8-2016

Bulletin No. 42: The Mamacoke Conservation Area

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Connecticut College Arboretum
BULLETIN 42

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August 2016

NOTICE TO LIBRARIANS

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Cataloging Information: Dreyer, Glenn, Robert Askins and Scott Peterson. The Mamacoke Conservation Area. Connecticut College Arboretum Bulletin No. 42. Published by the Connecticut College Arboretum, Box 5201 Connecticut College, 270 Mohegan Avenue, New London, CT 06320-4196.

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FOREWORD

THE TRADITION of the Connecticut College Arboretum drawing attention to special natural areas in our state began in 1956, with Connecticut Arboretum Bulletin No. 9, titled *Six Points of Especial Botanical Interest in Connecticut*. In addition to a short description of ecological research at Connecticut College, that bulletin highlighted the Barn Island marshes, the North Haven sandplains, Caitlin Wood, the Cathedral Pines and an old-growth hemlock stand in Norfolk. Two decades later, Bulletin 34 (1995) focused on the *Tidal Marshes of Long Island Sound*, and Bulletin 37, published in 2001, on *the Living Resources and Habitats of the Lower Connecticut River*. Most recently the Arboretum published *Trap Rock Ridges of Connecticut: Natural History and Land Use* as Bulletin 41 in the series.

Katharine Blunt Professor of Biology Robert Askins' long-term studies of bird life on the Thames River near Mamacoke Island led him to realize the conservation significance of this part of the Arboretum. Connecticut's National Audubon Society staff agreed, and the location became part of the Important Bird Area (IBA) network. Compiling a comprehensive report for the IBA program led us to realize how many academic and management projects, both terrestrial and aquatic, were done in this relatively small area. Although it took 10 years for the original report to evolve into this bulletin, the time allowed us to add even more information, especially 10 additional years of waterfowl population data. To illustrate that this is an ever-evolving story, in mid-June 2016 as we prepared to send this publication for design and printing, the US Navy Submarine Base Natural Resource Manager reported that federally endangered Atlantic sturgeon *(Acipenser oxyrinchus oxyrinchus)* had been detected in the river near the base (and the Mamacoke Conservation Area) for the first time since the 1980s (June 16, 2016, *The Day*, New London, CT).

To me, this publication is a tribute to the many students, staff and faculty who studied, worked and played in this less well known area of the Arboretum and its surrounding neighborhood and waters. Hopefully the record of past work will inspire future activities in this beautiful and diverse location.

Glenn Dreyer
Charles & Sarah P. Becker'27 Arboretum Director

Figure 1. Great Egrets regularly hunt for food on the salt marsh at Mamacoke Island during the late summer and early fall (B. MacDonnell)

INTRODUCTION

IN 1999, MAMACOKE ISLAND and the adjacent coves on the Thames River were proposed for inclusion in the National Audubon Society's Important Bird Area (IBA) program. This was due to the importance of this area for bird species that have a high priority for conservation and because it is used by more than 500 waterfowl during winter. Of primary conservation importance are the brackish coves that harbor large numbers of ducks during periods when freshwater lakes and ponds are frozen. Common winter-resident waterfowl include American Black Duck, Greater and Lesser Scaup, and Hooded Merganser. During the summer, Great Egrets (Figure 1) and Snowy Egrets forage along the edges of these coves. Since the IBA was first established in this location, the Arboretum has increased the acreage of early successional habitat near the river coves, and these areas and adjacent uplands were incorporated into an expanded IBA designation because they support several declining bird species.

This Arboretum bulletin first took shape during 2006-07 as a conservation plan for the Mamacoke Important Bird Area. Drawing in part on that report, our aim here is to summarize what is currently known about the cultural and natural history of Mamacoke and its environs and to describe conservation priorities for this area. Throughout this publication, we will usually refer to the "Mamacoke Conservation Area," rather than the IBA because the site has significant conservation value beyond its importance to birds. It should be noted that the area delineated and described is not a legal entity and has no official recognition at this time beyond the National Audubon Society. Some of the upland areas are preserved and protected by Connecticut College, and there are various tidal and coastal zone regulations in effect which limit human use of some parts of the area, but other areas are not protected from development. A description of Audubon's Important Bird Area Program can be found in the Appendix.

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Figure 2. Aerial photo from 2005, showing the boundary of the Mamacoke Conservation Area in yellow and other physical features.

SITE DESCRIPTION AND HISTORY

LOCATION

THE MAMACOKE CONSERVATION AREA comprises sections of the Thames River and both developed and undeveloped land on its west bank in the Quaker Hill section of Waterford, Connecticut, opposite the U.S. Naval Submarine Base in Groton. Scotch Cap Road and Best View Road bound the irregularly shaped 317 acres on the north

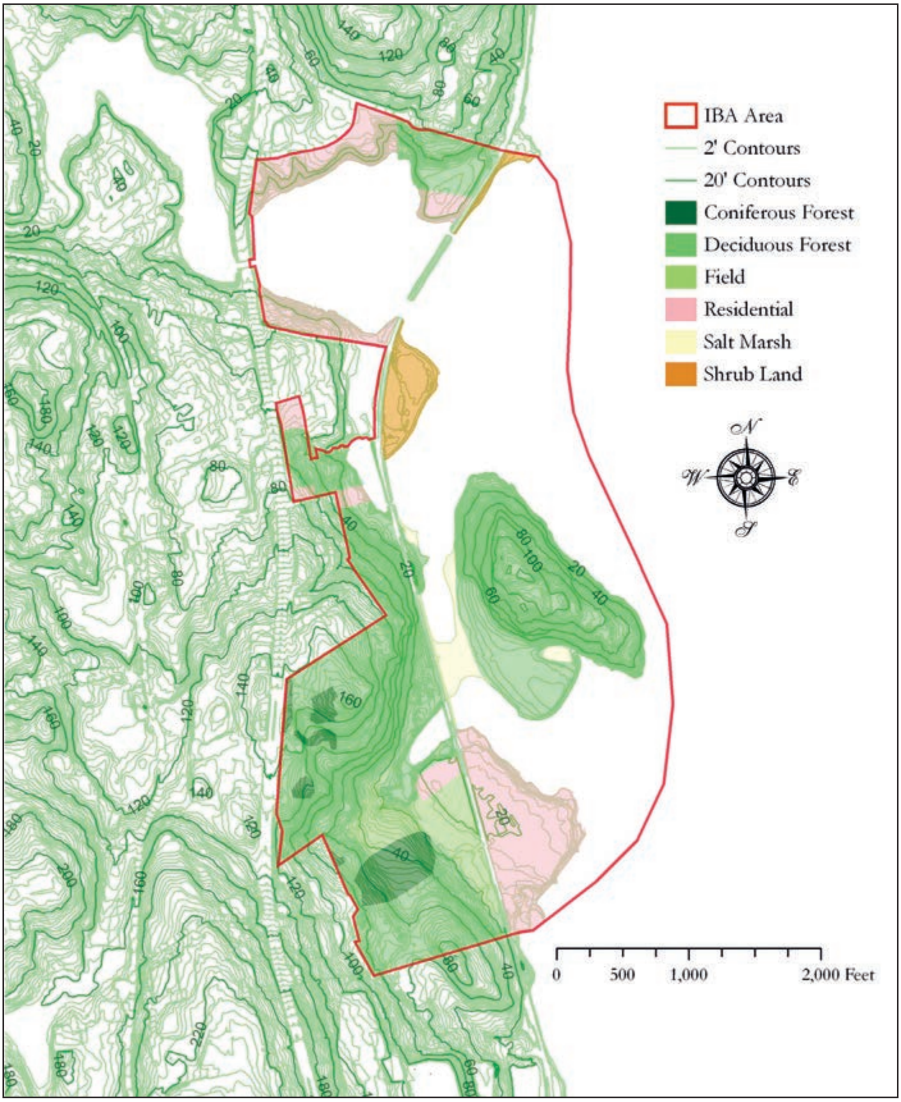


Figure 3. Topography and major vegetation types in the Mamacoke Conservation Area

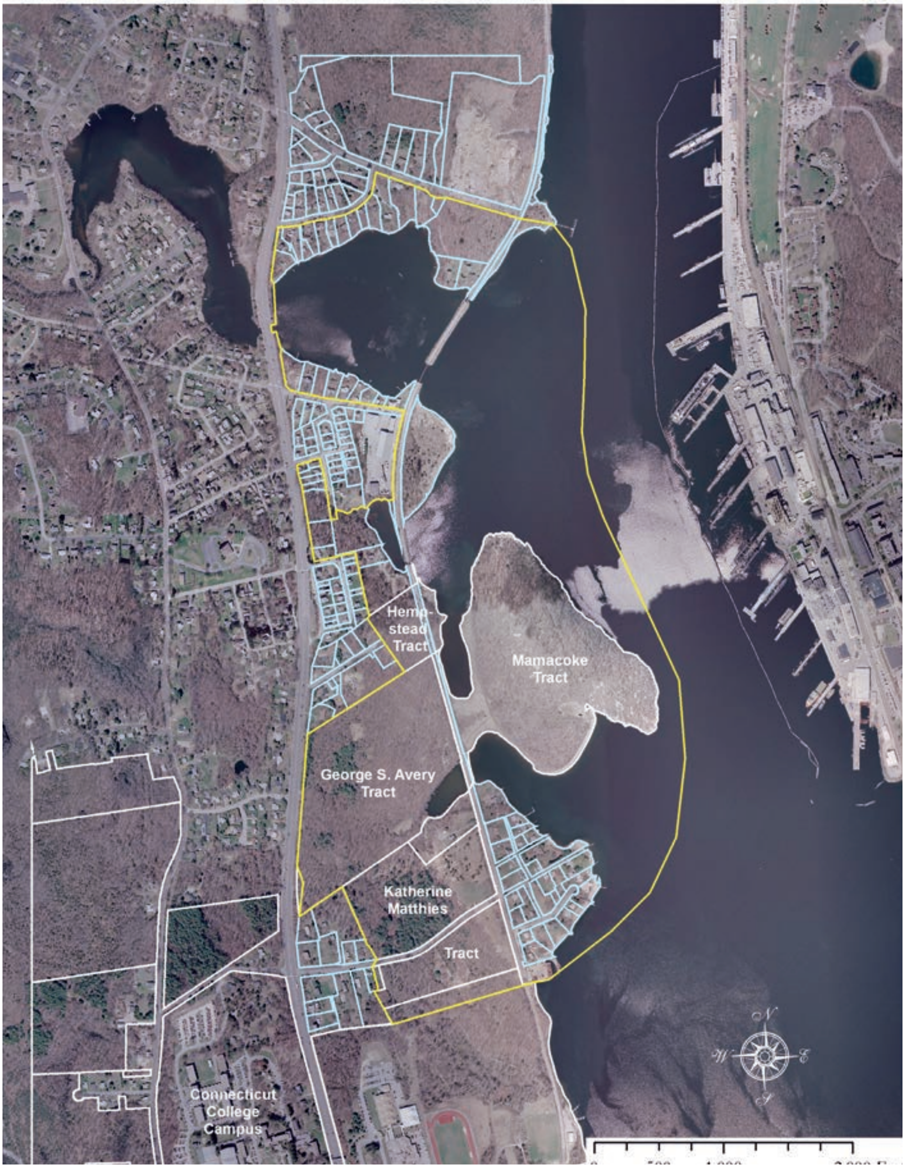


Figure 4. Land ownership parcel map of the Mamacoke Conservation Area in 2006 showing Connecticut College Arboretum tracts (white) and other neighboring residential and commercial parcels.

(Figure 2). The western edge follows Mohegan Avenue (Route 32), or the rear boundary of residential lots east of this road, and the Waterford-New London town line forms the southern boundary. The boundary extends east into the Thames River from the Waterford-New London town line and follows the approximate western margin of the dredged river channel north until reaching the terrestrial boundary again northeast of Smith Cove. With this approximate aquatic boundary to the east, the Conservation Area encompasses all tidal coves and waterways surrounding Mamacoke Island as well as Smith Cove. Elevations range from about 160 feet on the Arboretum Avery Tract to about 2 feet at the river's edge (Figure 3). Railroad tracks follow the river edge from north to south, separating Mamacoke Marsh and Mamacoke Island from the mainland.

Of the 168 acres on land, 114 are owned by Connecticut College. College property comprises a number of parcels within the Connecticut College Arboretum: Mamacoke Island and Mamacoke Marsh, the George S. Avery Tract, the Katherine Matthies Tract, the Hempstead Tract, and the small Espinosa Lot in the northeast corner of the Matthies Tract (Figure 4). The College acquired these five properties separately between 1944 and 1963. A complete summary of parcel history, including previous owners, buildings, uses, and method of acquisition and costs, can be found in Richard Goodwin's history of the Arboretum (Goodwin, 1991).

Mamacoke Island is actually a peninsula connected to the mainland by a four-acre tidal salt marsh. The center of Mamacoke is a dome of rock rising 130 feet above the Thames River with outcrops, glacial erratics, ledges, and pockets of glacial till supporting large areas of woodland, as well as thickets and small, grassy ridge tops with scattered trees. There is a second, smaller salt marsh covering less than one acre on the southern side of Mamacoke at the head of a small cove.

The Mamacoke Conservation Area includes five noteworthy water bodies. Starting from the north, these are Smith Cove (only the portion east of Route 32); a small, unnamed pond west of the railroad tracks and north of the Hempstead Tract that is connected to the river via a culvert; North Mamacoke Cove; South Mamacoke Cove; and the brackish pond west of the railroad right-of-way that is connected to South Mamacoke Cove by a culvert. These water bodies are important shallow, tidal, aquatic habitats supporting numerous bird species throughout the year, and they are especially important for waterfowl during winter (Askins, 1990). Together with portions of the Thames River, the aquatic area portion of the Mamacoke Conservation Area covers 149 acres.

HUMAN HISTORY

Prehistoric

ARTIFACTS AND OTHER EVIDENCE OF SETTLEMENT indicate that Native Americans inhabited much of this land as early as 4,000 years ago (Juli, 1992). There are four Native American archeological sites within this part of the Arboretum property that the late Professor of Anthropology Harold Juli investigated and designated as Harrison's Landing, Mamacoke Cove, Graves' Rockshelter and Soccer Field (often called Dawley Field).

A shell midden at the Harrison's Landing site that covers an area of 500 square meters was the first to be archeologically studied in the early 1970s. Harrison's Landing is the name of the small, residential development east of the railroad tracks and south of Mamacoke Island. This archeological site is located in the southeast corner of the Arboretum Avery Tract at the head of the brackish cove west of the railroad and South Mamacoke Cove. Middens are areas of food remains that include bones, artifacts and, most commonly (especially along coastal regions), an abundance of shell refuse — often resulting from years of prehistoric meals eaten in one place. At Harrison's Landing, 95-percent of the midden deposit is represented by the common eastern oyster (*Crassostrea virginica*).

Figure 5. Archeological excavation of a Native American shell midden on the south side of Mamacoke Island, circa 1980 (Arboretum Archives)

Clams, mussels and scallops, as well as some animal bones and projectile points, compose the rest of the material (Juli, 1992). This site and other middens within the Arboretum represent evidence of seasonal use by Native Americans from the late Archaic period up until colonial times. Snow (1980) estimated that approximately 13,300 people inhabited the Thames drainage and eastern Long Island prior to European contact in 1600 CE. His population density findings suggest that the local Mohegan-Pequot tribe had 266 persons per 100 square kilometers, constituting the highest density in New England during pre-colonial times.

A Connecticut College undergraduate discovered the Mamacoke Cove archeological site, located on a hill on the southern side of the island, in 1975 (Figure 5). Yielding remains of shell, bone, stone tools and prehistoric ceramics, the site suggests inhabitants were present during the Middle to Late Woodland stage (ca. 1-1600 CE). A midden here was composed of much of the same deposit material as the Harrison's Landing site but also included remains of deer, raccoon, beaver, rabbit, muskrat, porcupine, wild turkey, gray and red fox, gray squirrel, vole, mouse, chipmunk, otter, duck and turtle, as well as some bird and fish bones. A large Woodland village was probably located across the river on the current site of the U.S. Naval Submarine Base in Groton, and the Mamacoke site may have served as a seasonal shellfishing station (Juli, 1992).

In 1980, local resident John Graves reported that as a boy in 1927 he found the remains of two human skeletons and a small collection of projectile points on the northern upland part of Mamacoke under a small rock overhang (subsequently named Graves' Rockshelter; Figure 6). Only one skull from the two skeletons remains, and it is apparently from an adolescent aboriginal female. Some projectile points were also found by an amateur archeologist in the field on the Matthies Tract north of Benham Avenue (Juli, 1992).

In 1981, during construction of an athletic field west of the railroad track and directly downhill from the College's athletic center, a large concentration of shell and bone was noticed. Professor Juli spent a week exploring the site and discovered the burial of a single Native American male. The skeleton was carbon dated to approximately 1620 CE, with a margin of 70 years, and showed signs of tuberculosis, indicating this individual was probably one of the many native victims who succumbed to disease shortly after first contact with Europeans. The site is to the south of a small stream that now enters the Thames River through a culvert under the railroad bed. Prehistoric habitation sites are commonly found where streams enter the river, and this area includes a number of shell middens in addition to the burial site (Juli, 1992).

Historic

COLONIAL SETTLEMENT OF THE THAMES DRAINAGE began in the early 1600s. The salt marsh connecting Mamacoke to the mainland was mowed by English settlers as early as 1645, which was the first year of true colonial settlement in New London (Caulkins, 2007). The Mamacoke Marsh and lowland terrace became part of the Mamacock Farm, an operation that belonged to the Rogers family for 198 years begin-

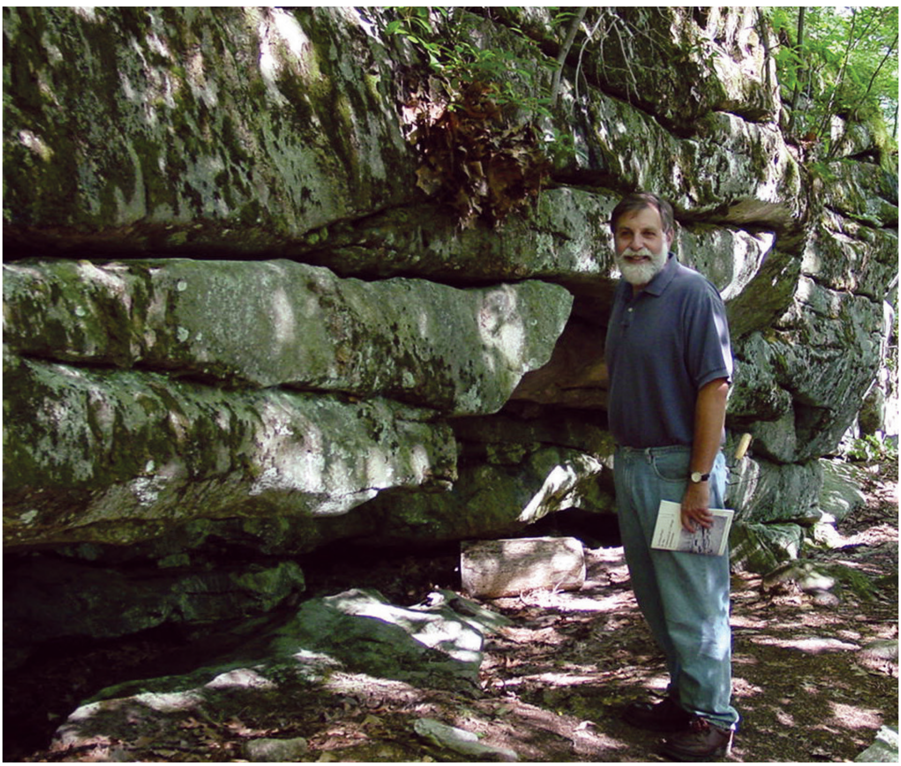


Figure 6. Professor Harold Juli at the Graves Rock Shelter, Mamacoke Island, in 2001 (G. Dreyer)

ning in 1647. This farm encompassed all of the land between Mamacoke Island and what is now Williams Street, as well as some 70 acres west of Williams Street (now also part of the Arboretum).

In the 1650s the property passed from John to James Rogers, a baker who operated John Winthrop's Mill, now the Old Town Mill located under the Gold Star Bridge on Interstate 95 (Goodwin, 1991). The next owner was James' son John, who founded the Rogerene religious sect (Caulkins, 2007; Hanlon, 1996). The local religious establishment persecuted this John, and he was regularly fined and spent many years in jail (Caulkins, 2007). The place name, Quaker Hill, is derived from this sect. This is a misnomer, however, since these people were not members of the group generally referred to as Quakers (the Society of Friends). Originally used to designate the farm and hill where the Rogers families lived (and where Connecticut College was built), the name Quaker Hill eventually came to designate the small village in the Town of Waterford to the north (Caulkins, 2007). The Rogers' farm houses were on the east side of Williams Street/Old Norwich Road, the only north-south road at that time. One house, which was built shortly after 1787, still stands east of Mohegan Ave. (Rt. 32) and south of Benham Avenue (Goodwin, 1991).

In 1751, James' son John laid out a family burial ground, just over an acre in size, at the southeast corner of the farm on the bank of the Thames River and on the south side of an unnamed stream (Hanlon, 1996; Goodwin, 1996). Several family members had already been buried there, and Professor Emeritus of Human Development Camille Hanlon found records for 60 to 80 interments, most with only field stones as markers. Some of the cemetery was washed away by a storm in 1815, and more was removed when railroad tracks were built along the west side of the Thames in the late 1840s. The portion of the cemetery that is still intact currently contains only three full-sized headstones (one upright, one leaning, and one flat on the ground), but many small stones are placed in rows at fairly regular intervals. The cemetery was investigated in 2009 as part of a Methods in Archeology course taught by Visiting Instructor Donna Rae Gould. Deborah Surabian, a soil scientist with the USDA Natural Resources Conservation Service, demonstrated the use of ground-penetrating radar over a portion of the cemetery. This type of radar is able to create images of subsurface features that can aid in archeological interpretation of sites. The results showed 41 likely grave locations oriented in north-south lines.

In the late 1800s, the terrace on the west side of Mamacoke Island, which was already cleared for pasture, was the site of a small shipyard for schooner construction. Also, on the eastern shore of Mamacoke Island there is evidence of quarrying by the Merritt-Chapman & Scott Corporation, from whom the Arboretum purchased the island in 1955 (Goodwin, 1991). However, until the 20th century, major human impacts on the Mamacoke Conservation Area were mainly agricultural, with the land being variously devoted to pasture, mowed fields, orchards and row crops. Based on old photographs and current tree size, the steep, east facing slopes of the ridge running north on the mainland across from Mamacoke Island was some of the first land to grow back to forest on the original Mamacock Farm.

Relatively little information is available about the history of the land outside of the Arboretum boundary, but some information was gleaned from old maps and from photographs in the Connecticut College Archives. The railroad was first built through the area in 1848 (Bachman, 1967). It cut off two small bays, creating the current ponds

Figure 7. A 1934 aerial photograph of the Mamacoke Conservation Area. The northern portion of the Connecticut College campus is in the foreground, and the U.S. Naval Submarine Base can be seen in the upper right, beyond Mamacoke Island. Mohegan Avenue (Route 32) was still a dirt farm road going off the middle left of the image.

north and south of Mamacoke Marsh and also mostly closed the eastern mouth of Smith Cove. New England Central Railroad of St. Albans, Vermont, has owned this line, used exclusively by freight trains, since 1995.

In the early 1900s, Mohegan Avenue was a dirt road that led to a few farms and ended at Smith Cove. Old Norwich Road, which is the continuation of Williams Street into Waterford located to the west of the Mamacoke Conservation Area, was the only road between Norwich and New London. A trolley line connecting New London and Norwich followed Mohegan Avenue and bridged Smith Cove in 1900 (Bachman, 1967). A photograph from 1934 (Figure 7) shows Mohegan Avenue paved only from the College property south. This was the year the trolley was discontinued and Mohegan Avenue, later designated Route 32, was extended for automobile traffic across Smith Cove.

Harrison's Landing, a small settlement east of the railroad tracks at the end of Benham Avenue in the southeastern corner of the study area, only had three houses mapped in 1850, and five houses are shown on an 1893 map. No houses appear around Smith Cove in the 1850s, and only one by 1893. Intensive development in this area did not begin until Mohegan Avenue was extended across the cove. There are currently 24 houses on the shore of Smith Cove and 23 houses plus one marina at Harrison's Landing.

During World War II, the U.S. Army installed a gun emplacement on the highest point of the Avery Tract overlooking Mamacoke Island and the river. A gun emplacement was also located at the south end of the Matthies Tract. In the late 1940s, a system of bridle paths for the Connecticut College riding program were developed through the Avery and Matthies tracts; these trails have been maintained and are currently used by the College and Coast Guard Academy cross-country teams, as well as by hikers and runners. In the 1940s, the Arboretum planted a one-acre white and red pine plantation on the Avery Tract and an approximately eight-acre plantation on the north side of Benham Avenue on the Matthies Tract (Goodwin, 1991).

Mamacoke Island and Mamacoke Marsh were designated as the Arboretum's second Natural Area when they were acquired in 1955 (Goodwin, 1991). Arboretum Natural Areas are primarily reserved for research and teaching and are managed to minimize human influence as much as possible. In practical terms, this means no planting, cutting or harvesting of plants, and no destructive experimentation or active recreation. Limited removal of invasive exotic plant species has recently occurred in some locations, however.

On the eastern side of the Matthies Tract, the southern section of the open field was used as a Waterford Little League baseball field from 1956-78 (Goodwin, 1991). From 1981 through spring 2005, College athletes used this area to practice throwing hammer, shot put and discus. A coach mowed this section of the field in spring and fall to maintain low turf. A small concrete pad in the southeast corner of the field, installed as a throwing platform, is still present. Part of the field south of Benham Avenue and adjacent to the railroad right-of-way served as a plant nursery for the College from 1955 until about 1985, and has served as a site for the composting of leaves removed from the campus grounds since 1970. In 2010, the Town of Waterford purchased a small lot from the College located on the south side of Benham Avenue and adjacent to the railroad tracks for construction of a sewer pump station. The pump serves the Harrison's Landing neighborhood east of the tracks, allowing sewerage to be piped from houses next to the river to the sewer main on Old Norwich Road.

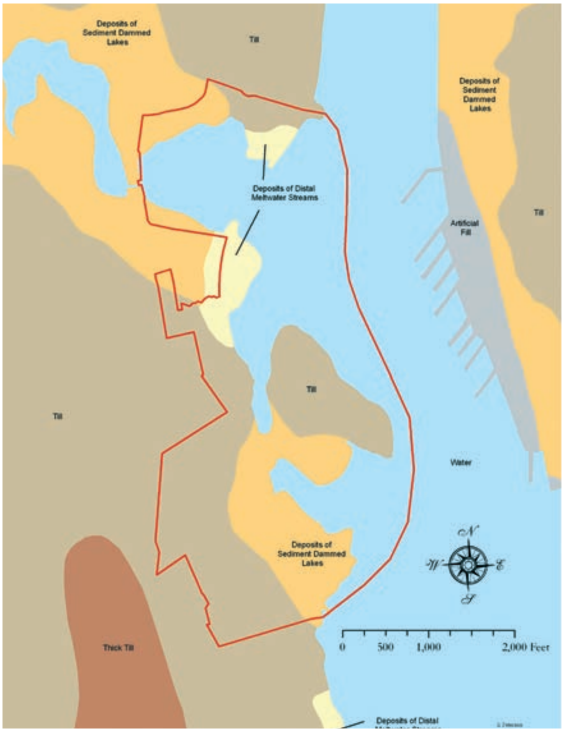
The U.S. Navy Submarine Base is located directly across the Thames River from Mamacoke Island. Established in 1868 as a dry dock and coaling station for naval ships on 112 acres in Groton, it became the first US submarine base in 1916 (Bishop, 2005). It has grown substantially to include various schools and commands, and is currently one of only a few homeports for U.S. nuclear submarines. Although not within the Mamacoke Conservation Area boundary, activities at the base undoubtedly influence local environmental conditions.

Figure 8. View of North Mamacoke Cove in 2006 from the railroad tracks. The west side of Mamacoke Island, with a slender fringe of tidal marsh, is to the right (G. Dreyer).

NATURAL ECOSYSTEMS

AQUATIC FEATURES

THERE IS A NATURAL SPRING on the southern border of the George S. Avery Tract, just east of the dirt road, which feeds a stream that travels through a beech grove on the steep bank, and then through an alder (*Alnus* sp.) thicket and a wet meadow before emptying into the brackish pond (Figure 2). There is also an intermittent stream that has formed from storm water runoff from Mohegan Avenue that runs in a northeast direction down to the head of the wetland above the brackish pond. This small water body is actually an extension of South Mamacoke Cove and is tidally influenced through a culvert that runs under the railroad embankment. The water entering through the culvert has a high enough salt concentration so that typical salt marsh plants grow at the eastern perimeter of the cove. The western end receives freshwater from the spring and intermittent stream and is bordered by typical freshwater species. A report prepared by consultants Brown and Root for the U.S. Naval Submarine Base in the mid 1990s used the brackish pond near Mamacoke for comparison to Goss Cove just south of the base. Pond depth averaged between two and three feet, except near the middle, which was four and a half feet deep. The report noted that salinity in the pond



was generally higher than that observed in the river, and dip netting produced "live softshell clams and Atlantic ribbed mussels along the shore (near the box culvert) … unidentified marine shrimp and live barnacles were noted attached to fallen branches... no minnows observed or captured" (Starkel and Cubbage, 1996).

Another unnamed, brackish pond, that appears to have been formed by railroad track construction, is located south of Richards Grove Road.

Little is known about the physical or biological features of the three coves (Smith, North Mamacoke and South Mamacoke) that comprise the most significant features of this conservation area (Figure 8). Judging by a stone wall on the west shore of Mamacoke Island that heads west out into South Mamacoke Cove, the shape of that cove and the marsh have changed over time, probably due to the installation of the railroad tracks. The salinity of the coves is high enough so that they remain at least partially unfrozen during almost all winters. This and the fact that they are shallow enough to allow waterfowl to forage are the most important qualities for birds.

TOP: Figure 10. Simplified surficial geology of the Mamacoke Conservation Area and surroundings

BOTTOM: Figure 11. Generalized soil types of the Mamacoke Conservation Area and surroundings

Figure 12. Mamacoke Marsh with the trail to the island arcing through the middle of the image. This is one of very few unditched tidal marshes in Connecticut (G. Dreyer).

GEOLOGY AND SOILS

BEDROCK IN THE MAMACOKE CONSERVATION AREA consists completely of various types of gneiss (Goldstein, 1967). The majority is mapped as the Mamacoke Formation, with a small area south of Smith Cove and east of Mohegan Avenue categorized as New London Gneiss. Although the bedrock is mostly below ground, outcroppings occur on Mamacoke Island (Figure 9) and on the Avery Tract along the steep ledges west of Mamacoke Marsh.

Mamacoke Island contains several interesting geologic features. The Thames River valley and the island are part of a horst and graben system. The island represents a horst, or protruding section of bedrock bounded on two sides by normal faults. The remainder of the valley is part of the graben system that dates back to the breakup of Pangaea approximately 200 million years ago (Rosemary Park Professor of Physics, Astronomy and Geophysics Douglas Thompson, personal communication). A graben is a section of rock that drops down between two normal faults. Pangaea was the name for the single, huge "supercontinent" from which all of today's continents derive.

More recently, the island was shaped by glacial activities. The distinct shape of Mamacoke —with a smooth northern slope and an abrupt, cliff bounded, southern slope —is a result of glacial smoothing and plucking. This landform is referred to as a roche moutonnée. During the period of glacial retreat, a block of ice melted in place on the south portion of the island to form a small glacial kettle hole that is now the small salt marsh (Figure 13). The large, flat southern section of the island represents a terrace formed when the Thames River was a larger system full of glacial meltwater and sediments from the retreating glaciers (Thompson, personal communication).

Figure 9. Icicles over a bedrock outcropping of Mamacoke Gneiss on the south side of Mamacoke Island (M. Braunstein)

The U.S. Geological Survey (1960) surficial geology map identifies the flat areas along the river from the Waterford town line north to the shores of North Mamacoke Cove, as deposits of sediment dammed glacial lakes (Figure 10). These sediments also occur around Smith Cove, except at its mouth, where the deposits were from glacial meltwater streams. The remaining uplands are covered in glacial till.

Upland soils in the study area are primarily of the Charlton-Chatfield and Canton and Charlton complexes (Figure 11; NRCS 2013). The terrace areas near water consist of Hinckley gravelly sandy loam, and portions of this soil type directly west of Mamacoke Marsh were historically mined for sand and gravel (Goodwin, 1991). All of the soils in the conservation area, with the exception of the tidal marshes, are at least in the well-drained category, with many excessively well drained.

VEGETATION

THE FORESTED portions of the Mamacoke Conservation Area can generally be classified as Oak Hickory Forest, part of the Central Hardwoods Vegetation Zone of Egler and Niering (1965; Figure 3). Red (*Quercus rubra*) and black (*Q. velutina*) oaks predominate, and hickory (usually mockernut - *Carya tomentosa*), red maple (*Acer rubrum*) and black birch (*Betula lenta*) are common. Other hardwoods, including white oak (*Q. alba*), American beech (*Fagus grandifolia*) and sassafras (*Sassafras albidum*) are occasionally present in the canopy. Flowering dogwood (*Benthamidia florida*), black cherry (*Prunus serotina*) and saplings of canopy trees sometimes form a middle stratum. Shrub cover can be sparse, with lowbush blueberry (both *Vaccinium angustifolium* and *V. pallidum*) and black huckleberry (*Gaylusaccia baccata*) common, as are thickets of the shrub/vine greenbrier (*Smilax rotundifolia*). Mountain laurel (*Kalmia latifolia*), which was removed on most of this former pastureland, is occasionally present. The only location with a dense mountain laurel understory is the northwest sector of Mamacoke Island, which was presumably too steep and remote for the farmers to bother clearing. On the drier, rockier sites the sparse herb layer includes Pennsylvania sedge (*Carex pensylvanica*) and hair grass (*Deschampsia flexuosa*) as common components.

In 1948, red (*Pinus resinosa*) and white pine (*P. strobus*) were planted on about eight acres of former orchard in the Matthies Tract on the north side of Benham Avenue. Nearly all of the red pines succumbed to red pine scale (*Matsucoccus resinosae*), which arrived in the 1980s, but the white pines are now mature and are the source of the increasing pine population south of Benham Avenue. Pines were also planted on the Avery Tract in 1949 along Mohegan Avenue and on a one-acre plot on the higher, flatter ground (Goodwin, 1991).

Bare mineral soil is exposed in some locations directly west of Mamacoke Marsh, due to small-scale gravel and sand excavation that ended about 1990. Some naturalized Scots pines (*P. sylvestris*) of unknown origin occur in this location. Progressing north, this site becomes the most mature, best-developed (possibly oldest) forest locally, with trees up to 20 inches in diameter, and a denser and more diverse shrub layer than other nearby forests. Saplings of American beech (*Fagus grandifolia*) and maple-leaved viburnum shrubs (*Viburnum acerifolium*) are present in the understory.

Mamacoke Marsh is very unusual in Connecticut for somehow escaping the widespread ditching of coastal marshes for mosquito control (Figure 12). The marsh is located four miles upriver from Long Island Sound. The water has a high enough salinity to support

Figure 13. View to the north across Little Mamacoke Marsh, which is located on the south shore of the island. Note the line of pink flowering marsh mallow (*Hibiscus moescheutos*) plants between the marsh and forest (M. Braunstein).

a complement of the typical tidal salt marsh species. A long-term vegetation study was established in the marsh in 1957 using a 15-by-15 meter grid (Niering, 1961). Multiple resurveys of the vegetation have been conducted through 2014 (Carey et al., 2015). The general vegetation pattern begins with an upland border of marsh elder (*Iva frutescens*) and switch grass (*Panicum virgatum*), both at the railroad embankment and along the stonewall on the eastern border of the marsh. Saltwater cordgrass (*Spartina alterniflora*) forms a slender band along both the north and south cove edges. In some locations blackgrass (*Juncus gerardii*) forms patches inside the *S. alterniflora*. In other locations large expanses of saltmeadow cordgrass (*Spartina patens*) and spikegrass (*Distichlis spicata*) are found. A fairly large depression in the middle of the marsh is occupied mainly by a stunted form of saltwater cordgrass. The marsh peat is three to five feet deep. Mamacoke is also the site of a long-term study that began in 1994 to measure marsh surface elevation changes in the face of rising sea levels (Carey et al., 2015)

Mamacoke also contains a much smaller marsh (approximately a half acre) on the south side of the peninsula (Figure 13). The current vegetation is dominated by saltmeadow cordgrass mixed with spikegrass and blackgrass. Combs and Orson studied the historic development of marsh vegetation here in 1983 using systematic peat coring. Maximum depth to bedrock was found to be approximately 23 feet. At 20 feet in depth, brackish peat deposits (below saltmarsh peat) had Carbon-14 dates of 3,500 years before present, indicating the marsh has been in place for about 4,000 years.

An interesting freshwater wetland sits at the head of the brackish pond west of Mamacoke Island's south cove. Fed by the previously mentioned spring and highway runoff stream, it contains alder (*Alnus* sp.) thickets, a diversity of wet meadow forbs, and a colony of narrow-leaved cattail (*Typha angustifolia*) at the top of the pond (Figure 14). It is heavily impacted by invasives, especially giant reed (*Phragmites australis*) at the cove end and multiflora rose (*Rosa multiflora*) on slightly higher ground. The vegetation of this wetland has yet to be surveyed or described in detail.

Early successional habitat is present on a five-acre lobe of undeveloped land located at the end of Richards Grove Road and east of the lumberyard and railroad tracks. This parcel, apparently owned by the railroad, juts into the river between the north end of Mamacoke and the mouth of Smith Cove. The upland vegetation is a savannah with scattered red cedar (*Juniperus virginiana*), young black and red oaks and red maple in a matrix of little bluestem, switch grass, bayberry (*Morella caroliniensis*) and smooth sumac (*Rhus glabra*). Well-established invasive plants include Oriental bittersweet (Celastrus orbiculatus), autumn olive (*Eleagnus umbellata*) and Japanese honeysuckle (*Lonicera japonica*). At the river edge is a slender band of tidal marsh grasses and forbs with some marsh elder at the upper border. Depressions near the tracks and elsewhere contain large, dense patches of giant reed.

Though little is known about the vegetation in the coves or in the river, based on the feeding behavior of waterfowl, aquatic plants are clearly present. A study in 1994 showed that sea lettuce (*Ulva lactuca*) covers the bottom of shallow areas and the alga *Melosira* covers many rocks in these areas. (See the waterfowl section for additional information.)

Susan Munger (2005) produced a report on the flora and plant communities of the West Farms Land Trust's 65-acre George Avery Tract, which is located north of Scotch Cap Road between Mohegan Avenue and the River. Though the area studied in this report is just north of the conservation area, the data may be helpful in future planning efforts.

Figure 14. A fringe of narrow-leaved cattail at the west end of the brackish pond in 2007. This water body formed when the railroad cut off a section of South Mamacoke Cove. Freshwater enters from a stream behind the cattails and mixes with the brackish river water coming through a culvert under the tracks (M. Braunstein).

Figure 15. A controlled burn in a post-agricultural field south of Benham Avenue on the Matthies Tract in 2003 (G. Dreyer)

MANAGING FOR EARLY SUCCESSIONAL HABITAT

BY 1968, THE ARBORETUM was experimentally managing some locations on the Matthies and Avery Tracts to retain early successional habitat (Niering et al., 1970; Niering and Dreyer, 1989). Small plots in post-agricultural fields were subject to periodic controlled burning for 35 years, most recently in 2003 (Figure 15). Forest understory plots in various locations were also burned during this period.

A meadow restoration project was initiated in 2004 on approximately 12 acres of the upland near South Mamacoke Cove and Harrison's Landing. The goals were to restore early successional habitat (Figure 16) and control invasive plant species. Thanks to funding from the USDA Natural Resources Conservation Service's Wildlife Habitat Incentive Program (WHIP), woody plant encroachment on seven acres of existing old field was reversed. In addition, about five acres of pine plantation and early deciduous forest heavily infested with invasive plant species were completely cleared in 2004 and 2005 and planted with native grasses and forbs during the summer of 2006. Detailed floristic sampling was done in August of 2008 and 2010, and a summary of the results was published (Jones et al., 2013).

Seven acres on the flat, well drained ground closest to the tracks and bounded by stone walls on the north and west borders were still partially open in 2003 when the project began. Management included cutting the encroaching trees, shrubs and vines, and spraying herbicides on invasive plants, especially Oriental bittersweet. Little bluestem (*Schizachyrium scoparium*) is common in the field north of Benham Avenue and is one of a handful of preferred native grasses for this site. Annual mowing during late winter and semi-annual, selective spraying during the growing season to control invasives and other woody plants continues. Mature red cedar and occasional flowering dogwood, crabapple (*Malus* sp.) and pear (*Pyrus* sp.) were left in the north-most sector of these fields in an effort to maintain savanna-like conditions and improve wildlife habitat (Figure 17).

During late June 2006, 100 pounds of a customized mixture of native grass and wildflower seed was planted to establish an uphill extension of the existing meadow in the area where woody vegetation had been cleared. The project was a success, and today this upper meadow is dominated by the tall Indian grass (*Sorghastrum nutans*), big bluestem (*Andropogon gerardii*), the shorter little bluestem, and wildflowers

TOP: Figure 16. Grassland with scattered trees in the restored meadows provides habitat for Orchard Orioles and other bird species that prefer open savannas (B. MacDonnell).

BOTTOM: Figure 17. View to the north in 2010 from near the east end of Benham Avenue, looking across post-agricultural fields managed by annual mowing and selective herbicide applications. Red cedar trees and the copper-colored, little bluestem grass are most prominent. The foreground is still dominated by cool season introduced turf grasses, 35 years after it stopped being a little league baseball field (G. Dreyer).

including goldenrods (*Solidago* spp.) and asters (Jones et al., 2013). This seeded section is also technically a savannah, since the few, large oak trees present before the clearing were retained (Figure 18).

Figure 18. Wendy Dreyer stands in the meadow restoration project in 2008 north of Benham Avenue, two years after it was cleared and seeded with a mixture of native grasses and wildflowers (G. Dreyer).

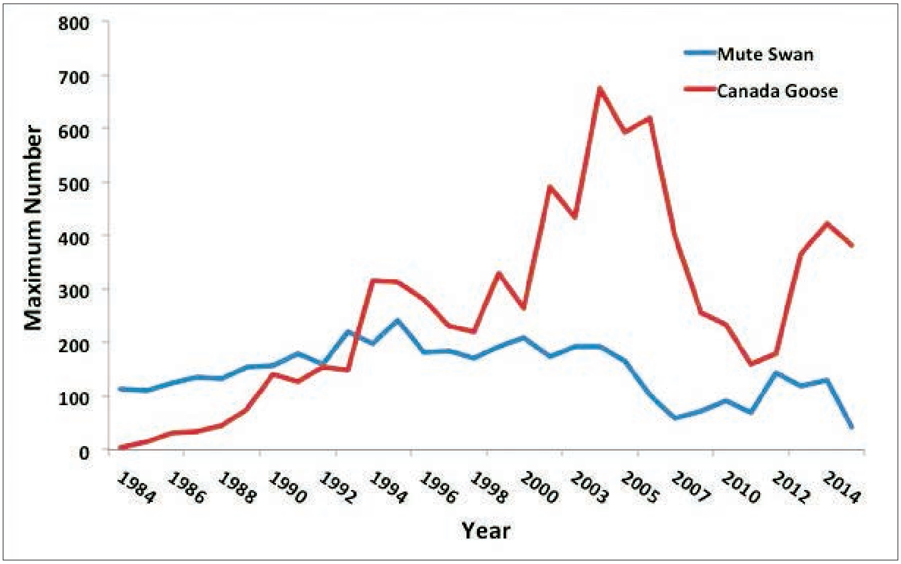
Figure 19. Buffleheads and a diversity of other species of diving ducks concentrate in the coves near Mamacoke Island during mid winter, when other bodies of water are frozen (B. MacDonnell).

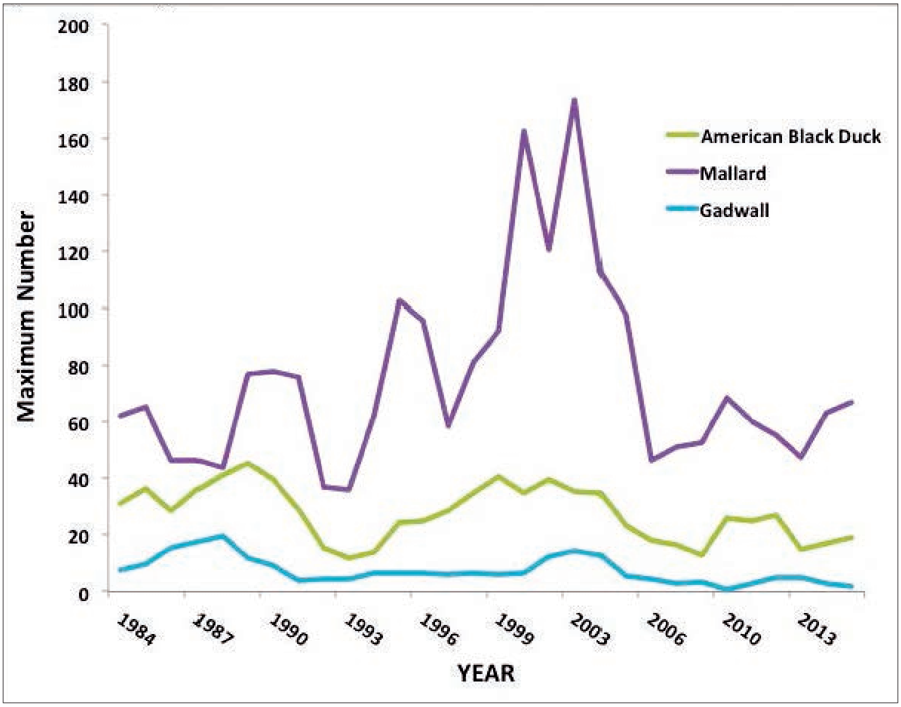
BIRDS

WINTER-RESIDENT WATERFOWL

THE MAMACOKE/SMITH COVE AREA was designated an Important Bird Area primarily because of the large numbers of ducks of several species that feed in Smith Cove and the coves west and south of Mamacoke Island during the winter (Figure 19). The largest concentrations of ducks occur during extremely cold periods, when freshwater lakes, reservoirs and many stretches of rivers in southeastern Connecticut freeze. Because the Thames River is a brackish estuary, it does not freeze completely and thus provides an open-water refuge for ducks during these periods. Although some ducks (especially Hooded and Red-breasted mergansers, American Black Ducks and Mallards) use Smith Cove and the Mamacoke coves regularly throughout the winter (October to early April), large concentrations of ducks only occur during extended periods of severe cold.

Since 1982, Professor Askins has completed frequent counts of waterfowl during the winter (October through April) in the area between Smith Cove and the U.S. Coast Guard Academy. Ducks, geese and swans move back and forth along this stretch of the river. There are relatively few winter-resident ducks in adjacent areas upriver (where there is relatively little shallow water) or downriver (which is heavily developed with port facilities). Typically the largest concentrations of waterfowl are located between South Mamacoke Cove and the northern end of Smith Cove, but the abundance estimates in Figures 20-21 are for the entire census area. The estimate for a particular year is the maximum number recorded during a winter for each species. This typically reflects times when ducks are heavily concentrated on the Thames River because of long periods of cold weather that forces waterfowl out of other sites. Because of great year-to-year variation in duck numbers (which partly reflects variation in ice conditions), we used three-year





TOP: Figure 20. Changes in maximum numbers of Mute Swans and Canada Geese counted during winter in the Mamacoke Conservation Area. The three-year running averages for the maximum number of individuals detected for each species are shown for the period between 1982 and 2016.

BOTTOM: Figure 21. Changes in maximum numbers of three species of dabbling ducks counted during winter in the Mamacoke Conservation Area. The three-year running averages for the maximum number of individuals detected for each species are shown for the period between 1982 and 2016.

running averages to plot changes in waterfowl populations. The graphs of running averages provide evidence for major changes in abundance for particular species.

Two introduced species of waterfowl, the Mute Swan and the Canada Goose, showed substantial population increases in the study site during the 1980s (Figure 20). Mute Swans increased during the 1980s, reaching peak concentrations in the 1990s and early 2000s, and then declined. Canada Geese showed a somewhat similar pattern, with a steep increase in numbers between 1984 and 2004, followed by a decline.

The Mute Swan was introduced from Europe in the late 1800s but did not become established in the wild in Connecticut until the 1930s (Zeranski and Baptist, 1990). Canada Geese originally were found in Connecticut only during migration and winter, but there is now a breeding population that derives from birds that were purposely released (Zeranski and Baptist, 1990; Conover, 2011). Mute Swans feed on aquatic vegetation and may compete for food with vegetarian ducks such as Canvasback, so they represent a threat to some native waterfowl species. In contrast, Canada Geese usually do not feed when they are swimming in the coves in the study area. They occasionally forage on the banks of the river, but usually commute to distant locations to graze in grassy upland areas. If they affect native ducks, it would be indirectly through fecal contamination of the water when large flocks of geese are concentrated in a cove.

Another introduced species, the Mallard, increased substantially after 1982, reaching peak numbers in the early 2000s, and subsequently declined to numbers similar to the 1980s (Figure 21). Mallards were rare autumn migrants in Connecticut in the 1800s, but later they were introduced to many parts of the state and are now a common breeding species (Zeranski and Baptist, 1990).

The Mallard is considered a dabbling duck, a group that includes other, closely related species of ducks that feed at or near the water surface. These ducks often reach food by "upending" (tipping vertically so that the bill reaches the river bottom and the tail sticks up in the air). These species don't usually dive for food. Two other species of dabbling ducks, the American Black Duck (Figure 22) and the Gadwall, have fluctuated in abun-

Figure 22. American Black Ducks are regular winter residents of the coves north and south of the Mamacoke salt marsh from early October to April (B. MacDonnell).

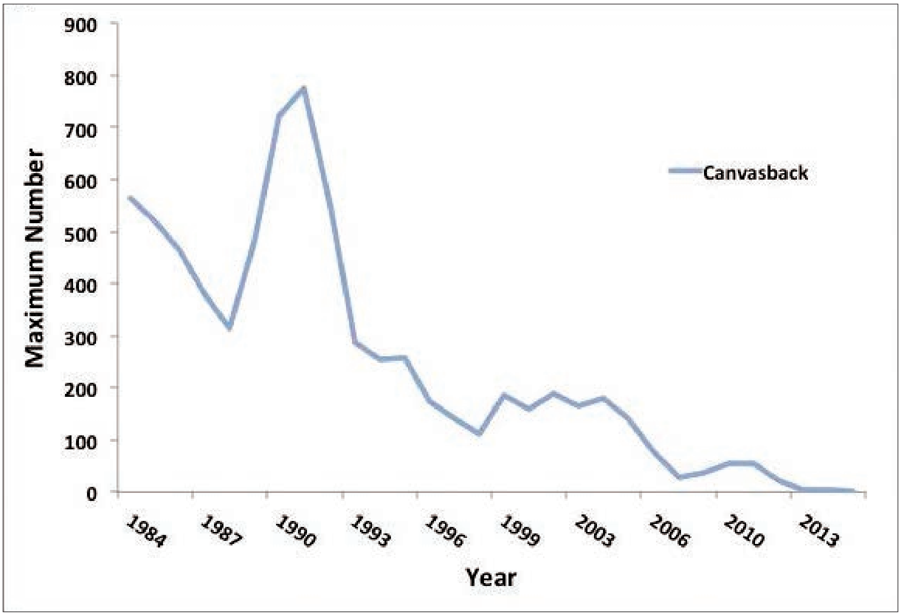
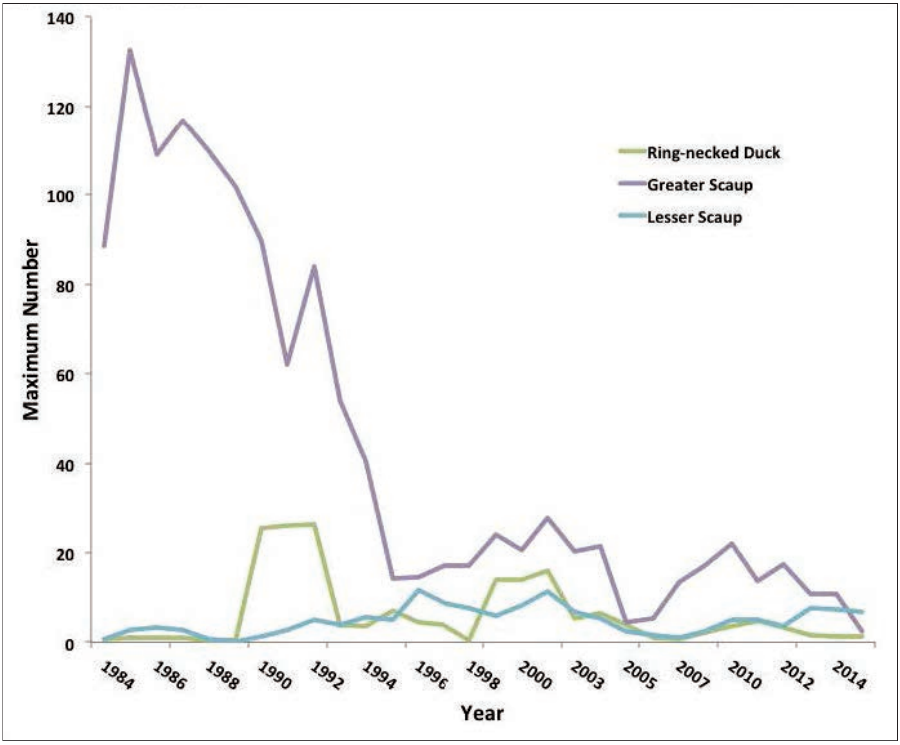


Figure 23. Changes in maximum numbers of Canvasbacks counted during winter in the Mamacoke Conservation Area. The three-year running averages for the maximum number of individuals detected are shown for the period between 1982 and 2016.

dance in the Mamacoke Conservation Area, but have shown slow, long-term declining trends (Figure 21). The Black Duck suffered historical population declines in the eastern U.S. and Canada, and is the focus of an international recovery program (Longcore et al., 2000). Another dabbling duck, the American Wigeon, has also declined, but it was never common in the Mamacoke area.

Among the diving ducks, Canvasbacks and Greater Scaups showed substantial declines in abundance since the 1980s (Figures 23 and 24). In recent years, only small flocks of Greater and Lesser Scaup have occurred in the Mamacoke area, and Canvasbacks (which were once regular winter residents at Smith Cove) are now seen only occasionally during periods of extremely cold temperatures. Hooded Mergansers (Figure 25) showed a much more moderate decline in abundance, while Red-breasted Mergansers fluctuated markedly but have generally increased in abundance (Figure 26). Common Mergansers have shown a declining trend, but, in contrast to the situation on the nearby lower Connecticut River, this species has never been common on the Thames River.

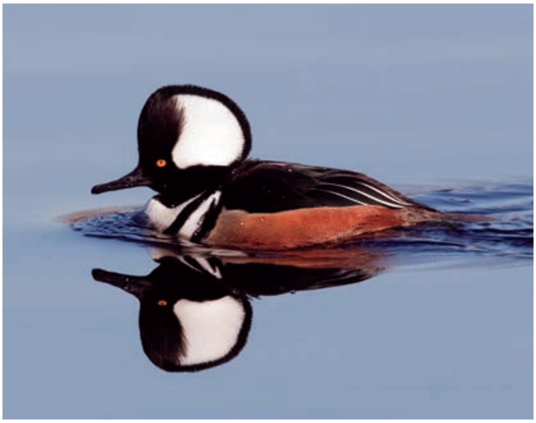
Some of these population trends probably reflect regional or even continental changes in waterfowl numbers. For example, total numbers of Canvasback and scaup declined on midwinter counts in Connecticut between 1982 and 2015 (Figure 27), the same period during which they were declining in the Mamacoke Conservation Area. The statewide data indicate the Canvasbacks were not very common before the early 1980s, while the steep decline in scaup has been underway since the 1960s. Aerial and ground surveys of duck populations across the United States and Canada during the summer breeding season show that the population of scaups declined throughout the continent since the early 1980s, whereas the continental populations of Canvasbacks have not shown a consistent, overall change (Zimpfer et al., 2015).



Mute Swans showed similar overall patterns of population change at Mamacoke and in statewide surveys between 1983 and 2015, with generally rising numbers until the late 1990s, when numbers began to decline. Thus, the population of this introduced species appears to be stabilizing after a period of rapid population growth in the 1960s and 1970s.

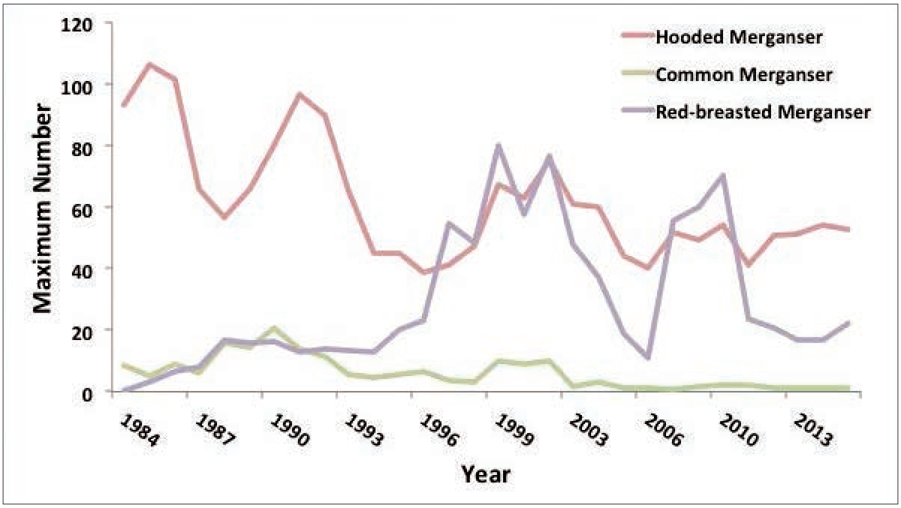
Changes in abundance of some other waterfowl species in the Mamacoke Conservation Area do not reflect statewide trends. Between 1983 and 2005, Canada Geese numbers increased at Mamacoke but didn't show consistent long-term trends in the state surveys (Figure 25).

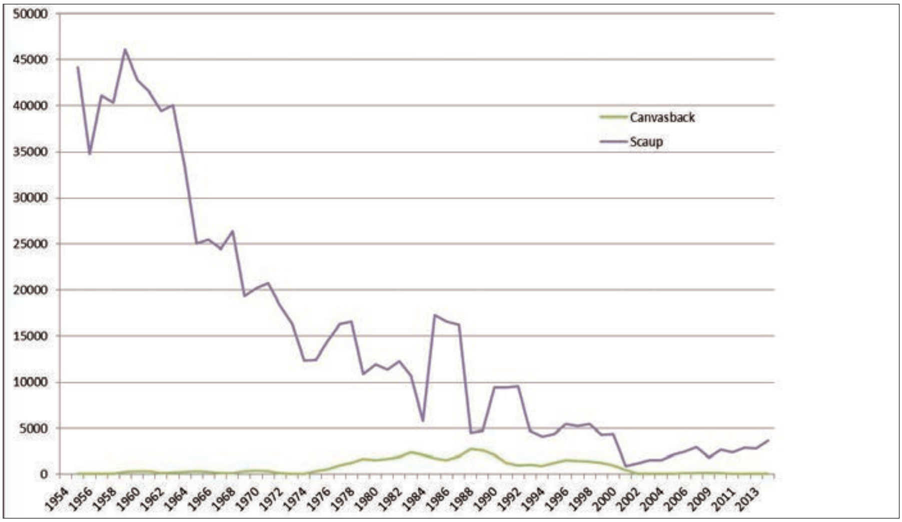
American Black Ducks gener-



TOP: Figure 24. Changes in maximum numbers of three species of diving ducks counted during winter in the Mamacoke Conservation Area. The three-year running averages for the maximum number of individuals detected for each species are shown for the period between 1982 and 2016.

BOTTOM: Figure 25. Small flocks of Hooded Mergansers can be seen dependably at Smith Cove and the coves around Mamacoke Island from mid-November until the end of March (B. MacDonnell).





TOP: Figure 26. Changes in maximum numbers of three species of mergansers counted during winter in the Mamacoke Conservation Area. The three-year running averages for the maximum number of individuals detected for each species is shown for the period between 1982 and 2016.

BOTTOM: Figure 27. Changes in the number of Canvasbacks and scaup counted in Connecticut during midwinter aerial surveys (Connecticut DEEP Wildlife Division, unpublished data). Three-year running averages for the maximum number of individuals detected for each species are shown for the period between 1954 and 2015.

ally declined in Connecticut since 1983, but their numbers were more stable (with only a slight decline) at Mamacoke. Mallards showed a recent increase in the statewide surveys that is not reflected in the Mamacoke data (Figure 18). Surveys of breeding populations across North America show that the number of both American Black Ducks and Mallards have fluctuated substantially since 1990, with a generally increasing trend in Mallards and relatively little long-term change in the abundance of Black Ducks (Zimpfer et al., 2015).

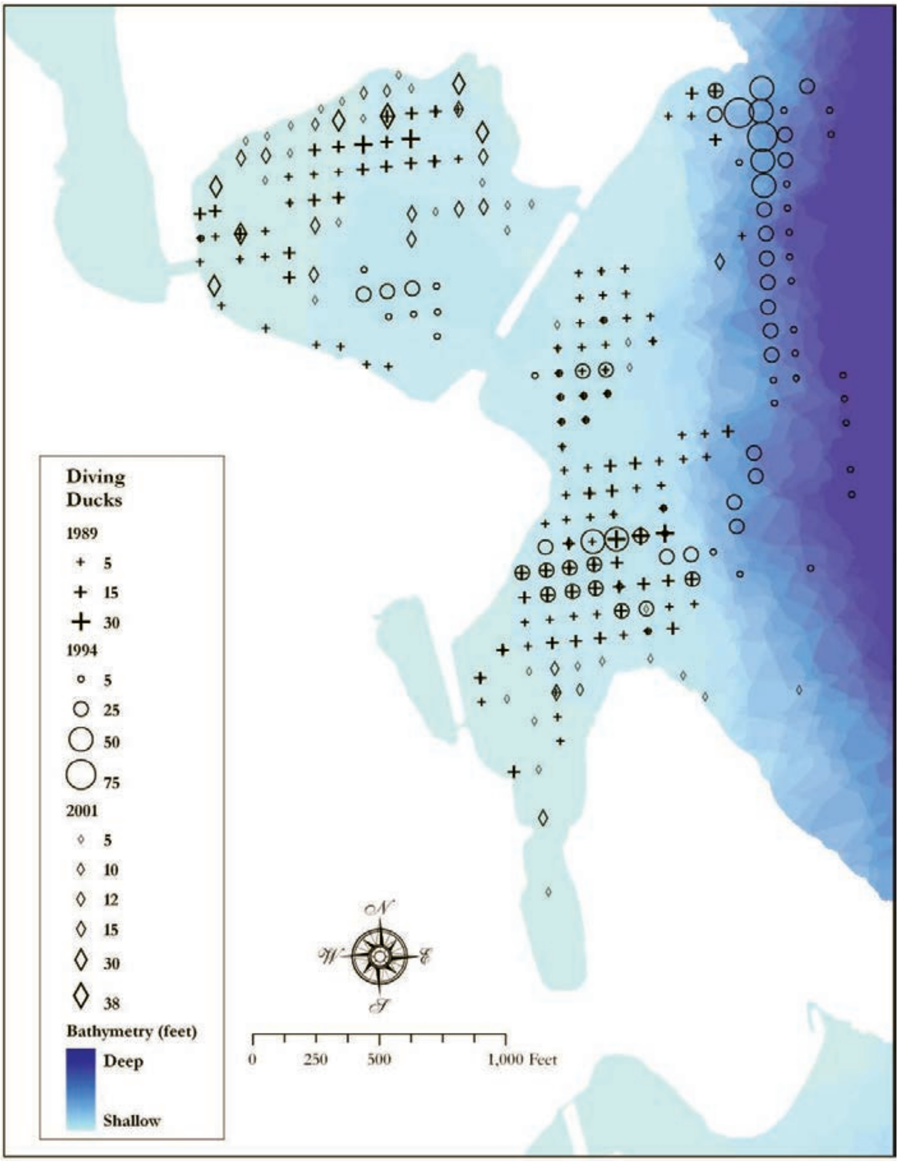


Figure 28. Distribution of diving ducks at Smith and North Mamacoke Coves during three winters (1989, 1994 and 2001). Relative water depth is indicated by shading, with darker blue indicating deeper water. Land is white in this map, with Mamacoke Island at bottom right. Prepared by Adam Zeender.

Several Connecticut College students completed semester-long research projects on the behavior of waterfowl in Smith Cove and the coves adjacent to Mamacoke Island. In 1989, Daniel Kluza '91 developed a research protocol that was followed by Jonathan Allegranti '94 in the winter of 1993-94 and Julie Groce '01 during the winter 2000-01. In all of these studies, the feeding behavior of individual ducks was described and their locations were recorded on a gridded map of the study area several times each week

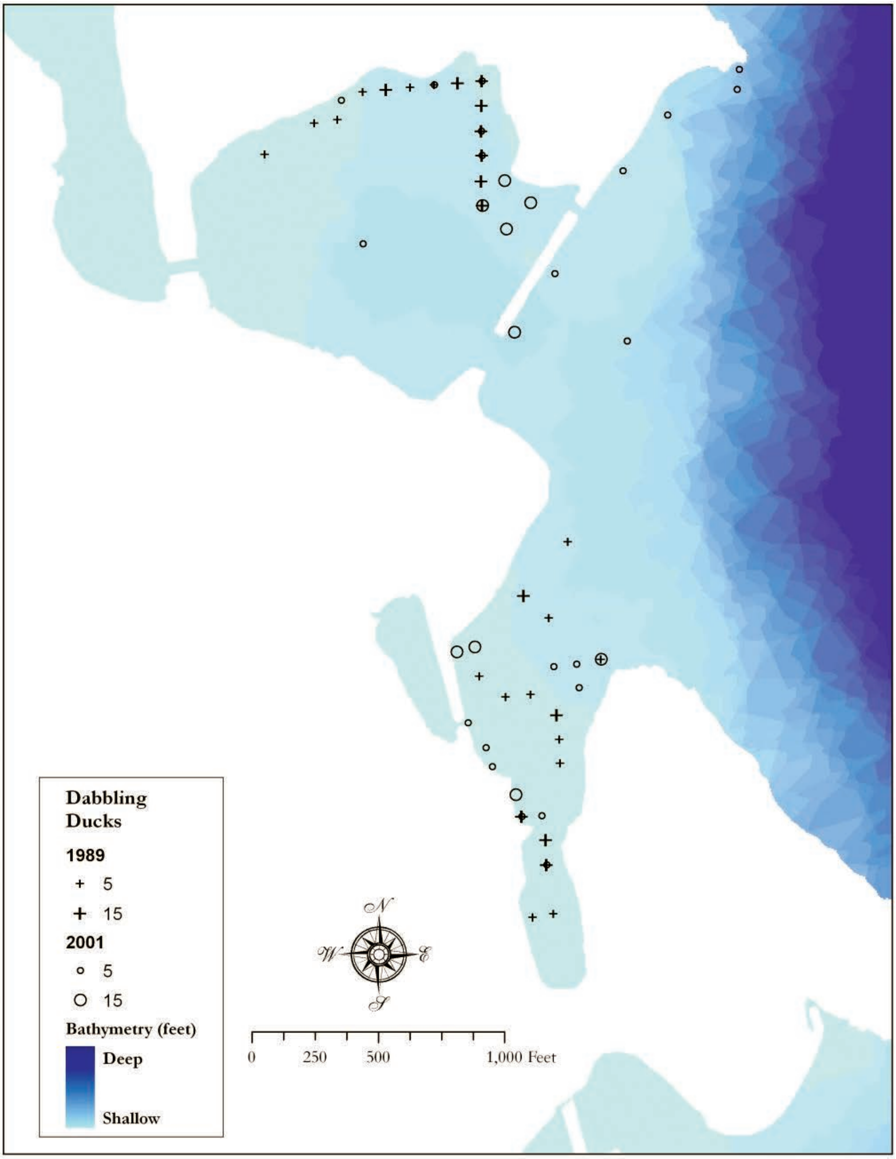


Figure 29. Distribution of dabbling ducks at Smith and North Mamacoke coves during two winters (1989 and 2001). Relative water depth indicated by shading, with darker blue indicating deeper water. Prepared by Adam Zeender.

during mid to late winter. The results from their unpublished reports are summarized in Figures 28 and 29, which was compiled by Adam Zeender '07 under the direction of Senior Lecturer in Geology and Environmental Studies Beverly Chomiak as a project for an introductory Geographical Information Systems (GIS) class The map indicates that both dabbling ducks and diving ducks are normally concentrated in the shallow waters of Smith Cove and North Mamacoke Cove. During the winter of 1994, however, exceptionally cold weather forced diving ducks into deeper water and apparently forced most dabbling ducks to leave the area. North Mamacoke Cove was covered with ice for the entire period of the study (February 2 to March 15), and the shallow-water areas of Smith Cove were only open sporadically. In general, however, both the dabbling ducks and diving ducks forage in water less than one meter (three feet) deep.

The dabbling ducks and Canvasbacks were observed feeding on sea lettuce. In 1987, vegetation surveys that used a grab sampler on five transects across North Mamacoke Cove showed that the entire bottom of the cove was covered with a dense carpet of sea lettuce. Sea lettuce also covered the shallow water along a single transect in Smith Cove, but no bottom vegetation grew in deeper water. In 1994, SCUBA surveys by Jonathan Alegranti '94 along transects at the northern and southern ends of Smith Cove showed that sea lettuce covered much of the bottom and was especially dense at the entrance of North Mamacoke Cove, which is an important feeding area for ducks (Figures 28 and 29). Many rocks on the transects were covered with the alga *Melosira*.

OTHER BIRDS ASSOCIATED WITH THE COVES AND MARSHES

WATERBIRDS AND OSPREYS frequently use the estuarine and tidal marsh habitats near Mamacoke Island during the summer. Particularly in the late summer, various species of herons forage in the shallow water on the edge of the Mamacoke Salt Marsh. Great Egrets, Snowy Egrets, Great Blue Heron, Green Heron and Black-crowned Night Heron occur regularly at this site, although none of these species are numerous. The two egret species are listed as threatened in Connecticut (DEEP, 2015).

Ospreys often hunt for fish over the Mamacoke coves in the summer and early autumn. They have not nested at the site (at least in recent decades) despite the construction of two osprey stands (one on Mamacoke Island and another on the shore of the salt pond) in the 1980s. Bald Eagles occasionally occur in this same area during the winter.

American Coots and Pied-billed Grebes regularly occur in Smith Cove and the coves near Mamacoke Island in the winter.

EARLY SUCCESSIONAL BIRDS

RECORDS FROM the Connecticut College campus and Arboretum from the early part of the 20th century indicate that the region supported a diversity of birds characteristic of open habitats with few trees. Northern Bobwhites, Ring-necked Pheasants, Horned Larks, Yellow-breasted Chats and Eastern Meadowlarks nested in the area (Goodwin and Grandjouan, 1958; Logan, 1958; Askins, 1990). As in most other regions of New England, these species declined or disappeared as open fields were replaced by closed-canopy forest (Askins, 2002). This habitat change led to major reductions in most early successional birds, especially those species that require savannah or open grassland.

The Mamacoke Conservation Area does not include large enough expanses of grassland to support Grasshopper Sparrows, Upland Sandpipers or other species that require extensive areas (more than 50 acres) of continuous grassland. The 12-acre meadow that was recently restored near Harrison's Landing has great potential to support other species of grassland and savannah birds, however. Although Savannah Sparrow, Eastern Mead-

LEFT: Figure 30. Pairs of Indigo Buntings were first recorded as summer residents in the Connecticut College Arboretum after meadows were expanded and restored, providing the type of open habitat they need (B. MacDonnell).

ABOVE: Figure 31. Numerous migrating sparrows stop in the restored meadows during fall migration. Swamp Sparrows are often one of the most abundant species in large flocks that include several types of sparrows (B. MacDonnell).

owlark and some other grassland specialists that nest in relatively small habitat patches may be attracted to the restored meadow, our main goal is to manage for savannah species. These species require grassland with scattered trees. Two savannah species, Northern Oriole and Orchard Oriole, nested at this site even before the amount of open habitat was expanded during restoration. Northern Oriole is a "high continental priority species" in the list of Partners in Flight [PIF] Priority Species for Southern New England (Rosenberg et al., 2014). Screech Owls have also been recorded at the site. One goal of restoration was to attract additional savannah species, such as Eastern Bluebirds and American Kestrels, to the site. Bluebird boxes and boxes suitable for American Kestrels and Screech Owls were installed at the site after the meadow was restored.

Prairie Warbler and Blue-winged Warbler also were recorded in the Harrison's Landing meadow during the summer before meadow restoration. Both of these species are "high continental priority species" in the list of PIF Priority Species for Southern New England and are included on the Audubon Watch List. The meadow restoration project may have reduced the habitat quality for these species, but continued successional change toward woodland would have eliminated their habitat if left unchecked. Of the two species, the Prairie Warbler is more likely to benefit from efforts to remove woody plants from the site. Although Prairie Warblers are associated with low, scrubby vegetation, they are found in a fairly wide range of open habitats, including "barrens (pines and scrub oak [*Quercus*], often sandy and maintained by fire); abandoned fields or pastures with shrubby growth; regenerating forest; abandoned orchards; grassland-forest contacts at edge of prairie" (Nolan et al., 2014).

To assess the impact of meadow restoration on nesting songbirds, Mary Buchanan '14, Clara Chaisson '12, Diane Hitchcock '75 and Professor Askins determined the abundance of different species by visiting the site repeatedly to map territories during the summers of 2012 and 2013. The following savanna or forest edge species had one or two territories in the restored meadows: Eastern Kingbird, Eastern Bluebird, Baltimore Oriole, Orchard Oriole and Indigo Bunting (Figure 30). Neither Indigo Buntings nor Eastern Bluebirds had been recorded at this site before the meadow restoration project. The bluebirds attempted to nest in newly installed bluebird houses but were unsuccessful because the nest boxes were taken over by House Sparrows. In contrast, bluebirds nested successfully in a restored meadow in another part of the Arboretum that is surrounded by woodlands and is not close to residential areas that support House Sparrows. Prairie Warbler did not occur as a breeding species in the restored Mamacoke Conservation Area meadow, but Blue-winged warblers nested for the first time in 2016.

The Harrison's Landing meadow is also important habitat for American Woodcock, which have had mating territories here since at least 1984 (Askins, 1990). This is a high continental priority species on the North American Bird Conservation Initiative Watch List (Rosenberg, 2014). Woodcocks continued to use the site for aerial courtship displays in March and April after the meadow restoration was completed (Mark Braunstein, personal communication).

The restored meadows may be most important for bird conservation during the fall, when numerous migratory species stop to search for food. The meadows are particularly important for migrating sparrows. Charles Coddington '13 and Mitchell Serota '13 completed bird surveys along transect lines in the restored meadow during the fall of 2012, and Professor Askins completed similar surveys during the fall of 2015. They found that the number of migrating sparrows peaked between late September and mid October. During this period, large, mixed-species flocks consisting of Song Sparrows, Swamp Sparrows (Figure 31), White-throated Sparrows, Dark-eyed Juncos and Field Sparrows moved through the meadows feeding on seeds. Savannah Sparrows, Lincoln Sparrows, Chipping Sparrows and White-crowned Sparrows also occasionally occurred in these flocks. However, when Tristan Cole '13 surveyed birds along the meadow transects in 2013, he found that relatively few sparrows spent the winter in the meadows, and that surprisingly few sparrows stopped during spring migration. The meadows were mowed in late March, however, which may have greatly reduced their suitability as a migratory stopover site. Beginning in 2016, the restored meadows will be mowed in mid-April to avoid the main migratory period.

Figure 32. Professor Anthony Graesch and students mapping a stone wall on the Avery Tract in his archaeology course, April 2014 (G. Dreyer).

OTHER TEACHING AND RESEARCH

THE MEADOW at the head of the Arboretum's brackish pond, located between the Espinosa Tract to the south and the Avery Tract to the north, was the site of a prescribed burn once in the 1970s. Many other prescribed burns have been carried out in open fields and plots in the forest understory of the Avery and Matthies tracts since 1968. Originally begun with a grant from the National Science Foundation to Professors of Botany William Niering and Richard Goodwin (Niering et al., 1970; Niering and Dreyer, 1989), these burn and control plots are parts of ongoing research and demonstration projects. They were last burned in 2003 (Figure 15). Herbicides have been used very selectively in other areas in the Avery and Matthies tracts since the 1950s as part of research and demonstration projects aimed at slowing vegetation change and maintaining open, "early successional" habitats (Niering and Goodwin, 1975). These vegetation manipulations have also allowed bird populations dependent on open, low vegetation to persist (Askins, 1990).

Starting in 1974, parts of the Matthies Tract field next to the railroad was used to test various applications of fungal mycelium derived as waste from the nearby Pfizer Inc. pharmaceutical production operations in Groton (Niering et al., 1981). Previously viewed as industrial waste, the recycled mycelial material was shown to be an effective soil amendment.

In addition to the Native American archaeological work done by Professor Juli, Associate Professor of Anthropology Anthony Graesch recently began a systematic surface survey project as a central feature of an archaeological methods course. In the spring of 2014, the first semester the course was offered, the students surveyed the Avery and Matthies tracts, documenting walls, wells and other stone structures from the colonial period (Figure 32).

Since 2004, the Connecticut College Environmental Studies Program has offered courses in Geographic Information Systems (GIS), a powerful technology that combines digital mapping with databases and other information sources. Over the ensuing years a number of students and staff have used the Arboretum's Mamacoke Conservation Area for spatial analysis projects.

Connecticut College faculty and students have used the Avery, Matthies, and Mamacoke Tracts for classes and studies too numerous to mention in detail. Topics have included: relating forest size to bird community composition and small mammal population density, old field succession, avian dispersal of Oriental bittersweet, foraging by honeybees, the stability of shrub communities, population genetics of white-footed mice, erosion and sedimentation by intermittent streams, tidal marsh vegetation patterns and development, archeological survey techniques, and a variety of other ecological, natural history and geological investigations (Goodwin, 1991; Arboretum Annual Reports, 1992-2015).

Figure 33. Mute Swan family in the cove near Mamacoke (M. Braunstein)

CONSERVATION ISSUES: CONCERNS, ACTIVITIES AND OPPORTUNITIES

AQUATIC HABITATS

THERE ARE A VARIETY OF WAYS that non-point-source pollution can enter the Mamacoke Conservation Area. Pollutants originating from many residences include lawn chemicals (herbicides, fungicides, pesticides and fertilizers) and sewage from individual septic systems. Sewer lines installed in 2014 for the Harrison's Landing neighborhood to replace septic systems will reduce pollutants from residences at this location. Runoff from the lumberyard at the end of Richard's Grove Road is likely to contain pesticide residues and hydrocarbons. The railroad beds on both sides of the Thames are regularly sprayed with herbicides, using very indiscriminant application techniques, for the purpose of preventing vegetation growth on the ballast.

An obvious series of point sources of pollution are the street and highway culverts, which direct salt- and hydrocarbon-laden water downhill toward the river. A condominium complex called Thames Landing was built on the west bank of the river at Scotch Cap Road in 2005. This development included a new double set of docks for a marina that could accommodate at least 45 boats. The docks have never been used but would likely be a source of hydrocarbons, trash and possibly sewage from boats should they begin to function as a marina. Overflows from sewage treatment systems upriver still periodically pollute the water. The massive submarine base across the river from Mamacoke is the likely source of point and non-point source pollutants of various kinds. The base also generates large amounts of noise and light pollution. Moreover, dredging to keep the river channel deep enough for nuclear submarines suspends sediments and probably remixes chemical pollutants from bottom sediments back into the water column.

Giant reed, a major invasive species in wetland habitats, has become established in the various salt and brackish wetlands within and adjacent to the Mamacoke Conservation Area. In particular, this plant dominates the salt pond south of the lumberyard and north of the Arboretum's Hempstead Tract.

Since waterfowl are so significant in the Mamacoke Conservation Area, food resources for these animals are clearly of interest. They primarily feed on aquatic plants and animals, and little is known about the location, diversity or quantity of these food resources. Quantitative surveys of the cove and salt pond bottoms for physical and biological characteristics are needed. The surveys should include the identification of any invasive exotic plants or animals that may be present.

Mute Swans, which are abundant in the Mamacoke Conservation Area, may have a negative impact on winter-resident ducks. The Connecticut population increased by 50 percent between 1982 and 1990 (Conover and Kania, 1999), and the swan population in the Mamacoke area also increased during this period. About 10 percent of the state's estimated winter population was recorded in the Mamacoke area in 2002, but winter-resident swans have declined at Mamacoke since then.

Mute Swan are a threat to native ducks for two reasons: they compete with other ducks for food (submerged aquatic plants), and they aggressively defend their breeding territories against other waterfowl, potentially excluding native ducks from favorable breeding habitat (Conover and Kania, 1994; Ciaranca et al., 1997). In the Mamacoke area, the primary concern is that large concentrations of Mute Swans might reduce the supply of winter food for plant-eating ducks such as Canvasbacks and American Black Ducks (Figure 33). Swans nest at the site, with typically two to three breeding territories between South Mamacoke Island and northern Smith Cove, but few ducks nest in this area. There are no recent breeding records of American Black Ducks in the Mamacoke Conservation Area, so the aggressive behavior of breeding Mute Swans toward other waterfowl may not be a problem.

O'Brien and Askins (1985) studied the interactions between introduced Mute Swans and native ducks at Smith Cove. Both swans and Canvasbacks primarily fed on sea lettuce (*Ulva*), but at Smith Cove the swans usually fed in shallower water than the Canvasbacks, which dive to feed off of the bottom. Swans are restricted to water less than about three feet deep, the maximum depth at which they can reach the bottom by "neck-plunging" (reaching to the bottom with an outstretched neck). Dabbling ducks such as American Black Duck generally foraged in shallower water than swans (except when wigeons followed swans to feed on pieces of aquatic vegetation dropped by the swans). Consequently, the dabbling ducks, swans and Canvasbacks partition the habitat by water depth to a large extent, minimizing potential competition for food. We do not know, however, whether Canvasbacks originally foraged in shallower water before they had to compete for food with introduced swans. Also, the depth zone used by swans shifts location with the tides, increasing the proportion of cove bottom affected by swan feeding.

The decline in Canvasbacks after 1991 followed a period of steady increases in Mute Swan populations, but Canvasbacks declined throughout Connecticut during this same period even though Mute Swan populations were also declining.

Conover and Kania (1994) built exclosures to exclude Mute Swans feeding on freshwater ponds and lakes in Connecticut to assess their effect on water plants used by ducks. They did not find a significant difference in density of aquatic vegetation on exclosure and control plots, indicating that swans do not have a large impact on the availability of aquatic vegetation. This study was completed during the breeding season on territories occupied by single pairs of swans, however, so the results are not necessarily relevant to the situation in winter, when feeding Mute Swans often congregate in feeding flocks with more than a hundred swans. Similar experiments should be completed in shallow estuaries with large, non-breeding flocks of swans.

TERRESTRIAL HABITATS

INVASIVE EXOTIC PLANTS are common in upland areas. The most problematic plants locally are Oriental bittersweet, Japanese and shrub honeysuckle (*Lonicera morrowii*), tree of heaven (*Ailanthus altissima*) and privet (*Ligustrum* sp.). Autumn olive and giant reed are locally present and are particularly abundant on the undeveloped, riverside parcel at the end of Richards Grove Road. The Arboretum actively manages for reduction of invasives in some locations, but has not had a policy of removing invasives everywhere due to limitations of budget and staff. We are not aware of any active program of invasive removal on non-Arboretum property within the Mamacoke Conservation Area.

Increasing the amount of early successional habitat has become a conservation priority in the northeastern United States. As previously mentioned, the Arboretum has recently reclaimed about 12 acres of meadow near the river and has maintained another few acres in an open condition through the use of controlled burning and mowing since the late 1960s. The parcel at the end of Richards Grove Road is also currently at a fairly early successional stage and could be maintained over the long term as meadow/shrubland cover.

The Mamacoke tidal marsh connects Mamacoke Island to the mainland, and foot traffic is causing significant erosion of the marsh surface. Mamacoke is one of two Arboretum natural areas that are primarily managed for teaching and research. Although Arboretum property is open to the public, efforts are made to prevent runners, both individuals and teams from Connecticut College and the U.S. Coast Guard Academy, from accessing the marsh and island. This is attempted, rather unsuccessfully, through signs, maps, occasional direct communication with runners, regular communication with athletic departments and intentionally not pruning back the sides of trails on the Island. It would be possible to build a boardwalk on the marsh connecting the railroad embankment to the island's upland. Materials that allow sunlight to penetrate through the walking surface to the marsh surface would minimize shading effects, and the marsh would presumably repair itself over time. One negative effect of a boardwalk would likely be increased pedestrian and running traffic on the island. Obtaining the necessary permits and funding for a boardwalk might also pose a challenge.

High densities of deer are a regional problem that affects plant and plant community regeneration (Figure 34). The effect of deer browse on forest regeneration has been

Figure 34. Since the Arboretum began acquiring land in the Mamacoke Conservation Area during the mid-1940s, white-tailed deer populations have soared and coyotes have appeared, June 2010 (M. Braunstein).

documented in many locations, including a study performed in another section of the Arboretum (Hartvigsen, 1987). While deer are common on Arboretum property, the current population size or their impact on habitats is not known. For Connecticut College property, which is the only significant open space in the Mamacoke Conservation Area, a comprehensive evaluation of deer populations, acceptable browse levels, and recommendations for control measures should be undertaken.

Another potentially important issue is that the Mamacoke Natural Area is the only Arboretum parcel in or near the Mamacoke Conservation Area that is "deed restricted" in such a way that the College must keep it in a "wild," undeveloped state. The College has seriously contemplated development of some of its property on the shore of the Thames River south of Mamacoke at least twice in the past 25 years. Also, with the exception of the Mamacoke and Hempstead tracts, College property in the Mamacoke Conservation Area is still zoned as residential.

ARBORETUM MANAGEMENT OBJECTIVES FOR THE MAMACOKE CONSERVATION AREA

THIS PORTION of the Connecticut College Arboretum has been actively used for college teaching, research and recreation since the first tracts were acquired in the 1940s. There is also a rich history of public educational programs using the Mamacoke Conservation Area, including guided walks on archeological sites and history, the geology of Mamacoke, tidal marsh ecology, and bird life. From 1952 until approximately 2004, the Arboretum maintained a naturalistic landscape demonstration area in a formerly post-agricultural setting north of Benham Avenue on the Matthies Tract. The site is now the southwestern corner of the expanded meadow area, which is used as a much larger educational demonstration of environmentally appropriate landscape management — an alternative to landscaping with turf and exotic plants. Past conservation activities in the area are documented in Arboretum Bulletins Nos. 20, 21, 22, 23, 25, 26, 27, 28, 31, 32 and 33 (Appendix 3), as well as in Arboretum Annual Reports.

The following management objectives are consistent with traditional college and public uses and with the conservation of the significant natural resources in the Thames River estuary and adjacent uplands.

- Maintain early successional habitat and the associated, increasingly uncommon plants and animals.
- Maintain nest boxes for bluebirds.
- Encourage low impact, passive recreation, teaching and research on Mamacoke Marsh and Island.
- Allow the continuation of controlled burning and selective herbicide vegetation management research on Avery and Matthies tracts.
- Support continued documentation and protection of historic cultural resources in the Mamacoke Conservation Area.
- Maintain running trails on the Avery and Matthies tracts, but not on Mamacoke Island.
- Allow large scale composting of leaves collected each fall on the main campus on the Matthies Tract south of Benham Avenue.
- Monitor winter-resident waterfowl populations.

ACKNOWLEDGMENTS

SUPPORT FOR WRITING A PLAN for the Mamacoke Important Bird Area, which formed the basis of this bulletin, was provided by the National Fish and Wildlife Foundation's Long Island Sound Futures Fund and the Jeniam Foundation. Patrick Comins of the Audubon Society, Connecticut, provided assistance and encouragement during production of the original IBA report. Beverly Chomiak advised students who were completing GIS maps of the site and prepared some of the maps herself. Her assistance and technical help were critically important. Professor Douglas Thompson supplied information about geologic features for this publication. The USDA National Resources Conservation Service provided partial funding for meadow restoration projects in the Mamacoke Conservation Area with the Wildlife Habitat Incentive Program. We thank Mary Howard for proof reading this publication and Susan Lindberg for book design.

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APPENDIX

THE IMPORTANT BIRD AREA PROGRAM

THE NATIONAL AUDUBON SOCIETY is the official Partner of BirdLife International for the IBA Program in the United States and is working to identify a network of sites that provide critical habitat for birds throughout the country. The IBA Program is a global effort to identify sites that are most important for maintaining populations of birds and to focus conservation efforts toward protecting these sites. The IBA Program recognizes that habitat loss and fragmentation are the most serious threats facing populations of birds across America and around the world. By working through partnerships, principally the North American Bird Conservation Initiative (NABCI), to identify and draw public attention to those places that are critical to birds during some part of their life cycle (breeding, wintering, feeding, migrating), the IBA program's goal is to minimize the effects that habitat loss and degradation have on bird populations at these sites. In the U.S. the IBA program has become a key component of many bird conservation efforts including Partners in Flight (PIF), North American Waterbird Management Plan (NAWMP), and the U.S. Shorebird Conservation Plan (USSCP) (Audubon 2006).

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No. 17. *Preserving Our Freshwater Wetlands,* 52 p., 1970. Reprints of a series of articles on why this is important and how it can be done.

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No.19. *Inland Wetland Plants of Connecticut,* 24 p., 1973. Some 40 species of plants found in marshes, swamps and bogs are illustrated.

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No. 36. *Amphibians and Reptiles of the Connecticut College Arboretum*, 48 p., illustrated,1998, This work combines a description of species reported from the Arboretum with a summary of the results of research projects that have been completed there.

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No. 38. *The Hidden World of Plants: A Scanning Electron Microscope Survey of the Native Plant Collection, Connecticut College Arboretum*, 40 p., 2003. Brief description of the scanning electron microscope and of the plant structures depicted in 50 stunning detailed close-up photographs.

No. 39. *Seaweeds of Long Island Sound*, 104 p., 2006. Revised guide with photographs of 79 different algae with keys to their identification. Replaces No. 18.

No. 40. *Salt Marsh Plants of Long Island Sound*, 38 p., 2009, second edition, 2015. Full-color, illustrated guide to 25 common salt marsh plants. Includes three-page foldout depicting the location of plants in the tidal marsh habitat. Replaces No. 25.

No. 41. *Trap Rock Ridges of Connecticut: Natural History & Land Use*, 58 p., 2013. Description of these unique natural features from geological, botanical, wildlife and human perspectives.

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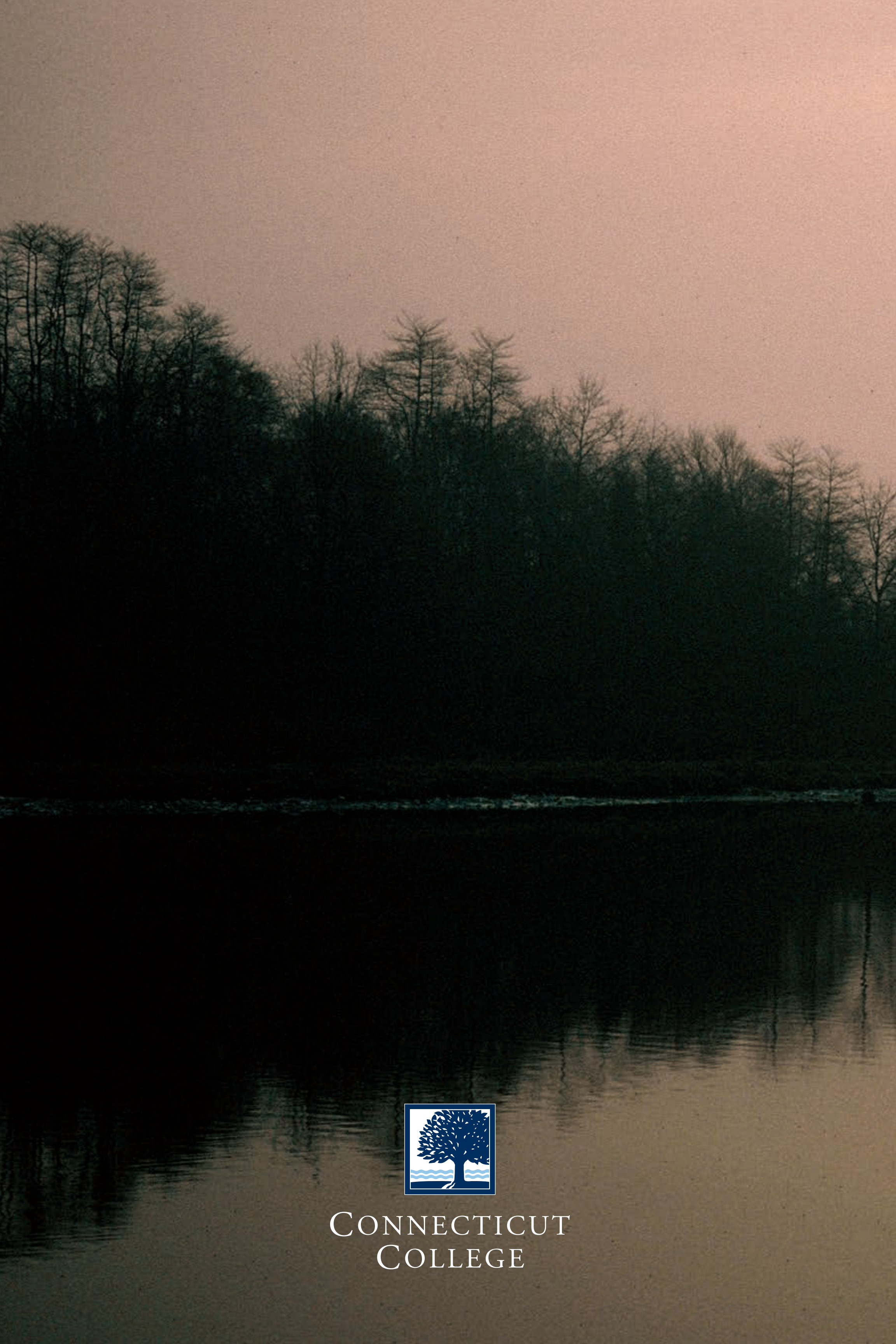
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