differentiate between the "active agency" (designed for prosperity) and the "idea agency" (designed for posterity). Active agency involves the organized construction and maintenance of groves, orchards, and gardens within woods, meadows, and seascapes that promoted the growth and accumulation of beneficial resource where and when they were desired. Idea agency involves kincentric responsibilities, or the "consequences" of achievement. Inheritance, trade and

exchange, feasting, and mortuary practices are some examples of the ideaology of excess, or the consumption of affluence and the symbolic storage of wealth. Together, these agencies seem to greatly intensify local mobility through accumulation, while offering periodic extensive mobility through trade and exchange.

Publically available surveys found on the Internet verify that ancestral Native American cultural landscapes, or PLACES, are typically found within one to seven miles' radius from the core areas of larger basecamps and villages. Any detailed Ethnoecological survey encompassing fifty square miles surrounding these large basecamps and villages should be sufficient to identify the types, characters, and locations of whatever cultural landscapes had been manufactured and maintained in the distant past. However, we need to be aware that development, agriculture, erosion, the proliferation of non-native species, and diseases are the principal destroyers of these PLACES.

The results of our recent Ethnoecological surveys (2013—2015) here in Delaware are very consistent with the information provided above. Thus far, our largest identified botanical cluster is a six-mile wide American Chestnut (*Castanea dentata*) circular nut-grove encompassing Kuskarawack Towne, a Native village documented by Cpt. John Smith (ca. 1608), along the banks of the upper Nanticoke River. After all these years, many of those planted Chestnut trees are still alive. We documented as many individual remaining trees as we could find using GPS readings (Mellin and Truitt, 2015).

We now know that many PLACES remain as significant cultural resources because we have found evidence that can only be described as cultural in origin. Recently, a number of other researchers have corroborated our interpretations. For example, Tulowiecki and Larsen (2015) described Ethnobotanical data for an entire county in western New York. Using sophisticated statistical analysis, they demonstrated meaningful differences in proportion for beneficial tree species in association with known Iroquois villages. How did they do that? They found that late eighteenth and early nineteenth century geographic grid system land surveys had itemized tree species along lines and axis points in Chautauqua County, NY. When the authors plotted these species, they found significant differences in proportion between beneficial (edible) species and non-beneficial (non-edible) species out to 10 to 15 km from Iroquois village sites. The authors attributed this phenomenon to pre-settlement "forest compositional modification" through persistent large-scale landscape burning (2015:3). Additionally, their analysis stipulates that Walnut and Butternut groves were found close to the villages and American Chestnut, Hickory, and Oak groves clustered further afield. We find it difficult to understand how their assumption of landscape burning could create and maintain groves of specific species without additional forms of cultural selection having been in play. Addressing their data within our model of PLACES provides opportunities for more thorough and more meaningful interpretations of both the anthropogenic landscapes and the worldviews of the people who created them.

Anthropogenic landscapes, like the ones Tulowiecki and Larsen found, continued on through the Colonial Period. Many of them are observable today, at least the ones that have not been erased by modern processes. For example, we found a distressed two-acre Chinquapin (*Castanea pumila*) tree cluster that contained about two hundred coppiced trees (coppicing is the result of an Asian bark fungus). We found Native ceramic shards and clamshell within that tree cluster, which indicates a ancestry or age of origin approximately 1,500 BP. *Castanea* roots are known to live for 1,600 years, so, together with any original (Native planted) trees and their descendant offspring (still growing in the very definable oval cluster), this cluster epitomizes what a small, relict Native American Chinquapin nut grove would look like today (Mellin and Truitt, 2013c). Since we (the authors) subsequently rescued that Chinquapin cluster (we bought it and restored it), we have become actors in our own archaeological narrative by rescuing and restoring the trees and subsequently eating the nuts. Essentially, this Chinquapin cluster exhibits continuity—it has quite remarkably retained its sustainability. But sadly, its original Native meaning has been lost, or at least temporarily misplaced.

This is by no means a unique story. For example, we documented the fifteen-acre ancestral Native American Pawpaw fruit orchard cluster in Alapocos State Park near Wilmington, Delaware (Mellin and Truitt 2013b). In addition to the popular hiking trails, the principal program at the park is the yearly Pawpaw festival where participants may compete by baking edible deserts. Here too, the State of Delaware as well as the park's participants are actors in our archaeological investigation and narrative.

Where few original (prehistoric) trees remain, Dendrochronology is usually not a dating option. However, determining the ancestry of these PLACES may be estimated using various forms of archaeological association. The age of carbon, animal bone, and shellfish remains found in or on candidate landscapes can be estimated using either carbon dating, direct association, or strata sequencing. These dating procedures can be applied to some of the found specimens in the first two of our three artifact categories (Mellin and Truitt, 2013a): (1) Archaeobotanical evidence consisting mainly of carbonized wood and seeds, and pollen, and phytoliths, and recently, starch grain identification shows promise, and (2) Traditional Plant Artifact evidence is usually preserved in either saturated or dehydrated environments. The above dating methods may be used to estimate the antiquity of each specimen tested, and by relationship, or association, offer an estimated ancestry of nearby PLACES. But, how can we address the ancestry of living artifact plants? (3) Living Artifact Plants are the actual plants, or the descendents of plants that were originally arranged in PLACES. We typically find these plants arranged in clusters within definable or candidate cultural or anthropogenic landscapes.

These plants may include native plant species whose original location or quantity have been altered (citing high bush blueberry as an example) and all of the adventive species that arrived in Delaware during the Holocene (citing jimson weed as an example). In Delaware, we suspect there are even now a couple of dozen plant species assumed to be native that probably are actually adventive (citing prickly pear as an example).

Some folks may be enamored with the idea that the ancestry or age of things like plant and animal clusters are un-dateable, thus, the origin of cultural processes like PLACES are un-dateable. Nevertheless, viewing evidence of these PLACES in association with dateable cultural contexts may provide avenues for "relationship precocity" or "origination brackets". Certainly, the origin of PLACES and the various elements of plant and animal arrangements, or the things that make up processes like PLACES did not occur evenly across the landscape or all at the same time.

Culturally Modified Soils (CMS) are a result of conditioning through previous cultural activities. Where found, CMS may have profound implications, especially at locations where no subsurface artifacts are located. These forms of soils may contain elevated amounts of carbon and organic material, reduced acidity, altered profile depths, as well as increased archaeoecological remains both within soil pit features and scattered throughout various layers of the local ancestral landscapes. For example, an area of culturally modified soil may exhibit use as a hickory nut grove during the Later Archaic Period, as well as exhibiting use as a chestnut grove or blueberry patch during the Late Woodland Period.

Where datable artifacts are present, we have telltale signs of ancestry. But that doesn't necessarily make our job easier. Any evidence of anthropogenic landscapes created in the distant past has probably been modified by the efforts of successive landscape modifications and by natural processes through time. At this point in time, we see no reliable association between the formation of PLACES and the Bifurcated tool tradition. We do see associations between PLACES and the technological development of the "Broadpoint" tool type, or as some have referred to these bifacial tool types as "pocket chainsaws", or the "Swiss Army Knife" of the era. We think the ideaological invention and use of these tool types was centered on Agroforestry. With the ringing of trees, the stripping of bark, and the processing of forest products, these tools, along with large cores and axes were likely the quintessential Agroforestry toolkit. The presence of these tools likely indicates economic activities such as landscape burning and the construction of browse lots, monoculture woodlots, gardens, groves, and orchards. Within this timeframe, we also see larger and more durable activity areas with large pits dug into the ground. Collectively, we see in these fragments of people's worldviews from the distant past that these folks had developed a durable sense of place supported through the construction of desired environmental landscapes, or PLACES, close to home.

The reality of PLACES may produce contradictions—but not necessarily conflicts, within our long-held professional principles. Examples of ancestral Native American sustainable anthropogenic landscapes, or PLACES, are all around us. They still exist as living artifacts, artifacts with DNA, they still function as parts and parcels within our contemporary landscapes. These remaining objects (the individual plants and animals) grouped together as remaining things (the clusters and gardens) fit together into larger processes (the traditional land and management areas) are built into systems (economic programs). We walk through these

PLACES on a daily basis—they are here, now! We are adding our footprints to footprints laid down in the distant past—along similar paths, solving similar problems.

What are we to make of these perceived dichotomies between them and us, or the distant past and the now? On the one hand, the new pragmatists might say there is little difference, if any at all—these PLACES simply exist as sustainable economic continuums (at least for the time being). On the other hand, hardcore traditionalists might make accusations of professional injury. These explanations need not be a paradox if we use Spacetime as the 4th dimension in archaeology, mapping-out and bridging these perceived dichotomies as this new century progresses.

We documented our restored Chinquapin cluster with "X" and "Y" GPS coordinates. There is no valid "Z" profile because this cluster is still growing at the surface of the earth, where it was planted, probably more than a thousand years ago. This Chinquapin cluster retains an important Native American ancestry; it has an age, yet it has continuity and meaning within our contemporary landscape. Only Spacetime can tie these attributes together, bridging the gaps between multiple time frames, various people, and alternative cultural pursuits. Spacetime allows all agencies to come together, and if we do not find detailed agreement in the meaning of this Chinquapin cluster, for example, at least we find agreement on its existence and its benefit measured in Spacetime. There is a human relationship, a bond, a responsibility in and across Spacetime that allows all agencies to discuss, share, and cherish these multi-faceted PLACES, and all of the various people who benefited from their creation.

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Lessons Learned From Witness Tree Surveys:
These PLACES are the Incubators of Domesticates

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Introduction

The past twenty years has witnessed profound new interpretations concerning how ancestral Native American's related to their landscapes. First, the recent mapping of witness tree surveys are segregating managed groups of vegetation within definable catchment areas associated with basecamps and villages, contrasted by groups of natural vegetation outside of these managed catchment areas. Second, the history, or time depth of these catchment areas is unknown. However, the broadpoint and grooved axe tool kit, seemingly designed for agroforestry, or silviculture stretches back in time some four thousand years. And third, we now realize these catchment areas, or anthropogenic landscapes probably represent previously unrecognized ancestral Native American economic systems, economic systems that were capable of incubating domesticates.

Even though landscape burn management could be considered a forager's management tool, the development of specific nut and acorn mast, and fruit and berry arrangements require social organization, land clearing, planting, selective breeding, and multigenerational management. These social and economic expressions would have to be much more developed than what is typically thought of in Hunter/Gatherer economic programs, yet seem to fall short of typical Horticulture/Agriculture economic programs. We refer to this intermediate economic system as PLACES, or activities designed to create and perpetuate these anthropogenic landscapes, where Public Landscaping, Agroforestry, and Creating Economic Strategies are the main economic pursuits (Mellin and Truitt, 2015a).

The creation of anthropogenic landscapes indicates a level of human social organization capable of manufacturing and maintaining a reliable and beneficial economic system. In doing so, persistent enhancement of the beneficial aspects of specific plant and animal species would lead to selective planting, selective harvesting, and active and/or passive genetic manipulation of those plants and animals being managed. In a very real sense, PLACES are the incubators of domesticates.

In the following section, we put together seven recently published essays that plotted specie specific witness trees as recorded in late eighteenth and early nineteenth century land surveys. Some of these surveys were quite large, involving several counties. Analysis of these plotted mast vegetation types allowed the researchers to identify catchment areas, or anthropogenic landscapes in areas of known Native American activity. After our presentation of these witness tree essays, we provide a summary, and present some findings in our local field surveys showing that remnants of these PLACES are still with us, and that specific examples are being identified without the benefit of witness tree surveys.

Seven Witness Tree Essays

In this section we chronologically trace the progress of researchers over the past twenty years in their attempts to identify and map pre-European settlement forest types based on mast species

composition. Early on, researches identified unexpected differences in proportion of certain tree specie communities, which had difficulty being explained using traditional ecological variables. The addition of Native American cultural variables shows that these differences of proportion in mast tree species formed catchment areas around ancestral Native American basecamps and villages.

Catchment areas, also described as anthropogenic landscapes containing less than fifty square miles co-occur with typically beneficial environmental attributes, such as cosseted landforms with fertile soils and adequate moisture in close proximity to known habitation sites. Strung together, these catchment areas may cover great distances. In some instances, these catchment areas may appear to occupy the majority of the reasonably accessible environment.

All seven of the following essays deal with analysis of witness tree surveys. These witness tree surveys were recorded in the late eighteenth and early nineteenth centuries. Predominantly, these early land surveys recorded mast species along lines and axis points on presettlement landscapes in the Allegheny Plateau, Ridge and Valley, some Piedmont, and some Coastal zones. The geographical range of these witness tree survey analyses is phenomenal. For the purpose of this essay, we include datasets from western New York, northwest Pennsylvania, south central Pennsylvania, northeastern West Virginia, and east-central Alabama. In addition, we include an early witness tree synthesis, and a position paper produced for the Penn State Environmental Law Review.

So there is no mistaking about who said what for each of the seven essays, we include properly referenced block quotes for each essay using a small font and large margin. We occasionally provide commentary in normal font and margin. These selected block quotes are used solely as expedient, unedited, comparative devices. We apologize in advance to everyone who is offended by our use of extensive block quotes. As always, we strongly encourage everyone interested in these topics to download and read each of these seven essays in their entirety.

After the presentation of these seven essays, we will summarize what we have gleaned from our comparative analysis. Furthermore, we will demonstrate the need to integrate the existence and significance of these PLACES into all aspects of our anthropological and archaeological thinking.

Essay One (1996)

In 1996, Marc Abrams and Deanna McCay presented an essay, "Vegetation-site relationships of witness trees (1780-1856) in the presettlement forests of eastern West Virginia", which was subsequently published in *Canadian Journal of Forest Research*, No. 26: 217-224. Abrams and McCay's essay is an eight-page document exhibiting two figures, three tables, and bibliography. They used standard Ecological approaches to map and interpret forest composition from early witness tree data in the Monongahela National Forest. They also compared their witness tree data to current vegetation communities in the following citations:

> p.217—Witness tree data from 1780—1856 for the Monongahela National Forest in eastern West Virginia were analyzed with respect to physiographic unit (Ridge and Valley versus Allegheny Mountains) and landform, and compared with present-day forest composition.
>
> p.221—An examination of present-day versus presettlement forest composition in the region suggests many dramatic differences (Table 3). Chestnut was eliminated from both the Allegheny Mountains and Ridge and Valley. White oak was substantially reduced, but chestnut oak, red oak, and scarlet oak increased in present-day forests of the Ridge and Valley. Pine species decreased and red maple increased in both units following European

> settlement. Black cherry and birch species were more abundant, while basswood was less abundant, in present-day forests in the Allegheny Mountains.
>
> p.223—In conclusion, the results of this study indicate that pre-European settlement distribution of tree species was markedly affected by physiography in eastern West Virginia, resulting in oak, pine, hickory, and chestnut forests in the Ridge and Valley and hemlock, beech, maple, and pine in the Allegheny Mountains. However, original forests on valley floor sites in the Ridge and Valley comprised up to 60% mixed-mesophytic tree species, illustrating the importance of elevation, landform, and apparently fire frequency, on species distribution within a physiographic province.

These results are an indication of the complexity of the issues involved, not only in illustrating past environments, but also in explaining variables in current environments. Much to their credit, they recognized the surveyed vegetation in the more habitable zones, the valley floors in the Ridge and Valley, contained more complex species' structure.

Essay Two (2001*)

In 2001*, Bryan Black and Marc Abrams presented an essay, "Influence of Native Americans and Surveyor Biases on Metes and Bounds Witness-tree Distribution", which was published in *Ecology,* Vol. 82, Issue 9, pages 2574-2586. Asterisk: Original document written in 1999, revised 2000, accepted for publication 2000, final revision 2000, Online publication date 2002. Black and Abrams's essay is a thirteen-page document, however; we were only able to download the Abstract, free of charge, which appears below:

> Abstract:
> Witness trees recorded in surveyors' notes have been extensively used to describe presettlement forest vegetation throughout eastern North America. Relatively few studies, however, have discussed surveying inconsistencies that could affect the quality of witness-tree data in Colonial metes and bounds surveys. To increase the accuracy of these data, we developed techniques to quantify and mitigate the effects of several irregularities in metes and bounds witness-tree data using Lancaster County, southeastern Pennsylvania, USA, as a model. Irregularities included unequal sampling intensities among regions of contrasting topographic relief, and on a finer scale, unequal sampling among landform classes. We mitigated the effects of these inconsistencies by subdividing the study area into physiographic (topographic) sections, and then subdividing each physiographic section into landform classes before witness-tree analysis. Pre-European settlement forests were dominated by *Quercus velutina* and *Q. alba,* with *Carya* spp. in regions of low topographic relief and *Castanea dentata* in regions of high topographic relief. We then assessed the effects of Native Americans using catchment analysis in which we tallied witness trees within 5 and 7 km of Susquehannock village sites and compared the forest composition to edaphically similar catchment areas of low Native American activity. Elevated frequencies of *Carya* spp., *Juglans* spp., and *Robinia pseudoacacia,* with depressed frequencies of *Quercus alba,* occurred on sites with a history of Native American occupation, possibly as a result of disturbance or active cultivation. Together, bias-correction techniques and catchment analysis greatly extend the usefulness of witness-tree data by improving methods for evaluating pre- and post-European settlement disturbance on forest change.

This is the first attempt of separate physiographic sections and landform classes as control mechanisms. Additionally, Black and Abrams compared vegetation near known village sites with vegetation in remote areas with respect to their control mechanisms. They found that within this study area, their bias-correction techniques greatly extended the usefulness of identifying and mapping catchment areas of beneficial tree species at and near known Susquehannock village sites.

The witness tree data shows an elevated frequency of hickory, walnut, and black locust, and a decreased frequency of white oak associated with a localized history of Native American occupation. Nevertheless, these interpretations were used to explain ecological changes associated with pre- and post-European settlement. The broader implications of Native American forest management had yet to be fully realized.

Essay Three (2004)

In 2004, Thomas Foster II, Bryan Black, and Marc Abrams presented an essay, "A Witness Tree Analysis of the Effects of Native American Indians on the Pre-European Settlement Forests in East-Central Alabama", which was published in *Human Ecology*, Vol. 32, No. 1. This essay is a twenty-one-page document exhibiting four figures, two tables, and bibliography. This appears to be the first detailed attempt to actually quantify the mast species contents of identified catchment areas in association with a series of known Native American archaeological sites. This essay is also important because the data used here were derived from witness tree surveys in Alabama, which may be compared to similar studies in adjacent states and regions:

> p.27—Abstract:
>
> Witness tree data from the southeastern United States (lat 33°30′ N, long 86°30′ W) were analyzed using catchment and distance analysis to quantify the effects of Native American settlement on the composition of forest trees. Thirty Creek Indian villages comprising 18 settlement catchments were included in the sample, which is the largest Native American–forest interaction study using witness trees to date. Lower frequencies of Pinus spp. were observed within village catchments of the Coastal Plain and Ridge and Valley. Elevated frequencies of early succession species were observed surrounding 2 km village catchments. Distance analysis at two relatively isolated towns showed that Pinus increases in frequency beyond 2000 m from villages while Carya had the opposite result. Field and fruit species were more frequent within 6000 m of villages and then dropped off in frequency. Fire-sensitive tree species appear to be in a spatially cyclical pattern.
>
> p.44-5—Distance analysis was performed on two towns. This analysis supplements the catchment analysis by quantifying gradual changes in the tree frequency distribution over space. *Pinus* increases in frequency beyond 2000 m away from villages. *Carya* shows the opposite result. This species is higher in frequency within the first 2000 m closest to villages. Field and fruit species were more frequent up to 6000 m away from villages and then dropped off in frequency. Fire sensitive tree species appear to be in a pattern which repeats itself or cycles over space with increasing and decreasing frequency as a function of distance from villages. This spatially cyclical pattern may be related to the placement of Native American villages along the river bottom.
>
> p.45—Previous studies of pre-European forests have stated that Native Americans may have influenced the distribution of specific trees but have not attempted to measure the degree of such changes. This study demonstrated that Native Americans might have altered a wide range of species in addition to the often-cited forest fire effect. Humans are not simply recipients of forest resources but have been actively altering the distribution of tree species. Any studies of diet, foraging, and resource use over time and space must be able to characterize the effects that humans have had on those resources.

As mentioned above, this Alabama witness tree study is quite remarkable. In 2004, Foster II, Black, and Abrams concluded (p.45) that ancestral Native Americans were "actively altering the distribution of tree species." We appreciate and applaud the bold steps taken by these authors because their commentary is essential in shaping our new paradigm of PLACES!

Essay Four (2006)

In 2006, Bryan Black, Charles Ruffner, and Marc Abrams presented an essay, "Native American influences on the forest composition of the Allegheny Plateau, northwest Pennsylvania", which was published in *Canadian Journal of Forest Research*, No. 36: 1266-1275. This essay is a ten-page document exhibiting four figures, four tables, and bibliography. In this witness tree survey, the authors attempted to introduce and integrate a wide range of multi-disciplinary approaches:

> p.1266—Abstract:
> We integrate witness tree distribution, Native American archaeological sites, and geological and topographic variables to investigate the relationships between Native American populations and pre-European settlement forest types on the Allegheny Plateau, northwest Pennsylvania. Detrended correspondence analysis of witness tree data separated the presettlement forests into oak–hickory–chestnut and beech–hemlock–maple communities. Oak, hickory, and chestnut forests were centered on Native American village sites. Using archaeological data, an index of Native American influence (NAI) was derived to reflect the intensity of Native American land use across the landscape. In a comparison among species, mean NAI value of oak, hickory, and chestnut trees was significantly higher than that of beech, maple, and hemlock. Logistic regression demonstrated that among geology type, landform, elevation, aspect, slope, and NAI, NAI was by far the most significant predictor of oak, hickory, and chestnut distribution. Although cause and effect of this relationship cannot be tested, we suggest that long-term Native American activity selected for the disturbance-adapted oak, hickory, and chestnut. We contend that Native American agriculture, burning, and resource extraction could have converted maple–beech–hemlock to oak–hickory–chestnut, or at least reinforced the dominance of this forest type.
>
> p.1274—In conclusion, catchment analysis demonstrates a strong association between regions of Native American occupation and oak, hickory, and chestnut forest distribution on the Allegheny Plateau of northwest Pennsylvania. Given the wide distribution of witness tree data, future catchment analyses could help clarify the extent and character of Native American influence throughout the eastern and midwestern United States and even allow for comparisons of Native American influence across diverse forest types, physiographic regions, and Native American cultures. Wherever possible, witness tree analysis should be combined with palynology and dendrochronology techniques. The deep time perspectives of palynology and dendrochronology would complement the landscape-level forest snapshots captured by witness tree analyses and yield the most robust estimates of Native American influences on forest composition.

The data presented in this essay may be approached and analyzed through many related disciplines. We found particularly interesting the authors' refinement of oak-hickory-chestnut communities occupying NAI predicted catchment areas, while beech–hemlock–maple populations actually represented the mast tree species populating natural, or climate-induced landscapes.

Essay Five (2008)

In 2008, Marc Abrams and Gregory Nowacki presented an essay: "Native Americans as active and passive promoters of mast and fruit trees in the eastern USA", which was published in *The Holocene*, Vol. 18, 7: pp. 1123-1137. Abrams and Nowacki's essay is a fifteen-page document exhibiting four tables and bibliography. This synthesis represents a fully engaged, pre-European settlement, social and cultural approach in explaining ecological profiles of the eastern United States:

p.1123—We reviewed literature in the fields of anthropology, archaeology, ethnobotany, palynology and ecology to try to determine the impacts of Native Americans as active and passive promoters of mast (nuts and acorns) and fruit trees prior to European settlement.

p.1123—First-hand accounts often mention mast and fruit trees or orchards in the immediate vicinity of Native American villages and suggest that these trees existed as a direct result of Indian management, including cultivation and planting.

p.1123—Although significant climatic change occurred during the Holocene, including the 'Mediaeval Warming Period' and the 'Little Ice Age', we attribute the multimillennia domination of the eastern biome by prairie grasses, berry-producing shrubs and/or mast trees primarily to regular burning and other forms of management by Indians to meet their gastronomic needs.

p.1124—In contrast to our understanding of Native American use of fire and the cultivation of crops, we know very little about their direct and indirect impacts on the distribution of the mast and fruit trees that were important in their seasonal diet. If Native Americans had the skills to develop sophisticated systems of agriculture, did they possess similar skills to manage forests?

The promotion of mast and fruit trees would have involved active silviculture and horticulture such as reducing competing vegetation via girdling, cutting or prescribed fire and the planting and tending of beneficial tree species, possibly even creating fruit or mast orchards (Delcourt and Delcourt, 2004).

p.1132—MacDougal (2003) reviewed 67 texts related to pre-European land management and plant use and reported that 21 mast and fruit trees and 16 berry-producing shrub species were potentially cultivated by Native Americans in the eastern USA. Indians actively manipulated oak-hickory-chestnut forests with fire to provide more abundant food resources (Caldwell, 1958). This included (1) increased browse quality and quantity for deer and for concentrating the herd in managed areas, (2) increased mast quality and quantity for winter-spring subsistence, and (3) a reduction of forest-floor litter to facilitate mobility and mast collection.

p.1134—In this respect, we believe that the vast majority of vegetation in the eastern USA was managed directly or indirectly by Native Americans, especially through the use of fire.

The dramatic changes in vegetation structure and composition as a result of fire suppression following the collapse of Native American populations (1600s–1800s) associated with European diseases and settlement, followed by government policies (the Smokey Bear campaign) during the last 70–100 years are unparalleled during the last 5000 years (Nowacki and Abrams, 2008). We conclude that Native Americans profoundly impacted the distribution and importance of mast and fruit trees and tallgrass prairie as a primary food source through both active and passive means, and that they *ubiquitously* impacted these vegetation types at the regional and biome levels (not only at the local level). Without their extensive influences prior to European settlement, the Eastern deciduous forest and prairie biomes would have been dramatically different, thus altering our perception of the natural vegetation of the eastern USA.

It should be clear that Abrams and Nowacki are describing (in anthropological terminology) anthropogenic landscapes organized through a sophisticated ancestral Native American economic system facilitated through Public Landscaping, Agroforestry, and Creating Economic Strategies, or PLACES.

Essay Six (2010)

In 2010, Marc Abrams prepared an essay: "Native Americans, Smokey Bear and the Rise and Fall of Eastern Oak Forests" for the *Penn State Environmental Law Review*, Vol. 18:2, pp. 141-154. Abrams's 2010 essay is a fourteen-page document exhibiting one figure and extensive footnote style citations. His presentation is an overview explaining the necessity for including Native American social and economic activities when describing past and present environments:

> p.148-9—I view the pre-Columbian eastern United States as a network of actively and passively managed forest and prairie used by Native Americans to promote mast, other edible plants, and grazing areas for the wildlife they hunted.[64] The vast majority of the eastern United States was *not* a climax forest dominated by late successional sugar maple, beech basswood or hemlock.[65] Nor was it an edaphic climax of mostly xeric and nutrient poor sites unsuitable for climax tree species.[66] The majority of the eastern United States at the time of European settlement was mixed-oak, hickory and chestnut forest, northern and southern pines, and tallgrass prairie maintained as such by Native American management to meet their dietary needs.[67] In the absence of such management, these vegetation types do not persist.[68] I have argued that the impact of Native American land-use practices in the eastern forest and tallgrass prairie were ubiquitous, not merely localized.[69]
>
> p.152—It is now well-recognized that periodic burning was and is an ecological requirement for the long-term perpetuation and health of tallgrass prairie and most oak, hickory, the former chestnut forests, and northern and southern pine.[104]

Clearly, Abrams is not intimating these landscape descriptions apply only to a small portion of his Penn State campus—he is addressing pre-Columbian ecological conditions in the majority of the eastern United States. He is positively supporting recently developed anthropological and archaeological theories concerning cultural landscapes, anthropogenic landscapes, and PLACES. Additionally, Abrams illustrates how ancestral Native American landscapes were degraded through Colonial settlement, farming, introduction of invasive species and diseases, various industries, fire suppression programs, and a plethora of other private and public activities.

Essay Seven (2015)

In 2015, Steven Tulowiecki and C. P. S. Larsen presented an essay: "Native American impacts on past forest composition inferred from species distribution models, Chautauqua County, NY", which is scheduled to be published in *Ecological Society of America* (Pre-print, 2015). Tulowiecki and Larsen's essay is an eighty-page document exhibiting nine figures, seven tables, and bibliography. This witness tree analysis is a product of members in the Department of Geography, University of Buffalo, NY. Their essay exhibits the use of a wide range of sophisticated statistical analyses applied to their witness tree database:

> p.2-3—Abstract
> Little consensus surrounds the extent of Native American impacts upon tree species composition in Eastern North America, prior to European-American settlement ("presettlement"). Native American land-use practices (e.g. forest clearance and burning) likely altered forest composition, but the spatial extent of these alterations remains vaguely quantified. Previous research has attempted to quantify the spatial extent of clearance

practices, but little research has addressed the more subtle alterations to tree species composition resulting from Native American land use.

Research has also inadequately distinguished between environmental and anthropogenic controls upon tree species composition, leaving open the possibility that instead of modifying forest composition, Native American societies instead settled where favored tree species were already present. This study employed species distribution models (SDMs) trained from tree species data within presettlement land survey records (PLSRs), in order to understand Native American impacts upon presettlement tree species composition in Chautauqua County, New York State. Using historical and archaeological data, this study developed "Native American variables" (NAVs), which represented human accessibility to features of Iroquoian settlement. This study then modeled the distribution of tree species in relation to both environmental variables and NAVs. Notable results indicate that NAVs significantly improved the predictive performance of SDMs for mast-bearing taxa, such as oak (*Quercus* spp.), chestnut (*Castanea dentata* (Marsh.) Borkh.), and hickory (*Carya* spp.). Under a simulated absence of Iroquoian settlement, the amount of "suitable" area in Chautauqua County decreased by 2 to 23 percentage points for five mast-bearing taxa, depending upon species and modeling procedure. Results imply that Iroquoian alterations to tree species composition covered a larger spatial extent, in comparison to previous estimates of the spatial extent of clearance practices in Iroquoian regions. Yet, the majority of forest compositional modifications occurred within 10 to 15 km of village sites. This study offers a novel methodology for quantifying Native American impacts upon past tree species composition, and suggests that Iroquoian land-use practices of the early Historic era shaped forest compositional patterns at local extents in one region of presettlement Eastern North America.

p.38-40—Conclusion

This study produced three direct findings regarding Native American impacts upon forest composition, specifically in relation to Iroquoian groups of the late prehistoric and early Historic eras. First, understanding the geography of Iroquoian settlement improved reconstructions of past forest composition using SDMs. Second, Iroquoian settlement was associated with higher probabilities of fire-tolerant and mast-bearing taxa recorded within PLSRs, as well as lower probabilities of fire-sensitive and non-mast-bearing taxa. Third, the land-use practices of Iroquoian groups shifted forest composition towards mast-bearing taxa in environments that were less optimal for such species.

This study also supports and advances previous research regarding Native American impacts upon past forest composition in many ways. The results align with the general framework of Native American impacts in the northeastern United States and southern Ontario: clearing and other practices near villages impacted a small portion of forested landscapes, but alterations to forest composition occurred over a larger total area (Whitney 1996). This study adds that where settlement occurred, Iroquoian land-use practices altered upland forest composition, but that their impacts did not extend into forested wetlands. The results also uniquely contribute that Iroquoian groups utilized resources from both naturally-occurring and human-modified forests, and that forest compositional modifications may have been more important to subsistence strategies where the underlying environmental conditions were less optimal for preferred mast-bearing tree species.

In addition, this study contributes to the understanding of the spatial extent of Native American impacts. This study suggests that Iroquoian impacts were observable at local spatial extents, generally occurring within a 10 to 15 km radius around settlements. The overall impact of Native American settlement upon forest composition may have been dispersed at continental scales, because the spatial extent of Native American influence may have been limited by human mobility; though, future estimates of Native American impacts may vary with numerous factors, which include Native American subsistence strategies and

> population densities (Patterson and Sassaman 1988). Large areas uninhabited by Native American groups (e.g. see Milner and Chaplin 2010) may have experienced little or no compositional modifications over long timescales.
>
> This study contributes a unique perspective on Native American impacts upon past forests, chiefly by using PLSRs, SDMs, and records of Native American settlement to simulate past forest composition in the absence of Native American impacts. Future synthetic analyses, additional modeling approaches, and improved representations of Native American land use will help reveal not only more nuanced relationships between Native Americans and forest composition, but also a deeper understanding of the past distribution of tree species within the forests of Eastern North America.

Tulowiecki and Larsen's statistical analyses of witness tree surveys for Chautauqua County, NY identified areas of forest compositional modifications within 10 to 15 km of known Iroquois Indian village sites. Additionally, the results of their mathematical models were that large areas of the uninhabited landscape are likely to show little or no compositional cultural modification over time. We think their results definitely support Abrams's earlier ideas about the vegetation in culturally modified catchment areas around village sites. However, we are left with the feeling that Tulowiecki and Larsen balked at Abrams and Nowacki's (2008:1134) ideas about how Native American's had "*ubiquitously* impacted these vegetation types at the regional and biome levels (not only at the local level)." We view these differing perspectives about potential extent of modification across various landscapes as very healthy academic and professional discourse. Certainly, what is needed here is on-the-ground field research, which has a real potential to help clarify these discussions.

Lessons Are Learned

The last twenty years has witnessed some new and interesting research. Recent developments in plotting these late eighteenth and early nineteenth century witness tree surveys allows us to see what the pre-European settlement surveyors thought was important—what they observed and wrote in their journals. Granted, biases and errors exist. For examples, the surveyors itemized mature mast species, and more casually mentioned lower tier vegetation, shrubs, and ground cover. The degrees of geographical errors are unknown. Yet, the purpose of these early surveys were to produce grid maps based on straight lines and right angles, so, even a series of individual errors would eventually be somewhat, self-correcting. At any rate, the cultural features we are trying to identify in these surveys (individual and specific vegetation clusters, the culturally modified soils, and the overall shapes and extents of the catchment areas under Native American influence and manufacture), some measuring over ten miles in diameter—and when plotted, these cultural features are not that easy to overlook.

These seven essays are derived from at least two schools of thinking. First, we have Abrams and his colleagues who call Penn State their home. Their idea of catchment areas identified through witness tree surveys is greatly enlarged through additional cultural forecasts of repetitive, extensive landscape burning with discussions about the creation and maintenance of meadows and prairies. Second, we have Tulowiecki and Larsen, and their colleagues at University of Buffalo. Their questioning of the extent of modification beyond the catchment areas identified through witness tree surveys seems to be more of a mathematical testing explanation—sticking strictly to what their statistical analyses revealed.

The explanations contained in these seven essays have profound implications for identifying and understanding ancestral Native American behavior and worldviews. All of these witness tree surveys were derived from specific moments in time, each representing a narrow span of time, the

transition from Native control of the landscape to settler control of the landscape in the eastern United States. Greatly simplified (and perhaps overly simplistic), we are now able to see that from at least New York to Alabama, oak-hickory-chestnut community catchment areas, associated with Native American activity areas, were created and maintained in naturally occurring, or climate induced beech–hemlock–maple communities and northern and southern pine landscapes.

Summary

What are the lessons learned from witness tree surveys, and what are some limiting factors? 1) The late eighteenth and early nineteenth century surveyors were fairly detailed in itemizing a range of mature, mast species that they encountered. The surveyors more casually mentioned understory trees, bushes, or ground cover. These data somewhat limit our understanding of the overall contents of the areas under management. Yet, we have a very real sense of oak-hickory-chestnut communities (beneficial edible species) constructed and maintained in larger beech-hemlock-maple landscapes (non-beneficial, non-edible species).

2) Once identified and plotted on maps, these oak-hickory-chestnut communities form catchment areas, which are spatially associated with known Native American activity areas. Each catchment area seems to occupy less than 60 square miles, but nearby activity areas and their associated catchment areas may be strung together forming very large manufactured landscape features.

3) If we think about the Iroquois, Susquehannock, and Creek, and other nations, as reported in these seven essays, all using these catchment areas to support their economies, then these topics need to be addressed beyond our traditional culture-region and geographical frameworks. We refer to this overarching economic system as Public Landscaping-Agroforestry-Creating Economic Strategies, or PLACES, that fit between the Hunter/Gatherer economic system and the Horticulture/Agriculture economic system. We also feel that because the resources found in PLACES are manufactured and maintained (a combination of botanical and zoological park-like, garden settings) they were created through socio-economic systems much more complex than any optimal abstraction of foraging.

4) Looking back in time, what is the ancestry of these PLACES? Do they extend all the way back to the end of the bifurcate tool tradition? Answer: we don't yet know. Looking forward, do elements of these PLACES exist in today's landscape? Answer: yes, they are all around us—we walk through them every day.

In Delaware, These Things Are Still Here

In Delaware, we do not have the luxury of paper records of large, government sponsored pre-settlement land surveys like the ones discussed in the above witness tree surveys. To assemble vegetative data around known Native villages and basecamps, we have to do our own surveys in today's environment. In the past three years we conducted a dozen such surveys and found meaningful results. We organized our results into essays, with maps, and GPS coordinates of the plants and clusters of plants that we believe constitute definable catchment areas. Our recent surveys in Delaware have presented detailed and reproducible records of some of the plants and clusters of plants, and shellfish beds (clam gardens) that we think are remnants of these ancestral Native American PLACES.

To date, our largest identified plant cluster is a planted, six-mile wide American Chestnut tree circle, surrounding the presettlement Native village known as Kuskarawack Towne on the Nanticoke

River (Mellin and Truitt, 2015b). Imagine, a circular nut grove encompassing an Indian town! Additionally, all the other important edible plant, utility plant, and medicinal plant clusters that we identified at that location, such as blueberry, yucca, and prickly pear, for examples, were located inside the chestnut tree circle. Our mapped survey data likely represent much more than simply planted and managed clusters of edible and medicinal stores, the data likely represents some form of organized Native Cosmos, an ancestral Native worldview. Accomplishing our Kuskarawack Towne survey was not for the faint of heart—we systematically walked a total area of twenty square miles. We were lucky on that survey because most of the land area we were able to survey was preserved in either State Park or by non-profit preservation programs.

We have discovered Chinquapin (dwarf chestnut) clusters found only at large basecamps and only at tidal river fording locations (Mellin and Truitt, 2014). We found a fifteen-acre pawpaw cluster on the lower Brandywine River where a leg of the old Susquehanna Trail joins a leg of the old Delaware Trail (Mellin and Truitt, 2013). The more elements of these PLACES that we find, the more it appears we are piecing together a series of manufactured landscapes, many demarking visible, information or navigational guides to important locations, just as road or trail signs on a map might function today.

Collectively, the witness tree surveys, the catchment areas, the anthropogenic landscapes, the PLACES, and all of the Ethnoecological examples contained within them are not considered hot topics at professional or academic conferences. However, we continue to point out that studying and protecting archaeological sites without identifying or understanding the ecological contexts in which they functioned is tantamount to collecting and storing random artifacts that have no provenience. Our idea of PLACES is an inclusive explanation. Native Americans certainly participated in these economic systems and they certainly made significant contributions in creating and managing sustainable landscapes that were much more productive than the natural or climate induced environments surrounding them. Our research demonstrates that in measuring both quantity and quality, Native Americans benefited by the fruits of their labors in constructing and maintaining these PLACES.

We view the current, general level of disinterest and the absence of public funding allocated to addressing these topics as affronts to the goals of our historic preservation programs. For living descendents of ancestral Native Americans, this unfortunate situation continues to misrepresent important aspects of their history, and obstructs the respectful stewardship of their worldviews.

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It's All About Teats And Hinds:
A Native American White-Tailed Deer Herding Economic Model

By Glen Mellin
1999, 2004 revised, 2009 revised

INTRODUCTION

Is there room in Delaware's Native American ancestry for a white-tailed deer herding economic model? Yes, of course there is! This paper attempts to fill the gap, a perceived absence of logical transition, or evolution between hunter/gather and horticulture economic programs.

Because white-tailed deer herding programs (whether real or imagined) have attracted little attention, we may have inadvertently discounted a wealth of fascinating social and cultural possibilities. To date, there is no direct archaeological evidence--no proof of a prehistoric white-tailed deer carnivorous or dairy economy. However, this effort is an attempt to jog our thinking about Native Americans and white-tailed deer beyond the predator/subsistence efficiency model into a subsistence/accumulation efficiency model.

This paper is not an easy read: it is very challenging! To open the passageway to this new challenge, we need to view accumulated white-tailed deer through the lens of three sexes. You read that right--three sexes: male, female, and gelding. Now, it's all about teats and hinds, a Native American white-tailed deer herding economic model.

THE RANGE AND DIVERSITY OF WHITE-TAILED DEER

White-tailed deer belong to the Order ARTIODACTYLA (even-toed hoofed mammals), with three surviving branches: the *Suina* (pig, peccary, and hippopotamus), the *Tylopoda* (camel), and the *Ruminantia* (tragulid, deer, giraffe, pronghorn, and bovidae). Deer, the Family Cervidae, divides into six subfamilies. Subfamily Odocoilinae, subgenus Odocoileus exists only in the New World. *Odocoileus virginianus* is the genealogical prototype, the species we call Virginia White Tail deer. From this prototype, L. L. Rue says, there are thirty-eight scientifically identified subspecies, and over one hundred genealogical breeds, or races, living in different areas of North, Central, and South America (Rue 1978:15). Given this extreme gene pool diversity, odds are favorable, I think, that Native Americans played some role in the diversity of white-tailed deer geography.

White-tailed deer seem to live everywhere there be adequate food, water, and agreeable temperatures. To the north, bitterly cold conditions restrict white-tailed deer habitat to southern Canada and Alaska. Deserts in the United States and Mexico also restrict habitat. Virginia white-tailed deer also live in Central America and the northern third of South America including the low to medium altitude portions of Peru. But, according to G. Whitehead, the southern Amazon basin and the Cone region of South America do not support white-tailed deer (Whitehead 1993:483). Other animals, like miniature deer, and camalids such as the wild guanaco thrive there. Most importantly, these South American areas were white-tailed deer populations are sparse or non-existent are frequently populated with the anthropogenetic alpaca and llama. These patterns in the presence or absence of ruminants as well as the variety of ruminant may have a culture/landscape connection. Are there other patterns?

When one overlays Alfred Kroeber's Native American "Linguistic Families" diagram (Kroeber 1923:figs. 16-7), with Whitehead's diagrams of thirty-eight subspecies of the white-tailed deer (Whitehead 1993:482-3), one may interpret—as I am inclined to interpret, similar patterns that may suggest some sort of connection between specific ranges of specific sub-species of white-tailed deer and the specific ranges of specific Native American root languages. A cautionary note—although scientists preferred to name newly identified subspecies of white-tailed deer after local Native American groups and/or perceived culture zones, one can not say the scientists were intentionally linking any particular Native American population with any particular Virginia white-tailed deer subspecies. Nevertheless, the following examples are so explicit they suggest culture/landscape connections: *Odocoileus virginianus yucatanensis* is the Virginia white-tailed deer living in the Mayan homeland while *O. v. toltecus* lives only in southern Mexico. Likewise, *O. v. seminolus* is the deer on the peninsula of Florida while *O. v. osceola* lives only on the panhandle. For these examples as well as a complete list of the thirty-eight subspecies consult the attached Appendix.

While comparing other information from the eastern half of the United States and Canada, even more bizarre patterns between the range of deer and the location of humans are noted. For example, Whitehead's diagram indicating the 'original" domains of the white-tailed deer called *O. v. virginianus* and *O. v. borealis* (Whitehead 1993:482-3) are (what I think is nothing short of breathtakingly) similar to Kroeber's map depicting a reconstructed geographic range of the Iroquois and Algonquian oral-language homelands.

There are many possible patterns that link Native American populations and the populations of their white-tailed deer. However, those possible patterns explain neither human economic choices nor the techniques used to exploit those deer.

When people invent different economic strategies to harvest deer, the associated economic benefits of those strategies can vary greatly. In the following section, I itemize the utility of deer hunting, herding, and ranching management techniques as I develop a progression in the complexity of economic programs, when humans harvest deer.

UTILITY OF DEER MANAGEMENT

This deer management outline uses three economic strategies: deer hunting, deer herding, and deer ranching. Tim Ingold, an anthropologist, developed a three-sided diagram to show how these different economic strategies are physically linked to each other. Think of an isosceles triangle with A at the top, B at the lower right, and C at the lower left angles. A is designed Hunting/Killing, B is designated Herding/Protection, and C is designated Ranch/Market. The line A to B represents subsistence, A to C represents predation, and B to C represents accumulation. Thus, subsistence and accumulation are the two legs of the triangle that identifies the herding angle (Ingold 1980:4).

If we were to integrate all known archaeological elements of Delaware's Woodland I Cultural Period (3000 BCE to 1000 CE) into Ingold's deer management triangle, the archaeological elements would align themselves more easily with the subsistence/accumulation aspect expressed through deer herding, and less easily with the subsistence/predation aspects expressed through deer hunting. Please note that in this paper, the Woodland I Cultural Period encompasses the traditional late Archaic, Early Woodland, and Middle Woodland temporal divisions. Now, let's take a closer look at how Ingold's diagram works.

The following examples of real life deer management strategies demonstrate the versatility and limitations of deer exploitation. For an example of deer hunting, I use a brief history of deer hunting in Delaware. For examples of concentrating and intensifying deer populations (minimal herding), I use an illustration from contemporary North Carolina and a description from colonial New England. I conclude this utility of deer management section with a contemporary deer ranch economic model from Saskatchewan.

In Delaware, colonists learned a hard lesson concerning deer, one that prehistoric people had obviously learned, or deer would not have lived in Delaware when the colonists arrived. According to David Small, legislation passed in 1740, for the three counties of Delaware, prohibited deer hunting from the first of January to the first of August (after the rut and through the birth and nursing seasons). Nevertheless, there were fewer and fewer deer until there were no deer left. In Delaware, deer hunting was suspended from 1841 until 1953 (Small 1996:15). Today, as a result of selective harvest management, there are more than twenty thousand deer living in Delaware. To explain this phenomenon, we need to understand two things: first, what are the reproductive mechanics of deer populations, and second, how do different harvest programs affect the replacement capacity of deer populations?

Members of protected white-tailed deer populations can live to be eight to ten years old. These deer, as a result of living in a secure and nourishing environment, can grow to weigh well over three hundred pounds, and Rue says, the world's record field dressed male white-tailed deer, from Minnesota, weighed four hundred two pounds (Rue 1978:130). But, because of Delaware's current management practices, members of Delaware's free-range deer population do not grow old, or large.

Ken Reynolds, from the Delaware Department of Natural Resources, organizes deer record keeping for the State of Delaware. He indicates during the 1995-6 hunting season (September 1, 1995—January 31, 1996) 8,778 white-tailed deer were legally harvested (Reynolds 1996:1). State officials recorded sex, weight, and antler development on that hunted harvest. During the 1995 calendar year, an additional 371 deer were reportedly killed by motor vehicles (ibid:12), but attributes of those deer were not systematically measured. Statistics on the 95-96 hunted-harvest is summarized below:

Seventy nine percent of the total known-age harvest was less than two years old. And, only seven percent were two and a half years old or older. Only forty percent of the total harvest was female (ibid:10), and only ten field dressed deer weighed greater than 199 pounds (ibid:2). These figures represent a young predominantly female deer population before harvest, only to be magnified after harvest. The number of quality bucks (established adult male deer with eight or more antler tines) in the overall population is low. Few deer live through three harvest seasons. The dynamics of Delaware's current hunting management program results in a young, fertile, and disease resistant deer population exhibiting greater than a thirty percent sustainable yield. Delaware's current deer management model represents a hunting management strategy based on predation and subsistence.

In areas where intensified or concentrated deer population programs are encouraged, but deer herding remains illegal, we see models similar to this one offered by North Carolina State University at their Internet site address (http://www.ces.ncsu.edu/wildlife). Their

"Standard Management Practices" includes the clear--cutting of woodland, 10 to 20 acres—not exceeding 40 acres (ibid:2). Good browse lots generate 2,000 to 3,000 pounds of forage per acre for a couple of years, but declines are expected when vegetation grows six feet high unless "thinning and prescribed burning treatments are applied" (ibid:3). This makes good sense--desirable vegetation must be within easy reach of the deer. These management practices do increase and concentrate deer populations. When humans frequent these project areas and behave in non-threatening ways the deer become accustomed, even inquisitive, to the activities of humans. Some people say these deer management practices constitute a form of minimal herding. However, most of the deer management models found on the Internet lack a stated mission—are these deer management practices for the benefit of deer, or humans, or both?

Another example of deer concentration and intensification comes from William Cronon's description of colonial New England. Cronon says many colonial settlers realized the Indians burnt extensive portions of meadow, fringe, and woodland to produce a mosaic of ecosystems (Cronon 1995:50-1). These manufactured landscapes performed two functions; they attracted desirable species of plants and animals, and they discouraged undesirable species (ibid:49). It is difficult to tell whether deer herding is a point expressed in these areas of landscape management. This is exactly why subtle telltale attributes of deer herding strategies are elusive. Nevertheless, one could assume an accumulation and subsistence economic base from Cronon's descriptions. Similarly, ancient landscape alterations in Delaware may have supported Native American deer herding economic programs that scheduled subsistence and accumulation.

White-tailed deer ranching is becoming increasingly popular. Were it is legal, it works! In Canada, for example, the Government of Saskatchewan organizes and maintains White-tailed Deer Financial and Production Information at its Internet site address (http://www.agr.gov.sk.ca/saf/live/97wtd). Currently, a number of sections of the Provincial government in Saskatchewan are devoted to enhancing and further developing their white-tailed deer ranch/marketing maintenance programs. The government produces brochures, which describe how to raise investment capital, where to buy breeding stock, and where to sell marketable deer and deer by-products including mountable trophies. This is deer ranch/market economics, and it should be easy to see that accumulation and predation are the economic strategies behind this deer harvest program.

Another aspect of humans protecting deer populations, regardless of whether hunting, herding, or ranching economic programs are expressed, is deer predator suppression. I am assuming deer predator suppression would be a planned effort or preoccupation within the deer herding and/or deer ranching economic models. Nevertheless, I am not willing to rule out opportunistic deer predator suppression within the deer-hunting model.

A deer-herding model would schedule an increased deer security program addressed through predator suppression. One example of deer predator suppression may have been identified when Custer illustrated the Native American artifacts found with a child burial at the Island Field Site, 7K-F-17. At that site, inhumation number sixty-one was prepared and/or laid to rest in association with a fore-set of five claws from an adult Puma (*Felis concolar*). The Puma is thought to have been of local origin (Custer et al. 1990:47).

In sum, deer hunting, deer herding, and deer ranching require different levels of human involvement. Deer populations are easily manipulated. Sex and age distributions within a deer population can be scheduled to produce a desired yield. If yield is ultimately the end result of all of these economic programs, then we need to take a closer look at measuring the quality and quantity of white-tailed deer yield. Is yield predictable?

IS WHITE-TAILED DEER YIELD PREDICTABLE?

In the previous section, utility of deer management, I addressed three different levels of white-tailed deer management--hunting, herding, and ranching. Since a variety of deer hunting as well as deer ranching models are currently in use, predictable levels of yield can be compared to actual observed levels of yield. But, predicting yield through deer herding is quite a different matter. Deer herding in the United States has been and continues to illegal. I have been unable to find any Native American white-tailed deer herding model other than my own. And, the few contemporary models that describe an intensification and concentration of deer populations, while lacking a stated purpose, seem to focus specifically on improving the quality and quantity of deer food through enhanced habitat within a circumscribed area. These models rely on successfully manufacturing overlapping deer family home-ranges.

Home-ranges and other elements of deer habitat and behavior will become apparent deeper within this essay, but simply improving the quality and quantity of deer food and habitat does not schedule a sustainable yield. A structured plan that calculates input and output, the frequency and duration of browse lot maintenance and the schedule of extraction or yield is absent.

Some aspects of deer herding must be like deer hunting, where skins, bone, and meat are obtained and either consumed or distributed. And some aspects of deer herding must be like deer ranching, where pregnant does, gelded males and antlered males constitute an inventoried collateral. From here on out, I borrow attributes from pastoral models involving other forms of ruminants, such as llamas and reindeer to flesh out a simulated white-tailed deer yield prediction for my white-tailed deer herding landscape model. I hope the reader will appreciate a herder's preoccupation with input/output equations and the extensiveness of social bond building in herding economics.

To get at the core of input/output, economists frequently use an economic equation called a production function. Production functions measure the degree of instability, or yield in a population. A stable population is an old population, a population with low yield. Conversely, an unstable population is a young dynamic population with high yield. James Simpson says input/output equations that express yield are framed around the Law of Diminishing Return (Simpson 1988:23).

I created a hypothetical white-tailed deer population curve that seems to me to be adequate no matter whether a hunting, herding, or ranching model is examined. Premature death is not addressed in this hypothetical population curve. The population curve is designed in three stages and addresses the age/weight ranges throughout the life of a deer.

The three stages are as follows: first, birth through adolescence, second, adulthood through maturity, and third, maturity through decline. Seasonal weight gain/loss, sexual dimorphism, and the process of gelding males will dramatically affect the quality and quantity of yield. Those physiological characteristics of white-tailed deer will be addressed in the following section.

Stage one spans from birth through adolescence or until the successive seasons' births appear (age zero to age one). Within the first year of life the female deer may grow from approximately four pounds to approximately eighty pounds (a twenty fold increase in one year).

Stage two spans from adulthood through maturity or until the growth rate is arrested (age one to age two and one half). Within this one and one half year period the female deer may grow from approximately eighty pounds to approximately one hundred sixty pounds (a two fold increase in one and one half years).

Stage three spans from maturity through decline or until death (age two and one half to age six and one half). Within this four year period the female deer may experience no weight gain at all (a zero fold increase in four years).

An excellent example of a stable free-range white-tailed deer population, Dale McCullough calculates, is a maximum per annum sustainable yield of forty-four out of one hundred animals with a residual population of fifty-six. The population yield represented individuals from my hypothetical stages one, two, and three. McCullough identified an aggressive yield core area in stage one that spanned over the duration of his study between eighteen and forty residual animals (McCullough 1982:538-41). McCullough's study was based on an isolated deer population that was not impacted by human hunters. The population yield (deaths) occurred as a result of natural free-range mortality and morbidity caused by indigenous wild predators. Predator related morbidity on a free-range population may be realized on the basis of opportunity. Morbidity can occur in stages one, two, or three, however, increased morbidity is expected early in stage one and late in stage three.

A protected deer population may experience yield (extraction) in a dramatically different fashion. A herder's rate of population extraction may be more or less spread out along stages one, two, and three, but the age/sex ratios of extraction within each stage would be carefully calculated to increase yield. These calculations would focus on culling individuals with depleted growth potential and providing good habitat and security for individuals with accelerated growth potential. For example, the herder would find it economically counterproductive to keep females past their reproductive prime. Additionally, geldings would not be allowed to reach stage three because the food that they eat could be applied to a younger individual with greater growth potential. Thus, the herder's goal would be to expand the positive growth margin expressed in stage one as much as possible while extracting the neutral margins of geldings at the end of stage one and females past their prime in stage three. When a herder's goal is maximum yield, nearly a one hundred percent per annum population replacement can be achieved. We can explore the following real life example of small herd management to simulate a Woodland I herding economic landscape model for Delaware.

An excellent example of non-white-tailed deer small herd management is from the llama herding families of Peru. Kent Flannery, Joyce Marcus, and Robert Reynolds developed computer models that replicated actual field observations of the Peruvian llama pastoral economic system. These models are important for two reasons. Virtual animals were successfully fashioned to mimic real animals (property), and simulated human interventions were fashioned to mimic how real people (culture) interacted with the herd (Flannery, Marcus, and Reynolds 1989:128-41).

To quantify a minimal sustainable llama herd (a minimum reproductive core), Flannery devised three computer models, which eventually became known as the "Oliver Twist," the "Santa Clause," and the "Surf City" models (ibid:128). Each model involved a virtual herd for a period of one hundred years, starting with four young female and two young male llama. Into each model, Flannery factored different consequences from his lists of observed behavior; mortality due to predators, theft, mange, gift giving, and gift receiving, and the routine consumption of geldings.

The Oliver Twist model runs initially experienced a population explosion, but, due to male population bias, they quickly ran down to zero. However, in the Santa Claus model runs, every time the female population hit three individuals, a young female was gifted into the herd. The Santa Claus model runs achieved a mean of 22.5 animals, and they ran for one hundred years. Those models runs survived the test of time, but the computer gifted many more females into the herd than was observed in the field. The Surf City model runs achieved a mean of 22 animals, and they also ran for one hundred years. The Surf City model runs progressed very near actual field observations for two reasons. Every time the female population hit three individuals, a young female was gifted into the herd, and geldings were either eaten or gifted out of the herd to maintain a desirable population proportion, as the Beach Boys once said, "two girls for every boy" (ibid:139-41). As one can imagine, it would be impossible to maintain that delicate population balance if not for a seemingly constant transfer of wealth and social security through llama gift giving. In fact, gift giving is the foundation of Peruvian herding society. They call it "Sunay" (ibid:128-41).

Sunay social strategy, which involves giving and receiving live llamas, protects the Peruvian pastoral economy. Sunay is an egalitarian form of gift exchange, a transfer of social security (even to fictive kin if necessary) that ensures the availability of llama breeding stock where and when it is needed. For example, if someone's llama herd is failing, for whatever reason, a neighbor or even a suitable stranger is obligated to give prime breeding stock to the stricken herder. Likewise, the stricken herder is obligated to assume a social debt in breeding stock. Thus, Sunay is an egalitarian, network-building, obligatory system of exchange and redistribution. Transient wealth, in the form of llamas, is circulated through the network by gift giving and debt receiving, knitting together communities of herders.

From Flannery's examples, we learn two vital consequences of small herd management. First, small herds work, but they require carefully thought out maintenance. Specified sex proportion within the herd must be maintained in order to perpetuate a sustainable yield. Second, a breeding stock exchange network is obligatory. Due to the consequences of accumulation, public feasting on culled geldings becomes more of a requirement and less of a luxury. Geldings are for eating, females are for breeding, and the odd male is only needed for his sperm contribution. Flannery's examples show that herd maintenance and obligatory human social systems are necessary to perpetuate small herd pastoral economies. Peruvian Sunay social strategy is just the type of human choice that may have perpetuated deer herding in Delaware's Woodland I time frame.

Delaware's white-tailed deer would have been well suited for potential Woodland I herding harvest programs. Indeed, a pastoral interpretation of the environmental and cultural attributes of the time period encompassed by the Woodland I period lends itself to a potential explanation of Native American herding harvest programs. To review these attributes, I call upon a bifurcated approach to the white-tailed deer--first, aspects of white-tailed deer biology, and second, aspects white-tailed deer behavior.

ASPECTS OF WHITE-TAILED DEER BIOLOGY

When I was developing this white-tailed deer-herding model for Delaware's Woodland I period, I realized there were significant aspects of white-tailed deer biology that had either been poorly addressed or were largely absent in traditional archaeological literature (Mellin 1997). I was not so much concerned about understanding the minute details of deer biology as I was concerned about figuring out how deer biology might have influenced the day to day, season to season, and year to year lives of the ancient people who depended on them for sustenance.

Although all of the following biological aspects of white-tailed deer could and should be addressed by anyone who wishes to argue the Woodland I period from a hunter/gather perspective, I view these biological aspects as being absolutely critical for anyone exploring the Woodland I period from a herding perspective. These aspects are: first, the white-tailed deer's diet and digestive system, and second, the white-tailed deer's physiological cycle. Lets begin with the deer's diet and digestive system.

All ruminants, including the Virginia white-tailed deer have a multi-chambered digestive system. Such specialization permits the deer to graze and browse quickly in open or unsheltered settings, and later, in more secluded setting, deer regurgitate and re-masticate their forage in a process called cud chewing. Cud chewing permits a deer to fully extract nourishment from hurriedly gathered or marginal quality vegetable material while presenting minimal exposure to predators and the elements. The ability to chew cud is the principle

biological specialization that allows all ruminants to produce and deliver milk, in such quality and quantity, that humans are able to exploit a ruminant's lactation process for their own benefit without causing harm to the milk producer.

Deer are highly selective in what they choose to eat. When grazing on legumes, forbs, and grasses, deer select drought resistant and weed resistant varieties with the highest protein, carbohydrate, and caloric content. Undigested seeds from those edible plants are expelled in the stool, thus providing a prime location for the enhancement and proliferation of desirable and nutritious deer food. Additionally, the surface soils of fringe environments and browse lots are churned by the hoofs of deer, which aerate the soil and bury undigested seeds.

When I compare and contrast my browse lot areas to surrounding naturally wooded areas, I see that my browse lots exhibit a marked increase in the number of plant species that are considered to be edible and nutritious deer food. Even though most if not all of those plant species are considered to be pioneering or emergent plant species, for example sassafras, grape, persimmon and a host of edible weeds. I wonder what percentage of those plants could have been introduced into my browse lots through deer manure?

It seems likely that humans and other animals participate in this process as well, for example birds might leave droppings containing blackberry seeds when they fly into the browse lot areas to eat black cherries or fox grapes. Additionally, both amaranth and chenopodium achieve a quick start on newly cleared browse lots. Those are among the kinds of plant seeds one would expect to recover from Woodland I archaeological contexts. Those plant species are also among the species one would normally classify as naturally occurring and/or climatically supported warmer/dryer, or xeric terrestrial landscape vegetation.

My simulated pastoral landscape model for Delaware's Woodland I period predicts there should be some sets of archaeological, or other environmental evidence, demonstrating either increased quality or increased quantity of those naturally occurring wild plant, herb, and weed seed varieties. I am not arguing the absence or those plant species in natural settings, but I am arguing the relocation, intensification, and selection of those plant species at archaeological sites, or anywhere an enduring Native American presence happens to be found. Those complex issues are underscored by the possibility that, at anytime in any place, a Native American use, or intensification, or a seeming proliferation of wild plant species may have benefited the deer population on a principal basis, and may have only secondarily benefited the human population when, or it, the humans consumed the deer.

Deer thrive on a variety of naturally occurring vegetation, but deer also crave cultigens like rice, beans, wheat, barley, corn, pilaf, and squash to name a few. One can not say that ruminants or any other Artiodactyla helped develop those cultigens, however; once cultigens became established, humans and ruminants often competed for those genetically improved vegetable, fruit, and grain resources.

How should one view these even-toed, hoofed animals? Are they an economic asset, or are they an economic debit? Today, ordinary, everyday people illustrate examples where pigs in the Middle East are demonized, or the cattle in India are deified. The varied forms of ideologically derived connections between Ariodactyla and humans may demonstrate more than the consequences of overlapping environmental niches. They may demonstrate competition for cultural efficiencies. It is certainly possible that humans and ruminants stepped into new and improved environmental and cultural niches in a sort of partnership, a symbiotic relationship. There is little doubt other things began to pile up around the yard that could unexpectedly be stepped into.

L. L. Rue says, white-tailed deer defecate about thirteen times a day (Rue 1978:398). The indigestible portion of what deer eat is mostly fiber, the residue of weedy and leafy vegetable material. Mixed in with this material are silica phytoliths, spherolites of calcite, pseudomorphosed calcium oxate, and other chemicals like phosphates. All of the above "stones", chemicals, and elements are measurable expellants of the digestive system and they are characteristic in all ruminants. If those fine particles were recovered from Woodland I sites, then we would need to address their presence from a herding perspective.

According to J. E. Brochier, phytoliths measure ±75 microns, spherolites measure ±30 microns, and calcium crystals measure ±20 microns (Brochier 1983:144-5). He claimed elevated accumulations of those fine particles along with concentrations of phosphate were associated with prehistoric browse lots at Old World archaeological sites (ibid:145). In the soil of Woodland I sites in Delaware, we routinely observe silica phytoliths and concentrations of phosphate, however; neither calcite nor calcium nodules have yet been observed. Furthermore, I'm not aware that anyone has ever look for them. At any rate, it may be likely that those very small particles quickly dissolve in Delaware's acidic soils, but we will never know unless someone looks for them. Do links between the tangible attributes of soil development within ancient landscapes, herding harvest programs, and the people on the landscape exist? In an effort to gather more clues about deer and people on the landscape, lets now take a look at elements of the White-tailed deer's physiological cycle.

Some ruminants, like sheep, goats, bison and other members of the bovine group grow horns out of the top of their skull between the ear and the eye. Those horns, like hair and hooves, are made of proteins. They stay attached to the skull for the life of the animal. But deer are different. In free-range white-tailed deer, male deer grow antlers and female deer do not grow antlers. Males grow a new set of hard, bony antlers every summer, and those successive antlers are cast away in late winter or early spring.

Both male and female deer are equipped with pedicles, or antler roots, one on each side of the skull, between the animal's ear and eye. On pre-pubescent deer of either sex, their respective pedicles are indistinguishable. However, when testosterone is produced in the male deer, during the onset of puberty, the antler cycle commences. When the antler growth cycle is triggered, the pedicle is reformed. As the antler grows out of the top of the pedicle, the pedicle corresponding and permanently broadens and becomes flattish. The new pedicle shape, G. A. Bubenik and A. B. Bubenik say, is retained in "trophic memory" when the first and subsequent antlers are cast each spring (Bubenik and Bubenik 1982:100-1).

If the male deer is gelded, however, before the onset of puberty, the antler cycle will not commence and the antlers will not appear. The gelding's pedicles will continue to be indistinguishable from a female's pedicles. Thus, when we observe a deer skull or antler base, either contemporary or one from antiquity, several important pieces of human dietary and economic information may be revealed.

Take the case of the antler. An antemortem antler that is cast from a living deer is fairly flat at its base, and the plane of antler detachment will next perfectly with its opposite, the skull pedicle plane. However, there are at least two methods humans may use to detach an antler from a deer skull regardless of whether the deer is living or dead. One method is to cut the antler off of the skull of a living or dead deer, a process, which may leave telltale cut marks on the skull and/or the antler. Another method is to break the antler off of the skull of a living or dead deer, a process which leaves telltale breakage marks on the skull and/or the antler. Since the antler/pedicle joint is stronger than either the antler shaft or skull, when the second method is employed, either the skull below the pedicle plane, or the antler above the pedicle plane will fail. In either case the pedicle will remain attached to the basal portion of the antler shaft. Fracturing and breaking away the skull section containing the pedicle of a living deer likely will result in the death of the deer.

When antler shafts or antler tines are recovered in archaeological context, some people leap to the conclusion that the deer was killed and consumed by humans. But in fact, an antler shaft may clearly show it had been cast by a living deer. Furthermore, the particular male deer that cast the antler may have cast six or more sets of antlers during his lifetime. Since the left or right antler typically is cast several days apart, pairs of cast antler are rarely found. Rodents and other animals find and gnaw away at deer antlers and other bones in an effort to recover their valuable mineral content, however; the telltale signs of gnawing should neither dictate the circumstances of the antler's introduction to material or spiritual culture, nor dictate the circumstances of its former curator.

The other side of this argument is this: if one were to recover an adolescent or adult deer skull from an archaeological context and its pedicles, due to lack of testosterone activation, appear to be female, who's to say the skull did not actually belong to a gelded male deer? Asking that question may be like throwing a monkey wrench into the gears of a seemingly smoothly running machine, but its purpose will become crystal clear.

In sum, hunted animals fall into one of two sex categories, male or female. But herded animals fall into three sex categories, male, female, and gelding. The practice of gelding is a very important issue when it comes around to calculating yield. If you count only the individuals in your potential deer harvest, you could unexpectedly starve to death, but if you count both individuals and calories in your potential deer harvest, you may be able to forecast you own future.

High sustainable yields in white-tailed deer populations are possible because of this deer's phenomenal reproductive capacity. In Nebraska, a recent study produced the following birth statistics for free-range white-tailed deer. When a doe gives birth, before the age of one—she usually has one fawn. After the age of one she has a twenty-one percent chance of having a single fawn, a sixty-seven percent chance of having twin fawns, and a twelve percent chance of having triplet fawns. However, natural and predator-related mortality and morbidity claims about one out of three fawns in the first year of life. Still, these figures are remarkable because they forecast at least a thirty percent population replacement capability in free-range white-tailed deer (The White-tailed Deer 1996:3). This kind of information expresses yield figures that an Archaic hunter/gather economic program or a subsistence/predator might experience. Nevertheless, a white-tailed deer herding economic program should be able to maintain a one-hundred percent herd replacement capability, providing neither gelding or male herd members are permitted to reach maturity, per annum. This reinforces why herders geld the males they plan to eat—gelding herd members allows herders the luxury of not having to eat their breeding stock. Ensuring that all of your breeding stock is either pregnant or in milk is the diesel engine of herd member replacement.

Breeding stock, or female herd members go through a yearly physiological cycle. The cycle begins with estrus, the period when a female deer is fertile. It is necessary for a fertile male deer to mate with the fertile female deer in order for the female deer to become pregnant. Conception dates vary according to climate and latitude, but for Delaware, most people assume the period of conception is during the month of November. I think most people assume November because that is the period when the rut is most noticeable. With the normal gestation period for a white-tailed deer being exactly two hundred days, some problems in reproductive schedule for deer in Delaware need to be discussed.

In Delaware, baby deer are born as early as the month of March. My earliest sighting this year, three adults with five newborn, was on March 11th. If the two hundred day gestation period is accurate, these females could not have been impregnated later than August 24, 1999. Nevertheless, some deer in Delaware are born as late as the month of June. Obviously, further work needs to be done on Delaware's white-tailed deer birth statistics. Some of that work needs to be sensitive toward figuring out whether these birth anomalies are normally distributed or whether some of these birth anomalies are a product of culturally induced genetic manipulation.

Milk production and delivery in the white-tailed deer starts during the birth process. The newborn deer, numbering between one and three, depending on the age and health condition of the mother, drink milk from either of the four teats of the mother's mammary glands. Surrogacy is uncommon.

Nursing deer cannot directly digest their mother's milk. Milk, upon entering the first chamber of the infant's stomach, comes into contact with rennet which is secreted from the infant's stomach lining. The mixture of milk and rennet ferments and turns into yogurt. The fully fermented yogurt is then digested and passed through the remainder of the gastrointestinal system. When a fawn is only three week old, it may begin nibbling vegetation in addition to suckling. It normally takes about four months before the mother deer refuses the juvenile offspring(s) a free lunch. However, fawns can be early weaned at three months and partially weaned even earlier. By aggressively demanding milk, the mammary glands of the white-tailed deer will continue to produce milk until just prior to estrus (ibid:3).

If one does the arithmetic, a mother white-tailed deer can successfully wean her fawns and continue to deliver two pints (two pounds) of deer milk every day for, at best, an additional fifty day before estrus. If her newborns are slaughtered, a good white-tailed milking doe is theoretically capable of delivering two pints (two pounds) of deer milk every day for approximately one hundred and fifty days, or an equivalent of twice the body weight of the mother deer.

Once extracted and dried, small pieces of a newborn deer's stomach can provide enough rennet to make a huge amount of yogurt, providing one has sufficient containers both to collect fresh deer milk and to ferment the yogurt. A number of other dairy products can be made from white-tailed deer milk, for example deer butter and deer cheese. Deer cheese can be press dried and stored for long periods of time. The reindeer herding Sami are fond of saying the old cheese should kiss the new cheese, suggesting that not only does some cheese last the year round, but the cheese bacterial cultures should be transferred from batch to batch, year to year, and from community to community.

My own search for literature on cervid milk and milk byproducts failed to uncover any documented evidence pertaining to dairy economics of Native Americans in North America prior to the arrival of the Europeans. Just because my search happened to turn out negative, doesn't mean that it did not happen, it only means white-tailed deer dairy economics hasn't been found yet (Mellin 1997).

While investigating the dental pathology of inhumations from the Island Field Site in Kent County, Delaware (7K-F-17), Custer reported, in 1990, not only did thirteen percent of all erupted permanent teeth have at least one carious lesion (tooth cavity), but incidences of antemortem tooth loss, periodontal disease, and apical abscesses appeared in unexpectedly high numbers (Custer et al. 1990:41-4). The Island Field population's incidence of carious lesions was compared to C. G. Turner's baseline study of dental indications, which compares the relative frequencies of carious lesions from hunter/gather, mixed economic, and agricultural economic programs.

Custer found, "The Island Field population had a frequency of carious teeth which was greater than all of the hunter/gather or mixed economies in Turner's data. In fact, the Island Field frequency was higher than the median frequency for agriculturalists" (ibid:42). Could the Island Field dental pathology represent something that was not found on Turner's chart? Could the consumption of milk and milk byproducts have been responsible for the relatively poor dental condition on the Island Field population? How would we know? How could we test for milk fat lipids in Native American contexts?

Residues of deer milk could be saturated into or adhering to objects like ceramic containers, stone bowls, or even whelk shell cups like the ones found at the Island Field Site (ibid:46).

Yet, deer milk and milk byproducts are only a few examples of how members of herding families could have exploited the biology of white-tailed deer to increase scheduled yield.

Scheduled exploitation of the deer's physiological cycle can effectively double nutritional yield. It is not just the amount of meat--it is the quality of the meat that is important. And, the quantity and quality of the meat on a deer changes from season to season and from sex to sex throughout the year. That is one reason why, when the hunter returns and exhibits the kill, everyone asks, is it fat? White-tailed deer loose a considerable amount of weight during the winter months.

Over the winter months, it is not uncommon, Gary Dusek explains, for a female deer to lose between ten and fifteen percent of her body mass, and for males, twenty to thirty percent (Dusek et al. 1989:21-2). Reindeer are comparable to white-tailed deer on the basis of cal/kg fat in the meat, on a gender basis, however; reindeer and white-tailed deer are directly comparable on a species basis. Arthur Spiess conducted the following gender and season calculations of cal/kg of reindeer fat. Spiess's argument is this: 1) a 110 kg buck in September provided 76 person-days of nourishment, 2) the same buck, having lost his fat during the rut, weighing 90 kg in December provides only 15 person-days of nourishment, and 3) an 80 kg doe in December, having not lost her fat, provides 34 person-days of nourishment (ibid:28-9). During the winter months, on a cal/kg basis, female deer and gelded deer can yield twice as much nourishment, pound for pound, than male deer. Thus, any ability by Native Americans to schedule consumption of deer meat according to gender and physiologic cycle would be a critical advantage over an inability to schedule gender bias consumption.

Scientific studies about white-tailed deer are numerous and interesting, but the ones that claim to interpret the pathology of white-tailed deer teeth have been particularly disappointing. The availability of quality food and overall environmental conditions cause extreme differences both in tooth growth through the lens of measuring overall tooth height and leveling. Most scientific studies cite the first age group of white-tailed deer permanent teeth as six months old and two and one half years old. Typically, these scientific studies also indicate that season of death can be reliably restricted to a six month period based on the probability of death occurring in one or another of two consecutive yearly quarters.

While Bryan Gordon was studying the teeth of reindeer, he cited disrupted and absent cementum layers in the teeth of pregnant reindeer. These cementum disruptions are probably affected by the pregnant female's restricted available metabolic protein (Gordon 1988:19). Additionally, cementum layer increment disruptions (rutlines) were thought to exist in male reindeer due to metabolic disruptions associated with the breeding season (ibid:22).

While Cherie Clark was studying teeth of ancient white-tailed deer in Oklahoma, she identified problems due to the lack of differentiated cementum annuli. A large portion of her deer tooth assemblage (deer that were harvested at the McCutchan-McLaughlin site, 34Lt-11, ca. 1500 BCE—1500 CE), she says, belonged to deer that were harvested before they reached the age of one (Clark 1987:37-42). Certainly, any analysis of yearly cementum ring layers on deer teeth that are less than one year old has its limitations!

Clark isolated two different deer bone yielding archaeological components at site 34Lt-11. The white-tailed deer remains in her component A (late Wister phase ca. 637 BCE—302 BCE) was separated from the white-tailed deer remains in her component B (early Wister phase ca. 1228 BCE—916 BCE) (ibid:21-2). When she compared the weight groups of harvested deer in the two components by measuring the deer's Astragalus bone, she found a meaningful difference (ibid:43-55). The ancient people (consumers) represented in component A were harvesting a high percentage of middle aged and old age deer, while other ancient people (consumers) in component B were harvesting a high percentage of young and middle aged deer (ibid:36). Now, that is interesting because it may reflect different deer-harvesting economic programs.

Even though Clark assumed a hunter/gather harvest program for both components A and B, I believe she is correct in assuming that these two sets of ancient people were using very different methods of selection or extraction in their deer harvests. Unfortunately, Clark neither addressed the issue of gelded males nor white-tailed deer herding economics in general.

Clark's age/weight harvest information for component A is what I would expect to see in a predator/subsistence distribution; conversely, I would expect a subsistence/accumulation distribution to resemble the age/weight information represented in component B. I do not have a problem with Clark's interpretation of component A, the component that I think resembles the predator model, being newer than component B, the component that I think resembles the accumulation model. An economic intensification that I suggest for component B may have simply ceased to function, at somewhere around 800 BCE, for any number of reasons.

It is interesting to note, however, that while Clark approached components A and B from a predator/subsistence economic assumption, she identified component A as the one revealing economic intensification, while I, approaching the same data from a subsistence/accumulation economic assumption, identified component B as the one revealing economic intensification. We applaud

Clark for her detailed and important analysis, but with my "outside the box" thinking, I have to readdress the implied meaning of these questions: what does intensification really mean and how do we measure it? Maybe my difficulty is self-inflicted--I just can't seem to get my brain wrapped around intensification without addressing accumulation. Approach *means* everything!

I have thus far successfully avoided the quagmire concept of white-tailed deer domestication, which by most people's standards indicates some degree of genetic manipulation. No measurable difference has yet been identified between ancient white-tailed deer and contemporary white-tailed deer from the same geographical range. I have to some degree addressed the concept of genetic diversion, but only at the sub-species (biologically identifiable) and land race (culturally identifiable) levels. The question of whether white-tailed deer genetic diversification is a function of nature or culture or both, as yet, is an insurmountable task. Now that we know which deer to protect, which deer to eat, and when to eat them, we need to know where to find them.

ASPECTS OF WHITE-TAILED DEER BEHAVIOR

White-tailed deer spend about 90% of their time in their home range, an area or landscape where a deer lives. The size and location of a free-range white-tailed deer's home range depends on the quantity and quality of naturally occurring food, water, and general security against the elements and predators. Yet, when humans manipulate the landscape, we can increase and concentrate deer populations by manufacturing more highly productive and secure home ranges.

There are several reasons home ranges for male and female deer are different sizes and shapes. Adult female deer observe a matrilineal nuclear family pattern that may contain from three to five deer, while adult male deer lead solitary lives. If, say, six to ten deer are feeding together they belong to at least two different families. As one looks for the subtle spatial gaps between families, smaller groups of deer, and the individual adult male deer—deer societal rules will become apparent. An adolescent male deer within a typical nuclear family should exhibit small spiked antlers. But, during his second spring, when the new fawns start to nibble solid food, he leaves his mother's home range. He would be out on his own exhibiting a multi-tined antler rack and beginning to lead a solitary life.

Free-range white-tailed deer nuclear families usually have a home range in excess of sixty acres, providing there is an attractive mix of forest, meadow, fringe, and water. An ideal female home range, Paul Beier and Dale McCullough state, is shaped like a convex polygon (Beier and McCullough 1990:27). Male home ranges, however, tend to be three or more times larger than female home ranges, and their shapes vary. In attractive locations, white-tailed deer home ranges often overlap. Gary Dusek suggests that in an idealized setting with multiple overlapping home ranges, free-range white-tailed deer populations can approach one hundred deer per square mile (Dusek et al. 1989:57). From this population information, we generate these questions: Why is it important to understand how deer populations behave, and how is it possible for humans to manage small herds of deer without building corrals, stockyards, or fences?

When people ask me, "Do you think ancient deer were domesticated?" I say, "No, I think they were not—but, they can be socially imprinted as functioning members of the human family." In the modern world deer don't make very good pets. They don't react well to modern technology, like automobiles, Seven Eleven stores, and wire fences. But, then again, there is my Gracie's story!

When I was gifted my first baby deer, Gracie, she was a newborn orphan. Her placenta was still wet and she probably had never suckled. Since deer milk has more than two times the fat of goat's milk, I started feeding her a condensed form of powdered goat milk replacer. By the third or fourth day of bottle-feeding, she was becoming socially imprinted. She though I was her mama! Familiar things and routine occurrences comforted Gracie, and unfamiliar or scary things, like a gust of wind, lightning, and strange noises, frightened her. Gracie retained all of her wild instincts, yet she socialized very well with familiar humans and my various pets (dogs, cats, chickens, sheep, ducks, and geese). Gracie had no instinctual fear of the animals that she grew up with. But, she did have strong fright/flight responses to unknown entities like stray dogs, or unfamiliar free-range deer, and the unexpected or unexplained, like a clap of thunder or something as elementary as the breaking of a twig.

In the morning when I would go outside, if she were in range of my house, I would hear her baying as she would come running for her morning greeting. I would comb her hair, and she craved the attention when I groomed her for fleas and ticks. She loved to lick my arms, hands, and legs to obtain salt. She quickly learned that delicious persimmons would fall to the ground when I shook a persimmon tree. I thought it humorous when she would nose most of the ground fall under leaves, hiding them for later, and run to the next tree expecting me to follow and repeat the tree shaking process. In the wither time when she was eating a lot of acorns she would frequent my experimental browse lot fire hearths and scratch out and nibble small pieces of charcoal. I think eating charcoal helped reduce her wintertime digestive toxins like tannic acid.

By the time Gracie was one and one half years old, she was a beautiful and powerful animal. Whenever I sat or knelt to manipulate her teats, even though she was not lactating, she would lean-out and assume a good milking posture. She was inquisitive about what I was doing, but she did not find it disagreeable. A few strokes to the underside of her neck would calm her down, but any attempt to stroke the top of her neck or along her backbone area would result in abrupt repositioning.

I did not try to outfit Gracie with backpacks. I learned, however, that she tolerated carrying weight against her rib cage, but she would not tolerate weight on her spine. She was certainly physically capable of carrying weight in that position, but there again, if anything expected were going on in her blind spot she would abruptly reposition.

Gracie did not breed in her first physiological cycle. Every time she saw or even smelled a free-range buck in rut, she would run up onto my porch for security. She would snort and stop her front feet in consternation. But, when Gracie was one and one half year old, she seemed more interested in courtship. By March 1999, Gracie's belly churned with the kicks and twists of her unborn offspring, but such as modern times would play out, she was unexpectedly struck and killed by a motorist. My desire to observe the second generation of white-tailed deer social imprinting would have to wait.

Infant and juvenile male deer exhibit similar pre-pubescent behavior. However, by the time a male deer reaches puberty (five to six month old), he can become quarrelsome, even aggressive. One way to make male deer docile is to geld or neuter them before the onset of puberty. Unfortunately, Delaware state law prohibits the practice of neutering male white-tailed deer; consequently, I cannot offer first hand observations on gelded white-tailed deer. However, assuming that gelded white-tailed deer would behave similar to gelded reindeer, while their biological and behavioral attributes are similar to an assortment of gelded ruminants, the following characteristics are likely to be close approximation.

Castrated male deer would neither have the desire to be solitary nor would they be aggressive during the breeding season. Gelded male deer would behave similar to female deer, except that geldings would become fatter, faster than either normal males or normal females. Gelded deer would represent the subsistence and storage component, and breeding does and female fawns would represent the accumulation and breeding stock component of this Native American white-tailed deer-herding economic model.

BROWSE LOT MECHANICS

I see a double meaning is browse lot mechanics. First, there is the mechanics of cultural forces working on the environment, the cultural niche or the selective *improvement* of a local natural environment. Second, there is the mechanics of natural forces working on the environment, a natural *entropy* governed by climate, gravity, and the effects of weathering. For the purpose of this paper the two meanings, like Siamese twins, cannot be addressed as independent entities. The two meanings have to be addressed as a functioning economic unit.

I began constructing my own deer browse lots some twenty years ago. Initially, I had a desire to experience and experiment with the cultural and physical mechanics involved in altering naturally occurring environments. My goals were numerous. For example, I wanted to create and monitor fringe and colonizing herbaceous species that pioneered into my freshly cleared upland settings. I also wanted to see how those clearing affected the indigenous free-range white-tailed deer population. I built experimental wigwams, dug experimental pit features, constructed experimental fire hearths, and I monitored the decay process as all of these environmental disruptions weathered.

Members of the local free-range deer population began to spend more and more time in my fresh forest clearings. Quickly, I realized several deer families had adopted the forest clearings as part of their home range. As these forest clearings matured, a wealth of nutritious deer food was available for the deer and they made good use of it. In short order, deer foot tracks, deer manure, and browse cropping of emergent vegetation were commonplace. I seemed like all known deer trails lead to my browse lots.

My smallest experimental browse lot measures less than one half acre and the largest measures more than five acres. I found that the productivity of white-tailed deer browse lots generally quadruples for each doubling in size. Temperature and sunlight are critical factors. Small browse lots are poor performers. They are overly prone to drying out and overheating due to the lack of mast shade and arboreal ventilation. Even though browse lots of less than two acres will eventually be colonized by nutritious deer food, their productivity will continue to be limited.

A browse lot surrounded by a mixed hardwood forest might be colonized by emergent species found naturally, but in low frequency, within the adjacent forest. These browse lot colonizers would principally consist of pioneer and edge varieties of mid to low-level vegetation that the deer are most likely to consume. They include, but are not limited to sassafras, hickory, oaks, legumes, ferns,

lichens, blackberry, fox grape, weed seeds, cactus, and cherry. In short, these pioneering, edge or fringe communities may be classified as xeric community species; nevertheless, they are simply colonizing a small manufactured xeric landscape within a much larger natural non-xeric landscape. The specific environmental signature of my experimental deer browse lots closely resembles, in my mind, the previously discussed Woodland I paleoenvironmental reconstructions (3000 BCE—1000CE) in what is now the coastal plain of Delaware.

On my larger experimental deer browse lots soil particle movement is commonplace. Soil particles have a net movement downwind, but the shape of the browse lot and its positioning to the overall seasonal wind direction, wind strength, ground cover, and soil moisture are key determinants for soil movement. Low every atmospheric systems move soil particles along by drift forming sand sheets. In this case, the soil particles may not become atmospheric, and these subtle soil movements may not possess enough energy to produce faceted sand particles. It is one thing to say that the presence of faceted sand particles indicates wind blown soils, but as I have observed, one should never assume that the lack of faceted soil particles indicates an absence of aeolian soil particle movement.

Soil particles, such as sand, silt, and clay occur in different sizes with different surface area to mass rations. Consequently, proportionally less force is required to move the smaller particle than to move the larger particle. The re-arrangement of surface soil particles in my deer browse lots, less than five years old, exhibit significant soil particle sorting, evidence that some soil particles are moving further and/or faster than others. In fact, on a very windy day, clays, silts, and some sands may become atmospheric where they are blown off the browse lot out into the adjacent landscape. Deer browse lots are dynamic landscape features. Once constructed, browse lots may change size and shape, they may evolve on their own. If a dune develops out of the Aeolian sand sheet it can continue to move downwind into and ultimately overtake and kill an area of mature forest.

Since the soils of these altered landscapes have a propensity to move downwind, the migration of sand sheets, dunes, and dune fields may be interrupted or carried away by streams or rivers. These migrating soils may also colonize areas of stable flood plain. For example, in Sussex County, Delaware, ancient cultural items, indicating the presence of human domestic sites, and Aeolian sand sheets, which may or may not be the remains of ancient manufactured landscapes, may be found on both the upwind and downwind sides of steams and rivers. Today, riverine dunes and dune fields, some of which may be the remains of manufactured landscapes, are principally found on the downwind side of the streams and rivers. One way to rationalize this phenomenon is that these drifting soils, originating on the up-wind side of streams and rivers, may have been blown into and may have been carried away by the force of the water in these streams and rivers.

How might the location of a suspected ancient browse lot play upon the location of an ancient habitation site, or visa versa? Prevailing wind direction probably was one of the many factors people considered when the location of an ancient habitation site was selected. One example of how wind direction may have impacted human choice in site selection may be revealed in the present day arrangement of the riverine sand dune fields along the east side of the Nanticoke River in Sussex County, Delaware. Ribbons of sand soils are nearly continuous, adjacent to the Nanticoke river, for mile after mile. Human habitation sites, however, when and where they have bee identified, seem to be interspersed, not at regular intervals, but located at various aspects along the riverine and tributary environments. Furthermore, the location of many yet to be located habitation sites may currently be hidden, deeply buried by sand sheets and/or sand dunes. Thus, even if some known ancient habitation sites in this area are interspersed along the river bank uplands, the suspected browse lot sand sheet or dune field complexes may have encroached upon and buried other adjacent sites, inhabited or uninhabited, as well as any other potential browse lot, maintained or abandoned, along the prevailing downwind direction.

Even though archaeological sites may appear to be interspersed along the Nanticoke River and its tidal tributaries, their locations may be, more or less, connected to each other by Aeolian sand sheets. It has bee my experience, however, that riverine dune fields appear to occur on the fringe of site clusters and/or where the dunes became stabilized in their present-day location, hence, the present-day location of riverine sand sheets and sand dunes may define, in some cases, the special limitations where ancient sand sheets and sand dunes of cultural origin were trapped by enduring or natural vegetation. Is it possible that some of the ancient soils may define the immediate are of, or an area representing the cumulative effects of ancient white-tailed deer browse lot construction, maintenance, abandonment, and subsequent weathering?

A Native American presence may be found on, in, and sometimes buried under some of these riverine sand sheets and sand dunes. Where in the profile the native American presence occurs, if at all, largely depends on the soils' degree of activity and the soils' age. Items of cultural hardware, such as ceramic shards, or earthworks, in addition to items of cultural software, such as affiliation, or maternal generosity may all still be present. Items of Native American presence may also be located far out into the suspected deer browse lot areas and beyond. These cultural hardware items may resemble cutting tools such as knives or choppers, as well as cultural software items, some of which may have existed or may still exist to safeguard prosperity.

Even though W. Ireland and E. D. Matthews recorded sand dunes and sand dune fields on their USDA Soil Series maps for Sussex County, Delaware, sand sheets and some other, smaller and isolated Aeolian soils were not recorded. Most, if not all, of the wind blown sand sheets that were not identified as sand by Ireland and Matthews possessed too much loamy material to qualify as sand. Simply put, Ireland and Matthews excluded sandy loam soils, some of which may be culturally derived Aeolian sand sheets, from their mapping criteria because identifying and/or recording those soils was beyond their scope and purpose. A further discussion on Ireland and Matthew's scope and purpose is presented in the next section of this paper.

In the future, other methods of mapping and identifying Aeolian sand sheets may evolve, but as it stands, one has to physically go out in the field and identify them. If an Aeolian sand sheet *signature* could be identified, then a remote mapping program could be applied to areas of unknown or unidentified potential sand sheet locations.

The traditional criteria used for archaeological site identification and limit definition as described in CRF 36 section 106 may disallow the inclusion of a potentially significant culturally derived Aeolian sand sheet. For example, by traditional Anthropological standards, sparsely distributed cultural hardware items located within an Aeolian sand sheet may exhibit a minimal native American presence, nevertheless, the Aeolian sand sheet, or the potential deer browse lot, may actually be the remains of what lured the people to settle there in the first place and may actually constitute previously overlooked evidence of an unrecognized economic system. Finally, the potential existence of ancient manufacture landscapes and the over-arching concept of native American herding economics should at least be addressed by, if not integrated into, traditional research methods and record keeping.

A MODEL DEER HERDING SITE

Is the Native American site 7S-E-19 a model deer-herding site? The site is situated on the east side of the Nanticoke River on a relatively flat low bluff two meters above high tide in an historically unplowed mature forest of mixed hardwoods and conifers just north of Middleford in Sussex County, Delaware. Native American artifacts may be found deeply buried within the Aeolian sand sheets. The contexts of those artifacts belong to the ceramic making portion of the Woodland cultural periods. Currently the site is bordered on one side by the riverbank and surrounded on the other here sides by xeric landscape Aeolian sand sheet, xeric community vegetation, and a sand dune complex immediately downwind of the site. The age and location of this Woodland I archaeological site indicates it may have been integrated within an extensive series of similar sites forming a riverine community of similar households supported by similar economic agendas.

I first became interested in site 7S-E-19 late in the 1960s. During that time, I conducted limited excavations as well as gathering artifacts exposed in a logging road cut along the edge of the floodplain bluff, and later, during the 1987—1988 University of Delaware Center for Archaeological Research (UDCAR) southwestern Sussex County archaeological survey. Native American artifacts largely consisted of lithic debitage, triangular, notched and stemmed bifaces, shell tempered ceramic and clay tempered ceramic and fire—cracked rock (Mellin 1991).

The content of site 7S-E-19 seems to be similar to other Woodland period archaeological sites that may be found strewn out along the brackish and fresh tidal portion of the Nanticoke River. I found artifacts dating to the Woodland II component at depths ranging from 0-20 centimeters, and artifacts dating to the Woodland I component at depths ranging from 20-60 centimeters. Based on the styles of clay ceramics found within the two components, the Woodland II occupation was active from 1100 CE to about 1300 CE, and the Woodland I occupation was active from 400 BCE to about 400 CE.

Ireland and Matthews had classified the surface soils present at site 7S-E-19 as EoD, or Evesboro sand with 5 to 15 percent slope. My excavation demonstrated that Woodland II artifacts were located at the top of the Evesboro sand (EoD) column and the Woodland I artifacts were situated lower, in an older stratigraphic sequence, within the Evesboro sand context. This sequential evidence may be used to suggest that an Aeolian sand sheet was active at this locale during and after the 400 BCE to 400 CE Woodland I occupation. The position of artifacts exposed within the profile of my excavation indicated no appreciable sand sheet activity between the two components, or from 400 CE to about 1100 CE. Then again, there seems to be some sand sheet activity associated with Woodland II occupation of the site from 1100 CE to about 1300 CE.

What physical and/or spiritual attractions did Native Americans perceive in the location of site 7S-E-19? Were these attractions founded on the ecological productivity of the Nanticoke River's main channel tidal fresh water shoreline or as some refer to as Daiber's Transition Marsh Zone? The transition marsh zone is the ecological zone where the majority of the known Woodland I domestic settings in Sussex County, Delaware have been found.

The transition marsh zone is what I call the front door environment. It is clearly the richest and most useful natural environmental asset available in Sussex County during the Woodland I period. And, as Custer reports, it is evident that the attractive qualities of these Woodland I domestic sites migrated upstream keeping pace with sea level rise so that this front door opportunity would be maintained. So how did Woodland I xeric terrestrial landscapes interact with Diaber's tidal transition marsh zone?

Xeric terrestrial landscapes are what I call the back door environmental asset, a secondary asset, at these Woodland I domestic sites. The xeric terrestrial landscape may not have been less important than the transition marsh zone, it may have been more important during the critical winter season. Nevertheless, it is difficult to compare the attributes of these complimentary front and back door environments because they are so seasonally distinct. It is easy to contrast them because, on the one hand, the transition marsh zone exists in nature, and on the other hand, xeric terrestrial landscape may be in essence a manufactured economic landscape. Thus, the transition marsh zone may have been, more or less, a fixed economic element, but the xeric terrestrial landscape may have been, more or less, an ephemeral or mobile economic element.

At site 7S-E-19, as well as many other Woodland I domestic sites along the Nanticoke River's transition marsh zone, one can drive around in an automobile, or look at USDA soil series maps, to find the remains of these xeric terrestrial landscapes. Many of these surface soil features are clearly visible today. The soil of these landscapes is predominantly coarse sand because the finer particles, the silt and clay particles at some point in time had become atmospheric and were blown away. Sand dunes are sometimes located downwind, to the northeast, east, or southeast of these sand sheet areas. These pure sand soils host an unusual variety of xeric community plants among which are cactus, yucca, pink ladyslipper orchids, reindeer lichen, and box huckleberry (*Gaylussacia brachycera*). All of the above xeric community plants are found on the sand dune located immediately downwind of site 7S-E-19.

Based on the size and maturity of the box huckleberry located at site 7S-E19, I predict the age of that plant to be approximately one thousand six hundred years old. This date would place the origin of the plant at about the time (400 CE) of the Woodland I abandonment, weathering, and stabilization of site 7S-E-19. I also think this particular Globally rare variety of huckleberry, based on previous observations, prefers to grow on burned-over xeric soils, the kind of soils that might be associated with potential Native American deer browse lots. I take this opportunity to question whether the box huckleberry at site 7S-E-19 was planted by Native Americans at or around 400 CE or whether the plant's occurrence, was simply due to happenstance?

Custer and Mellin found that the location of Woodland I archaeological domestic sites found during the 1987—1988 southwestern Sussex County survey fit well with the present location of Sussex County's Evesboro sand surface soils (Custer and Mellin 1989:15). Evesboro sand in Sussex County, according to Ireland and Matthews, is either on of two types. First, EoB is sand with 0 to 5 percent slopes and second, EoD is sand with 5 to 15 percent slopes. Both types of sand are developmentally distinct from the larger and older Evesboro surface soil parent material series due to the sand's lack of organic content, poor soil structure, large particle size, and sorted soil content. These sands probably developed more recently than the parent material Evesboro sandy loam and Evesboro loamy sand series. Sand fields or sand sheets are noted along the Nanticoke river's transitional marsh zone in the vicinity of clusters of archaeological sites dating to the Woodland I period. These sand fields are of very local origin exhibiting a 0 to 5 percent slope and the downwind boundaries of the sand fields may be associated with sand dunes exhibiting a 5 to 15 percent slope.

When the USDA set out to identify and describe the soils of Sussex County, Delaware, including the surface soils of site 7S-E-19, its mission was based on the best contemporary use of the land it surveyed. In most cases the soils described in Ireland and Matthew's 1974 edition were meaningful for contemporary agricultural, waste water, well water, and developmental purposes. These soil descriptions were less meaningful for archaeological and environmental reconstructive purposes. Hence, Evesboro sand in Sussex County, Delaware was described according to slope, dryness, stability, and location, and was not described or mapped according to its specific age or specific origin.

Several other people, at several other times, have addressed the sand soils of Sussex County, Delaware for a variety of reasons. Three specific studies that I feel are relevant to this landscape synthesis are as follows:

In 1979, two geologists, Charles Denny and James Owens, reevaluated the geologic and climatic formation of the sand soils of central Delmarva. Their findings are significant for two reasons. First, they concluded that microscopic fragments of peat "suggests that the dunes on the uplands formed in a spruce parkland during the late Wisconsin glacial maximum," and second, "the river dunes may also be of late Wisconsin age, but could be Holocene" (Denny and Owens 1979:C1).

Denny and Owens offered excellent geologic and climatic explanations to what I have assumed for some time. Why do inland or upland sand dune features often exhibit very old archaeological sites, some dating back to 10,000 BCE with Paleo Indian artifacts exposed on their slopes and crest surfaces? Meanwhile why do riverine dune features and riverine sand sheet features often contain

much more recent archaeological sites, many dating between 3000 BCE to 1000 CE, layered inside them and sometimes layered under them? It does not take a rocket scientist to figure out that the sand features of Sussex County, Delaware lie in at least several different locations and date to at least several different time periods.

I believe some areas of EoB and/or EoD sand soils are truly of Pleistocene origin, but other areas of EoB and/or EoD sand soils are truly of Holocene origin. Knowing the relative age of cultural resources on, in, or under EoB and/or EoD sand soils provides relative ages of the sand soil formations themselves.

More recently, in 1995, Cara Blume presented her investigations on sand soil development on the Nanticoke River watershed, in Sussex County, Delaware (Blume 1995). After test excavating more than a dozen Woodland I period sites within the James Branch Watershed, she reconfirmed her bias away from strictly explaining Aeolian deposition and environmental amelioration in climatic terms. She correctly developed, I think, a strong link between large scales landscape alteration and the corresponding intensity of Woodland I economic activity (ibid:191-202).

During the time period between Clark, 1987 and Blume, 1995 I also took a look at sand soils, but on a much larger scale. I wanted to see how the soil type "signature" of the sand sheet at site 7S-E-19 fit into the overall trans-Peninsular picture. I created a huge map of all USDA identified sand soil locations for nine contiguous counties, constituting the bulk of the Delmarva Peninsula (Mellin 1993a and 1993b). The location and pattern of plotted sand soils mated exceptionally well to the State of Delaware's large database of known Woodland I sites (Mellin 1993c and 1993d).

I conclude this section by asking my favorite two questions. First, are there sufficiently large enough xeric landscapes in an otherwise non-xeric climatic zone to warrant the generation of sand sheet features and sand dune features? And second, if so, did Native Americans of the Woodland I period create and maintain those culturally derived xeric landscapes as white-tailed deer browse lots (Mellin 2000)? These questions follow for Delaware precisely what Cronon had suggested happened in New England and elsewhere; the likelihood of meaningful and durable changes in the land within a fractionally manufactured economic landscape (Cronon 1995).

CONCLUDING REMARKS

This paper suggests the potential herding of white-tailed deer in Woodland I times could have increased and scheduled the yield of deer and deer by-products. On the one hand, the female deer is a potential breeder, a potential meat and dairy provider, as well as potentially an item of social security—storable, inheritable, and exchangeable property. On the other hand, the gelded male deer is potentially a participant in the division of labor, potentially a meat provider, as well as potentially the preferred item of gift giving, feasting, or exchange.

Successful herding techniques can potentially double the head count yield, and gelding the ones destined to become winter stores can potentially double again their nutritional value. We see in community cooperation and social networking, as described in Sunay social strategy, that small herd management techniques are not only sustainable, they may provide the degree of social security that may have been necessary to achieve the defining characteristics of the Woodland I economic period; economic stability, provision storage, and cultural diversity.

Is there room in Delaware's antiquity for a white-tailed deer herding economic model? Yes, there is room. But regrettably, all existing archaeological literature continues to view and explain Woodland I material and spiritual culture from the hunter/gather perspective.

APPENDIX

Subspecies *Odocoileus virginianus*
List of 38 subspecies with geographical location
After Whitehead (1993:483).

Odocoileus virginianus acapulcensis (southern Mexico).
Odocoileus virginianus borealis (southeastern Canada and northeastern United States).
Odocoileus virginianus cariacou (French Guiana and north Brazil).
Odocoileus virginianus carminis (northern Mexico).
Odocoileus virginianus chiriquensis (Panama).
Odocoileus virginianus clavium (Florida Keys).
Odocoileus virginianus couesi (Santa Cruz, Arizona).
Odocoileus virginianus curassavicus (Curaçao Island).
Odocoileus virginianus dacotensis (Alberta to northern Dakota).
Odocoileus virginianus goudotti (Columbia (Andes) and west Venezuela).
Odocoileus virginianus gymnotis (Venezuela and Guianas).
Odocoileus virginianus hiltonensis (Hilton Head Island).
Odocoileus virginianus leucurus (Oregon and western coastal area).
Odocoileus virginianus macrourus (Kansas and neighboring States).
Odocoileus virginianus margaritae (Margarita Island).
Odocoileus virginianus mcilhennyi (Louisiana).
Odocoileus virginianus mexicanus (central Mexico).
Odocoileus virginianus miquihuanensis (central Mexico).
Odocoileus virginianus nelsoni (southern Mexico and Guatemala).
Odocoileus virginianus nigribarbis (Blackbeard Island).
Odocoileus virginianus oaxacensis (southern Mexico).
Odocoileus virginianus ochrourus (northwestern United States and Canada).
Odocoileus virginianus oseola (northwestern Florida).
Odocoileus virginianus peruvianus (Peru and marginally).
Odocoileus virginianus rothschildi (Cobia Island).
Odocoileus virginianus seminolus (Florida).
Odocoileus virginianus sinaloae (mid-western Mexico).
Odocoileus virginianus taurinsulae (Bulls Island).
Odocoileus virginianus texanus (Texas and adjoining States).
Odocoileus virginianus thomasi (southeastern Mexico).
Odocoileus virginianus toltecus (southern Mexico).
Odocoileus virginianus tropicalis (western Columbia).
Odocoileus virginianus truei (Nicaragua and adjacent States).
Odocoileus virginianus ustus (Ecuador (Andes)).
Odocoileus virginianus ventatorius (Hunting Island).
Odocoileus virginianus veraerucis (eastern Mexico).
Odocoileus virginianus virginianus (Virginia and adjacent States).
Odocoileus virginianus yucatanensis (Yucatán to Honduras).

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THE RISE AND FALL OF THE PASSENGER PIGEON VIEWED THROUGH THE LENS OF NATIVE AMERICAN AGROFORESTRY

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They took all the trees
Put 'em in a tree museum
And they charged the people
A dollar and a half just to see 'em -- Joni Mitchell

INTRODUCTION

Sadly, the last living example of the passenger pigeon (*Ectopistes migratorius*), named "Martha" (in honor of Martha Washington) died in her cage at the Cincinnati Zoological Garden at 1 p.m. on September 1, 1914. She was 29 years old. Our passenger pigeon extinction (our finger prints are all over this one) may be described as the largest and fastest avian population failure ever recorded--from an estimated population of over three billion individuals to zero individuals in a little over a hundred years. This unprecedented eradication unquestionably deserves a more detailed, if not complete, explanation. This essay illustrates our Native American economic model: Public Landscaping--Agroforestry--Creating Economic Strategies, or PLACES, as an alternative, yet pragmatic cultural explanation for the rise and fall of the passenger pigeon.

SCULPTING OUR RESEARCH QUESTION

A great wealth of research and documentation concerning the extinction of the passenger pigeon exists, for examples, in journals and printed form, photographs, drawings, as well as on the Internet. How do these data contribute to our question; is there an association between the rise and fall of the passenger pigeon and the rise and fall of Native American agroforestry? First, we "cherry-picked" a few, brief block quotes (see below) in order to set the stage and refine a contemporary explanation of passenger pigeon population dynamics through time. Second, we viewed what is said about these population dynamics through our lens of Native American agroforestry.

PASSENGER PIGEON BACKGROUND INFORMATION

At the time of early European exploration and beginning settlement, it is a well-grounded and sound assumption that the ecological habitat of the eastern half of North America supported a 3 billion to 5 billion sustained population of passenger pigeons. This massive population migrated on a seasonal basis from central Ontario, Quebec, and Nova Scotia in the north to the uplands of Texas, Louisiana, Alabama, Georgia, and Florida in the south. Because passenger pigeons were forest dwellers and constructed their nests in trees, few were ever sighted on the Great Plains. The nesting zone stretched from the Minnesota lakes region east through New York State (Smithsonian, 2001).

We downloaded David Biello's (2014) article: "3 Billion to Zero: What Happened to the Passenger Pigeon?" from the Scientific American web portal on May 1, 2016. Biello (2014) lists genomic research projects involving museum specimens of the passenger pigeon, and suggested that Hung, et al., (2014): "Drastic population fluctuations explain the rapid extinction of the passenger pigeon" offers the most relevant and up-to-date discussions of both passenger pigeon population size through time (the last one million years) and the geographical range (the eastern, south-eastern, and mid-west forested biomes). The association of space and time is necessary to answer our research question. Biello (2014) summaries recent passenger pigeon research in the following block quote:

> In the case of the passenger pigeon, Hung and his colleagues concluded that the population of breeding birds was roughly 330,000 on average, falling to as few as 50,000 birds at points in the last million years. This mismatch between these numbers and 1880 estimates of at least three billion suggests that the passenger pigeon may have been what is known to ecologists as an "outbreak" species, like locusts, that boom and bust with changes in conditions, rather than a species that experiences a singular population explosion, as *Homo sapiens* has in the last 200 years.
>
> This answer from genetics matches up well with ecological modeling of the abundance of passenger pigeon food—acorns, beechnuts and other forest mast—in North America over the last few thousand years. Such computer simulations suggest a population crash for passenger pigeons some 21,000 years ago as glaciers buried the trees that gave them food, followed by a rebound around 6,000 years ago to as many as 1.6 billion birds.

> This boom-and-bust scenario also lines up well with arguments by some that human immigration from Europe may have artificially swelled the ranks of the passenger pigeon by eliminating their Native American hunters and foragers, who competed with the birds for nuts and other forest foods. This population growth, the story goes, would have been temporary, because large flocks would have damaged the forests that provided food to the pigeons. "I suspected that the huge flocks of passenger pigeons that were observed when Europeans first arrived in North America were something ephemeral," notes paleogenomicist Beth Shapiro of the University of California, Santa Cruz, who was not involved in this work but is also working on sequencing the passenger pigeon genome. "It is hard to imagine how these birds could sustain such enormous populations over the long term. They were so incredibly destructive to the forests!"
>
> After all, the massive flocks were like a biological storm, cracking trees under the weight of birds and covering the ground in excrement, among other impacts. European settlers exacerbated this arboreal destruction, clearing the great U.S. eastern forest over the course of the 19th century. This downward trend in the abundance of forest mast paired with increased hunting by these same humans may then have combined to trigger the passenger pigeon's rapid extinction. "I think the reduction of habitat definitely decreased their population size," Hung says, noting something similar may explain the extinction of other outbreak species in North America, like the Rocky Mountain grasshopper in the western U.S. "Our study suggests that the combination of natural population size changes and human disturbances drove the rapid extinction of this bird."

These interpretations and discussions are very interesting, yet we need to drill down further--we need more data. We also need to look beyond seemingly imbedded assumptions, as David Biello and others suggest, of the natural, or climate induced ecological context, as well as where Native Americans were supposedly married to (see above) "hunter and forager" economic programs. To delve deeper into this discussion we need to look at what Hung and his colleagues actually deduced from their genomics study of the passenger pigeon. The following block quote is their "Abstract" statement:

> **Abstract**
> To assess the role of human disturbances in species' extinction requires an understanding of the species population history before human impact. The passenger pigeon was once the most abundant bird in the world, with a population size estimated at 3–5 billion in the 1800s; its abrupt extinction in 1914 raises the question of how such an abundant bird could have been driven to extinction in mere decades. Although human exploitation is often blamed, the role of natural population dynamics in the passenger pigeon's extinction remains unexplored. Applying high-throughput sequencing technologies to obtain sequences from most of the genome, we calculated that the passenger pigeon's effective population size throughout the last million years was persistently about 1/10,000 of the 1800's estimated number of individuals, a ratio 1,000-times lower than typically found. This result suggests that the passenger pigeon was not always super abundant but experienced dramatic population fluctuations, resembling those of an "outbreak" species. Ecological niche models supported inference of drastic changes in the extent of its breeding range over the last glacial–interglacial cycle. An estimate of acorn-based carrying capacity during the past 21,000 y showed great year-to-year variations. Based on our results, we hypothesize that ecological conditions that dramatically reduced population size under natural conditions could have interacted with human exploitation in causing the passenger pigeon's rapid demise. Our study illustrates that even species as abundant as the passenger pigeon can be vulnerable to human threats if they are subject to dramatic population fluctuations, and provides a new perspective on the greatest human-caused extinction in recorded history.

Clearly, Hung and colleagues (2004) described their research as an avian population spanning over the past 21,000 years that had experienced dramatic population fluctuations, even after 6,000 years before present, where we may see population growth numbers that are within the range of classic "outbreak" patterns. Unfortunately, Hung and his colleagues suggest that somehow, the naturally occurring and principally acorn-based diet during the Holocene may have allowed the population of passenger pigeons to explode to outbreak numbers. And later, the catastrophic ecological disruption that occurred with European settlement and the ensuing western expansion--coupled with other negative factors, like large-scale market hunting and the destruction of nesting sites, quickly doomed the entire species to extinction.

A detailed analysis of Hung's data might answer some of our concerns. Why does Hung cite the date of 6,000 years before present as both a divergence in trend (both population and food) and the beginning of the population outbreak, while the available food remained constant? Did Hung really say that passenger pigeon genomics indicate a breeding population of 1.6 billion birds at 6,000 years before present? And, how might the activities of ancestral Native Americans effect our assessment of the passenger pigeon? Feel free to read the complete, Wen-Hsiung Li, (University of Chicago) edited version of Chih-Ming Hung, et al. (2014) (hereafter in our essay cited simply as Hung), at: http://www.pnas.org/content/111/29/10636.full.

What Did Hung Actually Say?

Hung produced the most extensive sets of passenger pigeon genomic analysis to date. That data, as interpreted, provided DNA statistical frameworks for population forecasts (both in the recent Holocene, and in the deep time Pleistocene). They also devised a prediction of passenger pigeon population based on ecological carrying capacity (for the past 21,000 years) based on available naturally occurring acorns (both red oak and white oak acorns--believed by some researchers to be the passenger pigeon's primary diet). These predictions of available naturally occurring acorns were based on the analysis of environmental pollen core reconstructions (assuming the pollen represented naturally occurring, or climate induced oak species).

As we (Mellin and Truitt) dissected Hung's data, we identified a number of important sets of information (see below), we think are critical in shaping our thesis in this essay, the rise and fall of the passenger pigeon viewed through the lens of Native American agroforestry.

Hung's Genomic Analyses

There is no population structure found within the passenger pigeon species, essentially--there was one, large interbreeding population (page 3).

The passenger pigeon was a migratory species, wintering in the south, nesting in the north (page 3).

Long-term average genetically effective population (minimum number of individuals to ensure genetic diversity within a stable population) size (*Ne*) of 3.3×10^5 (330,000 individuals) (page 3).

Hung and colleagues said the passenger pigeon genomic analysis for The Generalized Phylogenetic Coalescent Sampler (G-PhoCS) estimate showed *Ne* (number effective) fluctuating between 0.5 and 1.7×10^5, 50,000--170,000 **population** over the last million years, decreasing significantly from the last interglacial period (LIG, approximately $1.1–1.3 \times 10^5$, or 110,000--130,000 **years** before present) to a minimum at the last glacial maximum (LGM, approximately 2.1×10^4, or 21,000 **years** before present) and then recovering (page 3).

Hung offers an effective population size (*Ne*) diagram (see his Figure 2 on his page 4) for the last 1,000,000 years. This display suggests passenger pigeon effective population size (*Ne*, as in number effective) through deep time was unexpectedly small and somewhat consistent with other avian species.

However, Hung's Figure 2 exhibits a significantly abrupt increase (as if the *Ne* data somehow goes haywire) in passenger pigeon *Ne* between 2,000 and 4,000 years before present and continues at an unexpectedly high level into the Colonial era. This dramatic rise in *Ne* indicates the passenger pigeon DNA gene pool was being shared in a dramatically larger (but, yet unexplained) population.

Hung tried to explain this unexpectedly small effective population size through deep time in the following block quote (see below, and on Hung's page 4). This discussion compares the passenger pigeon population of *Ne* (as in number effective) with other regionally or continentally widespread birds (with *Ne* between 130,000--24,000,000 individuals) with the passenger pigeon *Nc* (as in number census) (3,000,000,000--5,000,000,000 individuals, estimated in the Colonial era). Typically, population studies should indicate values where *Ne* is at $1/10^{th}$ the value of *Nc*. In the case of the passenger pigeon, however, the *Ne*/*Nc* differential is closer to 1/10,000 than 1/10.

Unexpectedly Small Effective Population Size.
The passenger pigeon's N_e is not larger than those of other regionally or continentally widespread birds ($N_e = 1.3 \times 10^5 - 2.4 \times 10^7$) (*SI Appendix*, Table S5). It is also much lower than expected given the census population size (N_c) of 3–5 billion. N_e is on average one-tenth of N_c (19), and the value of ~0.0001 for N_e/N_c inferred in this study is much smaller than those estimated from other animals' genome sequences (0.0125 – ~1) (*SI Appendix*, Table S6) or from nongenomic data on other birds (0.05–0.74) (19).

N_e is sensitive to population fluctuations (20, 21); in particular, low values of N_c occurring at population minima anchor N_e so that the extremely low N_e/N_c suggests remarkably large population fluctuations (19, 21, 22). A low N_e/N_c is typical of outbreak species, which are characterized by dramatic and recurrent changes in population size (21, 23). For example, the Australian plague locust (*Chortoicetes terminifera*) can reach as many as 100 billion individuals during outbreak phases, yet its estimated N_e is merely approximately half a million (24). If the population of passenger pigeons behaved in a similar way, only occasionally numbering in the billions during "outbreak" phases, we would expect a low N_e for this bird over the last million years, which we found in this study. A low N_e would also have been observed if the passenger pigeon population had remained small until a recent population explosion, as in the case of humans (current human N_c is 7×10^9 and long-term N_e ranges around $0.9–1.7 \times 10^4$) (16, 17, 25), but our ecological analyses support a history with repeated rises and falls in population size (see below).

Hung's Ecological Analysis

Quite logically, Hung began to wonder what 3 to 5 billion passenger pigeons would have eaten. To address this question, they devised an ecological niche model based on acorns. The context of the below block quote is about deep time, or the last one million years. Abbreviations include Ecological Niche Models (ENM), Last Interglacial (LIG) and Last Glacial Maximum (LGM) (Hung, pages 4-5).

Environmental Conditions in the Past Support Large Population Fluctuations.
Because population size depends on environmental suitability (26), we constructed ecological niche models (ENMs) to assess whether changes in the pigeon's breeding range between the LIG, LGM, and current day would provide independent support for large fluctuations in population size. By associating current species occurrences with environmental conditions, ENMs can reveal species' ecological niches in environmental space, which are then mapped to a geographic area to reveal their potential distributions (27, 28). Our purpose here is to estimate the potential magnitude of population fluctuations in potential areas suitable for breeding passenger pigeons.

The ENMs using a threshold that allows for a maximum of 1% omission rate indicated that areas with suitable climatic conditions for breeding passenger pigeons were much more limited at the LGM than at the LIG (47-times LGM) and at present (60-times LGM area) (Fig. 3). The mobility-oriented parity method (29) identified the areas with novel environments during the LGM (projection region) relative to current day (calibration region), which are concentrated in the northeast and southeast portions of the study area (*SI Appendix*, Fig. S8). However, even if these novel environments caused the ENMs based on the current environmental niche to underestimate the LGM range, our conclusion of a substantial reduction in the LGM ranges is still robust. This result is because the northeast portion of the study area—where model extrapolation issue is most severe—was covered by ice sheets during the LGM (*SI Appendix*, Fig. S9), and thus was not suitable for breeding passenger pigeons. It is, however, unknown how many passenger pigeons could have bred successfully at the LGM in the limited suitable range.

On Hung's page 5, the reader will see his Figure 3 with descriptions, a series of three maps of North America, which predict the breeding ranges of the passenger pigeon through deep time. See the following block quote for their discussion:

Predicted breeding ranges at current day (*A*), the LGM (*B*), and the LIG (*C*). Predicted breeding ranges are based on ENMs built with 19th century occurrences of breeding passenger pigeons (triangles in *A* as training data and circles as testing data) and the seven bioclimatic variables that each contributed at least 5% to the current-day model. The green areas delineate potential breeding ranges for the passenger pigeon. Increasing shades of green represent suitable areas for the passenger pigeon using thresholds of increasingly higher omission rates (0%, 1%, and 5%).

> We supported this climate-based analysis of long-term population fluctuations for the passenger pigeon with one based on the post-LGM distribution of oaks inferred from fossil pollen records, current-day median annual acorn production per square kilometer, and estimated daily consumption of acorns by a passenger pigeon, an approach that also allowed us to test the accuracy of the early naturalists' N_c estimates. The expansion of oaks from their LGM refugia (*SI Appendix*, Fig. S9) drove an increase in passenger pigeon carrying capacity, which peaked at 1.7–2.3 × 10^9 individuals at 9,000–10,000 y before present, and subsequently stabilized at approximately 1.1–1.6 × 10^9 individuals from 6,000 y before present to present (Fig. 4).

The result of Hung's ecologically available (natural, and/or climate induced) food resources model (where he assumed red oak (*Quercus rubra*) and white oak (*Quercus alba*) acorns were the principal passenger pigeon food sources) indicated a Holocene landscape carrying capacity maximum for passenger pigeons at 1,700,000,000 to 2,300,000,000 individuals at 9,000--10,000 years before present. And curiously, by 6,000 years before present the assumed carrying capacity based on available acorns fell to a predicted population of 1,000,000,000 to 1,600,000,000 individuals. Additionally, Hung said the predicted acorn based carrying capacity of passenger pigeons seems to remain somewhat stable from 6,000 years before present until European settlement. However, the population of passenger pigeons seems to rise from 1-1.6 billion to 3-5 billion by the time of European settlement, suggesting a two to five fold population increase. No natural explanation is suggested for this dramatic population increase, while the assumed natural food source remained somewhat stable. This "natural, and/or climate induced" available acorn/assumed population conundrum suggests there is likely a cultural solution to this food deficiency question. We will demonstrate our cultural solution as a result of Native American agroforestry economic programs, from 6,000 years before present to the Colonial era, in the second half of this essay.

Hung illustrated Figure 5 with descriptions (on his page 6) to display Carrying Capacity and Oak Coverage that were converted from fossil-pollen records and contemporary landscape data for northern and eastern North America. Additionally, Hung supplied a list of natural and cultural variables that may have affected both the ecological environment, as well as possible causes of an outbreak patterned population explosion. The following block quotes from Hung's pages 7-8 illustrate some of his more interesting ideas:

> **Short-Term Fluctuations in Food Supply.**
> Acorn production varies significantly from year to year across oak species (30, 31). For example, acorn production by red oaks can vary as much as 12-fold between years, and for white oaks as much as 136-fold (*SI Appendix*, Table S7). Inclement weather can cause mast failures over large areas (32) and, as a result, a reduction in population sizes of mast-consuming species (33⇓–35). Applying similar good- to bad-year variations to the median value calculated above, the projected acorn production could have supported between 0.6–1.7 × 10^8 and 6.7–8.0 × 10^9 passenger pigeon individuals from 6,000 y before present to the present (*SI Appendix*, Fig. S10), a range for which the peak is consistent with the early naturalists' N_c estimates, but which also shows how large the short-term natural fluctuations might have been.
>
> The ENMs, fossil pollen records, and acorn-production data suggest that the passenger pigeon experienced large, natural population fluctuations, but these do not explain completely the three orders-of-magnitude difference between the estimated and expected N_c inferred from our genomic analysis. Other factors, however, might have also contributed to fluctuations in passenger pigeon's population size, either by reducing past population minima or by increasing the 19th century population.
>
> For example, the pigeon's enormous roosting and breeding colonies might have increased the species' vulnerability to density-dependent regulation resulting from physical damage to trees or outbreaks of infectious diseases (13, 36, 37). Furthermore, the bird's dependence on large flocks (12, 13) could have exacerbated its vulnerability to predation following years of inadequate food supply, thereby reducing population minima further (2). It has also been argued that European immigrants contributed to an outbreak in the numbers of passenger pigeons by providing them with supplementary food resources (e.g., agricultural crops) or releasing them from competition (for mast) and hunting pressures from Native Americans (38, 39).

Carrying Capacity Estimation.
We defined passenger pigeon carrying capacity as the number of pigeons that could be sustained by annual acorn production. We estimated annual acorn production by multiplying modern-day acorn production per square kilometer with historical oak coverage from 21,000 y before present to present day (inferred from fossil pollen records) for northern and eastern North America (47). For modern-day acorn production, we used the minimum, median, or maximum acorn production by red oaks or white oaks from published data collected across multiple sites and years (30, 31). Daily consumption of 30 acorns per pigeon was assumed (8, 38).

As it turns out, Hung's passenger pigeon predicted dietary sources based on red oak and white oak acorns are within the production limits to periodically, or occasionally sustain a population of 3 to 5 billion individuals from 6,000 years before present until the timeframe of eye witness accounts, or the *Nc*, during the Colonial era. However, this food/population ratio would require above average to maximum acorn yield over very long periods of time--persistent and perhaps uniform yield over thousands of years. Yet, these two questions remains: 1) Why do we see this proposed food/population ratio beginning only after 6,000 years before the present? 2) Is this proposed food/population ratio a result of natural phenomena, or are we seeing the effects of highly efficient anthropogenic landscapes created through Native American agroforestry programs?

We are including Hung's Conclusions for two reasons: 1) Hung correctly suggests that population fluctuations typically follow climatic, food-resource, and other ecological variations, and 2) Hung compares the extinction of the Rocky Mountain grasshopper to the extinction of the passenger pigeon during the similar timeframe, perhaps for similar reasons. Sadly, the vulnerability to extinction of once abundant species should not be taken lightly--our fingerprints are all over these topics. Hung's Conclusions follow:

Conclusions
To our knowledge, our study provides the first empirical perspective on the passenger pigeon's population history. Proper evaluation of factors determining a species' extinction requires more than the average or a snapshot of its population size. Based on our estimates that the passenger pigeon's N_e was persistent at approximately 10^5 throughout the last million years (Fig. 2), this species probably experienced frequent and dramatic population fluctuations following climatic, food-resource, and other ecological variations, thereby increasing its extinction risk (40, 41). We suggest that before human settlement the passenger pigeon routinely recovered from population lows. We hypothesize that a downward trend in its population size occurred simultaneously with human exploitation in the late 1800s and that the combination of the two triggered its rapid extinction. Once below a minimum threshold population size, the conspicuous roosting and breeding behaviors of this bird could prevent its recovery. This hypothesis may also explain the mysterious extinction of the Rocky Mountain grasshopper (*Melanoplus spretus*), which periodically formed immense swarms and was the most serious agricultural pest in the western North America but went extinct rapidly from the late 1800s to the early 1900s (42). Insights gained from the demise of the passenger pigeon shed light on the vulnerability of abundant species, especially those that are prone to dramatic population fluctuations.

OUR SUMMARY OF PASSENGER PIGEON BACKGROUND INFORMATION

Hung's genome analysis indicated a persistent minimum sustainable passenger pigeon population in the hundreds of thousands of individuals over the last million years. Even though the genome analysis did not indicate an average or maximum population, Hung offered a Holocene landscape carrying capacity maximum based on predicted red oak and white oak acorns available to passenger pigeons at 1,700,000,000 to 2,300,000,000 individuals at 9,000--10,000 years before present. Curiously, by 6,000 years before present the assumed landscape carrying capacity based on available acorns fell to a predicted population of 1,000,000,000 to 1,600,000,000 individuals. Additionally, Hung said the predicted acorn based carrying capacity of passenger pigeons seems to remain stable from 6,000 years before present until European settlement. We feel it is not pragmatic to imagine a natural, or climate-induced landscape could have produced nearly maximum acorn yield persistently over thousands of years, which would be necessary to support the 3-5 billion passenger pigeon population observed during the Colonial era. However, ecological consequences associated with European settlement did seem to be the primary culprit for the catastrophic and rapid population decline, followed by additional negative consequences and eventual extinction as is depicted in the historical record.

NATIVE AMERICAN AGROFORESTRY BACKGROUND INFORMATION

The cultivation of wild plant species for the production of food, medicine, utility materials, and ceremonial purposes is a useful and accurate definition of agroforestry. In traditional Anthropology, agroforestry is typically explained as the manipulation of the available plant resources in an effort to increase a beneficial yield. Ideally, agroforestry based economic systems should fill the gap between the Hunter/Gatherer and the Horticulture/Agriculture economic systems, while theorizing there is a progression--an increased economic benefit through increased social, cultural, and economic complexity over time.

Agroforestry is an important piece of a wide range of experimentation and economic development that typically is associated with increasingly complex societies, more complex than Hunting and Gathering, yet less complex than adopting existing, or creating new cultigens as a dietary foundation. To explain how this process works, we proposed a series of intermediate economic pursuits that were developed through Public Landscaping--Agroforestry--Creating Economic Strategies, or PLACES (Mellin and Truitt, 2015a). In essence--people learned how to manipulate and alter their respective local environments to increase yield. In our PLACES economic model, we forecasted periodic landscape burning, ringing and removing unwanted trees, moving and planting desirable botanical species, forming and maintaining monoculture woodlots, creating meadows and fringe environments, developing medicinal, berry, fruit, and utility gardens, shellfish gardening, as well as, but not limited to actively managing terrestrial mammals, such as deer, and avian, such as turkeys. The same anthropogenic landscapes that benefited Native American people(s) also benefited the resident, natural and adventive species being managed, including migratory and transient species, such as the passenger pigeon.

Writers from the Colonial era occasionally made reference to Native American managed landscape features and practices. We read about clusters of fruit and nut bearing trees, meadows well set with grapes or berries, and seasonal landscape fires, but these examples were usually mentioned without full comprehension of either the landscapes or the peoples who managed them. It was generally accepted within the Colonial's (English) legal authority and religious belief to deny any accomplishments in Native American ecological improvement, or landscape management. However, management of the landscape was about to change.

On May 20, 1785, the Continental Congress passed the Land Ordinance Act, which authorized the Treasury Department to "survey before settlement" and sell parcels of the Public Domain as a source of revenue (BLM.gov, 2016). Literally hundreds of government surveys were recorded as the frontier moved westward, and just after the War of 1812, some government surveys were conducted to the west end of Lake Superior.

Sometimes referred to as witness tree surveys, these early American records often involved large areas of land, occasionally the size of counties, for examples, in south-central Pennsylvania (Black and Abrams, 2001) and in east-central Alabama (Foster, Black, and Abrams, 2004). As surveyors recorded the quantities and species of witness trees along survey lines and axis points, they constructed a geographic-botanical grid system that actually documented the character of the landscapes at the very moments Native Americans were losing control of their lands as part of the Federal Government's preparation for settlement. These surveys are our best landscape-scale views of what Native American anthropogenic landscapes actually looked like.

Many of these witness tree surveys clearly exhibit large oak-hickory-chestnut anthropogenic catchment areas associated with known Native American settlements. These catchment areas, or cultural landscapes typically appear within otherwise natural or climate induced beech-hemlock-maple landscapes with associated northern and southern pine communities. Many of these individual catchment areas measure 60 square miles in size, and where strung together along entire river systems, these managed landscapes reached astonishing sizes. Tulowiecki and Larsen, (2015:73) plotted the U. S. Government pre-settlement land survey of Chautauqua County, NY. They discovered an American Chestnut cluster that had been maintained by local residents of the Iroquois Nation. As plotted, that chestnut cluster measured approximately 10 miles east/west and 60 miles north/south, where we have estimated 384,000 acres of nut producing chestnut trees.

Similar evidence from witness tree surveys demonstrate that Native Americans living in the eastern Woodlands were fully engaged in large-scale agroforestry economic programs, converting large portions of

their forests from inedible seed producing plant communities to edible nut, acorn, berry, and fruit producing plant communities. Recently, we wrote a comparative analysis of seven recently published witness tree surveys ranging from western New York state to east-central Alabama. Collectively, these witness tree surveys demonstrate an inescapable agroforestry pattern--Native Americans had produced a very large patchwork of productive anthropogenic landscapes, replacing large areas of natural and fairly unproductive landscapes with creative and very beneficial landscapes of their choosing (Mellin and Truitt 2015b).

Additional surveys during the nineteenth century show that soon after Native Americans lost control of their anthropogenic landscapes, the beneficial economic aspects of those manufactured landscapes quickly deteriorated. By the later portions of the nineteenth century, former anthropogenic catchment areas not converted to farms, and left without regular Native American burning and maintenance were well on their way to reverting back to the climate induced, or natural plant community signatures, as well as exhibiting an overabundance of inedible emergent species, like red maple. From the hundreds of early witness tree surveys spread out over more than a dozen States, we have a very good understanding of what those Native American anthropogenic landscapes looked like. We also have a very good understanding of the circumstances of their rapid decline. Lets take a brief look at how and when those anthropogenic landscapes got started.

In Delaware, and the broader Mid-Atlantic region, beginning about 6,000 years before present, we see a marked change in Native American settlement patterning and technology. We think marked changes in economic procurement systems were associated with these developments. Extensive base camps now supported storage pits, and the development of large, hafted stone knives, and the invention of the three-quarter grooved stone axe reflects increased efficiencies in managing forest resources. We believe large hafted knife styles, such as "Poplar Island", "Lackawaxen", and "Morrow Mountain" represented the stone tool technology that shaped agroforesry. These hafted knife styles developed into other styles, like the so-called Broadspears, which were produced in such great quantity, that by 4,000 years before present, large stone quarry complexes and long distance trade and exchange networks developed to placate the demand. The addition of steatite vessels and later ceramic containers, by 3,000 years before present, allowed for more efficient conversions of cultivated starchy foods into more easily digested sugary foods. Adventive plant species as well as cultigens were added to existing anthropogenic forests and garden plots where desired. Thus, the acquisition or adoption of cultigens like squash, corn, and then beans by some groups of people who desired such plants, was simply an additional step within existing agroforestry economic systems.

Until the beginning of the present century, discussions about Native American agroforestry programs in the continental United States have been shunned. This consequence is largely the result of post-War explanations where environmental change signaled cultural change. Agroforestry, however, attempts to show cultural demand signaled increased ecological efficiency. Perhaps in twenty years these two theories may compliment each other, but that complex and albeit thorny task is clearly beyond the scope of this essay.

OUR SUMMARY OF NATIVE AMERICAN AGROFORESTRY BACKGROUND INFORMATION

We see the efforts of Native Americans in the eastern Woodlands, through their agroforestry economic systems, greatly increased the quantity of edible plant species through manufacturing oak-hickory-chestnut anthropogenic landscapes in otherwise beech-hemlock-maple natural landscapes. These forest focused economic strategies probably began around 6,000 years before present and continued until Native Americans lost control of their indigenous economic systems and anthropogenic landscapes in preparation for settlement.

IMPLICATIONS FOR FUTURE RESEARCH

Given the 2-5x population rise of passenger pigeons after 6,000 years before the present, and the population collapse during the preparation of Native American anthropogenic landscapes for settlement, our support for Native American agroforestry economic systems in the eastern Woodlands provides explanations in both timeline and causation. We do not view the passenger pigeon as an outbreak species. Rather, it seems to be a very large migratory avian population that became reliant on highly efficient (2-5x natural landscapes) Native American anthropogenic landscapes. Once those landscapes were severely degraded, or appropriated for other uses, members of the passenger pigeon species quickly fell below the minimal effective population size, *Ne*, and sadly, the possibility of passenger pigeon extinction became a reality.

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AGROFORESTRY IN THE EASTERN WOODLANDS: WHAT WE LEARNED ABOUT METHOD AND THEORY

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INTRODUCTION

The purpose of this presentation is threefold: first, to initiate the topic of Native American agroforestry in the Eastern Woodlands of the United States and to identify useful methodological and theoretical underpinnings for agroforestry within the framework of our umbrella Native American economic model called PLACES in Spacetime. Difficulties encountered while applying traditional method and theory to current field research are explored. Second, we designed and conducted more than a dozen ethnoecological surveys. We provide results of our field investigations in Delaware and beyond, where the remnants of Native American agroforestry, as well as other forms of anthropogenic landscapes are supported. And third, we include a variety of research topics designed to investigate and identify additional methods for increasing ecological efficiencies. For the latter half of the Holocene, our use of Cultural Ecological assumptions has produced a near universal predilection toward forager economic explanations, where supposed subsistence based cultures adapted to a series of resilient external factors, like climate-induced environmental changes. To move forward, we need to reject these Cultural Ecological shortcomings, and embrace new sets of pragmatic methods and theories under Historical Ecology, where we envision habitable environments as objective, fully malleable, contextual landscape features.

The word agroforestry is not found in a standard English dictionary. However, the United States Department of Agriculture defines agroforestry as "the intentional integration of trees and shrubs into crop and animal farming systems to create environmental, economic, and social benefits." (USDA 2013:1). We assume ecologists and anthropologists can subscribe to this broad line of thinking regardless of the "who said it first" arguments or the provincial tweaking by advocates in various disciplines. For the purpose of this presentation, we suggest the reader initially focus on the "systems to create environmental, economic, and social benefits" portion of the definition and how evidence of those systems might be researched, documented, and in some cases, where the sustainability of living remnants of ancestral Native American agroforestry are indicated, restoration and preservation for future generations is a desirable option. Our idea of restoring and preserving these living, ancestral Native American botanical arrangements as exhibits within a living anthropogenic landscape museum is a new and important concept. To identify these remaining elements of anthropogenic landscapes, we found there are a number of ways to discover and document them, which we will explore next.

Recent witness tree analysis clearly demonstrates that Native Americans had used agroforestry techniques to transform much of the Eastern Woodlands of the United States from climate induced seed producing beech--hemlock--maple communities to anthropogenic acorn and nut producing

oak--hickory--chestnut communities. These agroforestry efficiencies were likely 2 to 5 times greater than forager efficiencies. We suggest the timeframe of these ecological transformations occurred between 6,000 and 400 years before present with the majority of the ecological transformations occurring between 4,000 and 3,000 years ago.

The authors' numerous ethnoecological surveys here in Delaware produced astonishing results. Easiest to find and document are the adventive plant species, likely moved to Delaware during the second half of the Holocene. Our largest find was a six-mile wide, planted american chestnut circle, which surrounds a series of archaeological sites along the Nanticoke River, known as Kuskarawack Towne. This chestnut circle may be viewed as a symbolic palisade, since the known archaeological sites together with recently identified berry, prickly pear, shadbush, creeping cucumber, yucca, and arrow-arum clusters are enclosed within the circle, forming an anthropogenic, ecological catchment area. Because the river runs through the middle of this catchment area instead of around it, our organization of these domesticated landscapes requires new approaches in defining how agroforestry catchment areas contrast and compare to what have previously been labeled forager "base camps". In the past, we have assumed forager base camp locations were restricted by nearest watercourse. Agroforestry catchment areas, however, appear to have the main watercourse running through them. Our ethnoecological surveys along the Nanticoke River demonstrate that each adjacent managed catchment area consists of arrangements of distinctly different species. This variety of provisioning may insure against catastrophic failure, and may actually promote lineage or clan diversity within one cultural group.

SECTION ONE: EXAMINING METHODS AND THEORIES

After the Second World War, anthropologists began to focus on the processes involved in how humans adapt to a wide variety of physical environments. In 1955, Julian Steward suggested Cultural Ecology, or processional explanations would offer contextual views by addressing cultural change as a function of adaptation to the environment. Steward's premise was that, over large periods of time, environmental change signaled cultural change. In 1982, William Gardner applied Steward's Cultural Ecology approach, suggesting that by reconstructing the environmental landscape associated with any given cultural system, one could discover the relevant or effective environmental variables, which influenced that system. Over the next two or three decades, as Carole Nash (2014) pointed out, Gardner's students often approached cultural change as an adaptive response to factors external to the group in question. Nash suggested there actually is an inescapable significance in addressing cultural attributes through the context of habitable environments, and we heartily agree! But, because most publications view those external factors as nature's problems to be resolved, we have assumed an association of subsistence based forager economic contexts. Why have we assumed that habitable environments should be external factors?

We have fashioned a powerful and enduring lens where cultures are viewed adapting to the opportunities and obstacles presented by their surroundings, but certainly not viewed as possessing the ability or desire to alter, improve, create, or manage their surroundings. Our regulated predilection toward forager behavior (as in culture) adapting to environmental change (as in climate) is nearly ubiquitous. This acceptance has unfortunately excluded all other possible forms of ancestral Native American economic programs until, as the memorialized story goes, some groups adopted cultivar annual plant species on a supplemental or ceremonial basis, and later, some groups developed a dependence on a variety of cultigens as a dietary foundation.

The missing element in Cultural Ecology, as explained today, is in how and to what degree humans organized their environment. Balée and Erickson (2006:1) addressed this missing element through

Historical Ecology with their interpretation, "…wherever humans have trodden, the natural environment is somehow different, sometimes in barely perceptible ways, sometimes in dramatic ways." Historical Ecology allows us to use methods and theories that address cultural activity signaling environmental or ecological change. At last, we have a "two-way street", signals and responses going in both directions. Erickson (2008) went on to identify Native American agroforestry economic systems in the Amazon Basin. He interpreted his new pragmatist cultural/ecological framework as an economic system that developed domesticated landscapes. We used this framework to reinterpret how ancestral Native American activities in the Eastern Woodlands of the United States possibly developed their own domesticated landscapes with agroforestry being just one of the many ways Native Americans created beneficial ecological changes where, and when they wanted them.

Because Cultural Ecological interpretations focus on humans adapting to habitable environments, while treating those environments as non-malleable, external factors, we must regard Cultural Ecology as a relic of the past. Historical Ecology supports, in theory, that humans are certainly capable of managing the efficiencies of their environments, where productive alterations are designed to produce beneficial outcomes. And, in method, that contemporary researchers are certainly capable of documenting and explaining those environmental alterations, as well as predicting what those beneficial outcomes might have been.

NATIVE AMERICAN ECOLOGIES IN THE EASTERN WOODLANDS

The first large-scale, professional ecological descriptions of the Eastern Woodlands began with the government witness tree surveys. On May 20, 1785, the Continental Congress passed the Land Ordinance Act, which authorized the Treasury Department to "survey before settlement" and sell parcels of the Public Domain as a source of revenue (BLM.gov. 2016). Literally hundreds of government surveys were recorded as the frontier began to move westward, and just after the War of 1812, some government surveys were conducted to the west end of Lake Superior. As surveyors recorded the quantities and species of witness trees along survey lines and axis points, they constructed a geographic-botanical grid system that actually documented the character of the surveyed landscapes at the very moments Native Americans were losing control of their lands as part of the government's preparation for settlement. These surveys, many recorded on a one-mile grid, sometimes recorded on a quarter-mile grid are our best landscape-scale views of what Native American anthropogenic landscapes, and their accumulated ecological capital actually looked like.

Many of these witness tree surveys clearly exhibit large oak--hickory--chestnut anthropogenic catchment areas associated with known Native American settlements. These catchment areas, or cultural landscapes, typically appear within otherwise natural or climate induced beech--hemlock--maple landscapes with associated northern and southern pine communities. Many of these individual catchment areas measure 60 square miles in size, and where strung together along entire river systems, these managed landscapes reached astonishing sizes. Tulowiecki and Larsen, (2015:73) plotted the U. S. Government pre-settlement land survey of Chautauqua County, NY, along the southwest shore of Lake Ontario. They discovered an american chestnut cluster that had been maintained by local residents of the Iroquois Nation. As plotted, that chestnut cluster measured approximately 10 miles east/west and 60 miles north/south, where we have estimated approximately 384,000 acres of nut producing chestnut trees existed (Mellin and Truitt 2015a October, and 2016a May).

Similar evidence from other witness tree surveys demonstrate that Native Americans living in the Eastern Woodlands were fully engaged in large-scale agroforestry economic programs. Very large

portions of their landscapes had been converted from inedible seed producing plant communities to edible nut, acorn, berry, and fruit producing plant communities. Recently, we wrote a comparative analysis of seven recently published witness tree surveys ranging from western New York State to east-central Alabama (Abrams 2010; Abrams and McCay 1996; Abrams and Nowacki 2008; Black and Abrams 2001; Black, Ruffner, and Abrams 2006; Foster, Black, and Abrams 2004; and Tulowiecki and Larsen 2015). Collectively, these witness tree surveys demonstrate an inescapable agroforestry signature--Native Americans had produced a very large patchwork of productive anthropogenic landscapes, replacing large areas of natural and fairly unproductive landscapes with creative and very beneficial landscapes of their choosing (Mellin and Truitt 2015a October).

Additional surveys during the nineteenth century show that soon after Native Americans lost control of their anthropogenic landscapes, the beneficial economic aspects of those manufactured landscapes quickly deteriorated. By the later portions of the nineteenth century, former anthropogenic catchment areas not converted to farms, and left without regular Native American burning and maintenance were well on their way to reverting back to the climate induced, or natural plant community signatures, as well as exhibiting an overabundance of inedible emergent species, like red maple. From the hundreds of early witness tree surveys spread out over more than a dozen states, we have a very good understanding of the plant species composition of those Native American anthropogenic landscapes. We also have a very good understanding of the circumstances of the rapid decline, and return to climate induced characteristics. Lets take a brief look at when and how and those anthropogenic landscapes originated.

WHEN: TIME FRAMES

In Delaware, and the broader Mid-Atlantic region, beginning about 5,000 years before present, we see a marked change in Native American settlement patterning and technology, as well as an assumed increase in human population. These changes were supported by changes in economic programs. Cooperative activities supporting the development of storage pits, as well as the development of large hafted stone knives, and the invention of the three-quarter grooved stone axe suggest increased efforts and efficiencies in managing available resources. We believe large hafted knives, such as the classic “Bare Island”, “Lackawaxen”, and “Poplar Island” styles embody the stone tool technology that shaped agroforestry related economic experimentation. These hafted knife styles developed into other styles, like the so-called Broadspears, which were produced in such great quantity, that by 4,000 years before present, large stone quarry complexes and long distance trade and exchange networks developed to placate the demand for such tools.

The addition of steatite vessels and later ceramic containers, by 3,000 years before present, allowed more efficient conversions of cultivated starchy foods into more easily digested sugary foods. Adventive plant species as well as likely crossbred or hybridized perennial plants were added to anthropogenic woodlots, meadows, and garden plots where desired. Thus, the acquisition or adoption of likely perennial hybrids such as pawpaw, maypop, creeping cucumber, and prickly pear, and self-seeding hybrid annuals such as sunflower, and jimson weed, and later cultigens like squash, corn, and then beans by some groups of people who desired such plants for ceremonial or spiritual purposes, were simply additional steps within existing agroforestry economic systems. And lastly, Native American economic programs that relied on cultigens as a dietary starchy basis, (including tobacco) typically referred to as various horticulture/agriculture economic systems, required entirely different and new rigorous seasonally based (frost free) activities and divisions of labor, as we will see below.

HOW: POTENTIAL ECONOMIC STRATEGIES

We use Historical Ecological methods and theories to drill down on how culture and the environment continuously sent signals and received feedback. The following proposed framework encompasses the entire Eastern Woodlands during the entire Holocene. Because we are discussing Native American economic strategies, relationships between signals and feedback over very large spaces and timeframes, we provide only generalizations and do not suggest synchronic or diachronic specifics. Because we have cultural diversity, as well as lineage diversity, the data shows that not all people were doing the same thing at the same time. For the following proposed economic programs (using Delaware as a sample location) we do make the following specific distinctions.

Native plants are considered indigenous to Delaware throughout the Holocene. Adventive plants are not indigenous to Delaware, but are native elsewhere in North America, and are currently "hosted" in Delaware sometime during the Holocene. Perennials are persistent and reinvigorate, or reappear every year from living roots, some are evergreen and some are deciduous. Annuals grow from a new seed every year--tough wall seed from some species (like amaranth) endure the winter, weak wall seed from cultigens (like corn) need to be harvested, stored, and replanted in the spring. Cultivar is a hybridized genetic form that can procreate with its source species. Cultigens are hybridized genetic forms that cannot procreate with their source species.

- Forager economies--12,500 to 400 years before present.

We suggest forager, formerly hunter/gatherer, economics focused on procuring and processing native perennials and annuals, a year round pursuit with seemingly limited storage capacity. In Delaware, we have no data to suggest anthropogenic landscape construction between 12,500 to 5,000 years before present. Seasonal landscape fire may have altered and improved the productivity of landscapes prior to 5,000 years before present, but specific examples are difficult to pin point in the archaeological record. For the time being, we think it is prudent to stick with the forager scenario, where Native American economic practices and ecological experimentation likely continued within climate-dominated ecologies.

- Agroforestry economies--5,000 to 400 years before present.

We suggest agroforestry economies started small and transformed through time, although archaeological evidence suggests landscape fire was pervasive. For the period 5,000 to 4,000 years before present, we suggest Native Americans were selecting native perennials (like white oak) and annuals (like pitseed chenopodium) into beneficial catchment areas, anthropogenic landscapes. For the period 4,000 to 400 years before present, adventive perennials (like chinquapin) and annuals (like jimson weed) were added to existing catchment areas. We think we see the first cultivar annuals (some cucurbits and possibly sunflower) around 3,000 years before present. Cultivar annuals are hybridized annuals that may, or may not re-seed themselves in a sustainable manner, and were likely added to existing perennial berry (like huckleberry), vegetable (like plantain), or medicinal gardens (like cohosh), and edge (like fox grape) and fringe (like raspberry) environments. Managing native and adventive perennials and annuals can be a year-round activity (examples: constructing, planting, pruning, or transplanting species like persimmon and pawpaw orchards, and acorn and nut groves), or bark ringing and preparing new ground, as well as using fire to reduce waste and invigorate the soil). We envision investments in organized, beneficial ecological arrangements, and the accumulation of anthropogenic landscape capital. For a description of the fifteen acre pawpaw cluster located in Alapocas Run State Park, DE., see Mellin and Truitt (2013a).

- Horticultural/agricultural economies--1,500 to 400 years before present.

Managing domesticate annuals (often referred to as cultigens) requires specific, intensive (frost free) seasonal activity (example: planting, growing, harvesting, and storing the yield). Any dependency on cultigens was likely a consequence of population pressures, and would not preclude or diminish the continuity of previously established agroforestry programs. Much has been written about groups of Native peoples in Delaware and New Jersey, for examples, allegedly relying on corn, beans, and squash as a dietary foundation. However, archaeological and historical data suggests, as Marshall Becker has repeatedly stated, many of these Native groups probably used cultigens only on a small scale, ceremonial basis (e.g. the green corn ceremony), and only increased corn production to measurable levels, in addition to brokering land transactions to take advantage of lucrative early Colonial markets. Some groups of people with large, concentrated populations developed dependencies on cultigens, which likely required organization at or above the incipient-chieftain social level, occupied defensible territories and/or lived in high density village locations.

OUR PLACES IN SPACETIME ECONOMIC MODEL

Attempting to integrate the above potential economic strategies into traditional, Cultural Ecological methods and theories presents a roadblock. Historical Ecological interpretations provide both complimentary and contrasting views of how we have explained Native American behavior over the past decades. The major limiting factor in Cultural Ecological assumptions traditionally pitted evolving forager adaptations against evolving natural external factors. While striving to achieve broad, multidisciplinary externally focused environmental contexts to frame population, settlement, technology, and economic expressions, we have limited the totality of alternative explanations by assuming that every society, or study group behaved as foragers prior to the adoption of, or dependence on domesticates (whatever that means). But, what does that mean? Doesn't the adoption of, or acquired dependence on domesticates require a conscious manipulation of the supposedly resilient factors external to the group in question?

Aware of the risks involved in creating yet another limiting and perhaps Eurocentric label, we decided to propose an all encompassing, umbrella framework to house alternative Native American economic strategies for the latter half of the Holocene (ca. 5,000 to 400 years before present in Delaware, and ca. 6,000 to 400 years before present elsewhere in the Eastern Woodlands). If we think of this umbrella framework as a "digital folder" where old and new data is added to individual digital files, we can inspect, analyze, and update the files without relying solely on traditional method and theory, as well as the cumbersome organizational labels that have evolved through the application of processional and post processional forms of method and theory.

Aligning with Historical Ecology, our new pragmatic umbrella folder might contain research files such as: Public Landscaping, Agroforestry, and Creating Economic Strategies, forming the acronym, PLACES (Mellin and Truitt 2015b July). New research topics such as landscape burning, culling non-beneficial plants, planting and transplanting beneficial plants, manufacturing monoculture woodlots, berry and fruit orchards, medicinal gardens, shellfish gardening, using shellfish debris to support calcareous plant species, and intensified parenting (formerly husbandry) of plants and animals (including local and/or regional selective breeding to enhance beneficial genetic characteristics) may be addressed in PLACES.

Many elements of these Native American anthropogenic landscapes are observable in the twenty-first century. For example, we identified, purchased, and restored a two-acre chinquapin (dwarf chestnut) nut grove adjacent to a Mockley through Townsend ceramic (200bce--1,600ce) archaeological site. Due to the fact that we have assumed tenure of the nut grove and regularly

harvest and eat the nuts, ancestral Native American ecological sustainability is an unmistakable feature of this plant cluster. Because many of these living cultural botanical features are still with us, still functioning as originally designed, we need to consider Spacetime as the necessary fourth dimension for discussing these primary and descendant Native American plant arrangements (Mellin and Truitt 2015b July). We are now the trustees, the beneficiaries, and the managers (or extirpators) of these ancient botanical features in our contemporary landscapes.

NECESSARY ADJUSTMENTS

Recent interest in the topic of climate change due to increased atmospheric carbon dioxide has reinvigorated our desire to research and document the configuration of past ecologies and environments. These studies are intended to form baseline descriptions, delineating ecologies and environments that existed prior to the industrial output of carbon over the last 400 years. Until quite recently, these reconstructions of past ecologies and environments in the Eastern Woodlands have been viewed through the lens that ecologies and environments existed solely in the natural state, wild and pristine, influenced only by climate. These data have been used to describe the natural ecologies and environments of the Eastern Woodlands for the entire Holocene, even back into the Late Pleistocene. These data were assumed particularly useful for comparative purposes when viewing atmospheric, ecological, and environmental changes over the past 400 years. Trends were identified and predictions were made about the future. Most of that data has been used by archaeologists to fashion Cultural Ecological explanations where forager behavior was viewed as adjusting to, or adapting to a series of "natural state", or climate signaled ecologies.

Historical Ecology and the concept of Native American agroforestry initiates a response where we need to reevaluate how we have interpreted these past ecological and environmental reconstructions. Again, past reconstructions viewed through the lens of Cultural Ecology have assumed forager behavior was adjusting to or adapting to external ecological and environmental changes. Historical Ecology and agroforestry initiates a paradigm where we address cultural demands sometimes signaling dramatic changes on the ecology and environment. For example, the implications for understanding ancestral Native American behavior has dramatic consequences when we interpret something like a simple pollen core retrieved from a wetland repository located in an anthropogenic catchment area. Perhaps the data core offers a stratified record of pollen, seeds, phytoliths, and carbon for the last 4,000 years--that is the biological data record--those are the factual, ecological fragments recovered. If we assume the environment signaled cultural behavior (as in foraging), then we assume the biological record represents the natural state, a reflection of climate. If we assume cultural behavior signaled the ecology (as in agroforestry), then we assume the biological record represents examples of anthropogenic landscapes. This brings into question how, and why we are applying the phrase, "forager subsistence". If subsistence defines the necessities of survival, as in successfully achieving a minimum threshold, then how can we assign forager subsistence characteristics to cultural groups whom clearly have invested in and amassed varying degrees of landscape capital? For all intents and purposes, the accumulation of landscape capital exhibits quantifiable excesses of stored wealth in culturally modified ecologies.

WHAT IS LANDSCAPE CAPITAL?

There have been thousands of essays written and presentations delivered discussing the accumulation and storage of useful things like; a pit feature containing an argillite cache, or a robbed-out pit feature that was used to store hickory nuts. But, few people are willing to discuss manipulating the environment in beneficial ways to form organized, localized, storable, and scheduled forms of ecological capital. For example, look out your window--do you see that

cornfield? Natural processes due to climate and soil might very well prescribe a mix of beech, hemlock/pine, and maple--with some gum and oak to be growing there. However, the local farm family has used various economic strategies and technology to grow corn, magnifying the edible caloric output per acre over a hundred fold. It's true the 19th century farmer spent a lot of time using axes, saws, and fire to clear the land for agriculture--not all at once, but adding acreage year after year. The product is a multi-generational investment in ecological capital, a reliable, renewable, sustainable, and inheritable economic pursuit, as Terrell and Hart (2008) are fond of saying in their pragmatic voice; domesticated landscapes put food on the table and a roof overhead.

In comparison, a local ancestral Native American family may have desired, for example, a predictable persimmon harvest to be available at a certain place at a certain time of the year. It would take a about a week to ring the bark from an acre of naturally occurring large trees--no need to cut them down--they will defoliate in a year or two. After the desired lot is defoliated and burned over, persimmon seedlings are planted. When the female persimmons start to produce fruit, the male persimmons are identified and their bark is ringed. More seedlings are planted. After about twenty years, a manufactured persimmon grove is established; a reliable, renewable, sustainable, and inheritable economic pursuit that puts both, food on the table and a roof overhead, as well as creating and knitting together a local and regional framework for economic trade and exchange. One could try to expand the restricted definition of forager subsistence to include this accumulation in landscape capital, and the resulting trade and exchange, but the traditional concept of forager behavior singularly adapting to environmental change remains problematic. Developing the use of stone quarries and the manufacture and distribution of stylized stone tools of the agroforestry trade are great examples of investing in landscape capital. Let's look at how the Appalachian Trial (AT) was built as a regional access and transportation feature, ideally designed to access these stone quarries, and to facilitate regional stone tool distribution.

While researching the ancestry of the AT, we realized the trail traverses and connects all of the major high quality lithic outcrops in the Appalachian mountain range (Mellin and Truitt 2014b June). These natural lithic outcrops were developed into extensive raw material quarry sites; representing intensive and extensive investments in landscape capital. Taking into account the diversified tasks involved, such as procurement, manufacturing, regional transportation, and distribution of suitable quarry materials, one could actually refer to these exploited lithic complexes as stone tool industries. We discovered the AT serviced the following lithic complexes (from north to south):

Munsungun Lake Formation (chert), Maine
Kineo Rhyolite Formation (rhyolite), Maine
Mount Jasper Rhyolite Formation (rhyolite), New Hampshire
Cheshire Quartzite Formation (quartzite), Vermont
Normanskill Association (chert), New York
Lockatong Formation (argillite), New Jersey--Pennsylvania
Reading Prong Formation (jasper), Pennsylvania
South Mountain Formation (rhyolite), Maryland--Pennsylvania
Flint Run Formation (jasper), Virginia
Rockbridge Formation (jasper), Virginia
Mount Rogers Formation (rhyolite), North Carolina--Tennessee--Virginia
Blue Rock Formation (steatite), North Carolina--Tennessee

The Appalachian Trail does not simply follow one geologic lithic vein, or provide access to one lithic type, it links together a host of very useful lithic types, such as argillite, chert, jasper, quartzite,

rhyolite, and soapstone, forming the primary north/south access and transportation corridor east of the Mississippi River. We need to recognize the AT as a transportation corridor, a truck route that facilitated the resolution of tool stone supply and demand issues on a multi-regional (Southeast Region, Mid-Atlantic Region, and Northeast Region) scale. The AT was likely defined some twelve thousand years ago--and we are just now re-discovering it? Many forms of landscape capital, such as the AT, became durable enough to still be identified in the twenty-first century, while many others have recently been destroyed and have become lost forever! Luckily, the Appalachian Trail is being protected, even though its ancestral Native American origin and multiple functions are misunderstood.

LOOKING BELOW GROUND

There are two landscapes to be addressed here: one underground, one above ground. Archaeology has offered many very interesting factual glimpses of past cultures within the context of their respective ecologies. We have the ability to gather and identify carbonized wood, stems and seeds, pollen, starch grains, and phytoliths from archaeological contexts. Some of these botanical remains can be typed by Genus, occasionally to species. From waterlogged locations, we may recover oxygen starved vegetative remains, like logs, cut wood, seeds, leaves, stems, bark, buds, berries, and fruits.

Generally speaking though, finding an identifiable rare carbonized seed in a datable pit feature context is the Holy Grail for archaeobotanists. Such a seed can be species specific and it may exhibit a specific local position in space and time. Rarity is relative, however! Truly rare plants are especially noteworthy, but rareness, as in survivability, presents a major problem. Most archaeobotanical remains are recovered from soil flotation samples and typically only carbonized examples are considered to have withstood the test of time buried in the earth sometimes for thousands of years. So, if my grandmother, for example, could crack a thin skin seed with her teeth, there is little chance such a seed would successfully carbonize when exposed to fire without being reduced to ashes. However, thick skin seeds like hickory, walnut, and in the Piedmont, butternut have a much better chance of being carbonized without being reduced to ashes. Unfortunately, through this selective process of carbonization, we typically recover many more fragments of the thick wall seeds than we do thin wall seeds.

LOOKING ABOVE GROUND

Few archaeologists have the ecological training, or even a desire, to identify examples of living plants and address them as candidates of ancestral Native American contexts. Yet, when we encounter a cluster of walnut trees, daffodils, and flowering periwinkle during a field survey, we automatically assume this is a location of historical interest. Evidence of cultural activity is truly visible in the character and content of the surrounding vegetation.

The roots of the american chestnut, for example, can survive for over 1,500 years. It is no wonder there are many Native American contextual plants that are still alive today--some individuals may be doing well, while other examples may be doing poorly. Many perennials can be identified on a year-round basis, while many annuals may not even be recognizable during the winter months. Shorter-lived plant species may still be found in definable clusters, representing Native American plant descendent populations. Searching for these plants and deriving meaning from their species type, configurations and cultural associations is a relatively new, but profoundly important enterprise. The recent computer mapping of some 18th and early 19th century witness tree surveys provide examples of where and what species were used to create Native American anthropogenic landscapes throughout the Eastern Woodlands. Our next step would be to design and conduct

actual field surveys in an effort to identify, document, and map remaining plants and clusters of plants from those Native American anthropogenic landscapes.

SECTION TWO: DESIGNING AND CONDUCTING ETHNOECOLOGICAL SURVEYS

Over the past three years, we successfully conducted over a dozen ecological surveys, but three locations on the Nanticoke River, a major tributary of the Chesapeake Bay, are excellent examples for discussing contiguous cultural botanical catchment areas still visible within this fairly well preserved watershed. These three locations were noted by Captain John Smith in his 1608 voyage of discovery (Barbour 1986), and further discussed by Griffith and Busby (2014). Navigating up the Nanticoke River, Smith visited the village of Chicone (near Vienna, MD.), the village of Kuskarawack (near Philips Landing, DE.), and was informed, but did not visit a village above the fork of Deep Creek and Gravely Branch (Rivers End, or Concord, DE.). Interestingly, these Native American village locations are evenly spaced along the Nanticoke River about eight miles apart. Smith indicated neither the people nor the structures within these Indian towns were concentrated. He described the Native American daily activities as being spread out over a distance of miles, (probably within the context of localized, daily visited cultural catchment areas). The results of our ecological surveys indicate these localized cultural catchment areas exhibit remnant botanical arrangements consistent with both the extent and geographical locations suggested by Smith. Next, we will review our physical inspection of these three Native American locations along the Nanticoke River, in reverse order; first Rivers End, second Kuskarawack, and third Chicone.

RIVERS END

In 2013, we looked into the likely Native American ancestry of a three-acre box huckleberry (*Gaylussacia brachycera*) cluster (an adventive species in Delaware) found growing adjacent to an unplowed, wooded archaeological site, 7S-E-19 (Mellin 1991), on one of our properties on the Gravely Branch of the Nanticoke River, two miles upstream from Seaford, Delaware. This site is situated on sandy, slightly acidic soils of the Lower Coastal Plain (Mellin and Truitt 2013d January). About twenty years ago, researchers from the United States National Arboretum in Washington, D.C. visited our box huckleberry cluster to document its GPS position and collect berries for DNA processing. I remember asking those researchers why this globally endangered plant was situated here? They explained the plant was probably 1,500 to 2,000 years old, and that Native Americans had likely transplanted it to this location.

It turns out the box huckleberry is indeed rare, only about one hundred examples are known to remain in North America, the vast majority of them confined to the Eastern Woodlands. The only known examples in the Atlantic Coastal Plain are from Delaware and Maryland. McAvoy (2016) described this species as: "This plant is clone forming and self-incompatible (not capable of producing seed without being cross-pollinated). Populations may persist indefinitely vegetatively for centuries or longer." The oldest known box huckleberry cluster is located in Pennsylvania. That cluster actually consists of two genetic strains, and based on its acreage, the older clone is estimated to be greater than 5,000 years (Pooler, Dix, and Griesbach 2006; Pooler, Nicholson, and Vandergrift 2008). We can speculate the fertility issue is a Late Pleistocene development and the reason the box huckleberry species survived the last 12,000 years (for purpose(s) unknown to us) is due to Native American management through transplantation. Additionally, our box huckleberry cluster has a line of five, evenly spaced american chestnut coppices running through it.

Directly across Gravely Branch from site 7S-E-19 and the box huckleberry cluster, we identified a chinquapin (*Castanea pumila*) nut grove cluster (an adventive species in Delaware). We mapped

about two hundred and twenty examples of this unusual nut-producing tree (found today only in coppice form due to the effects of an Asian bark fungus introduced in the early twentieth century), forming a two-acre oval nut grove. The chinquapin normally would grow forty feet high, well suited for Piedmont slopes, but not at all suited to survive in the one hundred foot canopies here on the flat coastal plains. Chinquapin requires daily doses of direct sunlight to produce nuts, and while examples are able to sustain themselves growing in the shadows on the coastal plain, these examples usually appear as a stunted, withered bush about three feet high and three feet wide, rarely producing fruit. On the coastal plain, the survival of this introduced species would require aggressive crowding maintenance in order to be successful. The root systems of this species can survive for 1,500 years, and where descendent offspring are capable, the sustainability of chinquapin on the coastal plain is virtually limitless, provided routine aggressive crowding maintenance is applied.

We wanted to restore our chinquapin cluster. We cut crowding species to allow some direct sunlight to hit the ground. We counted twelve nut burs the first summer. Continuing to eliminate crowding species, our little bushes reached six feet high, then twelve feet high offering thousands of nut burs (see Figure 1). This spring, new sprouts emerging from ground-fall nuts proved our chinquapin cluster was once again sustainable. Our program was designed to strengthen and restore the root systems of these trees because to date, there is no treatment or antidote for the Asian bark fungus--all above ground stems will eventually become infected and die-back with new stems erupting from the below ground living bark. Comparing our restored chinquapins at 7S-E-19 to non-restored chinquapin clusters, for examples, we have thus far identified five other chinquapin clusters in Delaware; one at Rivers End (Mellin and Truitt 2014c May), two at Trap Pond State Park (Mellin and Truitt 2013c August), and two at Killen Pond State Park (Mellin and Truitt 2013b August), we found that good root health and adequate sunlight in our restored cluster directly increased the height and stem diameter, nut production (see Figure 2), and seems to have dramatically increased resistance to the Asian bark fungus.

When we compared the Rivers End chinquapin cluster along Deep Creek (two miles south of our chinquapin cluster associated with site 7S-E-19 on Gravely Branch), we made some interesting observations. The Rivers End cluster was associated with several more known Mockley and Townsend ceramic base camps, prickly pear clusters, yucca plants, arrow arum growing in the river, and along the southern shore of Deep Creek, another long line of american chestnut coppices. Difficult to prove, with some residential developments and agricultural fields erasing large landscape areas, yet, we had an indication all of these chestnuts lines represented some sort of large botanical feature. We literally walked for a week in the nearby wooded areas looking for random chestnut trees--but, we couldn't find any random chestnut trees. All of these chestnut trees, some forming lines of evenly spaced trees, likely formed two portions of a single chestnut circle cluster we measured at least three miles wide. We could not confirm the overall chestnut cluster dimensions due to potential loss of data in residential developments and agricultural fields. It certainly looks as if the Rivers End archaeological sites and associated remnant botanical clusters (one mile up Deep Creek) together with similar findings at 7S-E-19 (one mile up Gravely Branch) are simply individual elements of one large, autonomous catchment area. Based on the similar archaeological sites and the similar remnant botanical species, we had discovered a fragmented, yet measurable anthropogenic catchment area at least three miles wide. We definitely needed to survey a larger area of protected land for comparison. We found a suitable area at Kuskarawack Towne on the Nanticoke River about eight miles downstream from Rivers End.

KUSKARAWACK TOWNE

The remnants of Kuskarawack Towne are largely situated on many thousands of acres of protected woodland, with some agricultural fields, pine plantations, and a few housing developments, mostly on the north side of the Nanticoke River. At least five DESHPO cultural resource identification numbers have been assigned to known archaeological sites (Johnson Farm, 7S-E-1; Barnes Woods, 7S-E-38, 39; and the Bead Site, 7S-H-114 along the north bank, and Phillips Landing, 7S-H-1; and Prickly Pear Island, 7S-H-18 along the south bank), collectively representing the Native American habitation area from Wrights Branch (downstream) to the confluence of Butler Mill Branch and Chapel Branch (upstream), the same Indian town area that Smith had visited and illustrated in 1608 (Griffith and Busby 2011).

Initially, we accomplished a twenty square mile pedestrian ethnoecological survey in and around the Kuskarawack Towne area, which consumed twelve full days of walking. We documented an arrow arum starchy tuber complex, an upland game complex, an anadromous fish complex, a two square mile highbush berry cluster, two prickly pear cactus clusters (one large cluster on Prickly Pear Island), two yucca clusters, creeping cucumber, christmas fern and crowsfoot garden areas, all contained within a planted american chestnut circular nut grove, which measured six miles in diameter. We identified and GPS documented sixty-two individual american chestnut trees forming this circular nut grove feature. We searched for, but found no random chestnut trees, therefore, we deduced this six-mile wide botanical feature was created by the addition of individual trees, and not through subtracting random trees. We GPS documented this six-mile wide, planted, circular nut grove running from Wrights Branch (downstream) to the east side of Chapel Branch (upstream), on both sides of the Nanticoke River, essentially encompassing the inhabited activity area of Kuskarawack. We quickly realized it would require an astounding fifty square mile survey area to hopefully frame these associated botanical features and material culture sites with a negative border at this Native American location (Mellin and Truitt 2015c February).

We now have a strong indication that within these anthropogenic catchment area locations here on the coastal plain, linear fragments or extant lines of ancestral american chestnut groves are pieces of larger investments in landscape capital, circular botanical features that may have performed many functions. These large botanical circles appear to be important food sources planted along footpaths, they may also represent highly visible or symbolic palisades, and physical expressions of identity or property. Another important observation is that the Nanticoke River runs through these circular american chestnut features, not around them. Following up on these possible expressions of identity or property, if you will, the river seems not to be a boundary at all, but serves as the physical core of self identity. Thus, when Smith approached Kuskarawack Towne, unannounced, via his river barge, he had likely committed the most profound Native trespass.

CHICONE

About eight miles downstream from Kuskarawack, we arrive at the Indian town of Chicone. We allocated two field survey days to make a preliminary botanical assessment, but first, some background information would be beneficial. Virginia Busby (2010) consolidated her work on historical Indian corn soils (previously suggested by the Maryland Historical Trust, Helen Rountree, Thomas Davidson, and others) at the Chicone Indian Reservation and archaeological site complex on the Nanticoke River. Busby inspired a critical conversation about how and why those Indian corn soils originated. If we assume Native Americans added corn and likely other cultivar and cultigen annuals to their existing anthropogenic garden areas, then we need to address how, why, and when those garden areas functioned in pre-cultigen, as well as pre-cultivar economies.

A few years after Busby's dissertation, Sullivan, Chambers, and Barbery (2013) published their Indigenous Cultural Landscapes Study… for the Nanticoke River Watershed. They suggested Indian corn soils are a significant cultural resource, in need of protection. We strongly recommend downloading their document, available on the Internet. Their figure 13 on page 40 plots these areas of Indian corn soils. Also, figure 17 on page 47 exhibits their Cultural Data and Indian Corn, a composite of Native American cultural data including known archaeological sites. Figure 17 is a very useful map where Chicone, Kuskarawack, and the Rivers End site clusters are arranged along the Nanticoke River. One should view this map for reference and to see how each of our identified botanical catchment areas line up with these named Native American locations. At first glance these spaces appear to be contiguous, possibly abutting one another, as well as being contemporaneously occupied by one defined group of Native people. Yet, while these individual activity areas appear evenly spaced along the tidal Nanticoke River, the material and botanical contents of these catchment areas offer a great deal of diversification.

We made a physical inspection of the Chicone Indian corn soils and found some fields exhibited light scatters of old shellfish remains as if, at some point in the past, there had been an effort to add calcium to the soil. We wondered if these scatters of old shellfish remains were intentional, or not, and when might this attempted calcification of the soil have occurred? We put our canoe into Chicone Creek and paddled downstream to the Nanticoke River. Reversing our course, we paddle upstream as far as we could go, and used vehicular survey to complete our upstream scouting. We found the lower 25% of Chicone Creek exhibits extensive multi-species fern gardens; the next 25% exhibits a tremendous amount of seaside alder. From our vehicle, we observed acres of mayapple in the next 25%, and finally, the upper 25% stream banks were carpeted with skunk cabbage, all beneficial and useful plants, and all likely remnants of ancestral Native gardens. On our second day, we surveyed Jones Thicket and found a five square mile soggy thicket still supporting an immense cluster of edible high-bush berry, probably in the *Gaylussacia* Genus. Certainly, a very rewarding comprehensive ethnoecological survey could be conducted in the Chicone catchment area. This is a large area where we would forecast an initial twenty-day pedestrian field survey. However, our initial contact with several local hunting clubs proved problematic.

LINEAGE DIVERSITY

All natural things standing on equal footing--Rivers End, Kuskarawack, and Chicone share the same elevation, the same base soils, the same climate, the same growing seasons, very similar anadromous fish runs, as well as the potential availability of similar tidewater and upland game species along the tidewater Nanticoke River. Yet, we discovered the remaining botanical contents of the individual Indian towns and their respective catchment areas are distinctly different. The residents of each town, or each lineage appear to have focused on different manufactured resources. With cooperative reciprocity, the entire Nanticoke group would have benefited from these diversified, focused ecologies--pure genius! Identifying these individual, group focused ecologies may be the key to unlocking the complex topic of clan-based lineages, or lineage-based clans within one definable cultural group.

The cultural catchment area at Rivers End exhibits many, many square miles of white oak, several adventive chinquapin nut groves, fragments of what appears to be a large, circular chestnut grove, extensive patches of lowbush berries, prickly pear, yucca, maypop (see Figure 3), and a box huckleberry colony. Archaeological sites within this catchment area exhibit a small amount of shellfish, and Indian corn soils are not projected for this catchment area. Based on the results of our survey, we suggest the main economic focus of this catchment area was acorn and nut production,

together with upland species, like turkey and deer that would have been attracted to this type of manufactured landscape. Attracting abundant turkey and deer is not necessarily a problem!

The cultural catchment area at Kuskarawack exhibits an arrow arum starchy tuber complex, a highbush berry and fern garden complexes, as well as prickly pear, yucca, creeping cucumber (see Figure 4), and shadbush arrangements. All of these individual elements are enclosed within a planted american chestnut circular nut grove. Archaeological sites within this catchment area exhibit a small amount of shellfish, and Indian corn soils are not projected for this catchment area. Based on the results of our survey, we suggest the main economic focus of this catchment area was arrow arum production, in addition to riverine, such as turtles and furbearing animals, and upland species, like turkey and deer that would have been attracted to this type of landscape.

The cultural catchment area at Chicone exhibits an Indian corn soil complex (see Busby 2011), a shellfish and skunk cabbage association (see Mellin and Truitt 2014a December for a description of smoking and storing shellfish), and a highbush berry, a mayapple, and fern garden complexes. Archaeological sites within this catchment area exhibit a large amount of widely scattered shellfish remains, and Indian corn soils are projected for this catchment area. Based on the results of our very brief survey, we suggest the main economic focus of this catchment area was tending a variety of perennials and annuals, growing cultivars and cultigens, together with shellfish acquisition and storage.

In review, the ecological data from these three adjacent locations along the Nanticoke River should give us a moment of pause. Looking back perhaps five hundred years ago, we have three adjacent habitation locations, occupied by one recognized and definable cultural group, situated in essentially a similar geographic area, exhibiting vastly different manufactured ecological catchment area signatures. How does this data effect our previous assumptions of group and individual mobility? How did individual lineages become actually, or symbolically, responsible for the health and welfare of individual catchment areas? And, how would the ecologically diversified products of each lineage participate in sharing and distributing their portion of seasonally accrued landscape capital within the whole "cultural group" economy?

SECTION THREE: IMPROVING ECOLOGICAL EFFICIENCIES

Following up on the concept of adding calcium in the form of shellfish remains to "sweeten" acidic soils, we turn next to McAvoy and Harrison (2012). Their ten-year research project investigated plant community classification and flora associated with fourteen Native American shell-middens along the upper east side of the Chesapeake Bay. Their discoveries were impressive: "…a unique and globally rare plant community that supports 202 native species and varieties of vascular plants, including 87 that are rare or uncommon on the Peninsula and 21 that are new additions to the flora of the Delmarva" (McAvoy and Harrison 2012:1).

With 21 new additions to the flora of Delmarva, we see that not only are new discoveries possible, but that through new research efforts, we should expect new discoveries. Even more fascinating, McAvoy identified a community of calcareous plants that cannot thrive on acidic soils, growing on Native American shell-middens. Initially, for examples, plants such as wild columbine (*Aquilegia canadensis*), large-seed forget-me-not (*Myosotis macrosperma*), bottlebrush wild rye (*Elymus hystris* var. *hystris*), smooth rockcress (*Boechera laevigata* var. *laevigata*), redbud (*Cercis canadensis* var. *canadensis*), eastern hop-hornbeam (*Ostrya virginiana*), and yellow chinquapin oak (*Quercus muehlenbergii*) were rationalized as growing about these shell-middens, outside of their normal ecological range (McAvoy and Harrison 2012:1-2).

Following Solbrig's (1972) organization of plant dispersal, McAvoy and Harrison agree the range of these calcareous and other plants was never continuous over the Delmarva Peninsula and these disjunct populations of calcareous and other plants are likely specific to individual, or groupings of contiguous shell-midden locations (McAvoy and Harrison 2012:18). Following Lowery (2005 and 2010), who was a consultant to McAvoy and Harrison (2012), the archaeological timeframe of these shell-midden sites span 1,800bce to 1650ce, but are more intensely deposited in the 0ce to 1650ce timeframe (McAvoy and Harrison 2012:16). One result of McAvoy and Harrison's research is the realization that many of these disjunct plant species currently found on these calcareous enriched soils are a result of ancestral Native American activity. These calcareous plants and other beneficial plants of cultural interest are able to prosper on these soils that were modified through the application of cultural shellfish remains.

Other clusters of rare plants have been identified at other material cultural sites and ceremonial locations. For example, a documented remnant population of american lotus (*Nelumbo lutea*) is located off Lotus Lane, Dover, Delaware in the immediate vicinity of the Puncheon Run Site (Berger 2005). McKnight and McAvoy (McKnight, email, July 22, 2013) attribute this population, as well as other populations or clusters of american lotus, on the Sassafras and Potomac rivers to likely Native American horticultural efforts. In addition, a documented population of holy grass (*Hierochloe odorata*) is located at the east end of Thompson Island, Rehoboth, Delaware (McAvoy 2000; McAvoy, email, July 22, 2013; and McKnight, email, July 22, 2013). Small populations of holy grass are known to exist at other, discrete locations in Maryland, and Virginia. McAvoy is quoted, "*H odorata* found on the Delmarva Peninsula may be a result of it being dispersed here by Native Americans" (McAvoy, email, July 22, 2013). Many of these rare and unusual plants are categorized as adventive, meaning they do not naturally occur in Delaware, but are considered indigenous elsewhere in North America and are likely "hosted" in Delaware through trade and exchange from other areas, at various times, and under various circumstances in the past.

SHELLFISH MANAGEMENT

We wanted to take another look at the largest known shellfish accumulation in Delaware, the shell middens found along Pot Hook Creek, south of Lewes, Delaware. These middens are associated with Wolfe Neck, Coulbourne, Mockley, and Rappahannock/Townsend ceramics (ca. 600bce through 1650ce). There are no Hell Island ceramics (ca. 500ce through 1200ce) associated with these shell middens on Pot Hook Creek. The makers of Hell Island ceramics lived nearby and did forage for shellfish at other locations (see Argo's Corner site), but evidently this small immigrant population (see Hunter's Home, Princess Point, and Point Peninsula sites in New York) did not have access to the indigenous clam gardening economic program on Pot Hook Creek. Why?

We designed an extensive ethnoecological survey of Pot Hook Creek, which could provide a broader view of the primary known archaeological sites, and their shellfish middens, and several broad areas of what appeared to be uniformly scattered shellfish (see above, adding calcium to acidic soils) within a holistic environmental framework, including the tributaries and tidal bay environment, as well as the available terrestrial plant communities (Mellin and Truitt 2014a December).

The process of ancestral Native American clam gardening should be addressed wherever we find evidence of huge amounts of multi-cultural Native shell debris. We need to be judicious in assessing evidence of Native shell debris, because the quantity of shellfish debris over time is important. We need to address whether a cultural deposit represents successive cultural inheritance of a managed

location, or are we looking at a small deposit representing an isolated, or short-term, or single component effort. Turner (2014, V1:212) reminds us, "Clam beds, carefully built up to extend their area and productivity, were created and sustained on many parts of the coast (Fowler and Lepofsky 2011; J. Williams 2006; Recalma-Clutesi 2005)". Quantifying successive shellfish sustainability is likely the key element that differentiates shellfish gardening from shellfish foraging!

Clam garden management, or shellfish stewardship, implies the cultivation of harvestable adult clams within a storable shellfish economy, promoting enhanced economic predictability with a large degree of permanence, even if permanence is based on a repetitive seasonal basis. Such factors might enrich trade and exchange networks and result in elaborations of ritual, ceremonial, and mortuary practices. Williams (2008:1) said, "The clam gardens were one of the foundation blocks of aboriginal economy for specific coastal peoples. If they are accepted as an essential cultivated and privately owned unit of Native economy, a term like "hunter gatherer", which has been used by social scientists to define Northwest Coast Native society, must be reassessed." This is why we are making a profound distinction between clam foraging and clam gardening. We strongly suggest our idea of clam gardening in Delaware involves maintenance and extraction regulations. While mature stocks are harvested, immature stocks are left to grow and reproduce. Our ethnoecological explanation of clam gardening as an anthropogenic landscape, or Traditional Land and Resource Management (TLRM) property (Turner 2014) simply cannot be properly addressed while relying on subsistence forager models adapting to environmental changes.

When we integrate the gardening of clams with the leaves of the skunk cabbage as smoking and storage wrappers, we have multiple ecological elements coming together to form an integrated procurement and management process. Economic systems like clam gardening may produce sufficient surpluses to facilitate material and ceremonial embellishments. It certainly appears some of these surpluses from the clam garden economy on Pot Hook Creek were used to acquire the trappings and embellishments that define Delmarva Adena (Mellin and Truitt 2014a December).

WHITE-TAILED DEER MANAGEMENT

While we are discussing increases of beneficial animal populations in managed environments, we need to address how "free-range" terrestrial mammal and avian populations might have reacted to the development of managed woodlots, fringe, edge, grassland, and open space environments as a result of agroforestry design. It might be easy to envision an increase and concentration of beneficial fruits and berries, but how about the deer and turkeys and other animals attracted to improved ecologies (Mellin 2009)?

White-tailed deer, for example, although they exhibit the ability to be socially imprinted as a "pseudo-pet", they are far from the ideal ruminant to succeed in domestication. We lack the proper words and phrases that might describe Native American low-level management of white-tailed deer (for examples, should we say; accumulation of pet deer, animal husbandry, or carnivorous and/or dairy pastoralism?). Low-level management techniques often involve gelding young males--thus, in order to accurately analyze white-tailed deer archaeological faunal remains, we need to teach ourselves how to identify three possible sexes: male, female, and gelding. We also need to employ uniform white-tailed deer milk fat lipid testing on Native American steatite bowls and ceramics.

Pietro d'Anghiera (1457-1526) was with Spanish speaking explorers in what is now coastal South Carolina prior to the economic and political disruption beginning with the transmission of European pathogens. We also know Spanish-speaking explorers were exploring the Chesapeake Bay during the second half of the 16th century, and we have to wonder how many Native American

economic strategies had collapsed or were in decline due to the spreading of European diseases before English-speaking explorers even arrived in the Mid-Atlantic Region. At any rate, d'Anghiera described (see MacNutt. ed. 1912) the relationship between Native Americans living in coastal South Carolina and their accumulated white-tailed deer:

> In all these regions they visited, the Spaniards noticed herds of deer similar to our herds of cattle. These deer bring forth and nourish their young in the houses of the natives. During the daytime they wander freely through the woods in search of their food, and in the evening they come back to their little ones, who have been cared for, allowing themselves to be shut up in the courtyards and even to be milked, when they have suckled their fawns. The only milk the natives know is that of the does, from which they make cheese.

Low-level herding techniques employed with the South American anthropogenic camalids (the alpaca and the llama) might be useful for discussing, or designing a North American white-tailed deer management model. When compared to a "free-range" population of white-tailed deer, successful management techniques in managed ecologies could potentially double the head count yield, and gelding the males destined to become winter stores can potentially double again their nutritional value. Socially imprinted white-tailed deer may have participated as a factor in the division of labor, possibly used as a beast of burden, and potentially making them a preferred item of gift giving, feasting, or exchange. We see in community cooperation and social networking, as described in Sunay social strategy (Flannery, Marcus, and Reynolds 1989), that small herd management techniques are not only sustainable, they offer a large degree of social security, contributing to the accumulation of landscape capital. Flannery suggested that within small herd management, a minimum number of thirty adult individuals, with two females for every male are necessary for small herd population sustainability. These figures allow for up to 50% yearly extraction related to scheduled consumption, disease, theft, and loss to predators (Mellin 2009).

GRAY FOX MANAGEMENT

The arrival of the gray fox into the Eastern Woodlands occurred very late, where it established itself as an adventive, low-level predator in the Mid-Atlantic and Northeast regions at the beginning of the Late Woodland Cultural Period. The preferred habitat of the gray fox is along edge and fringe transitions and deciduous wooded environments, while the preferred habitat of the red fox is evergreen forests with moderate ground cover (Mellin and Truitt 2016b March).

Recent DNA analysis of the gray fox identified some interesting details that likely offer direct implications for Native American economics. Christine Bozarth, et al. (2011) found the gray fox migrated into the northeastern United States during a significant warming period (ca. 950ce to 1250ce), often labeled the Medieval Climate Anomaly (MCA). What was happening in Europe during the MCA? Although the composition of forests in central Europe were completely anthropogenic by 3,000 years before present (Nemec 2009:11), clear cutting practices culminated during the fourteenth century, which bid King Charles IV the necessity in his "Majestas Carolina" (1,350ce) to initiate Europe's first mandated reforestation programs.

What was happening in the Mid-Atlantic and Northeast regions of the United States during that timeframe? We see dynamic changes in Native American populations, with events in population consolidation, and significant changes in economic strategies and settlement patterns. Some groups were attaining incipient chieftain level societies with increasing reliance on hybrid annuals, such as cucurbits, corn, and beans, etc. These groups are frequently referred to as having adopted

horticulture/agricultural economic patterns, while other groups, generally with smaller, dispersed populations, likely experimented with or adopted hybridized annuals on a limited or ceremonial basis.

It is interesting the arrival of the gray fox paced the movement of hybridized annuals into the Mid-Atlantic and Northeast regions during this timeframe. We do not yet know whether this predator migration represents a natural, or a culturally related phenomenon, or possibly a combination of the two. We should remain open to the possibility Native Americans acquired and used the gray fox as working pets principally for rodent suppression, catching mice, moles, voles, chipmunks, rabbits, squirrels, ground hogs, even snakes, various classes of burrowing animals and rodents, known to be disruptive to horticulture/agricultural efforts.

PASSENGER PIGEONS

The genetic history of the passenger pigeon offers very interesting population figures through time. Population increase in the latter portion of the Holocene may have responded to the construction of beneficial habitats as a result of Native American agroforestry (Mellin and Truitt 2016a May). One recent publication (Hung, et al. 2011) used DNA analysis to reconstruct population figures through time linked with environmental reconstructions in an effort to justify the passenger pigeon as a dynamic population outbreak and collapse species. Hung's research program assumed Native American populations were foragers. They did not take into account the possibility of Native American ecological alteration, or the development of anthropogenic landscapes.

Hung's genome analysis (2011) indicated a persistent minimum sustainable passenger pigeon population in the hundreds of thousands of individuals over the last million years. Even though the genome analysis could not indicate an average or maximum population, Hung offered a Holocene landscape carrying capacity maximum based on predicted red oak and white oak acorns available to passenger pigeons at 1,700,000,000 to 2,300,000,000 individuals at 9,000--10,000 years before present. Curiously, by 6,000 years before present the assumed landscape pigeon carrying capacity based on available acorns fell to a predicted population of 1B to 1.6B individuals. Hung then assumed the predicted acorn based carrying capacity (excluding chestnuts) of passenger pigeons seemed to remain stable from 6,000 years before present until European settlement. However, Hung's plot chart (2011, Figure 2, page 4), based on DNA analysis, exhibits a dramatic rise in passenger pigeon effective population (*Ne*) from 0.5B to approximately 1B to 2B birds, which likely projects an increase in total breeding population (*Nc*) of between 3B and 5B birds during the 2,000bce--0ce timeframe (a 2x to 5x increase). The *Ne* progresses with mild fluctuations between 1B to 2B pigeons into the beginning of the nineteenth century.

We feel it is not pragmatic to imagine a natural, or climate-induced landscape of the Eastern Woodlands could have produced nearly maximum acorn yield persistently over thousands of years, which would be necessary (according to Hung's population projection) to support the 3-5 billion passenger pigeon observed population during the early Colonial era. However, ecological disruption associated with European and early American settlement did seem to be the primary culprit for the catastrophic and rapid population decline, followed by additional negative consequences and eventual extinction as is depicted in the historical record.

As stated earlier, we see the efforts of Native Americans in the Eastern Woodlands, through their agroforestry economic systems, greatly increase the quantity of edible plant species through manufacturing oak--hickory--chestnut anthropogenic landscapes in otherwise beech--hemlock--maple natural landscapes. These forest focused economic strategies probably began around 6,000

years before present and continued on until Native Americans lost control of their indigenous economic systems and anthropogenic landscapes during preparation for settlement. We also suggest maximum landscape transformation through agroforestry within the timeframe, ca. 3,000bce--1,000bce, which likely bolsters Hung's projected (*Ne*) pigeon population increase.

Interesting, Vento, et al. (2008), suggest a mid-point for the hemlock forest decline (ca. 2,600bce--2,200bce), with this hearty evergreen species being displaced by deciduous oak and hickory. Vento associates this timeframe with increased lateral channel migration and floodplain alluviation, likely a consequence of massive, if not regional landscape disturbances. And later, Vento suggests that pollen signatures exhibit a mix of oak, hemlock, and chestnut with increased floodplain stability beginning around, ca. 1,000bce. These data suggest the landscape transformation from hemlock forest to a mix of oak-hemlock-chestnut in the lower half of the Susquehanna River drainage is fairly complete by 1,000bce, or at the end of the Broadspear toolkit period.

Given the 2-5x population rise of passenger pigeons after 6,000 years before the present, and the population collapse during the preparation of Native American anthropogenic landscapes for settlement, our support for Native American agroforestry economic systems in the Eastern Woodlands provides explanations in both timeline and causation. We do not view the passenger pigeon as an outbreak and collapse species. Rather, it seems to be a very large migratory avian population that, over many years, became reliant on highly efficient (2-5x natural landscapes) Native American anthropogenic landscapes. Once those landscapes were severely degraded, or appropriated for other uses, members of the passenger pigeon species quickly fell below the minimal effective population size, *Ne*, and sadly, the possibility of passenger pigeon extinction became a reality.

DOGS

Today, the Carolina Dog, the Chihuahua, the Xoloitzcuintli, and the Perro Sin Pelo del Peru are the only extant Native American dog breeds, which are descended from domestic dogs from the early Native American migrations. Within the past 300 years, the Tahltran Bear Dog, the Hare Indian Dog, the Salish Wool Dog, and the Innu Canoe Hunting Dog have been extirpated. All of these breeds are thought to have ancestry with the early migrations starting around 14,000 years before present. The Thule working dogs, arriving around 4,000 years before present, represented by the Inuit sled dog, the Canadian Eskimo Dog, and the Greenland Dog, as well as modern variants are doing well in higher latitudes. Beginning around 3000 years before present, we see the Alaskan Malamute and the Siberian Husky belonging to the Spitz ancestral grouping are associated with the ancestral Mahlemuit, or today's Inupiat culture (Mellin and Truitt 2016b March).

To date, the most far-reaching study on Native American domestic dogs is Barbara Van Asch et al. (2013) entitled, "Pre-columbian origins of Native American dog breeds, with only limited Replacement by European dogs, confirmed by mtDNA analysis." Their study was designed to take cheek swabs and blood samples from a variety of living dogs alleged to have pre-columbian, or Native American context(s) in the western hemisphere. The results of their DNA samples indicated there were no distinct haplogroups unique to American dogs. However, they did discover several genetic mutations that had occurred in the western hemisphere since the domestic dog's arrival (est. 12,000bce). We will discuss these genetic mutations within their two sets of data: 1) the Carolina Dog breed, and 2) the Mexican Chihuahua breed.

Van Asch et al. (2013) sequenced the DNA of nineteen living individuals of the Carolina Dog breed from South Carolina and Georgia. They discovered a mutation known as haplotype A184, unique to

the Carolina Dog breed. No archaeological or ancient samples were tested for comparison. Additionally, in the same study, they sequenced the DNA of fourteen living individuals of the Chihuahua breed in Mexico. They discovered a mutation known as haplotype A185 in 5/14 of their living Chihuahua samples, and that mutation is evident in one pre-columbian, archaeological sample from Mexico (showing geographical continuity). Van Asch et al. registered their discoveries (A184 and A185) with GenBank under accession numbers HQ452424-HQ452430, and HQ452435-HQ452438, respectively.

This research suggests that the early types of Native American dogs, the small-boned dogs--the size of a Terrier, have no distinct haplogroups different from East Asian domestic dogs. However, after these migration(s) were completed, specific haplotype mutations did occur. Given enough samples, these haplotype mutations (and who knows how many more haplotype mutations will be discovered in archaeological examples) may be traced back through space and time to their origin. We could then identify descended individuals to figure out who bred these dogs, where these dogs ended up, and who owned them. Clearly, large-scale genomic DNA sequencing of archaeologically recovered dog burials would permit any number of new and interesting avenues of research.

We suppose one could make the case for foragers owning dogs as hunting companions, and those dogs would likely be regarded as prestige items. Dogs in agroforestry settings could be very useful for hunting, as well as suppression of squirrels in acorn and nut groves, rabbits in gardens, and a variety of small pests throughout managed areas.

U. S. DEPARTMENT OF AGRICULTURE, NATIONAL AGROFORESTRY CENTER (USDA NAC)

The USDA NAC maintains offices in Topeka, KA and Blacksburg, VA. (USDA NAC 2016). In their May, 2014 electronic news letter, Agroforestry Notes, we found their essay entitled, Indigenous Traditional Ecological Knowledge in Agroforestry (USDA NAC 2014). The NAC defines traditional ecological knowledge as "a cumulative body of knowledge, practice and belief ... about the relationship of living beings (including humans) with one another and with their environment." Furthermore, it evolves "by adaptive processes and [is] handed down through generations by cultural transmission." Often traditional ecological knowledge represents an indigenous worldview or value system, and thus it is rooted in ceremonial and spiritual practices (USDA NAC 2014:2).

The NAC continues to work with groups of Native Americans to both identify past, and increase current efforts in agroforestry. It is interesting to see the NAC recognizes that previous Native American agroforestry practices have been persistent within our National Forests and National Parks, areas that some very prominent and influential conservationists, such as John Muir and Gifford Pinchot, have referred to as wild and pristine landscapes, supremely shaped by the hand of God. Below, we include seven examples of how the NAC is working with Native groups to restore their indigenous economic systems (USDA NAC 2014:4-5).

> **Haudenosaunee (Iroquois Six Nations):** People of the Mohawk Tribe of the Iroquois Six Nations are working with both New York State Department of Forestry and the US Fish and Wildlife Service to restore black ash trees for use in traditional basketry. Additionally, they harvest maple syrup from maple trees grown in an agroforestry context, as they have done for generations. Both the ash and maple trees were part of the Haudenosaune agroforestry landscape that European colonists encountered when they came to America.

Yakama Nation and Confederated Tribes of Warm Springs Reservation: The Yakama Nation regularly does prescribed burns on their reservation to enhance huckleberry growth in forest understories. They also partner with the US Forest Service to thin out trees and do prescribed burns at the Gifford Pinchot National Forest in Washington in order to increase forest health and restore huckleberries. The huckleberries grow back from underground rhizomes more vigorously after fire, producing more berries in the third or fourth year, and thrive in the enhanced light conditions created when shady canopy trees are removed. The Confederated Tribes of the Warm Springs Reservation are also working with the US Forest Service to thin stands, and incorporate prescribed burns to enhance huckleberry production on the Mount Hood National Forest.

Confederated Tribes of the Siletz: The Confederated Tribes of Siletz worked with the US Forest Service's Willamette National Forest to turn a fallowed ranchland full of invasive European blackberry, Scotch broom, Queen Anne's-lace, and Oregon ash trees into a productive agroforestry landscape. One of the main goals was to restore camas, a plant traditionally considered a delicious food by native peoples. Small populations of it had been found on the site, so the team reintroduced prescribed fire, a main tool traditionally used by the tribes, and planted camas after the burn. They also seeded other native plants used by the tribes, including meadow barley, western red cedar trees, and hazelnut.

Karuk, Yurok, and Hoopa: In Northern California, the Karuk, Yurok, and Hoopa Tribes are using thinning and prescribed burns to manage tanoak and Douglas-fir dominated forests for acorns, huckleberries, mushrooms, hazelnuts, firewood, and beargrass for basketry. Their burns clear dense underbrush, making it easier to access and harvest these resources. These projects are being conducted on reservation, tribal allotment, private, and adjacent public national forest lands.

Tohono O'odom and Pima: The Tohono O'odom and Pima manage mesquite trees for their pods, which are eaten fresh or ground into flour. The Tohono O'odom also manage and consume saguaro cactus fruit, tepary beans, chia seeds, acorns, and many other desert foods, which are part of their traditional systems. Mesquite pods, tepary beans, and other traditional foods have been found to help native people struggling with diabetes caused by a less natural diet.

Alabama Coushatta: In Texas, the Alabama-Coushatta Tribe is working with USDA's NRCS to reestablish native longleaf pine ecosystems, and is using the needles for basketry in the years between timber harvests. Longleaf pines, which used to cover 90 million acres of the southeastern United States, now only cover three percent of that landscape. Longleaf pines provide a home for many native plant and animal species, and are adapted to grow with periodic fires.

Sealaska Native Corporation: The Sealaska Native Corporation recently partnered with USDA's NRCS to thin spruce trees in order to produce more blueberries in the understory for their members to harvest. They acquired USDA organic certification for those acres, and thus, their members are able to harvest and process wild organic blueberries in large quantities as they had traditionally done. Some of these blueberries are made into jams and jellies and sold in local markets.

IMPLICATIONS FOR FURTHER RESEARCH

Self-analysis is always a challenging proposition. Historical Ecology offers a wide range of new, progressive, and necessary views. No longer do we have to discount large bodies of perennially produced data that, for one reason or another, awkwardly refuses to fit into various forager subsistence based economic assumptions, where climate change, or a continuous transition within the "natural state" are viewed as external factors, thereby signaling, or initiating cultural change.

This is the time to ask some difficult questions. Why did it take so long for us to question a predilected subsistence forager assumption? Why do we see ethnoecological research and field survey being conducted on a voluntary basis, and only by volunteers? Why is there so little support from academia, and the regulated, commercial side of archaeology? As far as we know, the only publically funded interest being allocated to researching, protecting, and restoring Native American agroforestry programs is through the USDA NAC. The NAC is experiencing great successes with their expanding program, as they are currently striving to identify and fund additional agroforestry programs.

Science is a data building process, which organizes sets of confirmed observations. We stand on the shoulders of those who came before us, and we provide a platform for future researchers to stand upon our shoulders. Any one of us may be successful in identifying a remnant Native American plant cluster, over here, or over there for example, but to actually document a series of plant clusters forming a cultural catchment area many miles in diameter, to actually understand and appreciate the Native American ecological context of an anthropogenic landscape, field surveys involving twenty, or even one hundred square miles may be necessary. Certainly, for those of us who are willing participants, we have a very large task ahead of us. Tulowiecki and Larsen's (2015) witness tree ecological reconstruction, for example, involved an entire county.

Space and time tend to diminish or even erase what we are looking for. Consequently, the newest botanical arrangements and manufactured ecologies are likely the easiest to identify. Older efforts, and the original intent in those efforts may have been modified, re-arranged, or even abandoned, thus decay and elimination of ancestral landscape capital becomes more difficult to define the further back one reaches in time. We currently have no data, which would support Native American ecological alteration beyond 6,000 years before present, or 4,000bce. However, we are very encouraged with witness tree analysis, the results of contemporary ethnoecological field surveys, and the advances in DNA analysis--providing evidence and meaningful explanations beyond the reach of traditional archaeology.

When we explored the various ecologies along the Nanticoke River, we discovered a new type of diversity. Beyond cultural diversity, we discovered what Marshall Becker has been talking about--lineage diversity. Many thanks to Marshall, he is a very bright spark! Initially Smith, and later Calvert (and others) referred to the inhabitants of the five Nanticoke Indian Towns along the Nanticoke River as one people. However, the results of our ethnoecological surveys at Rivers End, Kuskarawack, and Chicone show a great deal of diversity in each manufactured catchment area that supported each lineage, or presumably each extended family, or clan at each location. Each town was said to have one male elder in authority, however; this may be a defensive, military oriented assumption, and the indigenous social and economic organization of each lineage may very well have been matrilineal.

SUMMARY

The purpose of this presentation was threefold: First, we initiated the topic of Native American agroforestry in the Eastern Woodlands of the United States and identified useful methodological and theoretical underpinnings for agroforestry within the framework of our umbrella Native American economic model called PLACES in Spacetime. Difficulties encountered while applying traditional method and theory to current field research were explored. We addressed these topic headings: Native American Ecologies in the Eastern Woodlands; When: Time Frames; How: Potential Economic Strategies; Our PLACES in Spacetime Economic Model; Necessary Adjustments; What is Landscape Capital; Looking Below Ground; and Looking Above Ground.

Second, we explored designing and conducting ethnoecological surveys. We provided results of our field investigations in Delaware and beyond, where the remnants of Native American agroforestry, as well as other forms of anthropogenic landscapes are supported. We addressed these topic headings: Rivers End; Kuskarawack; Chicone; and Lineage Diversity.

And third, we included a variety of research topics designed to investigate and identify alternative methods of improving Native American ecological efficiencies. We addressed these topic headings: Shellfish Management; White-Tailed Deer Management; Gray Fox Management; Passenger Pigeons; Dogs; and the United States Department of Agriculture, National Agroforestry Center.

Regardless of whichever discipline(s) we are affiliated with, we collectively need to embrace the methods and theories expressed in Historical Ecology. We need to stop trying to manipulate the definition of forager subsistence, where cultural change is signaled by environmental change or territory expansion due to population pressures, just to get a small portion our data to neatly fit within the Cultural Ecology paradigm. Our new pragmatic view is an inclusive, ecological oriented Native American economic model (ca. 4,000bce--400ce) based on Public Landscaping, Agroforestry, and Creating Economic Strategies, or PLACES. We should recognize and address these ancestral Native American anthropogenic landscapes still with us as PLACES in Spacetime. Spacetime is the necessary fourth dimension in archaeology because we still use, and appreciate these ancestral Native American domesticated landscapes. The phenomenal time-depth of these managed ecologies, as well as the humanitarian expressions in what appears to be cultural, as well as lineage diversity is not simply a result of cultural adaptation to habitable environments through time, but a reflection of active human agency in creating and managing these domesticated landscapes.

The authors are solely responsible for this presentation. Working independently and voluntarily, the authors used a high degree of due diligence in "fact-checking" the data presented within, as well as including appropriate citations. All Internet sources were valid on the day referenced in the section, Works Cited. Any errors or unintended misrepresentations are solely the responsibility of the authors.

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Three Scaled Approaches for Modeling Native American Anthropogenic Landscapes

Lenny Truitt and Glen Mellin
July 2017

Abstract
Small, medium, and large-scale Native American anthropogenic landscapes are discussed. The identification and mapping of "indicator species" (Johnson and Abrams 2017), as well as deciphering percentages of pre-settlement pyrophobic/pyrophilic species (Thomas-Van Gundy, Nowacki, and Cogbill 2015) are used to define Native American land use patterns. These landscape use patterns are crucial factors for archaeologists and ecologists to accurately describe past human/ecology relationships.

Introduction

We reviewed dozens of twenty-first century Native American ethnobotanical projects and found they fit nicely into three scaled project classes. As a visual aid, Figure 1 shows the Abbott Farm Historic Landmark near Trenton, New Jersey as the focal point of three scaled anthropogenic landscape contexts (see Figure 1).

This presentation discusses how these three size classes are defined, as well as how Native American botanical descriptions and resolutions are attained. This data is presented as: 1) The small-scale model--archaeological site(s) and ecological catchment area description, 2) the medium scale-model--watershed and cultural landscape description, and 3) the large-scale model--State and Regional description.

Because the timing and scope of identified ecological data is revealed at different spatial dimensions and at different resolutions, it is important to match appropriately sized research questions to the size of the landscape being addressed. We use this data to address implications for Native American economic behavior during the second half of the Holocene (6,000--400 years before present) in the Eastern Woodlands of the United States.

At Penn State University, Sarah Johnson and Marc Abrams (2017:3) provide context in their discussion of "indicator species", as follows:

> A general hypothesis is that Native Americans left a legacy of their land uses in the present-day ecosystem by propagating certain important wild plant species and crop species in the forest, known as "indicator species". Study of indicator species is based on the idea that the presence and number of certain plant species, including trees, shrubs, and herbs, can be an indicator of preferential utilization by Native Americans.

Indicator species are easily recognized when found in groups or clusters. These groupings are assumed to represent remnants of Native American managed landscapes where human agency was the deciding factor of which plants grew where, and to what extent. Obviously, the small-scale ethnobotanical survey should produce the best species resolution because surveys at this scale are conducted on a pedestrian basis.

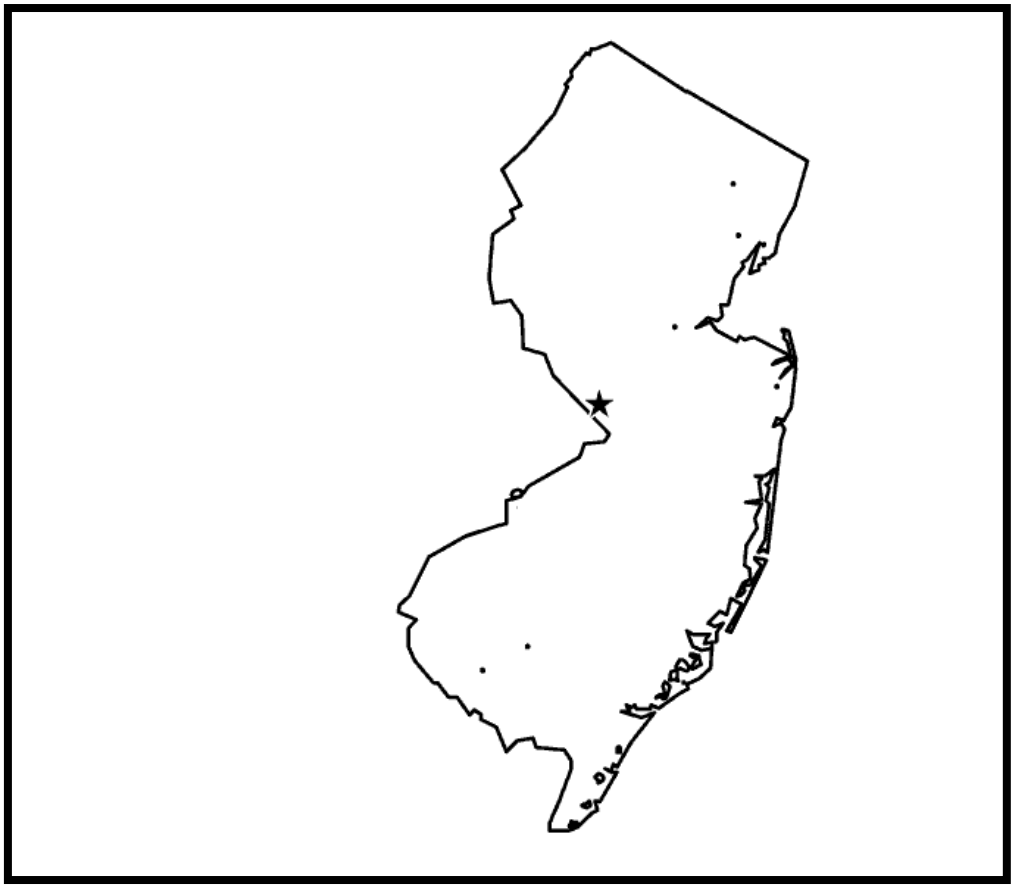
At the USDA Forest Service, Melissa Thomas-Van Gundy and colleagues (2015) provide context in their discussion of percentages of pyrophobic/pyrophilic species documented in witness tree surveys. These data are assembled from pre-settlement government and private surveys, as well as

Figure 1: Hypothetical Examples of Small, Medium, and Large-Scale Approaches

Small-Scale Survey, Abbott Farm Near Trenton, New Jersey

Medium-Scale Survey, Abbott Farm Near Trenton, New Jersey

Large-Scale Survey, Abbott Farm Near Trenton, New Jersey



town level surveys, which form biological/geographical grid systems. These records are plotted first by plant Genus/species, and second by whether those individual records indicate susceptibility or tolerance to fire. The result is a plotted percentage of pyrophobic/pyrophilic landscape disturbance. Witness tree surveys are used to sort out indicator species within medium and large-scale landscapes.

1) Small-scale models--Archaeological site(s) and ecological catchment area description

Small-scale landscape models may be site specific, or address site complexes, or any land area measuring less than one hundred square miles. Surveys of this size identify and map remnant descendent clusters of living indicator species within definable ecological catchment areas. Our pedestrian survey of Kuskarawack Town discovered 62 living American Chestnut trees forming a six-mile wide, semi-circular botanical feature around the Indian town as depicted on our field map (see Figure 2). We were unable to confirm the northern portion of this tree circle due to recently installed residential subdivisions, and agricultural fields. This circular nut grove likely represents more than a planted food source, it may also be viewed as a symbolic palisade, or a marker in Native American landscape cosmology (Mellin and Truitt 2015, 2017).

Our Kuskarawack survey consumed twenty field days of walking and bicycling. We GPS documented blueberry, huckleberry, and serviceberry clusters, various fern gardens, a creeping cucumber garden, prickly pear cactus clusters, yucca clusters, as well as arrow arum growing in the river. Interestingly, all of these plant varieties were found growing inside the chestnut circle. Large remnant stands of oak, hickory, beech, and pine are found nearby.

Surveys with this resolution can provide critical data on remnant plants that were under Native American management. The creeping cucumber we found, *Melothria pendula*, is a deciduous perennial creeper vine that produces little watermelons. Native in Mexico, and adventive in Delaware, this tropical species was likely introduced in the far distant past--perhaps as long as 5,000 years ago, before examples of this Genus were hybridized into the annual watermelons and cucumbers we all know and love to eat.

2) Medium-scale models--Watershed and cultural landscape description

Medium-scale landscape models involve computer mapping of historic witness trees in areas up to one thousand square miles. This example of a medium-scale model is the Allegheny National Forest (NF) in Pennsylvania (see Figure 3). This map shows the location of 3,003 witness trees defined by Genus/species in the 2,594 square mile Allegheny NF study area (Thomas-Van Gundy, et. al. 2015).

The dendrogram (see Figure 4) displays the same witness trees based on tolerance to fire in 10 percent increments. Predominantly pyrophobic species appear in the green areas while predominantly pyrophilic species appear in the red areas. The numbered blue stars (1 through 7) indicate the locations of known archaeological sites (see Thomas-Van Gundy, et al. 2015, Table 2, p.9 for site identifications and published references).

Arithmetic mean pyrophilic species for the Allegheny NF were calculated using two scales; the 5 km mean, and the 10 km mean. The 5 km mean shows 60.7% pyrophilic species within 5 km of Native American sites and 36.7% pyrophilic species beyond 5 km of Native American sites. The 10 km mean shows 51.8% pyrophilic species within 10 km of Native American sites and 32.2% pyrophilic species beyond 10 km of Native American sites (Thomas-Van Gundy, et al. 2015:20).

The Allegheny NF witness tree data shows that dramatic anthropogenic disturbance was persistent around known Native American settlements. Many persistently burned areas extend beyond 10 km

Figure 2: The Location of Kuskarawack Town, on the Nanticoke River in southwestern Sussex County, Delaware, as Captain John Smith reported in 1608, together with the location of the remnants of a six-mile wide American Chestnut Circle, or symbolic botanical palisade, identified by Mellin and Truitt in 2015. (Seaford West 7.5 minute quadrangle).

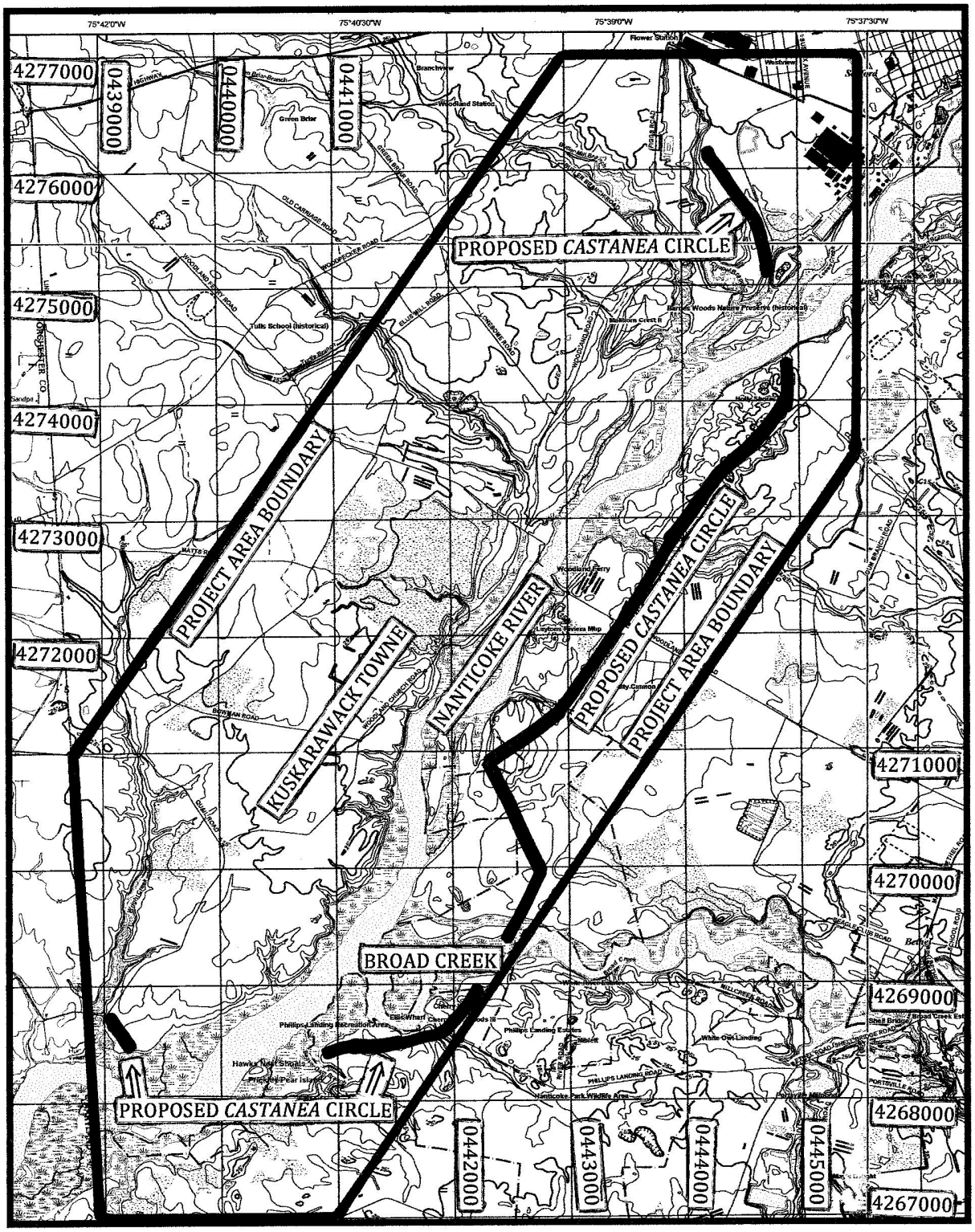


Figure 3: Witness tree locations by indicator class for the Allegheny National Forest.

This image is reproduced with permission from Melissa Thomas-Van Gundy, USDA Forest Service.

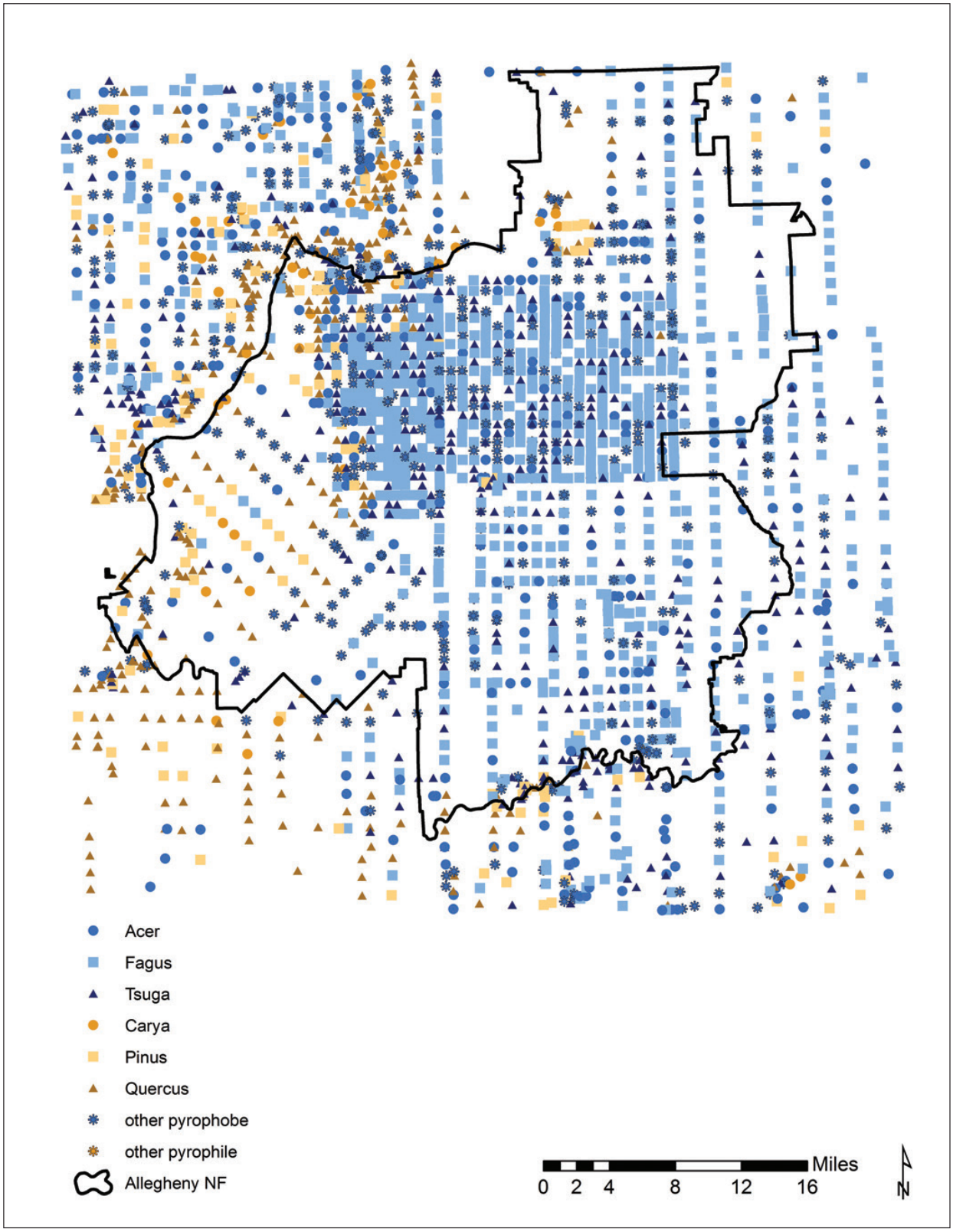


Figure 4: Pyrophilic percentage interpolated from witness trees on the Allegheny National Forest.

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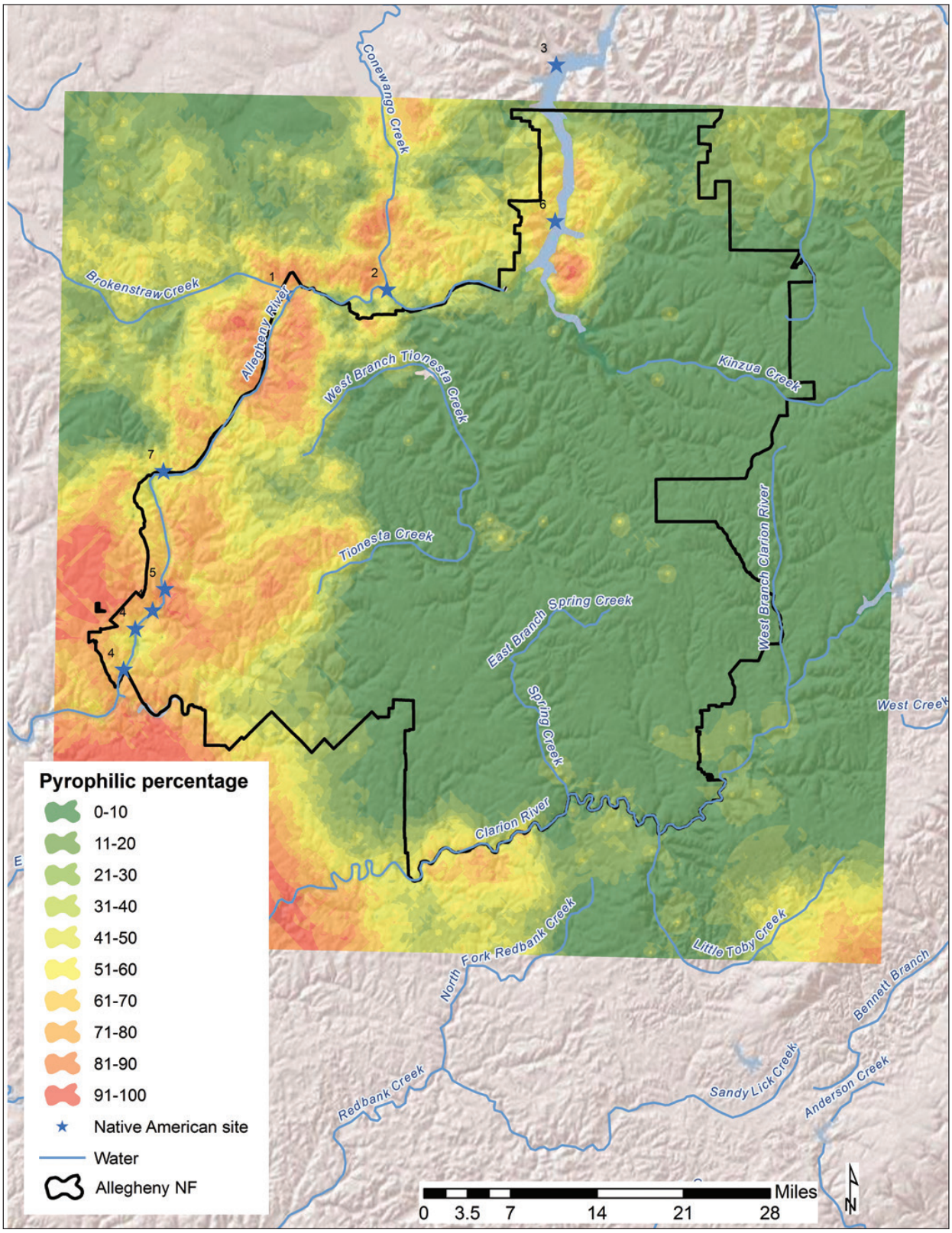


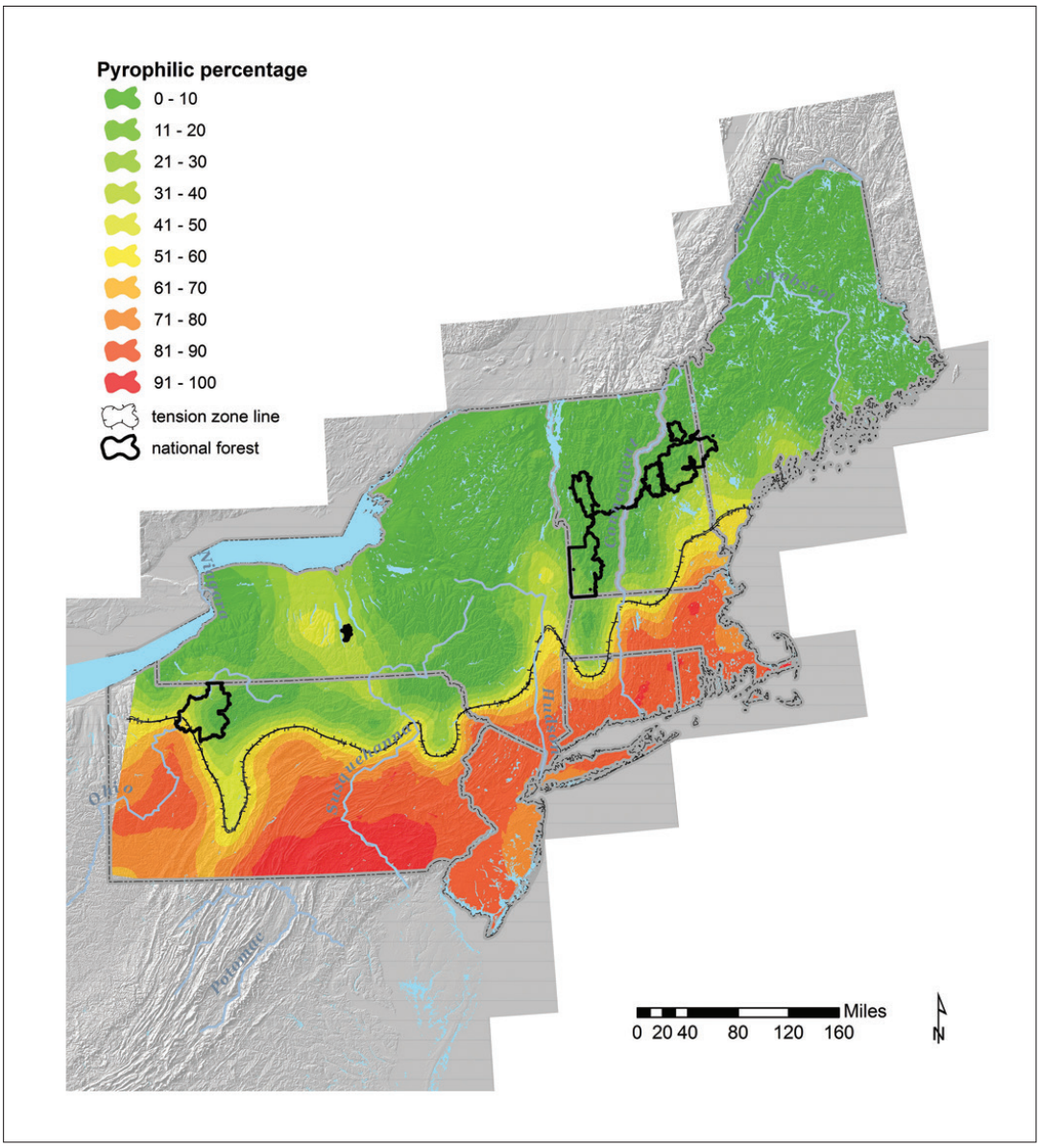
from individual Native American settlements. At this scaled resolution, it is still possible to define the remnants of monoculture woodlots and other spatially arranged botanical species. Contiguous ecological catchment areas likely indicate the presence of contiguously spaced Native American settlements operating within a shared economic program.

3) Large-scale models--State and Regional description

Large-scale landscape models use historic witness tree analysis and computer mapping programs to plot pyrophobic and pyrophilic vegetation regimes in areas up to one million square miles. At this resolution, large-scale models are necessary for viewing States, Regions, and the entire Eastern Woodlands of the United States (see Figure 5).

Figure 5: Pyrophilic percentages as interpolated from town-level witness trees across the northeastern United States. Tension Zone line represents the 50th percentile pyrophilic contour.

This image is reproduced with permission from Melissa Thomas-Van Gundy, USDA Forest Service.



At this scale, Native American ecological management within the larger framework of culture area is revealed. As with the previous medium sized model, the green areas show less evidence of landscape fire, while the warmer colors indicate more landscape fire. The yellowish zones indicate landscapes that share an equal amount of pyrophobic and pyrophilic vegetation forming a "Tension Zone" (Cogbill 2000).

One reason we chose the Allegheny NF as a medium-scale model is because the Tension Zone line runs through the southwestern portion of that study area along the upper limits of the Allegheny River. Protrusions of pyrophilic landscapes run deeply into otherwise pyrophobic landscape areas following Native American settlement patterns along major river systems including the Allegheny River (PA), the Susquehanna River (West and Main branches, PA), the Delaware River (PA and NY), the Hudson River (NY), the Connecticut River (MA), and the Merrimack River (NH), as well as several "islands" of pyrophilic landscapes along the Finger Lakes Region of New York, and along the upper Hudson River in New York State (Thomas-Van Gundy 2015:13).

Are we looking at the effects of Foraging, or Silviculture, or Agroforestry?

We see the effects of Native American ecological manipulation at every scale of spatial landscape analysis. These environmental manipulations were beneficial economic assets organized to increase ecological capital. However, when it comes down to discussing which economic programs produced these landscapes, not all informed people are in agreement. We provide three examples.

First: many archaeologists have assumed forager economic pursuits are associated with these anthropogenic landscapes. For example, Michael Stewart (2015:8-9) summed up traditional Native American economic explanations in the following:

> The management of wild resources traditionally exploited can be thought of as a new subsistence technology. Management could be in the form of any number of behaviors that ethnohistoric and ethnographic hunter-gatherers have employed (e.g. Keeley 1995; Smith 2001). Periodically burning over certain habitats promotes the growth of favored plants, reduces competition from undesirable species, aids some hunting practices, and clears landscapes for the sowing of wild plant seeds. Other management strategies include weeding and transplanting economically useful plants and pruning and coppicing shrubs and trees.

Second: Melissa Thomas-Van Gundy and colleagues (2015:18) summarize their witness tree analysis with the following:

> …we were able to convert witness trees into pyro-indicators to gain perspective on past fire regimes at two spatial scales in the Northeast. However, nothing in this analysis should preclude the use of prescribed fire as a silvicultural tool at the site level where supported by other means.

And third: Glen Mellin and Lenny Truitt (2015) support explanations where Public Landscaping—Agroforestry—and Creating Economic Strategies, or PLACES, in Spacetime are used to address the formation, use, and sustainability of these anthropogenic landscapes.

It is not particularly useful to discuss the formation of anthropogenic landscapes through active human agency while having such differences of opinion about the economic strategies employed. To move forward, these peculiar circumstances need to be resolved through continued research and non-zero-sum discussions.

To properly address these anthropogenic landscapes and the human agencies that created them, we need to devise accurate and meaningful terminology that is informative in cross-disciplinary settings. We also need to reinterpret the human thinking that created these anthropogenic landscapes, and strive to match appropriate economic and technological behavior with appropriate cultural traditions.

We thank Melissa Thomas-Van Gundy and her colleagues for graciously allowing us to reproduce her Allegheny NF maps, as well as their Tension Zone map of the Eastern Woodlands.

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INDEX FILE FOR SPREADSHEET: McAVOYxMOERMAN.DE.xlsx.

Glen Mellin and Lenny Truitt
February 12, 2014

This document is an index file for the spreadsheet: McAVOYxMOERMAN.DE.xlsx. This file contains vital information useful for interpreting data presented in the spreadsheet. Essentially, the spreadsheet exists as a collation of other peoples' work, notably, the following two pre-existing data sets: 1) McAvoy's list of Plants of Delaware (2013), and 2) Moerman's list of Native American Medicinal Plants (2009) (see cover photo below).

The collated list of the above two sets of data is useful as a reference tool in determining whether a particular plant species occurs in Delaware, and whether that plant species has a history of Native American medicinal value. Plant species, which are listed in Columns A and B on the spreadsheet are alphabetically illustrated in Moerman's book from page 31 through page 521. Moerman's illustrations offer both Tribal affiliation and medicinal use. We recommend obtaining a copy of Moerman's book (see photo) for future reference. McAvoy's contributions, Columns C through U contain useful facts about the plants found in Delaware (see column list below).

Definition
Moerman (2009:12) suggests that although medicinal properties and uses of plants may vary widely from culture to culture, his simplistic definition of medicine is this: "…medicine has the effect we want it to have, that it meets our expectations." Moerman devotes an entire chapter to cultural values and properties of medicines.

The Spreadsheet
You should have received one spreadsheet in **xlsx** (not protected) so that you can add to it or sort as needed. Please make an archival copy or two.
Column A: Moerman's (2009) Native American medicinal plants (Latin name).
Column B: Moerman's (2009) Native American medicinal plants (Common name).
Column C: McAvoy's (2013) Delaware's known plants (Latin name).
Column D: McAvoy's (2013) Delaware's known plants, synonym (Latin name).
Column E: McAvoy's (2013) Delaware's known plants (Common name).
Column F: McAvoy's (2013) Family Scientific Name (Latin name).
Column G: McAvoy's (2013) Life Form.
Column H: McAvoy's (2013) Duration.
Column I: McAvoy's (2013) Dioecious.
Column J: McAvoy's (2013) Flowering Period.
Column K: McAvoy's (2013) Wildlife Values.
Column L: McAvoy's (2013) County Distribution.
Column M: McAvoy's (2013) Physiographic Province.
Column N: McAvoy's (2013) State Status.
Column O: McAvoy's (2013) Wetland Indicator Status.
Column P: McAvoy's (2013) Habitat.
Column Q: McAvoy's (2013) Geographic Affinity.
Column R: McAvoy's (2013) Northern Limit of Distribution.
Column S: McAvoy's (2013) Southern Limit of Distribution.
Column T: McAvoy's (2013) North American Distribution (Adventive Species).
Column U: McAvoy's (2013) Additional Information.

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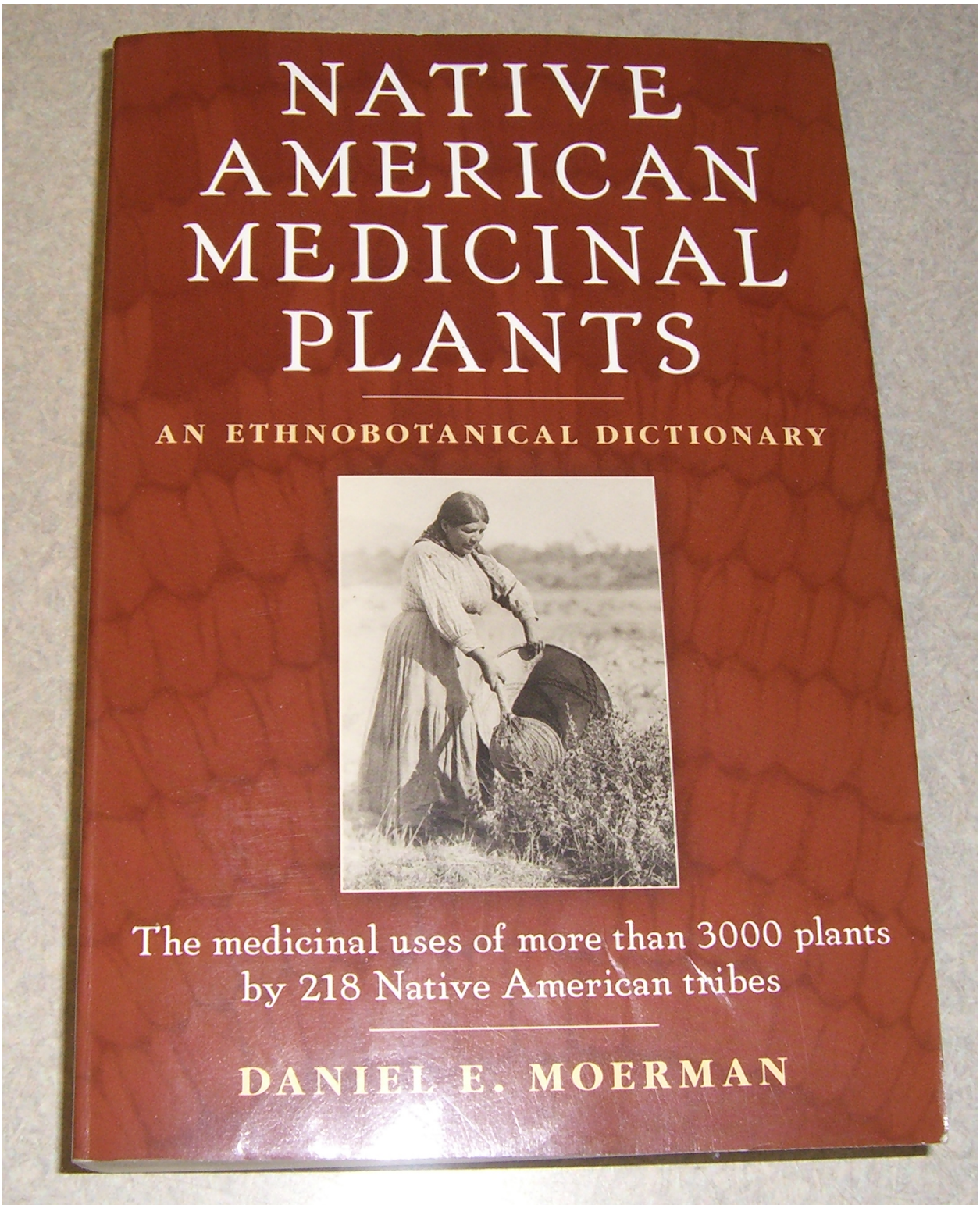
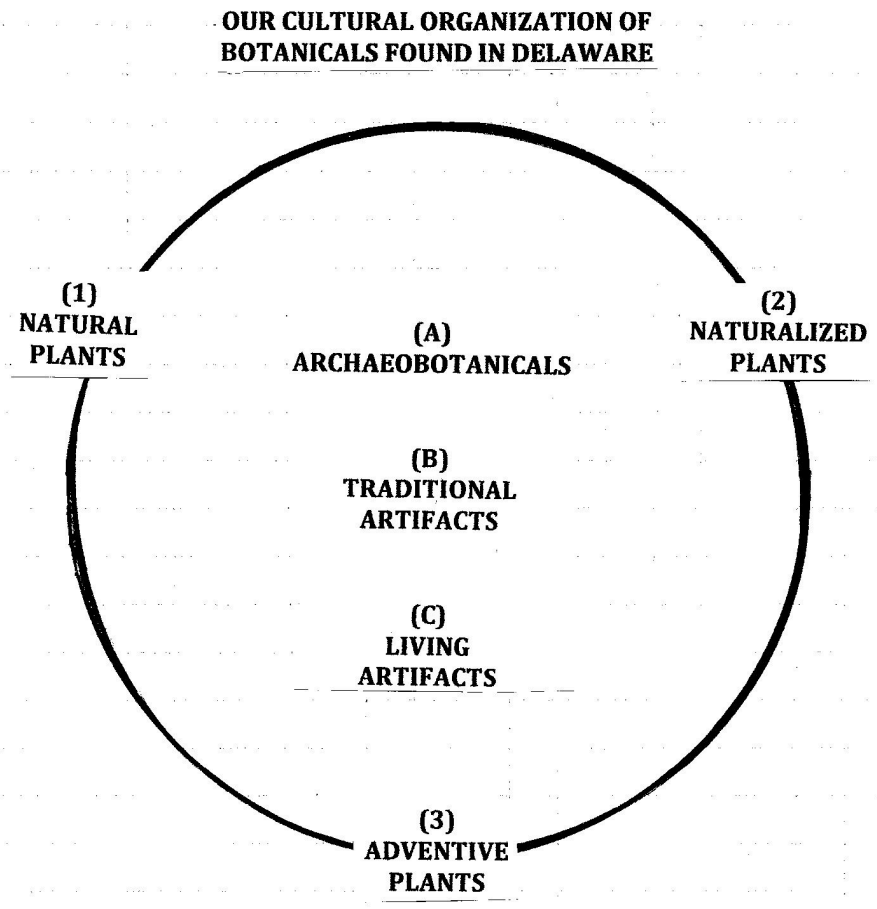


TRANSFORMATION OF NATIVE AMERICAN AND HISTORIC BOTANICALS

Glen Mellin and Lenny Truitt
November 2013



A SYNTHETIC FRAMEWORK FOR MULTICULTURAL AND INTERDISCIPLINARY BOTANICAL EXPLANATION

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APPENDIX 2 (COMPLETE LIST OF ARCHAEOBOTANICALS FOUND IN 28 DELDOT REPORTS)

SECTION 1: BOTANICAL FACTS AND THEORIES

Oh, bein' friendly is a privlege sum hurried folks ferget,
Bein' friendly is a tonic, which the more you give, you git.
Bein' friendly is a duty of'en to th' four winds hurled,
But th' Great Creator planned this to be a friendly world. –Anonymouse (Sis and Jake 1966:56)

This poem, sourced to a person living in the Ozark Mountains, reminds us of the importance of personal character: privilege, tonic, and duty, within a sense of place. It also reminds us of our answerable relationship between the Great Creator and all of Creation. Intrigued by this concept of friendship, or respect, we offer this synthesis as a foundation to consider a Transformation of Native American and Historic Botanicals.

When people become part of a landscape, both people and landscape are changed. As people and landscape present opportunities and challenges to each other, middle grounds are realized--fruition ensues. Over larger periods of time and space, like looking into a mirror, culture and landscape often become reflections of each other.

Before Native Americans arrived in Delaware, there was a natural, botanical landscape. As the Ice Age waned and temperatures moderated, plant species colonized higher latitudes. As the Holocene Epoch developed, the Lower Coastal Plain, the Upper Coastal Plain, and the Piedmont Regions of Delaware supported most of the botanical species we see today. However, some non-indigenous plants arrived in Delaware while ancestral Native Americans were the dominant culture on the landscape, additional non-indigenous plants arrived during, and after the European Colonial Period, and a variety of non-indigenous plants, and plant products continue to arrive today.

AUDIENCE

Because this synthesis strives to engage many different points of view, various cultures, and ventures further than simply meandering around the edges of structured, scientific disciplines, we seek to find and discuss this topic on a common ground. As we think and speak in a variety of human "voices", we strive to be inclusive and respect various views.

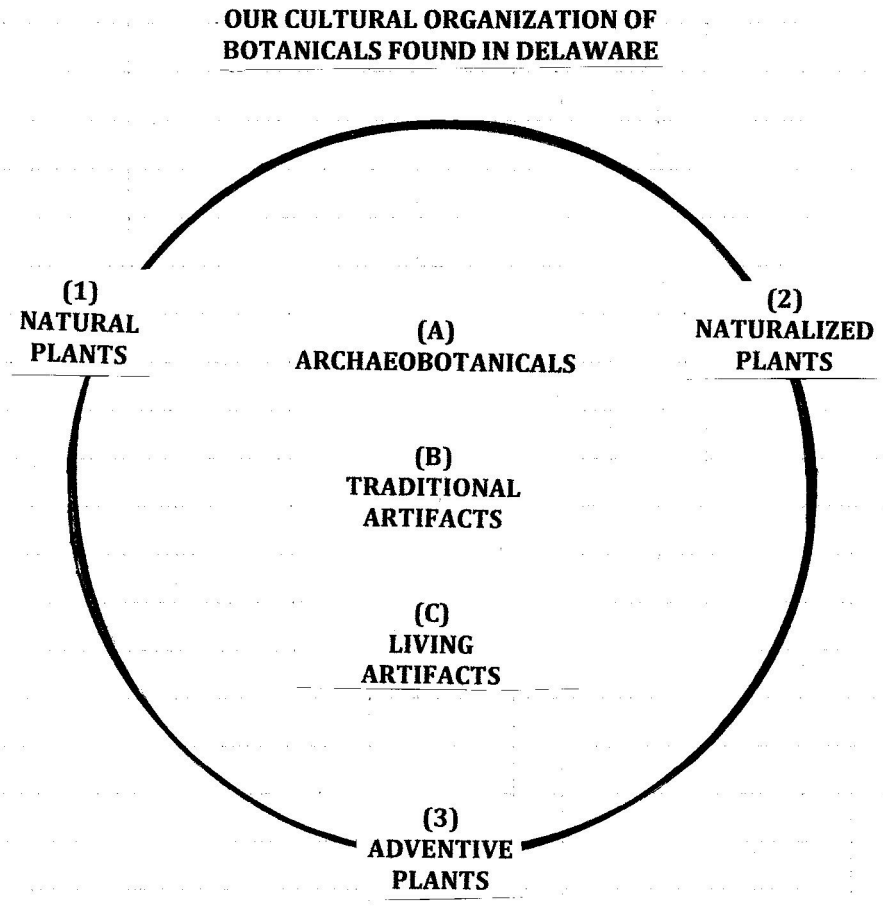
THE BIG IDEA

As people discover which plants are culturally beneficial, they attempt to move them to more desirable or easily accessible locations. Desirable plant species are encouraged to increase in both quantity, and quality.

This idea forms the basis of how and why Native American and Historic botanicals become transformed. Plants that have been moved from their indigenous location and plants, which have had their natural characteristics altered (quantity or quality) have been influenced by culture. If they owe their position, or characteristics, in time and space to human involvement—they are artifacts. When we shift a particular plant's designation from being in its natural state to becoming an artifact, it is a topic of great scientific and multi-cultural interest. Even though we may realize the result, there are no easy answers to exactly when these shifts in designation began to happen.

OUR BOTANICAL DIAGRAM

Pardon us for not using a standard, box and line flowchart. We could have used a triangular chart, but we chose to use a circular chart (see below) to eliminate the suggestion of sharp angles and straight lines. We placed three plant categories: (1) the Natural, (2) the Naturalized, and (3) the Adventive plants on the circle. One might assume that any given plant or plant species should be assigned to only one of the plant categories (found on the circle). However, as a consequence of ancestral Native American involvement and possibly other factors, many species thought to be Adventive have also achieved natural or indigenous designation. It is important to understand that when the first Europeans observed this land we now call Delaware, they "discovered" a Native American landscape, not a natural landscape. It is critical to fully understand the definitions and relationships of the categories of plants arranged on the circle before addressing the categories of artifacts contained within the circle.



In the center of the circle, we have (A) Archaeobotanical Artifacts, (B) Traditional Artifacts, and (C) Living Artifacts. We provide definitions and realistic example(s) (from Delaware when possible) for each category of artifact, in addition to providing derivative relationships between artifact categories and plant categories.

(1) NATURAL PLANTS

"***Native and Indigenous***: A native species indigenous to the State of Delaware is one that has, over time, evolved and adapted to the environmental conditions of the area and is thought to have occurred in Delaware prior to the time of European settlement, or has established itself within the state independent of direct human activity." (Delaware Dept. of Natural Resources and Environmental Control, Division of Fish and Wildlife, Delaware Natural Heritage and Endangered Species Program, Flora of Delaware, On-line Database, Glossary of Terms, March 2013, [attributed to McAvoy]).

An example of a Natural Plant is the Black Walnut (*Juglans nigra*) an edible nut-producing tree commonly found and indigenous to all three counties of Delaware. This species is typically found as an isolate or in small clusters. As a result of our recent botanical surveys, a large cluster of Black Walnut is documented at Lums Pond, which is recognized as a candidate botanical cluster of ancestral Native American origin (Mellin and Truitt 2013j).

(2) NATURALIZED PLANTS

"***Non-native***: A species that is not native to North America (north of Mexico). Non-native species are thought to have been introduced by humans, primarily through agricultural or horticultural practices. These species have become established in Delaware and are reproducing as if native (i.e., naturalized)." (Delaware Dept. of

Natural Resources and Environmental Control, Division of Fish and Wildlife, Delaware Natural Heritage and Endangered Species, Flora of Delaware, On-line Database, Glossary of Terms, March 2013, [attributed to McAvoy]).

An example of a Naturalized Plant is the Chinese Chestnut (*Castanea mollissima*) moved from Asia to Europe and then to Delaware. This Chestnut is an edible nut-producing tree occasionally found on or near Historic sites in all three counties of Delaware. This species is successful in its new surroundings and documented examples are behaving similar to indigenous species (Mellin and Truitt 2013b).

(3) ADVENTIVE PLANTS

The following caption from William McAvoy explains his current definition of "Adventive" species in Delaware (McAvoy, personal communication, July 22, 2013) written exclusively for "Sampling Archaeobotanicals: Past, Present, and Future." (Mellin and Truitt 2013g:4-5).

> Section II is a list of plant species considered to be adventive in the state of Delaware. This list was compiled by William A. McAvoy, state botanist with the Delaware Division of Fish & Wildlife, Species Conservation and Research Program. McAvoy defines an adventive species as: a species native to North America, but not to Delaware that is now found growing in Delaware outside of its natural range. Adventive species are not considered to be part of Delaware's native flora. These species usually arrive due to the human-caused breakdown of natural barriers to dispersal. Adventive species also include plants that have been introduced, or intentionally planted in Delaware and are now escaping and surviving without cultivation. We feel that many of these plants thought to be adventive in the state, may actually be native and could have become established in the state sometime during the Holocene and may owe their position in time and space to human involvement.

An example of an Adventive Plant is Jimsonweed (*Datura stramonium*) introduced to Delaware from farther west of Delaware. It prefers to grow in disturbed areas, agricultural fields, and along roadsides. Agriculturalists currently treat this species as a detrimental weed. However, this species possesses medicinal--cardioactive, and ceremonial--psychoactive properties, which Native American groups and others are known to have exploited.

(A) ARCHAEOBOTANICAL ARTIFACTS

As part of an overall paleoethnobotanical research program, Archaeobotanicals may constitute any and all plant remains found during archaeological excavation. These remains are analyzed for a number of reasons, for examples: 1) Archaeobotanical samples are used to establish archaeological integrity of the site, 2) Archaeobotanical samples are used to define characteristics of cultural property types, and 3) Archaeobotanical samples are used to explore long-standing subsistence questions surrounding settlements in Delaware. In addition, Archaeobotanical data from sites contribute to the growing floral database for the Middle Atlantic region (Dent and Kauffman 1985; LeeDecker et al. 1998) attributed to Justine McKnight, Appendix C Volume II page 5 (Berger 2005:C1).

Examples of what has been archaeologically recovered in Delaware are carbonized and non-carbonized wood, nutshells, seeds, and structural plant remains, such as leaves, pods, cones, stems, and bark, etc., as well as miscellaneous plant remains, such as phytoliths, spores, starch grains, and pollen, etcetera. Nearly all of these recovered specimens are identified at the genus level, many to the species level. As always, caution is warranted due to archaeological sample size, quality of specimen diagnosis, and naturally occurring contamination of (pre- and post-) recovered samples.

Honeybees produce honey and beeswax from the reproductive parts of flowering plants. These products have been recovered from archaeological sites (for example, from burial tombs in Giza, Egypt), but not yet identified in an ancestral Native American context in Delaware. Nevertheless, we imagine that the residue of these honeybee products could decay into recoverable substances having trace properties similar to raw nectar and pollen.

(B) TRADITIONAL ARTIFACTS
An artifact is anything made by a human or anything that owes its position in time and space to human involvement. An example of a surviving Traditional Artifact is an excavated section of a carbonized woven basket recovered from a Native American burial at site 7K-F-17, ca. 800ce. Other examples include a 19th century carved Iroquois wooden war club, currently archived in a New York museum, and a section of a likely ancestral Native American dugout canoe, currently archived in a New Jersey museum.

(C)) LIVING ARTIFACTS
Here, we must make a distinction between the pre-contact and post-contact time frames. Most plants that arrived in Delaware in the historic period are fairly easy to identify. The following three examples are products of human design, or owe their position in time and space to human involvement. 1) A living McIntosh apple tree growing in an apple orchard in Sussex County, Delaware is a product of an arborist grafting the stem of one apple variety onto the rootstock of another apple variety. 2) A row of mature Osage Orange trees growing along a farm lane in New Castle County, Delaware was planted along a property line, field edge, or toft to create a physical boundary. And 3), a living Chinese Chestnut tree was planted in the yard of a 19th century farm house in Kent County, Delaware to produce edible nuts for the benefit of the residents.

Plants, and/or the descendents of those plants of pre-contact, or prehistoric age are a different matter. To our knowledge, there are no known, documented plants or the descendents of those plants that qualify as pre-contact or prehistoric Living Artifacts. But, with that being said, we suggest it would be disrespectful to think that there are no such plants living in present-day Delaware.

The closest we have come to authenticating a living prehistoric artifact plant, is a Box Huckleberry growing in one of the authors' woodlots in Sussex County, Delaware. The size of this particular plant indicates it is likely to be 1,800 year old. It grows next to a Native American archaeological site of similar age. Because the Box Huckleberry apparently lost its ability to sexually reproduce at the end of the Pleistocene (it currently only reproduces by cloning, or transplanting) we make a strong argument this plant was planted there, in the distant past, by Native Americans, for an unknown reason(s) (Mellin and Truitt 2013a).

Potentially, plants such as the Chinquapin, which today appear in definable clusters in Sussex and Kent Counties, Delaware, may be the remnants of ancestral Native American nut groves. In such cases, the cluster, or grove may currently be populated by the descendents of the original trees, making the cluster, or grove a living, descendent artifact (Mellin and Truitt 2013a, 2013d, and 2013e).

CULTURAL DISCUSSION OF BIOLOGICAL RELATIONSHIPS
This discussion of biological relationships between categories of plants and plant residues found on our organizational chart is included to aid some readers, but we expect the majority of readers will find this discussion to be obtuse and confusing. Nevertheless, as the cultural histories of some plants in Delaware are further researched and explored, we suggest that some categories and classifications may need to be broadened or adjusted in the future. We definitely view future research and the results of that research as opportunities to ask great questions and continually offer more meaningful explanations.

1) Natural Plants in Delaware are native and indigenous to Delaware. This plant category may include categories 3, A, B, and C.

2) Naturalized Plants in Delaware are neither native nor indigenous to North America, north of Mexico. This plant category may include categories A, B, and C.

3) Adventive Plants in Delaware are native or indigenous somewhere in North America, north of Mexico (under certain circumstances an Adventive plant may now be considered Native). This plant category may include categories A, B, and C.

A) Archaeobotanical Artifacts. This artifact category may include categories 1, 2, 3, and B.

B) Traditional Artifacts. This artifact category may include categories 1, 2, 3, and A.

C) Living Artifacts. This artifact category may include categories 1, 2, and 3.

As a result of ancestral Native American cultural activities, a 3 (Adventive) can become a 1 (Native), some 3s (Adventives) probably have become 1s (Natives). But, in the future, some 1s (Natives) will need to be researched as 3s (Adventives). However, plants in categories 2 (Naturalized) and 3 (Adventive) that were moved into Delaware during the post-Contact, Colonial, or Historical Periods likely will never be included in category 1 (Native). Clearly, if we only organized botanicals through archaeology, this might be pretty simple. And, if we only organized botanicals through botany, this might seem easy. But, remember: we are trying to organize botanicals in a Native American landscape, not in a native (natural) landscape!

We need to establish this reasoning to see at what point in the past ten thousand years a subject species first arrived in Delaware. Some archaeologists divide ancestral Native American economics into four groups (from oldest to newest): Paleo, Archaic, Woodland I, and Woodland II. Other archaeologists use a techno-temporal framework (from oldest to newest): Paleo, Early-Middle-Late Archaic, Transitional, and Early-Middle-Late Woodland. Whichever labeling method is used, we certainly would like to know which culture(s) moved which plants and what those plants were used for. At this point in our research, we have identified candidate species, which likely are associated with Woodland economic programs, but likely not associated with Archaic economic programs.

Lets review a possible history of the Prickly Pear cactus cluster we documented growing in a shell-midden at the Prickly Pear Site, on Prickly Pear Island, in the Nanticoke River (Mellin and Truitt 2013c). Prickly Pear cactus is a species that needs further delineation: where on our chart should it be listed, where does it belong? Currently, the Eastern Prickly Pear Cactus (*Opuntia humifusa* var. *humifusa*) is listed as a Native plant in Delaware, commonly found in Kent and Sussex Counties. With the Prickly Pear first appearing in Mexico, this culturally beneficial and hardy plant spread up through the American southwest, into the eastern states and eventually on into Delaware. There are a number of various speculations reported on the world-wide-web that Prickly Pear cactus moved along with maize and spread throughout North America in a matter of only several thousand years. Some of those arguments, interestingly, say that Prickly Pear's arrival on the east coast was around 1000ce, or the beginning of the Woodland II economic period (1000ce—1650ce). If that were true--a Prickly Pear in Delaware could actually be listed on our Cultural Organization of Botanicals Found in Delaware chart in categories 1 (Native), 2 (Naturalized), and 3 (Adventive).

A complete list of plants currently found in, and previously found in Delaware appear in Appendix 1.

SECTION 2: PREVIOUS RESEARCH

This section addresses Archaeobotanicals and Living botanicals as described in our research statement, The Big Idea, and in our botanical chart, Cultural Organization of Botanicals Found in Delaware, see pages 1, 3, and 4. Traditional Artifacts or archived objects made of plant material(s) occur in cultural classes by themselves (i.e. family and community heirlooms, antiques, collectables, or museum curatorial pieces) and are not specifically addressed in this synthesis.

ARCHAEOBOTANICALS

As part of an overall paleoethnobotanical research field, Archaeobotanical specimens may constitute any and all plant remains found during archaeological excavation. These remains are analyzed for a number of reasons, for examples: 1) Archaeobotanical samples are used to establish archaeological integrity of the site, 2) Archaeobotanical samples are used to define characteristics of cultural property types, and 3) Archaeobotanical samples are used to explore long-standing subsistence questions surrounding settlements in Delaware. In addition, Archaeobotanical data from sites contribute to the growing floral database for the Middle Atlantic region (Dent and Kauffman 1985; LeeDecker et al. 1998) attributed to Justine McKnight, Appendix C Volume II page 5 (Berger 2005:C1).

Examples of what has been archaeologically recovered in Delaware are carbonized and non-carbonized wood, nutshells, seeds, and structural plant remains, such as leaves, pods, cones, stems, and bark, etc., as well as miscellaneous plant remains, such as phytoliths, spores, starch grains, and pollen, etcetera. Nearly all of these recovered specimens are identified at the genus level, many to the species level. As always, caution is warranted due to archaeological sample size, quality of specimen diagnosis, and naturally occurring contamination of (pre- and post-) recovered samples.

For Delaware, we recently provided a synthesis of Archaeobotanical studies, a tabulation of the results of twenty-eight DelDOT sponsored archaeological projects (Mellin and Truitt 2013g). Although we strived to present a fair and meaningful representation of the results, we strongly encourage readers to review the original DelDOT sponsored reports (found on DelDOTs website, www.deldot.gov/archaeology/) to view and assess the original findings for themselves.

Of these twenty-eight reports, Delaware Park Site is the oldest, published in 1981, and Gray Farm Site is the newest, published (as revised) in 2013. Because we collected many of the flotation samples from Delaware Park and from Gray Farm, as well as on many of the other projects through the ensuing years, we speak with some authority on the soil flotation collection process. However, we are not authorities on the physical identification of individual Archaeobotanical specimens.

A wide range of data collection has been accomplished. We have collected and processed soil flotation samples from "cultural features," "natural features," and "living floors", and we have collected off-site samples for controlled comparison. We have used 3" and 4" bucket augers, and 3" vibra-core tube samples to collect data from wet and sub-aqueous environments. From these various sampling techniques, we have found and identified a variety of wood carbon, nut hulls, seeds, plant fibers, pollen, spores, starch grains, and phytoliths. All of these found items, viewed in context, help to describe changing Native American behavior within a changing environmental landscape.

As scientists, we view every newly identified plant species as an important addition to the overall database. But, when it comes down to comparing species found from one site to another, we have a problem. The process of comparative study usually requires a comparative database generated through sets of comparative samples. The problem is not with the size or locations of the sites themselves, or with the overall integrity of the samples collected. The problem is in the lack of controlled sample size, and in some cases, no samples at all.

At the Delaware Park Site, flotation samples were counted in full, five-gallon bucket loads. The wealth of Archaeobotanical specimens identified was, consequently, a reflection of the massive soil volumes sampled. Essentially, we were looking to identify as many plant species as possible. At the time, one of our objectives was to create a database where results of future excavations could be compared.

We noted that in some of the tabulated twenty-eight DelDOT sponsored archaeological projects, some researchers decided to forego collecting flotation samples altogether. Some other researchers collected flotation samples at ridiculously small volumes, soil volumes that appear to be testing for mere presence or absence instead of collecting reasonable sample sizes for a reasonable description of Archaeobotanicals present.

How have these efforts, and in some cases, lack of effort, affected the comparative ability of our overall Archaeobotanical database? The combined database of identified Archaeobotanicals, in Delaware, is largely not comparative, except for a few nut hull species and a small grouping of seemingly ubiquitous carbonized seed species.

Despite these obvious sampling shortcomings, the processing and identification side of Archaeobotanical and ethnobotanical reporting remains stellar. Although we see some reluctance in these labs' published comments—in not instructing us how to collect our samples, we do see their repeated advice--they suggest that scantly identified botanical remains is due to small soil sample size. And, where we do take larger samples, we get robust results. So, it would appear that some level of botanical remains are recoverable from

all archaeological sites, and that the measure of results are proportional to the measure of sampled soil collected.

Collecting and processing large, uniform, measured soil flotation samples is the only way to achieve large, uniform, measured Archaeobotanical results.

The Hickory Bluff Site and the Puncheon Run Site excavation programs include significant botanical surveys and records of the present day botanical landscapes, larger than the affected areas of the archaeological sites themselves. The resulting Archaeobotanical descriptions appear within a realistic botanical landscape. These efforts and descriptions are well worth a detailed read, especially the milestone syntheses compiled by Justine McKnight. For examples, some of McKnight's achievements appear in the appendices of the Puncheon Run Site report (Berger 2005) and are listed as follows.

Landscape Assessment of the Puncheon Run Site. (Berger 2005, Appendix B, Volume II).

Paleoethnobotanical Data From the Puncheon Run Site. (Berger 2005, Appendix C, Volume II).

A Study of Native American Plant Use Based on a Review of Early Historic Comments on Subsistence and Technology. (Berger 2005, Appendix Ea (part 1), Volume II, and Appendix Eb (part 2), Volume II).

Not only has McKnight placed the bar higher for individual site, and site complex interpretations, her presentation of past and present day environments serve as a more inclusive context for these cultural explanations. McKnight has demonstrated we need to understand that what grows on the land and in the water are "incentive factors" for site formation and cultural durability. And, that site formation and cultural durability, in a very real sense, differentiates what species, and the quantities of those species, are found on the land and in the water.

A tabulation of Archaeobotanical specimens identified in our review of twenty-eight DelDOT sponsored archaeological reports appears in Appendix 2.

LIVING ARTIFACTS

Ever since Captain John Smith (1986 [1608]) reported where and how various plant species were being managed by the Naturals (Native Americans) in and around the Chesapeake region, the reading public has been intrigued by these fascinating and strange, New World revelations. What most people do not realize is that what Captain Smith had observed and reported was the continuation of dedicated horticultural programs that had developed over thousands of years. These cultural landscapes might have been new to Captain Smith, but these cultural landscapes were well-developed subsistence and economic programs. Many of these cultural landscapes have undergone significant alteration or "put under the plow", but some of these cultural landscapes remain. It may be increasingly rare to find a living plant that was growing before the Europeans invaded the Chesapeake region and Delaware in particular. However, first and multiple generation living descendents of those ancient plants are not that hard to find. It is simply not rational to think that four hundred years could have erased all evidence of those Native American cultural landscapes. In fact, many of Delaware's plants have explicit Native American connections.

Europeans were so enamored with many of the Native American, culturally beneficial species, they not only adopted the Native American horticultural techniques—they adopted many of the Native American names given to these plants. For examples, the Chinquapin (*Castanea pumila*) is an edible nut-producing tree. Taber claims, "The name is derived from two words: *chinkwa* and *min* of Delaware Indian language" (1937:99). In addition, the fruit producing Pawpaw (*Asimina triloba*) Taber says, "The genus name *Asimina* is Latinized from the Indian name *asmin* for the tree" (1937:147).

Living plants, descendents of plants that were included in the Native American cultural landscape, are of special interest. These plants, plants that owe their position in time and space to human intervention are Living Artifacts. But, how are we to know when we find one?

McAvoy and Harrison addressed this question and other questions in their ten-year research project resulting in, Plant Community Classification and the Flora of Native American Shell-middens on the Delmarva Peninsula (2012). Among the fourteen Native American shell-middens investigated, they found: "a unique and globally rare plant community that supports 202 native species and varieties of vascular plants, including 87 that are rare or uncommon on the Peninsula and 21 that are new additions to the flora of the Delmarva" (McAvoy and Harrison 2012:1).

Obviously, with 21 new additions to the flora of the Delmarva, we see that not only are new discoveries possible, but that through new research efforts we should expect new discoveries. Even more fascinating, McAvoy identified a community of calcareous plants that do not tolerate acidic soil, growing on Native American shell-middens. Initially, for examples, plants such as Wild Columbine (*Aquilegia canadensis*) Large-seed Forget-me-not (*Myosotis macrosperma*) Bottlebrush Wild Rye (*Elymus hystris* var. *hystris*) Smooth Rockcress (*Boechera lawvigata* var. *laevigata*) Redbud (*Cercis canadensis* var. *canadensis*) Eastern Hop-hornbeam (*Ostrya virginiana*) and Yellow Chinquapin Oak (*Quercus muehlenbergii*) were rationalized as growing about these shell-middens, outside of their normal ecological range (McAvoy and Harrison 2012:1-2).

Following Solbrig's organization of plant dispersal (1972), McAvoy and Harrison agree the range of these calcareous and other plants was never continuous over the Delmarva Peninsula and these disjunct populations of calcareous and other plants are likely specific to individual, or groupings of "contiguous" shell-midden locations (McAvoy and Harrison 2012:18). Following Lowery (2005 and 2010), who was a consultant to McAvoy and Harrison (2012) the archaeological timeframe of these shell-midden sites is roughly 1800bce to 1650ce, but more likely fits into a 0ce to 1650ce timeframe (McAvoy and Harrison 2012:16). One result of McAvoy and Harrison's research is the realization that many of these disjunct plant species currently found on these shell-middens are a result of ancestral Native American activity.

Other clusters of rare plants have been identified at other locations. For example, a documented remnant population of American Lotus (*Nelumbo lutea*), is located off Lotus Lane, Dover, Delaware in the immediate vicinity of the Puncheon Run Site (Berger 2005). McKnight and McAvoy (McKnight, personal communication, July 22, 2013) attribute this population, as well as other populations, or clusters of American Lotus, on the Sassafras and Potomac rivers to likely Native American horticultural efforts.

In addition, a documented population of Holy Grass (*Hierochloe odorata*) is located at the east end of Thompson Island, Rehoboth, Delaware (McAvoy 2000; McAvoy, personal communication, July 22, 2013; and McKnight, personal communication, July 22, 2013). Small populations of Holy Grass are known to exist at other, discrete locations in Maryland, and Virginia. McAvoy is quoted, "*H odorata* found on the Delmarva Peninsula may be a result of it being dispersed here by Native Americans." (McAvoy, personal communication, July 22, 2013).

In Sections 1 and 2, we provided examples of plant species found in Delaware and on the Delmarva Peninsula, which may owe their position in time and space to ancestral Native American involvement. Other plants, due to their rarity, or special, or odd location on the Lower Coastal Plain, Upper Coastal Plain, and Piedmont Regions may owe their presence to ancestral Native American involvement. In general, we assign plants that appear to have first arrived in Delaware during the Holocene Epoch to the Adventive plant category. However, some plants that are now considered Native in Delaware may actually have been Adventive (review definitions of plant categories 1-Native, 2-Naturalized, and 3-Adventive). Further complicating these issues is the concept of plant migration where some plant species have colonized higher latitudes due to warmer conditions associated with Holocene climate change.

William McAvoy applies the term Adventive to a select group of plants, (one hundred and thirty individual plant species) currently found in Delaware. All of these Adventive plants are considered indigenous to North America. Even though they now occur in Delaware, they are likely hosted in Delaware from other areas, at various times in the past, and under various circumstances in the past. McAvoy's list of Adventive plant species for Delaware appears in Mellin and Truitt (2013g:39-46).

SECTION 3: AN EXPLANATION OF OUR RESEARCH

Now we feel like dogs let off the leash! If you have ever wondered what to do while wading through a sea of May-apples, here is a great recipe from Sis and Jake (1966:55).

> There's jest lots of people who really git a bang out of gatherin' May-apples, but don't know how to go 'bout fixin' 'em. Now here's a real simple method. Gather the may-apples from the stalks after they have become a golden yellow. They are then buried in the ash hopper and left there a week or so or until the skins turn dark. The pulp on the inside is then ready to eat raw, just as it comes from the skins.

IN OUR BACK YARD

We have two rare plant clusters, one on either side of an ancestral Native American site (7S-E-19) in our back yard along the riverbank of the upper Nanticoke River in Sussex County, Delaware. The first plant cluster is Box Huckleberry (*Gaylussacia brachycera*), the second plant cluster is Chinquapin (*Castanea pumila* var. *pumila*), and the archaeological site is dominated by Mockley style ceramics, carbon dated in Delaware from 200bce to about 600ce.

As we surveyed about 200 acres of upland, unplowed woods around site 7S-E-19, we determined these two botanical clusters are indeed rare and isolated, illustrating the uniqueness of these finds. We believe these two botanical clusters are the remains of ancestral Native American plantations, or heirloom landscapes, dating back to the Woodland I Cultural Period. We are suggesting the people living at that site, at that time, manufactured both the Box Huckleberry cluster and the Chinquapin cluster as botanical plantations in an effort to increase and concentrate these specific species for their own use.

BOX HUCKLEBERRY

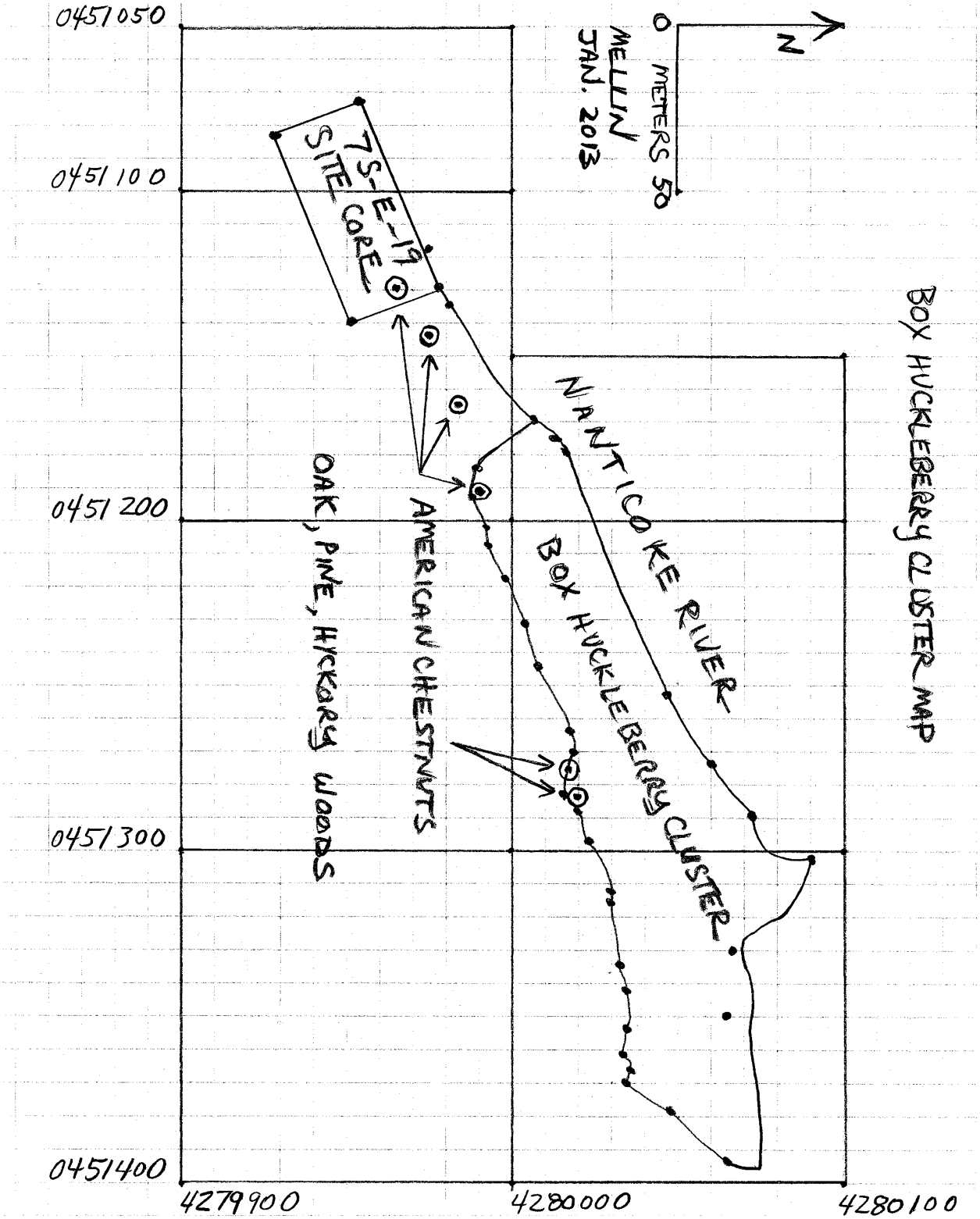
The Box Huckleberry cluster in our back yard covers about one hectare or one and one half acres and is estimated to be 1,500 to 2,000 years old. That is the same age as adjacent habitation site, 7S-E-19. The only reasonable explanation for the occurrence of this plant, in time and space, is that an ancestral Native American person(s) planted it there some 1,500 to 2,000 years ago. How can we be sure? To be sure, we need to understand the unique characteristics of the Box Huckleberry species itself.

The Box Huckleberry is a globally endangered, edible berry producing plant with a worldwide count of about 100 known specimens. The incredible rarity of this plant is surpassed only by its unique history--having lost its ability to sexually reproduce during the Pleistocene, all Holocene occurrences are self-sterile. Only found in isolated colonies, optimally growing at an overall rate of 15 centimeters per year, the species is only able to sustain itself through cloning in a subsurface process known as root extension (a natural process), or by physically transplanting prepared settings through relocation (a cultural process).

Pennsylvania may have the largest (therefore oldest?) known Box Huckleberry plant in the world, dating to about 5,000bce. DNA tests (Pooler et al. 2006, 2008) demonstrate several genetic strains within that cluster, an indication there are likely several different plants, or "plantings", contributing to the overall cluster. An interpretation of those Pennsylvania DNA tests strongly suggest the genetic strains present are not cloned sister plants, but they are probably more like cloned aunts, or cloned grandmothers--genetically separated from each other prior to the Holocene.

Various writings concerning the Box Huckleberry suggest some sort of co-occurrence association between Mountain-laurel (*Kalmia latifolia*) and possibly other rhododendrons with the Box Huckleberry. We confirmed this association at our Box Huckleberry cluster adjacent to habitation site 7S-E-19. In fact, Mountain-laurel and other rhododendrons occupy a similar spatial "footprint" as the Box Huckleberry cluster. In addition, we identified six American Chestnut stump sprouts, forming a linear pattern, spanning between the habitation site 7S-E-19 and the Box Huckleberry cluster. The co-occurrence of surviving American Chestnut may, or may not, be coincidental.

We recorded the GPS UTM location of the Box Huckleberry cluster in association with the archaeological site on our original hand drawn field map (Mellin and Truitt 2013a).



CHINQUAPIN

The Chinquapin cluster in our back yard, on the north bank of the Nanticoke River, covers about one hectare or one and one half acres and is made up of about 200 Chinquapin trees. An exhaustive search on several hundred acres surrounding ancestral Native American site 7S-E-19 produced no other Chinquapin trees, which illustrates the uniqueness of this intense cluster. This Chinquapin cluster is of undetermined age.

Before the twentieth century, Chinquapins were documented in Delaware as obtaining a height of forty to fifty feet with a girth of perhaps two feet at chest height. The species is characterized as a mid-range tree, not reaching the upper canopy, but does benefit from some direct sunlight. The species is noted as growing best on acidic, xeric landscapes. In Delaware, Chinquapin is listed as being a State Rare species. Taber (2012:99) claimed, Chinquapin "is derived from two words: *chinkwa* and *min* of the Delaware Indian language". In the Eastern Cherokee language, Chinquapin means squirrel-tree.

Early in the twentieth century, an Asian bark fungus, or Chestnut blight, wiped out mature Chinquapins. Subsequently, some stump shoots appeared as regenerative growth. However, these slender shoots are also susceptible to the persistent fungus when the regenerative growth reaches sexual maturity. Consequently, the new growth very rarely produces a seed burr, which normally would contain a fertile nut. Taber (2012:99) said, "The chinquapin is somewhat more resistant to the chestnut blight than the American chestnut but because of its slow growth and limited distribution is perhaps more susceptible to extermination than the chestnut".

We have been maintaining our Chinquapin cluster for three years now. We have been clearing brush, opening up the canopy, and applying limited fertilizer, which has increased the vibrancy of both individual specimens and the overall cluster. During the summer of 2013, we counted over one hundred seed burrs on at least four of the Chinquapin specimens. Since some of the specimens appear to be young seed sprouts, we assume at least some of the seeds are fertile, which means this Chinquapin cluster appears to be self-sustaining despite the adverse effects of the fungus blight.

We recorded the GPS UTM location of each living Chinquapin specimen and created a useful specimen log. Location and arrangement of each specimen is plotted on the Chinquapin Cluster Map (see Mellin and Truitt 2013a).

THINKING ABOUT WHAT IS GROWING IN OUR BACK YARD

We began addressing our existing Box Huckleberry and Chinquapin clusters as candidate cultural elements of Native American site 7S-E-19. Based on the rarity and likely ages of these botanical clusters, we assumed they owed their existence to pre-colonial Native American activities. We envisioned pre-colonial Natives Americans selecting, digging up, transplanting, arranging, and managing botanicals in locations that benefited their lifestyle. By increasing and concentrating sparsely occurring botanical specimens, Native Americans were able to introduce, relocate, and make more reliable economic schedules for the harvest and storage of desirable botanical resources.

We realized these are difficult concepts for archaeologists and botanists alike. For examples, which botanical species might be candidates for Native American involvement? Did any of these candidate plants or clusters of plants survive into the twenty-first century, and if so, how might we recognize their existence? And if those questions were not daunting enough, how would we address these ideas on larger scales, such as within a river system, or perhaps the entire State of Delaware? We also know that in order to achieve realistic answers, like Siamese twins, these disciplines of archaeology and botany would have to become, more or less, joined at the hip!

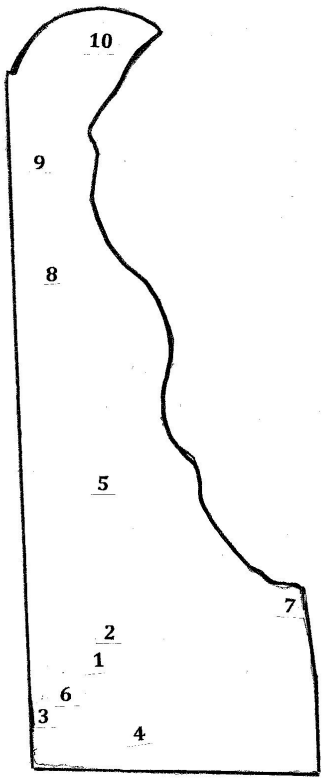
We understood the only way to gather new and interesting sets of field data that fit our criteria was to go gather it ourselves. As we selected a number of landscape locations in Delaware for further study, we devised a series of pedestrian programs to look for, and document plant species and plant clusters that might be candidates representing these living artifacts. We ended up with ten survey locations, seven on the Lower Coastal Plain, two on the Upper Coastal Plain, and one on the Piedmont, in Delaware. The ten study locations are as follows:

OUR TEN BOTANICAL SURVEYS IN DELAWARE FOR 2013

(1) Our back yard in Middleford, Delaware. "Box Huckleberry and Chinquapin Clusters: Ancestral Native Plantations?" January 2013. See folder Mellin and Truitt 2013a. We discussed American Chestnut (*Castanea dentate*), Box Huckleberry (*Gaylussacia brachycera*), Chinquapin (*Castanea pumila*), Mountain-laurel (*Kalmia latifolia*) and Rhododendrons (*Rhododendron* spp.) as candidate living artifacts.

(2) Middleford North Preserve (The Nature Conservancy). "Interesting Botanicals on a Historic Site in Delaware: Recognition, Significance, and Meaning." June 2013. See folder Mellin and Truitt 2013b. We discussed Black Walnut (*Juglans nigra*) and Red Mulberry (*Morus rubra*) as candidate living historic artifacts and Chinese Chestnut (*Castanea mollissima*) Norway Spruce (*Picea abies*), and Sawtooth Oak (*Quercuts acutissima*) as Naturalized species.

STATE OF DELAWARE:
TEN BOTANICAL SURVEYS IN 2013



(1) Botanical survey of our back yard in Middleford, Delaware (Mellin and Truitt, 2013a)
(2) Botanical survey of Middleford North Preserve (Mellin and Truitt, 2013b).
(3) Botanical survey of Prickly Pear Island and Philips Landing State Park (Mellin and Truitt, 2013c).
(4) Botanical survey of Trap Pond State Park (Mellin and Truitt, 2013d).
(5) Botanical survey of Killen Pond State Park (Mellin and Truitt, 2013e).
(6) Botanical survey of Robert Graham and Barnes Woods Preserves (Mellin and Truitt, 2013f).
(7) Botanical survey of a field in Lewes, Delaware (Mellin and Truitt, 2013h).
(8) Botanical survey of Hell Island in the Appoquinimink River (Mellin and Truitt, 2013i).
(9) Botanical survey of Lums Pond State Park (Mellin and Truitt, 2013j).
(10) Botanical survey of Alapocas and Brandywine Creek State Parks (Mellin and Truitt, 2013k).

(3) Prickly Pear Island and Philips Landing State Park. "Prickly Pear and American Chestnut Clusters Identified in the Lower Nanticoke River Basin." July 2013. See folder Mellin and Truitt 2013c. We discussed American Chestnut (*Castanea dentate*), Mountain-laurel (*Kalmia latifolia*), and Prickly Pear (*Opuntia humifusa*) as candidate living artifacts.

(4) Trap Pond State Park. "A Botanical Survey in Trap Pond State Park Identifies Three Chinquapin Clusters." August, 2013. See folder Mellin and Truitt 2013d. We discussed Chinquapin (*Castanea pumila*) and American Chestnut (*Castanea dentate*) as candidate living artifacts.

(5) Killen Pond State Park. "A Botanical Survey of Killen Pond State Park in Kent County, Delaware." August 2013. See folder Mellin and Truitt 2013e. We discussed American Chestnut (*Castanea dentate*), Chinquapin (*Castanea pumila*), Ironwood (*Carpinus caroliniana*), and Pawpaw (*Asimina triloba*) as candidate living artifacts.

(6) Robert Graham Preserve and Barnes Woods Preserve. "A Botanical Survey of the Robert Graham Preserve and the Barnes Woods Preserve in Sussex County, Delaware." August 2013. See folder Mellin and Truitt 2013f. We discussed American Chestnut (*Castanea dentate*), Black Walnut (*Juglans nigra*), Catalpa (*Catalpa* spp.), Prickly Pear Cactus (*Opuntia humifusa*), and Yucca (*Yucca filamentosa*) as candidate living artifacts.

(7) A Field in Lewes, Delaware. "A Tree Circle Cluster in Lewes, Delaware: Sycamorehenge?" September 2013. See folder Mellin and Truitt 2013h. We discussed Sycamore (*Platanus occidentalis*) as a candidate historic living artifact, and Sycamore (aka. London plane, *Platanus orientalis*) as a Naturalized specie.

(8) Hell Island in the Appoquinimink River. "Hell Island Botanical Survey." September 2013. See folder Mellin and Truitt 2013i. We discussed Mountain-laurel (*Kalmia latifolia*), and Rhododendrons (*Rhododendron* spp.) as candidate living artifacts.

(9) Lums Pond State Park. "Lums Pond Botanical Survey." September 2013. See folder Mellin and Truitt 2013j. We discussed American Wild Crab Apple (*Malus coronaria*), Black Walnut (*Juglans nigra*), Club Moss (*Diphasiastrum digitatum*), and Pawpaw (*Asimina triloba*) as candidate living artifacts.

(10) Alapocas and Brandywine Creek State Parks. "Pawpaw Clusters Evaluated in Alapocas Run and Brandywine Creek State Parks." October 2013. See folder Mellin and Truitt 2013k. We discussed American Wild Crab Apple (*Malus coronaria*), Black Walnut (*Juglans nigra*), Elderberry (*Sambucus canadensis*), Mountain-laurel (*Kalmia latifolia*), and Pawpaw (*Asimina triloba*) as candidate living artifacts.

SUMMARY

This synthesis, Transformation of Native American and Historic Botanicals is a summary of our efforts in exploring, arranging, and explaining the terrestrial plant species that are known to occur in Delaware, within a cultural framework. In doing that, we respect many things. On the one hand, we recognize that climate change, soil chemistry, elevation, disease, efficiency in reproduction, availability of nutrients, water, and sunlight, etcetera, have played major roles in which plants are found and not found in Delaware. On the other hand, this synthesis presents a framework, a foundation, for a cultural organization of botanicals found in Delaware.

Make no mistake about it—many plants, descendant plants, and plant clusters found in Delaware, today, are artifacts. We need to investigate them, document them, and preserve what we can before we make them disappear from our landscape. In the past four hundred years, we have devastated, arguably, about half of the available land where these plants prospered. In addition, because we aspire to use similar landforms as our ancestors did, the most culturally significant landscapes have witnessed, statistically speaking, even greater modifications than less significant areas. In short, we continue to lose what we don't even know we have—at an accelerated rate! However, we think there are some remedies to these harsh facts.

We fashioned the previously discussed simple chart, a cultural organization of botanicals. The circular part of the chart describes the how botanicals are organized in Delaware; (1) Natural, (2) Naturalized, and (3)

Adventive Plant categories. It is imperative to understand that all Naturalized plants have a cultural connection. Many Adventive plants have a cultural connection, and because specific Adventive plants have (or may have) become Natural plants, they too, may have a cultural connection. In the center of our chart, we find (A) Archaeobotanical Artifacts, (B) Traditional Artifacts, and (C) Living Artifacts. Archaeobotanical evidence demonstrates which plants Native Americans were using and possibly suggesting when specific plant species arrived in Delaware. Traditional Artifacts are objects (using additive and subtractive methods) made by humans. Living Artifacts are the actual plants, plant species acquired (i.e. introduced), and plant clusters (i.e. identified by shape, quantity, or location), that humans found beneficial to enlarge, acquire, concentrate and/or maintain.

Mellin and Truitt are not the first to discuss these ideas in Delaware (see McAvoy 2000 and 2013; McAvoy and Harrison 2012; McKnight 2004a, b, and c, in Berger 2005; McKnight 2013; and Taber 1937 for specific examples and theories concerning botanical introductions, species concentration, and species location disjunctions). In addition, we have had productive discussions with Daniel Griffith and Dr. Darrin Lowery concerning the Prickly Pear cactus, and with Dr. Carole Nash about her botanical research in Virginia. Finally, we have had many interesting and productive discussions with contemporary people of Native American ancestry.

Mellin and Truitt conducted and distributed the results of ten botanical surveys in 2013. In addition, we compiled a synthesis addressing Archaeobotanicals found in twenty-eight Delaware Department of Transportation sponsored Cultural Resource Management projects. We compiled this synthesis, Transformation of Native American and Historic Botanicals, which you are currently reading. And finally, we combined all twelve of the above botanical research documents into one, comprehensive folder called, Botanicals 2013.

Our botanical research for the calendar year 2013 was self-directed, self-funded, and not constrained by academic, or bureaucratic agendas. We are solely responsible for the decisions, theories, and discoveries made. We have made every effort to provide accurate citations on shared and proprietary data, and we have made numerous attempts to explain our progress through email attachments, even though some may be wondering why we are sending them this weird "stuff". We thank everyone mentioned above for sharing their ideas on these important topics.

INTERPRETATIONS

We think the discoveries achieved through our botanical surveys are the foundation of a new awareness of what exists in our environment. We appreciate that there are many, varied approaches to investigating our environment. During the calendar year 2013, we chose to explore culturally influenced botanicals through quantifying the differences between theoretical randomness and measured disjunction. Simply put, looking for clusters of rare, or oddly spaced, culturally beneficial plants seemed to be the best fit with our particular skill level. We found a number of instances, or examples, where these plant clusters decidedly fell into the measured disjunction category, making cultural explanations decidedly more relevant than natural explanations. We identified the candidate specie clusters, recorded the cluster locations using GPS UTM coordinates, and attempted to explain the cultural circumstances of the finds (i.e. edible, fuel, construction, medicinal, ceremonial/religious, decorative/arts, and undetermined).

We documented the following clustered species, in alphabetical order: American Chestnut (*Castanea dentate*), American Wild Crab Apple (*Malus coronaria*), Black Walnut (*Juglans nigra*), Box Huckleberry (*Gaylussacia brachycera*), Catalpa (*Catalpa* spp.), Chinese Chestnut (*Castanea mollissima*), Chinquapin (*Castanea pumila*), Club Moss (*Diphasiastrum digitatum*), Elderberry (*Sambucus canadensis*), Ironwood (*Carpinus caroliniana*), Mountain-laurel (*Kalmia latifolia*) Norway Spruce (*Picea abies*), Pawpaw (*Asimina triloba*), Prickly Pear (*Opuntia humifusa*), Red Mulberry (*Morus rubra*), Rhododendrons (*Rhododendron* spp.) Sawtooth Oak (*Quercuts acutissima*), Sycamore (*Platanus occidentalis*), Sycamore (aka. London plane, *Platanus orientalis*), and Yucca (*Yucca filamentosa*).

We offer the following comments on the process of species disjunction as an interpretation of the clustered species we documented. There are many culturally beneficial plants in the natural environment. It used to be

fairly difficult to spend an hour in a Delaware forest, in November, and not see ground scatters of acorns, hickory nuts, persimmons, and occasionally chestnuts and walnuts, etcetera. It was equally easy to see the detritus where squirrels, mice, and deer were busy making use of those natural bounties.

Years ago, when we were surveying the centerline of the future State Route 1, northeast of Dover, Delaware, we walked through several miles of poorly drained uplands featuring extensive stands of Gum and Oak. But when we arrived at each little hillock, the vegetation shifted to Hickory and Yellow Poplar. Some larger hills, hills that contained ancestral Native American archaeological sites, such as site 7K-C-360, were dominated by Oak and Hickory. At this point in our research, it would be prudent to assume these types of Hickory clusters are more aligned with the shift from poorly drained Fallsington soils to the higher percolation rates associated with the (presumably) Sassafras soil hill or dune features. Future research may suggest otherwise, but at this point in time, we do not consider these types of Hickory clusters (and similarly occurring clusters) to be disjunct (i.e. random selection on a large scale). Our ten botanical surveys in 2013 documented a number of plant clusters we think are disjunct. When a disjunct population appears to be associated with a cultural site, we assigned them to the candidate cultural plant cluster category (i.e. cultural selection).

All of the candidate Native American cultural plant clusters we documented are in close proximity to archaeological sites. In addition, all of those plant clusters are documented within two hundred feet of the river (or current edge of the flood plain). An interesting aspect of the seven Chinquapin clusters we documented is that we found them upstream from the water lily zone and downstream from the poorly drained uplands. As indicated by Mellin and Truitt, this particular range (on the Nanticoke River [2013a], Broad Creek [2013d], and the Murderkill River [2013e]), we think, is a result of cultural selection, falling well beyond the natural factors expected in the large-scale random thesis.

In an effort to be friendly, as suggested earlier in the anonymous poem offered by Sis and Jake (1966), we would like to leave you with two recipes using a few of the very plants we found in our botanical surveys. Sassafras Tea: Sis says, "Wash root well. Put six dry roots in pan or coffee pot in about a quart of water. Soak overnight. Then place on fire and boil slowly till fairly strong. Weaken or sweeten to taste. Serves seven or eight" (p.5). To make a traditional Pawpaw Pie, you will need 1 cup sugar, 1 cup milk, 1 egg, ¼ teaspoon salt, 1 ½ cups pawpaws (peeled and seeded). "Place all ingredients into stew pan and stir together. Cook over medium heat until thickened. Pour into unbaked pie shell and bake until the crust is done. Can be topped with meringue or other topping" (p.37). Enjoy!

We hope our efforts serve as a useful foundation. There is a lot of work yet to do! Every time we feel overwhelmed, we consol each other by acknowledging that we have walked through ancestral Native American gardens, orchards, and nut groves—picked and eaten, and relished the fruits of their insightful efforts. For those rare pleasures, we heartily say--thank you, what wonderful gifts!

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2013d. A Botanical Survey in Trap Pond State Park Identifies Three Chinquapin Clusters. August 2013.

2013e. A Botanical Survey of Killen Pond State Park in Kent County, Delaware. August 2013.

2013f. A Botanical Survey of the Robert Graham Preserve and the Barnes Woods Preserve in Sussex County, Delaware. August 2013.

2013g. Sampling Archaeobotanicals: Past, Present, and Future. August 2013.

2013h. A Tree Circle Cluster in Lewes, Delaware: Sycamorehenge? September 2013.

2013i. Hell Island Botanical Survey. September 2013.

2013j. Lums Pond Botanical Survey. September 2013.

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