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Chapter 3. Affected Environment

This chapter describes the natural and human environment of the Chesapeake Bay ecosystem, the Refuge Complex, and our Environmental Assessment study area. Their biological diversity, biotic integrity, and environmental health are crucial in planning the future management of the Refuge Complex under the provisions of the Refuge System Administration Act and other laws.

International, National, Regional, and Landscape Context

International and National Context

The Refuge Complex is internationally and nationally important in several ways. Most notably, it provides important migration, breeding, and wintering habitat for migratory birds, including waterfowl, shorebirds, marsh and water birds, raptors, and Neotropical migratory birds in the Western Hemisphere. One illustration of its importance is its designation in 1987 as a “Wetland Of International Importance,” under the Convention on Wetlands (Ramsar, Iran 1971). The Refuge Complex is one of only 18 such sites in the United States to have received that designation.

Figure 1. The mid-Atlantic coast of the United States and Chesapeake Bay (Ellison and Nichols 1975)

That first modern global intergovernmental convention on the conservation and wise use of natural resources is popularly known as the “Ramsar Convention.” The official name of its treaty, "The Convention on Wetlands of International Importance Especially as Waterfowl Habitat," reflects its original emphasis on the conservation and wise use of wetlands primarily to provide habitat for water birds. Over the years, however, the Convention has broadened its scope to cover all aspects of wetland conservation and wise use, recognizing wetlands as ecosystems that are extremely important for biodiversity conservation in general, and for the well-being of human communities. As of February 2000, the Convention was represented by 118 Contracting Parties worldwide, and 1016 sites had been designated to protect almost 73 million hectares of wetlands.

The Refuge Complex wetlands are also an Atlantic Coast Joint Venture focus area, one of six priority areas identified in the North American Waterfowl Management Plan (NAWMP), which established a cooperative effort between the United States, Canada, and Mexico to reverse declines in waterfowl populations and protect and enhance their habitats. The Service is also a partner in the international Partners in Flight program, a voluntary collaboration of governmental and private organizations in North, Central, and South America. Blackwater and Martin NWRs were designated as Internationally Important Bird Areas in March 1997 by the American Bird Conservancy to bring recognition to places significant to the conservation of birds.

At the international level, the United States is also obligated to conserve wetlands, biological diversity, and natural areas through the establishment of refuges and other protected areas, and establishing and enforcing regulations. The Refuge Complex contributes to those obligations by protecting and enhancing wetland habitat, conserving natural biological diversity, protecting natural features of the landscape, and supporting the goals of the National Wetlands Priority Conservation Plan.

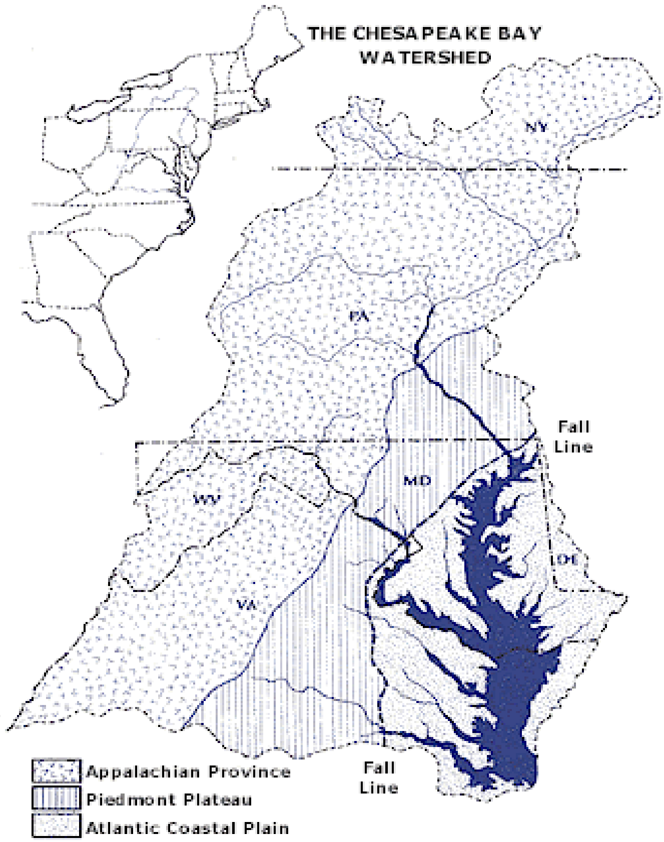
The Refuge Complex is also internationally renowned for its long association with outreach programs and training activities sponsored by our Office of International Affairs. Because of the uniqueness, diversity, and complexity of management problems encountered on the Refuge Complex and its role in the various international programs previously mentioned, international staff assignments and personnel exchanges are common occurrences. Its diversity and abundance of wildlife, combined with its close proximity to Washington, D.C., also make the Refuge Complex a favorite destination for national and international visitors, particularly birders, and the subject of articles in nationally circulated magazines, such as Southern Living, Audubon, National Geographic, and Field and Stream.

Regional Context

The Refuge Complex is situated in the Mid-Atlantic Coastal Plain Physiographic Area, and in the heart of the Region 5 Chesapeake Bay/Susquehanna River Ecosystem, on Maryland's famous Eastern Shore. The Chesapeake Bay, North America's largest and most biologically diverse estuary, is home to more than 3,600 species of plants, fish, and animals. For more than 300 years, the Bay and its tributaries have sustained the region's economy and defined its traditions and culture. It is a resource of extraordinary productivity and beauty that merits the highest levels of protection and restoration. Accordingly, in 1983, 1987, and 2000, the States of Virginia, Maryland, and Pennsylvania, the District of Columbia, the Chesapeake Bay Commission, and the U.S. Environmental Protection Agency signed historic agreements that established the Chesapeake Bay Program partnership to protect and restore the Chesapeake Bay's ecosystem.

As the largest Federally owned system of lands and waters in the Bay ecosystem, the Refuge Complex, by encompassing more than a third of the Bay's tidal marshlands in Maryland, plays a critical role in supporting the regionally renowned Chesapeake Bay Watershed Partnership, and in protecting the diversity of living resources that the Chesapeake 2000 Agreement was developed to protect. In a regional context, the Refuge Complex is interconnected to the Bay's living resources and the importance of protecting the entire natural system. Thus, management actions on the Complex are integrated and coordinated throughout the region to assist in achieving the following goals of that agreement.

Figure 2. Regional context



1. Restoring, enhancing, and protecting the finfish, shellfish, and other living resources, their habitats and ecological relationships to sustain all fisheries and provide for a balanced ecosystem;

2. Preserving, protecting, and restoring those habitats and natural areas vital to the survival and diversity of the living resources of the Bay and its rivers;

3. Achieving and maintaining the water quality necessary to support the aquatic living resources of the Bay and its tributaries and to protect human health;

4. Developing, promoting, and achieving sound land use practices which protect and restore watershed resources and water quality, maintain reduced pollutant loading for the Bay and its tributaries, and restore and preserve aquatic living resources; and

5. Promoting individual stewardship and assisting individuals, community based organizations , local governments and schools to undertake initiatives to achieve the goals and commitments of the agreement.

Another contribution of regional importance and significance is the role the Refuge Complex plays in the Atlantic Coast Joint Venture, a component of the North American Waterfowl Management Plan. As a major part of a focus area identified by the Atlantic Coast Joint Venture, the Complex contributes to achieving their primary goal, which is to "provide for the long-term conservation of wetland habitats and their associated wildlife." Another major goal of the joint venture is to restore and maintain migratory bird populations at 1970 levels. Specific population targets and habitat objectives are listed in the Atlantic Coast Joint Venture Implementation Plan. About 1 million waterfowl, or about 35 percent of all waterfowl in the Atlantic Flyway, winter on Chesapeake Bay. The Refuge Complex provides significant diverse habitats to support those waterfowl.

As well as contributing to wetlands protection and restoration and the protection of significant migratory bird populations, the Refuge Complex is recognized regionally for its role in protecting Federal-listed endangered species, particularly, the American bald eagle and the Delmarva fox squirrel. The Complex supports the largest nesting population of the former species north of Florida on the Atlantic coast, and the largest extant population of the later. The Refuge Complex also provides vital wetland habitat that supports regionally important fin and shellfish fisheries. The adjoining Fishing Bay is the Chesapeake Bay's number one producer of blue crabs, and Martin NWR is the largest producer of soft-shelled crabs in the Bay.

The Refuge Complex is renowned as a regional ecotourist attraction, and many people from the metropolitan areas of Baltimore and Washington, D.C. frequently travel to these refuges, particularly Blackwater, to enjoy wildlife dependent recreational activities, including bird watching, wildlife observation, photography, hunting, and fishing. The Complex's environmental education program is well established and contributes to the education of thousands of students throughout the region annually.

Landscape Context

Scaling down from the regional context to the landscape context, the Refuge Complex also forms part of the Nanticoke and Blackwater River Bioreserve, an Atlantic Coastal Plain river system supported primarily by the Nanticoke and Blackwater Rivers on the Eastern Shore of the Delmarva Peninsula.

> "The Delmarva Peninsula is certainly one of the most unique geographical, social, economic, and political divisions of the United States. Although nature made it a peninsula, man has, in a sense, made most of it an island. On the east are the Delaware River, Delaware Bay, and the Atlantic Ocean; on the south, the Atlantic Ocean and Chesapeake Bay meet; on the west are the Chesapeake Bay and Susquehanna River. The Chesapeake and Delaware Canal separates all but a small northern portion of the Peninsula into an island. This 'Land of the Evergreen' is composed of fourteen counties: two of Virginia, nine of Maryland, and three of Delaware—the entire state. Although three states are represented, in many respects the people are one; man-made political boundaries are all that separate the three divisions. Both Maryland and Virginia are known as 'the Eastern Shore,' because the Chesapeake Bay separates them from their western mainlands."[1]

The Nanticoke and Blackwater Rivers watershed was recognized as a regionally significant natural area more than 20 years ago, and was designated as a "Last Great Place" by The Nature Conservancy in 1991. These rivers flow into Tangier Sound, an embayment off the Chesapeake Bay and home to Martin NWR and the other Chesapeake Island Refuges of the Refuge Complex. The watershed comprises 716,751 acres: 314,933 in Delaware, and 401,818 in Maryland. Of

[1] Robertson 1963

that acreage, 41 percent is forested, 39 percent is agricultural land, 10.6 percent is tidal and non-tidal wetlands, and 2 percent is urban or suburban development (see below).

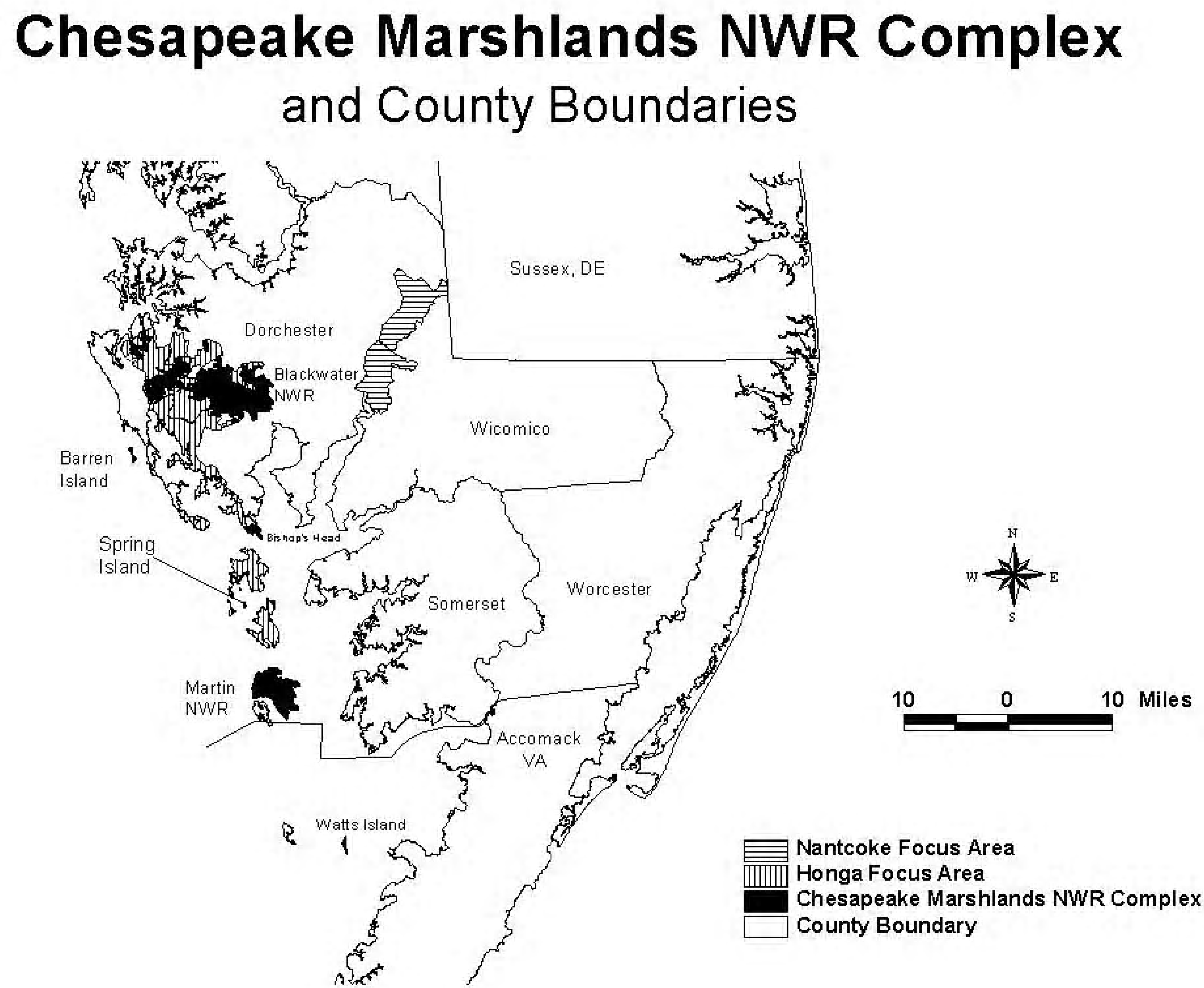


Figure 3. County boundaries

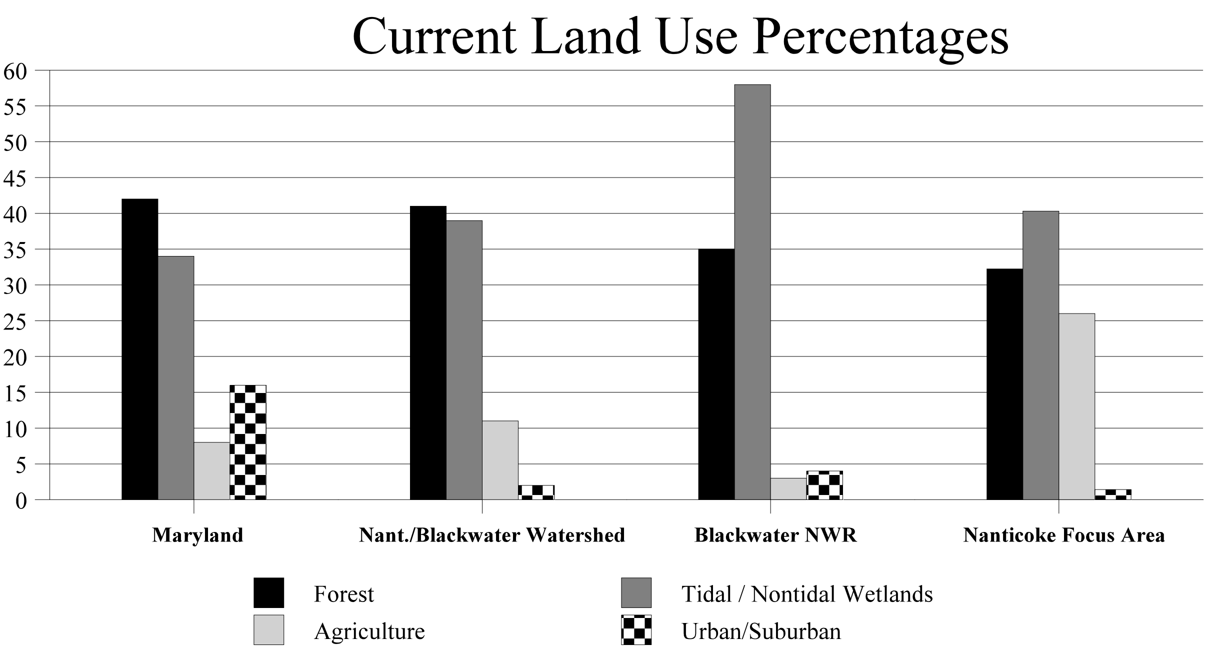


Figure 4. Current land use

Most of the urban and suburban development is concentrated in the small towns in the watershed and along the main highway corridors of State Highways 13 and 50. The Nanticoke/Blackwater watershed was chosen as a bioreserve because of its unique biological significance. It harbors 200 plant and 69 animal species that the Maryland and Delaware Natural Heritage Programs recognizes as rare, threatened, or endangered; an extremely diverse wetland system that is threatened; significant community types; and the only focus area in the Atlantic Coast Joint Venture to include two states.

The watershed includes an impressive assemblage of freshwater non-tidal and tidal wetlands, brackish tidal wetlands and palustrine wetlands, as well as significant upland sites. The watershed contains almost 76,000 acres of tidal and non-tidal marshes and wooded swamps, and includes a third of all tidal wetlands in Maryland.

The Nanticoke is the larger of the two watersheds and river systems in the bioreserve. The headwaters lie in southwestern Delaware, near Bridgeville. From there, the river flows southwesterly 55 miles through Maryland to Tangier Sound. The watershed consists of portions of two Delaware counties, Sussex and Kent, and three Maryland counties, Dorchester, Wicomico, and Caroline.

In Maryland, the Nanticoke has one principle tributary, Marshyhope Creek, which arises in the northwestern corner of the watershed and joins the main stem of the Nanticoke about midway down its length. The Delaware portion of the river includes a number of smaller tributaries, including Broad Creek and Deep Creek. The Nanticoke flows through the towns of Seaford and Laurel, in Delaware, and through Vienna, Sharptown, and Federalsburg, in Maryland.

In Delaware, the main stem of the river winds a meandering path above Seaford, with dense riparian forest overhanging the river. The tidal influence extends just north of Middleford, Delaware along the main stem and up to several miles upstream in many tributaries. As the Nanticoke nears Maryland, it becomes wider and slower moving, ultimately widening more and more until it empties into the Bay. Near its mouth, the waters of the Nanticoke merge with flow from the Blackwater River to the west, forming a vast area of tidal marsh and shallow open-water habitats known as Fishing Bay and Tangier Sound.

The Blackwater River watershed is much smaller, and is composed of the Blackwater, Little Blackwater, Transquaking, and the Chicamacomico Rivers, which drain southern Dorchester County and empty into Fishing Bay. The Blackwater is only 15 miles long, and flows from west to east across lower Dorchester County. The Little Blackwater runs south from Cambridge until it joins the Blackwater about midway along its length, directly in the heart of Blackwater NWR.

This watershed consists almost entirely of low lying tidal and non-tidal wetlands, which combine to form most of Blackwater NWR and Fishing Bay Wildlife Management Area. To the east of Fishing Bay is a low marshy peninsula that connects the mainland to Elliotts Island and separates the Blackwater watershed from the Nanticoke drainages until they eventually join in Tangier Sound. Lacking major cities, dams, industrial facilities, or residential developments along much of the lengths of these rivers, the Nanticoke and Blackwater watershed has long been regarded as one of the most pristine and ecologically significant major watersheds in the mid-Atlantic region.

Federal and state natural resource agencies and numerous private groups, including land trusts, non-profit organizations, citizen alliances, and corporations, have long recognized the watershed’s natural features and environmental qualities, and are working to preserve the wonders of this magnificent watershed in a landscape context.

Partners in protecting this landscape include, but are not limited to,

- The U.S. Fish and Wildlife Service and its protection and management of the lands and waters of the Refuge Complex; Delaware and Maryland and their respective Nanticoke and Fishing Bay Wildlife Management Areas;

- The Chesapeake Bay Foundation and its environmental education and outreach efforts on the Nanticoke R. and at its many residential environmental education facilities at Bishops Head, Fox Island, Smith Island, and Tangier Island;

- The Lower Shore Land Trust and Eastern Shore Land Conservancy and their efforts to protect lands by establishing easements and other landowner agreements;

- The combined advocacy and outreach of community-based organizations, such as the Friends of the Nanticoke River, the Wicomico Environmental Trust, The Nanticoke Watershed Alliance, and the Nanticoke Watershed Preservation Committee, and the resulting united confederacy of these and other organizations;

- Chesapeake Forest Products, Inc. and their assistance in developing sustainable forestry practices in the watershed;

- The Association of Forest Industries and Maryland Forest Association, working with Federal and state agencies to develop a regional Habitat Conservation Plan that will protect endangered species and sensitive habitats throughout the current natural range of the Delmarva fox squirrel in Maryland, and;

- The Nature Conservancy and The Conservation Fund, both active in acquiring and protecting important land parcels and forging partnerships throughout the watershed.

Ecological and Socioeconomic Conditions of the Chesapeake Bay Estuary

Geographic and Physiographic Setting

The Chesapeake Bay, the drowned ancestral valley of the Susquehanna River, is fed by runoff from tributaries of other rivers, including the Potomac, James, Rappahannock, York, Patuxent, and the rivers of the Eastern Shore, including the Chester, Choptank, Nanticoke, and Pocomoke. It is located in the Chesapeake Bay subregion of the Virginian biogeographic region and Maryland's Coastal Plain Province within the Atlantic Coastal Plain.

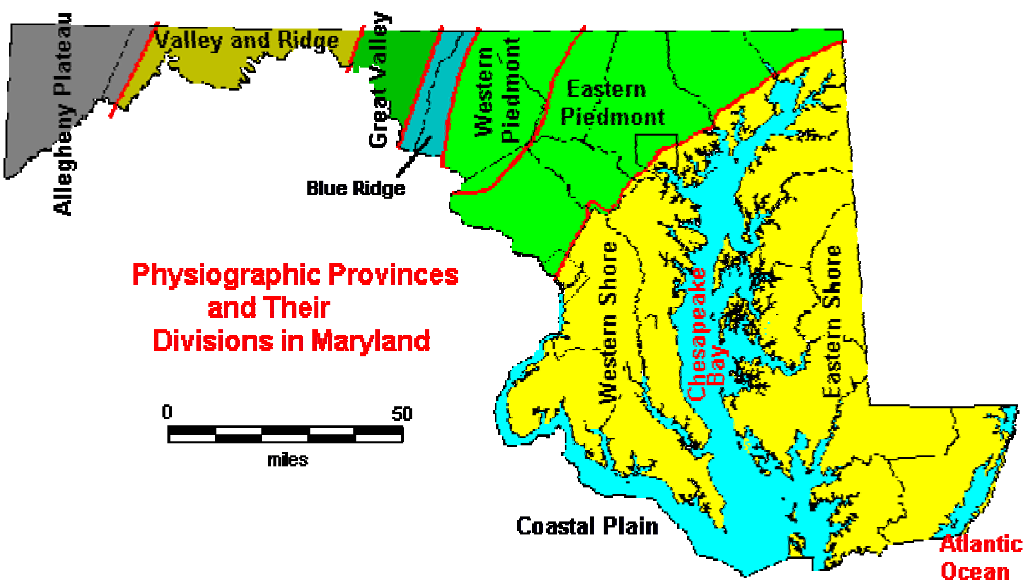


Figure 5. Physiographic setting

Approximately half of the Bay lies in the State of Maryland; the other half lies in the Commonwealth of Virginia. Long before John Smith first sailed past Cape Henry, the Algonquin Indians named it *Chesepiooc*, or "Great Shellfish Bay." In retrospect, this was clearly an understatement. Since their first drawings, geographers have described the Bay in glowing superlatives. It is the largest (2,500 square miles) and the longest (195 miles) estuary in the United States, with the greatest number of tributaries (150). It has more miles of shoreline (4,000 miles) than the entire West Coast. Its watershed encompasses more than 64,000 square miles, and more than 498,000 wetland acres.

Its productivity is unsurpassed. In 1986, the Chesapeake harvest represented 20 percent of the oysters and more than 50 percent of the blue crabs and soft-shell clams caught in the entire United States. Annual harvest figures are impressive and in some respects almost incomprehensible: 150 million to 240 million blue crabs, 95 percent of the Nation's soft crab catch, and 17,000 pounds of sturgeon. The numbers of mink, muskrat, nutria, and otter trapped in the marshes of Dorchester County are second only to Louisiana. More than 200 million pounds of seafood with a wholesale value of more than $100 million are harvested from these waters each. No other coastal fishery can equal the Bay’s harvest. In fact, only the Atlantic and Pacific Oceans exceed the Bay in annual seafood production.

> “[The origin of the estuary] dates back 20,000 years to the last ice age, near the end of the Pleistocene, when a colder climate ruled the earth. At that time, sea level was 325 feet (100 m) lower than it is today. Mammoths roamed the exposed continental shelf. For the previous 100,000 years, the Atlantic had steadily retreated into its main oceanic basin as if someone had pulled a plug. But the water had not disappeared; it was simply locked up in ice. Temperatures on the average were 20°F colder than today, still warm enough to excite massive evaporation from the sea, but in northern latitudes, the water rarely fell as rain. Year by year, over those 100 millennia, the North American ice sheet had grown and thickened with new-fallen snow. On warmer days some of the water returned to the sea, but more often, the snow remained frozen, adding weight and measure to the ice below. The mile-thick glacial sheet stretched from the Arctic Circle across the Canadian Shield into New York, stopping in Pennsylvania, just short of the present site of the Bay.
>
> “The tongue of this enormous glacier fed the headwaters of the Susquehanna—mother river of the Chesapeake—with glacial melt. For centuries, this ‘upstart’ river had carved a deep valley through Pennsylvania, Maryland, and Virginia, as well as 100 miles across the dry, flat, continental shelf. Then, 18,000 years ago, the ice sheet began to melt. The climate grew warmer. The end of the long Pleistocene winter was at last in sight. Now, the Susquehanna raged. Centuries melted away as the torrential river flowed south, south past the old Patapsco, south past Calvert Cliffs and the Patuxent towards her surging, deafening convergence with the Potomac, the Rappahannock, the York. From there with doubled force she spilled toward the remote Atlantic with a power surpassing the Mississippi of today.
>
> “The Atlantic overflowed. The long-dormant ocean crawled out of its basin, then marched across the continental shelf at a rate of 50 feet per year. The river mouth retreated, and its racing freshwater current flowed over the advancing salt-laden water, turning the continental shelf into a brackish sea. Around 10,000 years ago, the brackish waters reached the longitude of Virginia Beach, Ocean City, and the current mouth of the Bay. At that moment the old river made its last unimpeded journey to the Virginia Capes. For the last time in recent history, the Susquehanna held dominion over its streambed. But the Atlantic kept coming, flooding the valley, backing up the river like a tidal dam. About 7,500 years ago, the Bay front reached the mouth of the Potomac—the Maryland/Virginia state line. Between 6,000 and 7,000 years ago, the rate of submergence began to slow, and the Chesapeake Bay took on its characteristic ‘drowned river valley’ shoreline pattern. Sea level at that time stood approximately 9 meters lower than the present level. In another 2,500 years, the expanding Bay passed Annapolis and the current site of the Bay Bridge.”[2]

Geologically, the Chesapeake Bay is in the middle of the Holocene Interglacial, a period to date lasting nearly 20,000 years. Interglacial periods are temporary time outs between glacial events, and are usually brief, on the average lasting 10,000 years. Glacial periods, on the other hand, last

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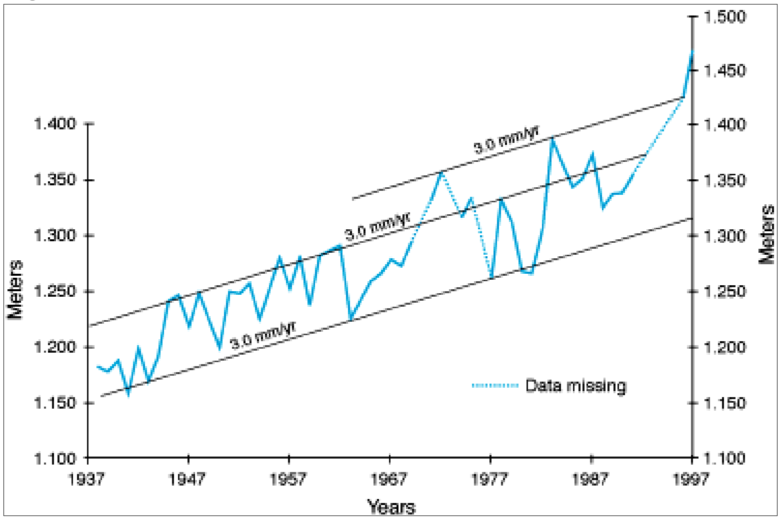
[2]White 1989

literally for an "ice age," the last one gripping the earth for 100,000 years. For the last several million years, the alternating glacial and interglacial episodes have caused fluctuations in the world's ice budget along with changing sea levels. It is possible that within the near future, another ice age could result in a recession of sea levels unless the climate is altered by man. As much as 75 percent of the existing Chesapeake Bay would be dry land with a 30-foot drop in sea level. Although we don't know when there will be another ice age, we do know that the Susquehanna will one day regain its valley only to lose it again to another estuary.

Relative Sea-level Rise and Its Effect

The Bay attained its present configuration by the time the first European and colonial maps were prepared, but as tide gauges and the continued inundation of low-lying areas indicate, relative sea level in the Bay is still rising. Sea levels have varied greatly from region to region in the past 10,000 years. Sea level is measured relative to fixed points on land, but the elevation of the land also changes due to natural subsidence and uplift of the Earth's crust. If the land surface is subsiding at the same time that ocean volumes are increasing, then the rate of submergence will be greater than it would be due to changes in ocean volume alone. If the land area is rising relative to the sea, apparent sea level may fall.

Figure 6. Annual mean relative sea level at Solomons Island 1937–1997



USGS reports that "continuous tide gauge records around the Chesapeake Bay show that the rate of sea-level rise during the 20th century has not been constant and that modern rates are more rapid than those determined by geologic studies conducted two decades ago…. The current rate of sea-level rise at the mouth of the Chesapeake is about 4 millimeters per year (about 1.3 feet per century) and decreases northward. Tide gauges with longer periods of record, like that at Solomons Island, Md. [see figure 6 (NOAA 1998)], midway along the length of the Bay, have recorded mean sea level since 1937, and illustrate a 3-millimeter per year rate of rise (about 1 foot per century)."[3] This rate of sea-level rise is almost twice that of the worldwide average. But why is sea-level rise so much greater here than elsewhere, and what are the effects of the invading sea on the human environment?

The effects of this increase in relative sea level are very obvious. Entire communities, such as those on Barren Island and Hollands Island, literally have vanished beneath rising waters. The

[3] USGS Fact Sheet 102–98

marshes of the lower Eastern Shore are being swallowed up as the waters advance on the forests, which leave behind their dead snags as reminders that the sea continues to rise.

As to its cause, scientists disagree. Is the increase caused by land subsidence? Is it related to a changing climate and ocean volume? Or, is it a combination of the two? Anthropogenic causes, such as ground water and oil extraction, can cause sediment compaction, which results in land subsidence. On a much larger scale, however, a zone of subsidence along the entire mid-Atlantic coast has been attributed to a reflattening of the Earth’s mantle that is still taking place, following the removal of vast thicknesses of glacier ice to the north thousands of years ago (isostatic adjustment).

USGS reports that the Chesapeake Bay has also been identified as one of four anomalous areas along the U.S. East Coast that appear tectonically active. A zone of crustal downwarping and sediment accumulation known as the Salisbury embayment has long been recognized beneath the Delmarva Peninsula. Clearly, vertical movement can occur along such zones. Another geologic factor that might account for unusual rates of sea-level change, at least for the mouth of the Bay, is possible subsidence related to compaction of the fill of a large buried impact crater that underlies much of the Norfolk, Hampton Roads, and Cape Charles area.[4]

Table 1. The Bay’s physical characteristics

Length	195 mi.
Width	4 to 30 mi.
Average depth	21 ft.
Greatest depth	174 ft.
Drainage area	64,000 mi.^{2}
Wetlands	498,000 ac.
Surface Area	
Bay proper	2,500 mi.^{2}
Bay and tributaries	4,400 mi.^{2}
Shoreline	
Bay proper	4,000 mi.
Bay and tributaries	8,100 mi.

Unquestionably, the rate of sea-level rise has certainly accelerated in the Chesapeake Bay, and this appears to be the norm rather than the exception. The future of the ecosystem, and certainly the Refuge Complex, revolve around understanding, coping with, and more importantly, planning for an ongoing dynamic Earth process like sea-level change.

Erosion and Sedimentation

Natural and anthropogenic processes of erosion and deposition are constantly at work within the Chesapeake Bay. The rivers and tributaries carry silt from the Appalachian and Piedmont Provinces and deposit them in the Coastal Plain. The current marshlands of the Chesapeake Bay are built upon these deposits, which have accumulated as the result of accelerated deforestation and agricultural expansion during the last 350 years. The sediments that are transported by the major rivers also drop out into “sediment traps” such as Baltimore Harbor, or eventually are deposited into the ancient river bed of the Susquehanna and shipping channels, making the need for maintenance dredging an ongoing problem and hotbed of contention.

Marsh grasses colonized the delta-like alluvial plains, characteristic of the historic Choptank and Nanticoke drainages. Over time, these areas have accreted, as additional sediments and organic deposits continue to build the marsh surface. However, as sea levels have continued to rise,

[4]Ibid.

sediment rates are being exceeded by erosion, and the peat layers that overlie the coarser sediments of the lower Eastern Shore marshes literally are being dissolved by interactions with the invading salt water. It is not uncommon to lose 10 feet or more of shoreline on Chesapeake Bay islands annually, and upwards of 7,000 acres of highly productive marshland vegetation on Blackwater NWR alone have succumbed to the rising salt water in just the past 60 years.

Salinity and Tides

The Chesapeake Bay holds close to 18 trillion gallons of water. If the entire tidal system were drained and the ocean blocked from entering the Bay, more than a year would pass before all the rivers, streams, and annual storm runoff could fill the basin. An estimated average of 70,000 ft^3 of water flows into the Bay each second from all its tributary sources. This freshwater flow represents only one-ninth of the volume of seawater flowing into the Bay at any instant, however, the influence of this disproportionate ratio of fresh to salt has a profound influence on the estuary and its natural resources. This is predominantly because of two important factors: storms and the size of the watershed relative to the volume of the brackish water basin. Here the Chesapeake excels once again.

The watershed spans an amazing 64,000 square miles into six surrounding states. Thus, any storm can have significant influences on the Bay's water quality. Of the 150 rivers, creeks, and streams draining the watershed, only 40 are considered major tributaries, and 8 of these provide 90 percent of the freshwater inflow. Six of these, previously mentioned, drain the western shore. The Susquehanna, which provides 50 percent of the freshwater, flows from the north, and the lone Choptank drains only part of the Eastern Shore. Thus, White calls the Chesapeake right-handed and top-heavy. (White, 1989).

Table 2. Salinity zones of the Bay estuary

Ecosystem	Zone	Venice System	Salinity
Riverine	Nontidal freshwater	Fresh	0 ppt
Estuarine	Tidal limit	Tidal freshwater	Fresh: 0–0.5 ppt
Upper bay/upper tidal rivers	Low brackish	Oligohaline	0.5–5 ppt
Mid-bay/lower tidal rivers	Brackish	Mesohaline	5–18 ppt
Lower Bay	High brackish	Polyhaline	18–30 ppt
Marine	Marine	Euhaline	>30 ppt

Salinity obviously varies according to the amounts of freshwater these eight major tributaries contribute to the Bay. Generally, salinity increases seaward as mixing slowly takes place. Circulation and mixing are slow, because the fresh water is more buoyant than salt water. The resulting salinity contours, or isohalines, shift according to seasons of the year and freshwater input, and have significant seasonal effects on the Bay's living resource. In April, for example, salinity of the water near the Bay Bridge may be as low as 7 ppt (parts per thousand), but by October following a dry summer, the salinity can be almost twice that amount.

Another interesting natural phenomenon, known as the “Coriolis force,”[5] causes flowing waters in the northern hemisphere to be deflected to the right due to the earth’s rotation. This condition has significant impact on the Eastern Shore, because the saltier waters moving up the estuary are pulled towards the eastern side of the Bay, where there is less freshwater input. The combined power of the western rivers and the Coriolis force create a counterclockwise circulation in the Bay, with the incoming salt water entering along Cape Charles and hugging the Eastern Shore, and freshwater exiting along Cape Henry and the western shore. This circulation and salinity pattern has definite influences on the estuary and its ecosystem.

Tides, too, have great influences on the ecosystem. The vertical range of tides in the Bay is greatest at the capes (2.5 ft.), intermediate through the main Bay where it averages 2 ft., and lowest along the upper reaches of tidal streams (1 to 2 ft.). Twice each day these natural forces expose and submerge shorelines and transport nutrients. On an average, it takes a parcel of water about 2 to 3 weeks to cycle along the Bay’s 195-mile length, and each second, the surface stream discharges nearly 700,000 cubic feet of brackish water into the ocean; 10 times greater than the average freshwater input.

Bay Wetland Ecology

The estuary basin’s salinity gradient and topography control the distribution of life and the number of species within the Bay. Five major communities within the estuary provide habitat for 2,700 species of aquatic and wetland plants and animals. These communities can be further segregated into freshwater, low brackish, moderately brackish, and highly brackish zones along the length of the Bay or its tributaries. Within each zone, species composition varies depending on local shifts in salinity, elevation (depth), sediments, and topography of the substrate. All of the following Bay communities are represented on the Refuge Complex.

Wetlands.—Surrounding the Bay are 498,000 acres of emergent wetlands. Kept wet by runoff, groundwater seepage, adjacent stream flow, and tides, these habitats range from shrub swamps and cattail marshes along secluded streams to the open salt marshes of the lower Bay. In addition to trapping sediments, recycling nutrients, and providing numerous other hydrologic and energetic benefits, these wetlands are the most productive plant communities in the world.

Submerged Grass Beds.—Another major community that only consists of fewer than 36 species that live in shallow waters of rivers, streams, and the Bay proper are collectively known as “submerged aquatic vegetation,” or SAV.

Plankton.—This community includes phytoplankton, zooplankton, bacteria, and large jellyfish. The tiny, floating larvae of benthic animals and fish, known as meroplankton are, for a short time, part of this community as well.

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[5]**coriolis force** *n., usu cap C*: the force corresponding to the Coriolis acceleration of a body equal to the product of the mass by the Coriolis acceleration and responsible as a result of the Earth’s rotation for the deflection of projectiles and the motion of the winds to the right in the northern hemisphere and to the left in the southern hemisphere—Webster’s Third New International

Nekton.—The larger aquatic organisms capable of swimming that form this community include fish, crustaceans, and other invertebrates. Nearly 300 fish species can be found in the Bay ranging from the permanent residents like silversides and white perch, to freshwater and marine species, to migratory anadromous and catadromous species.

Benthos.—Inhabitants of the bottom sediments are commonly known as benthos. Benthic communities, often described in terms of animal groups such as oyster beds, also include algae, bacteria, and ciliates. Intertidal species are a special class of bottom dwellers that can survive temporary exposure to air.

Freshwater Swamps

Wet, soggy habitat located at the headwaters of many Bay tributaries are known as "freshwater swamps." These are seasonally saturated or permanently flooded wetlands with a greater than 50-percent coverage of woody vegetation. Swamps, unlike bottomland forests, are saturated to the surface or flooded by up to a foot of water. In the Bay, wooded swamps typically are dominated by red maple/green ash, bald cypress, loblolly pine, or occasionally Atlantic white cedar.

Unforested shrub swamps typically contain swamp rose, alder/willow, or maple/ash seedlings in linear thickets along creeks or adjacent to freshwater marshes. Freshwater swamps consist of herbs, vines, shrubs, and trees entangled into a wetland jungle.

Freshwater Tributaries and Adjoining Freshwater Marshes

More than 150 tributaries contribute fresh water to the Chesapeake Bay. Of these, nearly half are tidal, and run either full-length into the estuary or converge with larger estuarine rivers before entering the Bay. River marshes are divided into two types: freshwater estuarine river marshes upstream and brackish-water estuarine river marshes downstream. Since the freshwater stream and adjoining freshwater marshes are interconnected, they are most often viewed as one integrated habitat. In the stream, aquatic species dominate, and, in the marsh, wetland species reign. Tidal fresh water is defined as the narrow region of the salinity gradient between 0 ppt (parts per thousand) and 0.5 ppt. Because of the indefinite boundary between fresh and brackish regions of a given river, plant composition is used to define the wetland habitat.

Marshes are typically covered with a few inches of water at mean high tide, though the community may extend to the spring or storm tide limit. The plants are generally herbaceous (i.e., non-woody) species, unlike freshwater swamps. Emergent plants far outnumber both floating-leaved plants and the handful of submersed aquatic species (SAV) in the stream channel. While shrubs and trees may grow at the upland (or swamp) margin, they are not typical of the marsh community. The shading canopy of trees limits the growth of herbaceous species at these margins, and, when overhanging a creek, may prevent sunlight from reaching and nurturing SAV.

Freshwater marshes are colonized by indicator plants. Important species include broad-leaved cattail, which grows in stable shallow-water areas; river bulrush, which typically grows in bands at the river edge; tall grasses, particularly wild rice and Walter's millet; smartweeds and tearthumbs; and, in shallow open water, spatterdock, arrow arum, and pickerelweed. In elevated areas of the marsh, swamp type shrubs, such as buttonbush, sweet pepperbush, or silky dogwood are found. In addition to these shrubs, red maple and common alder may colonize the marsh edge, representing the transition (and succession) of marsh into woody swamp. Compared to salt and brackish marshes there is a more heterogeneous mixture of plants. Freshwater tidal tributaries provide habitat important for transient anadromous and catadromous species, such as shad and river herrings and American eel, respectively.

Estuarine Rivers and Brackish Marshes

More than 45 major rivers flow directly into the Chesapeake Bay. Each river has a salinity gradient that can vary greatly along its length. These estuarine rivers and their associated brackish marshes are important breeding and nursery grounds for fish and birds. In summer, marsh hibiscus blooms along the banks amidst stands of big cordgrass and narrow-leaved cattail.

Brackish waters are broadly defined as the middle range of the salinity gradient between tidal fresh water and marine. A lot of territory in the Bay (or any estuary) falls in this range; in fact, during autumn the entire Chesapeake (and some of its shorter rivers) may be brackish, that is, between 0.5 and 30 ppt. The brackish salinity gradient, therefore, is divided into three brackish zones: oligohaline (0.5–5 ppt), mesohaline (5–18 ppt), and polyhaline (18–30 ppt), which can be termed low (or slightly) brackish, moderately brackish, and highly brackish, respectively.

Indicator species include narrow-leaved cattail, Olney three-square, switchgrass and common reed, along with associated species such as hibiscus, tidemarsh water hemp, and saltbushes. Additional plant communities include big cordgrass and black needlerush. These plants must be able to survive a wide range of salinities. The most characteristic brackish-wetland species for example, Olney three-square, can grow in waters from 1 to 18 ppt. These marshes are home to muskrats, the infamous nutria, and other wetland mammals.

Fresh Estuarine Bay Marshes

Between the mouths of the Susquehanna and Sassafras rivers north of Baltimore, there is a 12-mile stretch of tidal fresh water marsh. Bordering these waterways and south to the Gunpowder delta is a limited acreage of fresh bay marsh that is very similar in plant composition to the wetlands along freshwater streams. The most extensive area of fresh bay marsh, however, is located landward of the brackish bay marshes in Dorchester County, Maryland, at the headwaters of the Blackwater River. Other Dorchester County rivers, the Transquaking and Chicomicomico, are also noted for these unique wetlands. These marshes are diverse and abundant with aquatic and wetland life.

The term “fresh bay marsh” is considered by some to be a misnomer. Because the estuary has a measurable salinity gradient along its length, one may logically expect fresh water to be absent, a pure form sequestered only in the headwaters of the tributaries. But in these habitats, freshwater species exist in abundance as long as seasonal brackish inundation is not prolonged. Major indicator plants include narrow-leaved cattail, Walter's millet, American three-square, wild rice, smartweed, fragrant waterlilly, and spatterdock.

Brackish Estuarine Bay Marshes

The middle of the Chesapeake is dominated by brackish marshes. In these moderately brackish waters, there is the transition from the taller plants of the freshwater marshes to the low-lying salt meadows of the lower Bay. Only very small pockets of bayside brackish estuarine wetlands remain on the western shore between the Patapsco and the Patuxent. The largest contiguous acreage, more than 90 percent of the Bay's total, is found on the Eastern Shore, mostly in Dorchester County, Maryland, in the Blackwater/Fishing Bay/Nanticoke River watershed. Most of these brackish wetlands are three-square meadows (*Schoenoplectus* spp.), with taller big cordgrass or narrow-leaved cattail along the margins of tidal creeks and ponds.

These *Schoenoplectus* marshes differ from brackish river marshes in having a broad, ill-defined drainage system. Slight changes in the marsh topography and waterfowl, nutria, or muskrat "eat-outs" may foster shallow tidal pools, or marsh ponds. These ponds are important habitat for migratory waterfowl. Submersed aquatics (SAV), particularly the pondweeds *(Potamogeton* spp.) grow here. Brackish bay marshes dominate areas inundated by slightly brackish (oligohaline) to moderately brackish (mesohaline) waters. The most important plant indicators include Olney three-square which grows in peaty soils with saltmarsh bulrush, hightide bush, dwarf spikerush, black needlerush in the sandier soils, switchgrass, big cordgrass, and common reed.

Salt Marshes

Salt marshes of the lower Bay extend for miles and miles, encompassing Taylors Island, the Honga River, Elliotts Island, Worlds End Creek, South Marsh Island, Watts Island, Tangier Island, and Smith Island. They extend on into Tangier Sound and stretch toward the mouth of the Chesapeake Bay. In some cases, entire islands, such as Bloodsworth and Great Fox, are overrun with black needlerush, the dominant vegetation. These vast wetlands are flat and monotonous. Only where small elevated islands appear does the eye find relief. There, in wax myrtle and loblolly pine jungles, egrets and herons nest in the Bay's largest and most productive colonial bird heronries. Only the willet, the clapper rail, and a few others reside in the marsh.

Salt marshes are a hostile environment. Few species, either plant or animal, can survive. A salt marsh may be defined quite simply as "Spartina- and Juncus-dominated wetland." Typically, only three species predominate: saltmarsh cordgrass (*Spartina alterniflora*), saltmeadow cordgrass (*S. patens*), and black needlerush (*Juncus roemerianus*). Saltmarsh cordgrass grows in tall colonies along tidal creeks below mean high tide (MHT) and in shorter stands at or above MHT. The tall form characterizes what is often referred to as the "regularly flooded salt marsh," or low marsh, while the short form of cordgrass (growing behind this zone) intergrades with the salt meadows of the irregularly flooded salt marsh, or high marsh. Saltmeadow cordgrass grows in large meadows in the high marsh where the soil is well drained; in wetter (lower) areas of the high meadow, saltgrass (*Distichlis spicata*) may persist.

The waters that flood these wetlands typically have salinities in the upper mesohaline range (10 to 18 ppt) and above. In this range, black needlerush and saltmarsh bulrush (*Scirpus robustus*) can still survive and compete with *Spartina*. The transition to pure cordgrass meadows takes place at a point farther north on the Eastern Shore than the western shore due partly to the Coriolis force. These salt marshes are the most productive plant communities on earth, producing a range of 4 to 10 tons of organic matter per acre per year.

Beaches and Tidal Flats

The shoreline of the Chesapeake Bay stretches for more than 4,000 miles around the basin. The banks of tributary rivers and streams double this figure to more than 8,000 miles. Unvegetated wetlands border most marshes and beaches from the mouth of the Susquehanna to Capes Henry and Charles. Unvegetated wetlands may be defined as wet substrates, devoid of rooted plants, that are subjected to tidal inundation. This definition includes streambeds, unvegetated shallows, and open water below mean low tide (MLT); sandbars and mud flats exposed at low tide; as well as sandy beaches. Upper beaches represent the shoreline continuum above mean high tide (MHT), only reached by storm and spring tides and salt spray.

The shoreline is divided into four distinct zones based on elevation relative to tidal fluctuations. Below MLT is the subtidal zone, which includes submersed aquatic vegetation and benthic algae, as well as unvegetated shallows Between MLT and MHT is the intertidal zone, which may be muddy, sandy, or a mixture of these. In this zone, a variety of snails, clams, and burrowing worms are found in the substrate. Above MHT, up to and somewhat beyond the limit of spring tides is the supratidal zone, which may support scattered plants. This is the area of dry sandy beaches where sand fiddlers dig their burrows, and where dips, or pannes, in the sand foster salt barrens where salt-tolerant plants (*halophytes*) are found. Above the supratidal zone is a transition zone, or ecotone, colonized by species such as wax myrtle and loblolly pine. Densities of major invertebrate groups range from 330–3,000 individuals per square meter on sandbars, to 5,300–8,300 individuals per square meter on richly organic sand-mud flats.

Shallow Water Habitats

Shallow waters are where much of the Chesapeake's remarkable productivity occurs. The Bay averages 21 ft (6.4 m) deep. Additionally, much of the basin is covered by less than 10 ft (3 m) of water. These shoal areas allow sunlight to reach the Bay floor, permitting photosynthesis in both the water and benthos. These shallow waters host 3 important plant communities: phytoplankton, benthic algae, and submersed aquatic vegetation (SAV).

Deep Open Water

The open Chesapeake is seasonal habitat: a summer haven for marine fishes and a winter refuge for migratory waterfowl. True estuarine species that remain in the basin year-round, such as the Bay anchovies, retreat to deepwater channels in winter. In spring, they return to forage along channel edges, and serve as prey for visiting bluefish and other large predatory fish that return from their Atlantic winter retreat. The biannual migrations of marine and anadromous fishes into and out of the Bay are well known to fishermen. Ten anadromous species migrate through the

Bay to spawn in freshwater tributaries in early spring. Also, 152 marine species may visit the estuary in summer as foraging adults or juveniles, but most depart by autumn. Six marine species are regular visitors in winter. Only 27 estuarine species (and 2 marine species) are permanent residents.

The open Bay, varying between 4 and 30 miles wide, can be divided into shoal, or shallow, areas and deepwater habitats. Shallows less than 10 ft (3 m) deep hug the shoreline of the Bay and its tributaries. Shoulders, less than 30 ft (10 m) deep, are the next step down and border the edges of the main and tributary channels, which run deeper than 60 ft (20 m). The main channel, the ancient riverbed of the Susquehanna, is more than 100 ft (30 m) deep for much of its length. The deepest point of the Bay, off Bloody Point just south of Kent Island, is 174 ft (53 m). The shoulders, channel edges, channels, and deep holes constitute the deepwater zones of the Chesapeake Bay. More than 50 of the Bay's 287 fish species are commercially valuable, and income for commercial fisheries and associated industries exceeds $100 million annually.

Socioeconomic Setting of the Tidewater and Delmarva Regions

As noted above, the Chesapeake possesses some of the world's most distinctive characteristics. These attributes contribute to its high human value and affect the surrounding human environment both socially and economically. Most of the present population of the total Chesapeake Bay watershed, about 15 million, affects and is affected by it. They cluster in the urban and suburban centers of Washington and Baltimore, major foci in the ever growing megalopolis from Boston to Norfolk. Many, however, live along the Bay's shores in hundreds of small cities, towns, and villages that arose because of the presence of the Bay. The living and quality of life of the residents of these communities are now, as they have been in the past, inextricably tied to the Bay and its rivers. (Lippson 1973)

The Tidewater areas of Maryland and Virginia form the land girdle of the Chesapeake Bay. Together, these two states divide the waters of the great Bay about equally between them. Tidewater Maryland sits like a chaplet about the head of the Chesapeake. So persistent is the appearance of water in the landscape that its land area seems only a little greater than the water area. Of the State's 23 counties, only 7 are untouched by tidal influence. In Tidewater Maryland, the counties are almost entirely water-bounded. So, although they are not quite islands, all of them are peninsulas or, in the Tidewater vernacular, "necks."

For example, Kent County has 209 miles of waterfront, yet its solitary 10 miles of land boundary against the Delaware line is actually longer than the land boundary of either Talbot, Somerset, or Calvert, and is within less than 5 miles of being as long as the land boundary of either Dorchester, Queen Anne, St. Mary's, or Anne Arundel. This abundance of water and irregularity of coastline have given the people a close relationship with the water for several centuries, and helped develop the socioeconomic setting of the region.

There are four portions of the Tidewater area. The region on the eastern side of the Chesapeake's Tidewater area is celebrated as "the Eastern Shore." It is one of the bestknown regional names without official status in America. One might readily imagine that the region across the Bay opposite the Eastern Shore would therefore be known as “the Western Shore.” As Wilstach puts it, “it is a natural and significant term, however, it is infrequently employed. When occasionally it is used (particularly by those on the eastern banks), its meaning is understood; but other adjectives are oftener on the tongue….”[6] The western side of the Bay north of Annapolis has no comprehensive name, but is sometimes recognized as “Northern Maryland,” if for no other reason than to set it off from the more noted region lying south of an imaginary line drawn between Annapolis and the District of Columbia. With an identity all its own, the southwestern portion of Tidewater Maryland has grown to be called “Southern Maryland.”

The shores of the four parts of Tidewater Maryland have been the theater of events that are significant in our national life, character and consciousness. Here, Lord Baltimore's colony settled three centuries ago. Religious tolerance, such as we enjoy universally today, first found expression here. On two occasions, Tidewater Maryland has been the seat of our national government; once when the Congress assembled in Baltimore at the beginning of the Revolutionary War, and again when it assembled in Annapolis at the war's end. Our national anthem was written at the mouth of the Patapsco. The first railway operated in America for public service ran from Baltimore, on tidewater, 14 miles inland and began operations in 1830. Fourteen years later, the first public telegraph line flashed its instantaneous messages between two tidewater ports, over wires reaching between Baltimore and Washington.

During its three centuries of English settlement, Tidewater Maryland has launched a procession of interesting figures out into the current of our national life. In the early colonial days, there were leaders in missionary life and in the demand for the political rights of women, and an American poet laureate. In the struggle for Independence and in the establishment of the young Republic, there were many of the most conspicuous characters in our naval exploits, military leaders, an unsurpassed bar, justices and a chief justice of the Supreme Court, and members of the Cabinets of the first fifteen presidents.

Wilstach characterizes the social environment of the Tidewater as follows. “Such men and women, and those who followed, established a mode of life which was unique and graceful, and a standard of character that survives today. Many of the residents have moved along with the currents of progress, significantly in some regions, yet in others, as slow as their own sluggish tides. Overall, the men and women of native stock are in character and conduct but little altered from their English immigrant ancestors. The traditions of the many intervening generations still rule strong. Now as then, ethics are held in high esteem; but in spite of the early infusion of some Puritan elements, of a considerable infusion of Quakers, and the presence and preaching of Friend George Fox, Presbyterian Makemie, and Methodist Francis Asbury among them, the mildness of the climate, the easy plenty of rich lands and richly yielding waters, coupled with the people's own apparent predilection for pleasure, produced a social order colored by ease, culture and a delight in sport and play.”[7]

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[6]Wilstach, 1931

[7]Wilstach, 1931

Tidewater Maryland is founded on three hundred years of tradition. The people are consciously devoted to their traditions, to their rugged independence, and to their ties with the lands and waters that support their livelihoods and provide recreational enjoyment. But whether devoted or indifferent, both the people and the environment of the people are inevitably influenced by their past. Tidewater Maryland retains the simplicity of its early years. The long low points and necks of land; the creeks and coves rimmed with forest; the cleared fields with their farm units; the surviving plantation mansions at the end of long shady avenues; the lazy leaning landings; the leisurely wind-driven ships; the struggling lines of poles rising out of quiet shallow channel banks where seines and nets hang unseen underneath; all carry on traditions little changed during nearly thirty decades.

Such regions, and particularly the Delmarva Peninsula, Wilstach says, are nationally known because they have character. “Character over long periods begets legends, and legends develop a cult. The Eastern Shore has such character and legends and a cult all its own." John Gunther in his book “INSIDE U.S.A.” wrote “‘The Eastern Sho’ held, until recently at least, a stable and gracious kind of life…. South of the Choptank, it is almost indistinguishable from Alabama; one jumps from the industrial age to the life of the deep South in the space of a county or two.”

The Eastern Shore is the most well understood area of the Tidewater because it lies geographically apart, a land of almost unvarying unity, of character, of history, of economy, and of interest. The heritage of the Eastern Shore and Delmarva Peninsula is as long and rich as any region of the United States. And the influence of this region, like that of the Tidewater, has been felt throughout the history of our Nation.

Almost a hundred years before the settlements of New England, Giovanni Verrazano, an Italian explorer sailing for France, landed on the Atlantic Coast of the Delmarva Peninsula. Today, not far from where Verrazano explored, there is an important NASA experimental station at Wallops Island, Virginia. It was here, too, that several of the Churches in America were established. Naturally the area is famous for the old church buildings of the Episcopal Church, several of them built in the 17th century. George Fox, the founder of the Quaker faith, held meetings on the Peninsula in the 1600's; while the Third Haven Meeting House in Easton, Maryland, built in 1684, is considered to be the oldest frame church building still in use today.

The first Lutheran Church of the nation was established in Delaware about 300 years ago. The Methodists often refer to the Delmarva Peninsula as the “Cradle of Methodism,” for it was at Barratt's Chapel, near Frederica, Delaware, that Francis Asbury and Thomas Coke held the first regularly administered Communion and also made the decision to organize the Methodist Episcopal Church. The Presbyterians refer to the region as the “Land of Makemie,” and the Presbyterian Church at Rehobeth, Maryland as “the Mother Church.” Francis Makemie, the father of Presbyterianism in America, preached here, used the churches of this faith as foundation for the first presbytery in America, and is buried at Makemie Park on the Eastern Shore of Virginia. Wenlock Christison, a Quaker who was persecuted, whipped, and threatened with death in New England, found a haven for religious freedom on the Eastern Shore of Maryland, and in honor of the fact called his small plantation “The End of Controversie.”

The list is long of important personages who were born on the Delmarva Peninsula, or later closely associated with it. Charles Willson Peale, the famous artist of the American Revolutionary period, was a native son. The Reverend Thomas Bacon, clergyman of the Church of England in Maryland in the 18th century, was a compiler of the Maryland laws and an outstanding leader in educational and philanthropic activities. John Dickinson, one of the few Americans to have had direct connection with the three famous political documents of our history—The Declaration of Independence, Articles of Confederation, and The Constitution—called this his home. Tench Tilghman, of Talbot County, was military aide to General George Washington, and made the famous ride from Yorktown to the Congress in Philadelphia. Anna Ella Carroll, who is sometimes referred to as the secret member of President Lincoln's cabinet, is buried in the land of her birth. Two of the greatest abolitionist leaders in American history, Frederick Douglass (c. 1817–1895) and Harriet Tubman (c. 1820–1913), were born and reared here. The list goes on.

But all is not well with the Bay or its long-standing qualities of human life which have been so admired and endured over the past 4 centuries. Man has imposed many changes on the Bay and its tributaries. Baltimore and Washington, both at the headwaters, produce tons upon tons of wastes, silts, and chemicals, and each demands better maintenance of shipping channels and more space for a growing human population. The various uses of the Bay are beginning to conflict. Entire species of fish and shellfish are no longer commercially viable. Some, like oysters, remain, but at a mere 1 percent of their former abundance.

Land Use

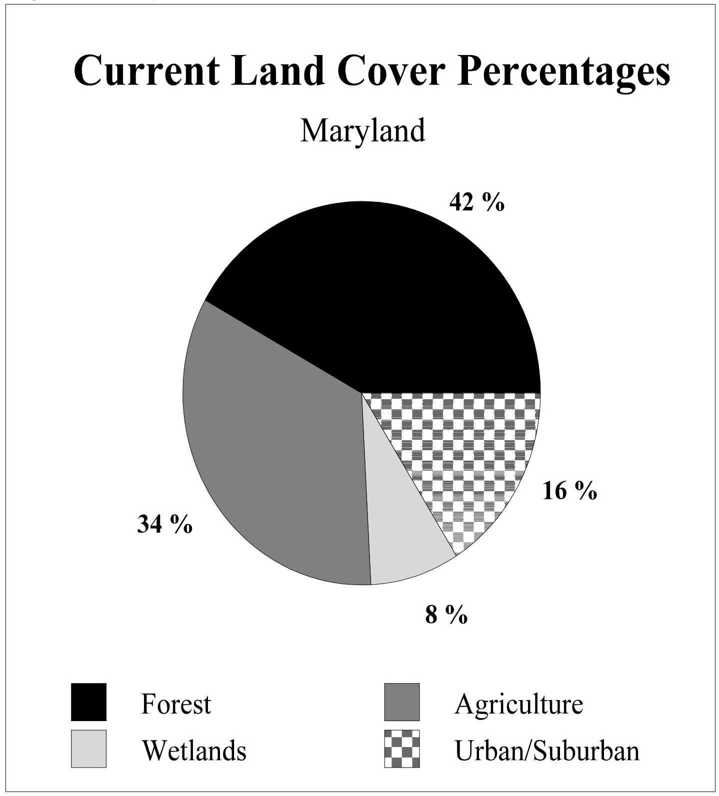
Land use is dominated by arable land agriculture and forest. In all counties, developed urban land accounts for less than 5 percent of total land use. Of all Maryland counties, Caroline County has the greatest change in land use due to development pressure. More than 6 percent of its agricultural and forest land has been converted to residential or urban use since 1973.[9] Much of the present and planned development centers around Federalsburg, along Marshyhope Creek.

Some of the most productive land in the Bay has been lost: wetlands, 60 percent gone; forests, 50 percent gone; open space, reduced by 90,000 acres annually. And the shallow areas of the Bay, which once supported vast meadows of underwater grasses, are now 90 percent barren. Maryland’s current land area is 42 percent forested, 8 percent wetlands, 34 percent farmland, and 16 percent urban. The urban area is projected to increase by 5 percent in the next 25 years.

[9]Maryland Office of Planning 1991

Just as the environment is changing, so too are the people. Each year, more and more urbanites flee the cities of the Western Shore and Northern States to find solace and a quieter life on the Eastern Shore. Just in the past 25 years, the human population in the watershed has almost doubled. New people mean new ways, more infrastructure, more schools, more shopping malls, more development. But more importantly, attitudes are changing, with a loss of ties to the land and changing demographics. The time-honored professions of the waterman, hunting guide, timberman, and farmer are being threatened, as are the resources on which they depend. Places to relax and play are increasingly in demand, and everyone wants to live on the water. Truly, those things that have made the Tidewater, Delmarva, and Eastern Shore unique are being threatened.

Figure 7. Maryland's land cover



The partners in the Chesapeake Bay Program recognize that the future of the Bay depends upon the actions of every citizen in the watershed. So too do many other local, state, and Federal organizations, including the Chesapeake Bay Foundation, which focuses on its mission, "Save the Bay." Only by promoting a broad conservation ethic throughout the fabric of community life, and fostering within all citizens a deeper understanding of their roles as trustees of their own local environments, will the health and well-being of the Bay be restored. Such is the social challenge for all residents within the watershed.

Maryland's remaining marshes, therefore, have become increasingly valuable as a public resource because the distribution and functional health of this habitat has been drastically reduced. The natural resources of Chesapeake Bay are highly valued by the public. Chesapeake Bay marshes are recognized as some of the most important wetlands in the United States, and have received global recognition as previously noted.

Loss of critical wetlands not only affects the health of the Chesapeake Bay ecosystem, but also impacts state and local economies. The natural resources of Chesapeake Bay significantly contribute to the economic well-being of Maryland, and also enhance the quality of life of Maryland's citizenry. Maryland's marshes are used for multiple purposes, including fishing, hunting, trapping, bird watching, and observing and photographing wildlife.

These marshes also serve as important spawning or nursery sites for many finfish and shellfish. Chesapeake Bay provides more than $60 million annually in commercial finfish and shellfish catches. Major tributaries of Chesapeake Bay account for about 90 percent of the striped bass spawned on the East Coast (Bergren and Lieberman 1977). Metzgar (1973) found that 44 fish species in Dorchester County used marshes for spawning, nursery, and feeding. In 1995, the catch of blue crab, Maryland's most abundant and valuable shellfish, was 40.3 million pounds valued at $29 million (Holiday and O'Bannon 1996). The Blackwater NWR and Fishing Bay estuary support one of the most important blue crab nurseries in the Chesapeake Bay.

In addition, $275 million was spent directly on recreational fishing with a total economic impact to Maryland of $524 million. More than 4,500 jobs and $31 million in state and Federal tax revenues are directly related to hunting and non-consumptive activities associated with migratory waterfowl and bird use in Maryland (Southwick Associates 1995). The overall economic benefits to Maryland from hunting waterfowl and other wildlife species dependent upon the Chesapeake marshes are estimated at more than $300 million annually (USFWS 1995). And the list goes on and on. Given all the other superlatives, why should the socioeconomic importance of the Chesapeake Bay be any different?

Environmental Assessment Study Area

What is special about the affected environment of the Refuge Complex and the EA study area? A few of its most noteworthy superlatives:

- Being internationally and nationally renowned as a showplace for the National Wildlife Refuge System

- Protecting one of the most significant areas for migratory waterfowl in Maryland

- Implementing the largest and most complex wildland fire management programs in Region 5

- Having the largest nesting population of American bald eagles north of Florida on the Atlantic Coast

- Providing habitat and protection for the largest extant population of Delmarva fox squirrels

- Helping to protect the most pristine river system in Maryland

- Protecting more than a third of all tidal wetlands in Maryland

- Being recognized by The Nature Conservancy as a “BioReserve of Critical Importance,” by The National Audubon Society as an “Important Bird Area,” and by the Contracting Parties as a “Wetland of International Importance”

- Protecting more than 200 species of rare, threatened, and endangered plants and 70 species of rare, threatened, and endangered animals (20 globally listed).

- Providing habitat and protection for anadromous and interjurisdictional fish species

- Being recognized as the center of the most productive blue crab, soft-shell crab, and peeler crab area in the world
- Contributing 12 percent of the striped bass production in Maryland waters and 10 percent of the entire Chesapeake Bay landings for this species (historically)
- Protecting two Maryland designated Wild and Scenic Rivers
- Implementing the most extensive invasive species control program in Region 5 for forest pests
- Providing wildlife dependent recreation to more than 500,000 visitors annually
- Contributing more than $15,000,000 annually to the local economy through tourism
- Being recognized as an Exceptional Recreational and Ecological System Waters (ERES)
- Having the largest and most active Friends Group in Region 5
- Providing 10 percent of income for Dorchester County residents, and 100 percent of income for Smith Island residents
- Protecting the northernmost three-square bulrush marshes
- Protecting 68 of 70 bird species identified by Region 5 as species of emphasis
- Protecting the largest brown pelican colony on Federal lands in the Chesapeake Bay
- Protecting the largest heronry in the Virginia portion of the Chesapeake Bay
- Protecting 16 percent of the remaining submerged aquatic vegetation beds in the entire Chesapeake Bay watershed
- Protecting essential fish habitat
- Protecting some of the largest contiguous mature forests, representative of mid-Atlantic Coastal Plain forest, on the Delmarva peninsula

Geographic and Physiographic Setting

The study area, for which chapter 4 identifies and analyzes potential impacts, is located in the Embayed Section of the Atlantic Coastal Plain, about 65 miles (40 km) east of the fall line marking the eastern boundary of the Piedmont Plateau (Hunt 1967).

- It begins at Susquehanna NWR, in the northern Chesapeake Bay, on Edmondson Island, at the mouth of the Susquehanna River.

- It extends south, along the Chesapeake side of the Delmarva Peninsula archipelago, from Popular and Jefferson Islands to the joining of the Choptank and Honga Rivers watersheds with the Bay.

- It includes all of the Nanticoke and Blackwater rivers watershed and the islands and waters of Tangier Sound, and continues just into northern Virginia.

Location and Size of Refuges

Within the study area lies the Refuge Complex, which now comprises three national wildlife refuges and several divisions, spread over almost 175 miles of the Chesapeake Bay in Maryland and northern Virginia.

- Blackwater NWR, approximately 23,444 acres, is situated midway on the Delmarva Peninsula in Dorchester County, Maryland, about 12 miles south of Cambridge.

- The Chesapeake Island Refuges, approximately 5,157 acres, consist of Martin NWR and the Spring Island Division, located in Somerset County, Maryland; the Barren Island and Bishops Head Divisions, in Dorchester County, Maryland; the Watts Island Division, in Accomack County, Virginia; and Susquehanna NWR, on 1-acre Battery Island at the mouth of the Susquehanna River, in the Sassafras-Elk-Northeast-Bush-Susquehanna Drainages in Cecil County, Maryland, about 2 miles offshore from Havre de Grace.

- The Nanticoke protection area, approximately 16,000 acres, is located in Dorchester, Wicomico, and Caroline Counties, Maryland.

The combined Nanticoke and Blackwater Rivers watershed comprises approximately 716,751 acres: 314,933 acres in Delaware and 401,818 acres in Maryland. Of that, 41 percent (293,493 acres) is forest, 39 percent (22,188 acres) is agricultural land, 10.6 percent (75,962 acres) is tidal and non-tidal wetlands, and 2 percent (15,063 acres) is urban or suburban development. Most of the urban or suburban development is concentrated in the small towns in the watershed, and along the main highway corridors of Routes 13 and 50.

Landforms

To understand the origin of these landforms, it is necessary to first consider the larger context of the geologic evolution of Chesapeake Bay and the Atlantic Coastal Plain. The geologic evolution of Chesapeake Bay can be divided into three sequential time periods: the Tertiary Period, the Pleistocene Epoch, and the Holocene Epoch. Each period has been studied; but fundamental questions remain, because of significant gaps in the geologic record.

The Delmarva Peninsula was formed during the upper Tertiary Period (1.8–10 million years ago) by regional uplift and emergence of the Coastal Plain along with deltaic and shallow-water marine deposition. The oldest of the major formations of this phase are the Miocene and late Miocene (5–10 million years ago) gravel sheets, which are the Brandywine, Bridgeton, and Pensauken formations (Owens and Denny 1979). These sheets were deposited by streams that transported material down to New Jersey and the Delmarva Peninsula from a source area in the vicinity of present-day Long Island. Overlying the gravel sheets are uplifted Pliocene (1.8–5 million years ago) shallow-marine formations, including the Beaverdam Sand and the Yorktown Formation (Mixon 1985; Toscano and York 1992). The top of the Tertiary sequence is an erosional surface thought to be cut by many episodes of sea-level regression (Mixon 1985; Toscano and York 1992).

Once the Delmarva Peninsula and adjacent Susquehanna River valley had been formed, the Pleistocene evolution of the system was marked by alternating periods of marine-estuarine deposition during high sea stands and fluvial down-cutting during low sea stands. Three generations of the paleo Susquehanna River channel have been revealed beneath the Chesapeake Bay and lower Delmarva Peninsula by seismic reflection profiles (Colman et al. 1990; Colman et al. 1992). The oldest paleo channel, the Exmore, is now thought to be 200,000 to 400,000 years old. The centerline of the paleo bay during the post-Exmore interglacial period went through the Honga River and the southwest corner of present-day Blackwater NWR. The center of the mouth of that paleo bay was located at Parramore Island and Wachapreague, about 50 miles (80 km) north of the present-day mouth of Chesapeake Bay. The primary depositional unit during the early Pleistocene was the Omar Formation (Toscano and York 1992).

The second paleochannel in the sequence, the Eastville, is presently thought to be 150,000 years old. In the vicinity of Blackwater NWR, the Eastville channel is broken into two main branches; the eastern branch underlies the present Honga River shoreline and westernmost Blackwater NWR. During the subsequent high stand of sea level, which lasted from about 125,000 to about 80,000 years ago, the vicinity of Blackwater NWR would have been the sandy bottom of a paleo bay. The Kent Island Formation underlying Blackwater NWR and vicinity has been dated to this time period on the basis of amino acid racemization, palynological evidence, and uranium series dating, and is thus estuarine in origin (Mixon 1985; Toscano and York 1992).

From 80,000 to 10,000 years ago, sea level was 80 to 400 feet (25 to 120 m) lower than the present level. During that period, the Cape Charles paleo channel was cut and the surface of the Kent Island Formation on the western flank of the Delmarva Peninsula was reworked by rivers and winds. Wetlands, including bogs and swamps, formed at various locations throughout this period. Peat samples from these wetlands have been dated to 13,000–30,000 years ago (Denny and Owens 1979). On parts of the central Delmarva Peninsula, wind action reworked deeply weathered exposures of Omar Formation beach and near-shore sands to form a surface cover of dunes known as the Parsonburg Sand Formation (Denny and Owens 1979). Exposed ridges of Parsonburg Sand Formation dunes are well documented on the central and eastern Delmarva Peninsula (Denny and Owens 1979; Hall 1973; Matthews and Hall 1966), but until a geomorphological reconnaissance study was completed in May 2000, they had not been identified on Blackwater NWR.

The most recent epoch, the Holocene, began 10,000 years ago. During this period, wind was responsible for transporting silt over the Delmarva Peninsula, where it formed deposits ranging between 1 to 8 feet (30 and 236 cm) in thickness (Foss et al. 1978; Markewich et al. 1986). Foss et al. (1978) found that the deposit is relatively thick near the ancestral Susquehanna River and thins toward the east, suggesting that the aeolian source was Pleistocene outwash sediments. Radiocarbon determinations indicate a post-11,000 B.P. deposition. These aeolian gray silts form a veneer across the region, and are now generally poorly drained.

Topography

Blackwater NWR.—The area is characterized by little relief, and elevations range from below mean sea level to approximately 8 feet (2.5 m) above mean sea level (AMSL). Landforms on Blackwater NWR include the local topographic highs (lowland flats) located in swamps such as Parsons Creek Neck, Green Brier Swamp, Kentuck Swamp, and Buttons Neck, and a few wooded islands. These swamps have very poor drainage and are thus flooded for part of the year and dry part of the year, in accordance with rainfall seasonality.

Northern tributaries of the Blackwater River, such as Little Blackwater, Buttons Creek, and the unnamed drainage between Peters and Buttons Necks, have broad, low relief wetland swamps. Some of the areas where the swamps border Blackwater River and its tributaries (fluvial banks) have been converted for agriculture and refuge management uses. The Blackwater River floodplain has been inundated by relative sea-level rise and filled with fluvial and estuarine sediment as well as organic peat-yielding tidal marsh. Tidal flats and marsh line the shore of the Blackwater River. A few forested (and deforested) islands such as McGraw Island exist in the tidal marsh.

Chesapeake Island Refuges.—The Island Refuges and Divisions are predominately flat and featureless, with average elevations of 2 feet AMSL, and a maximum elevation of 5 feet AMSL. High ground is limited, but crucial for shrub- and tree-nesting colonial water birds and bald eagles.

Nanticoke Protection Area.—The topography of the proposed protection area is characterized by slight and very localized relief, most of which exists along the middle section of the basin where short but steep slopes are evident immediately adjacent to the river. Elevations range from 62 feet AMSL in the basin's upper reaches, to sea level or below at the intertidal areas at the mouth. The southern end of the Nanticoke watershed is extremely low lying and marshy, with a broken and embayed shoreline.

Lithic Resources

Chert and quartz cobbles have moved down the Susquehanna River valley after being deposited at terminal moraines during glaciation. Local areas where this material is exposed or close to the surface include near Federalsburg in Dorchester County (approximately 25 miles [15 km] northeast of Blackwater NWR); west of Cambridge, Maryland (approximately 7 miles [4 km] north of the main body of Blackwater NWR); the mouth of the Nanticoke River (approximately 15 miles [9 km] southeast of the main body of Blackwater NWR), and near the towns of Upper Fairmont, Westover, and Princess Anne in Somerset County (approximately 35 miles [21 km] southeast of the main body of Blackwater NWR) (Hughes 1980). Other sources of chert, jasper, rhyolite, and quartzite were available to the inhabitants of the Eastern Shore through trade from southern Delaware, New Jersey, and southeastern Pennsylvania. High quality lithic material such as "Iron Hill Jasper" can be found in outcrops near the ancestral Susquehanna River in New Castle County, Delaware (Custer and Gallaso 1980:2).

Soils

Soils are important in identifying environmentally sensitive and compatible future land uses. We will discuss soil data for each of the three units of the study area: Blackwater NWR, the Chesapeake Island Refuges, and the Nanticoke protection area.

Blackwater NWR .—Soils data for Blackwater and its surrounding focus area included in the approved Preliminary Project Plan for additional land acquisition are compiled in a survey of Dorchester County by Brewer (1995), a recent update of an earlier report (Anonymous 1963). Soil associations in these areas include Elkton-Othello and Tidal marsh, with the latter type encompassing a majority of the current refuge. The Elkton-Othello association is described as "moderately fine textured to medium-textured soils that are dominantly poorly drained."[10]

Tidal marsh designates areas subject to flooding by salt water. A total of 11 major soil types are present in the survey area. The table below presents these soil types, their slope, and permeability. The most prevalent are the Bestpitch and Transquaking series, found on estuarine tidal marshes; Elkton series, found on lowland flats and small depressions; Honga peat, found on brackish submerged upland marshes along tidally influenced bays; Othello series, found on lowland flats; and Sunken mucky silt loam, found on lowland flats (Brewer 1995). The better drained soils on the refuge occur only in small, isolated areas. These include Matapeake and Mattapex series, both found on the edges of lowland flats, or the fluvial banks.

Table 3. Blackwater NWR soil types

Soil Type	Permeability	Acres	Percent of Total
Bestpitch and Transquaking (BT)	Very poorly drained	5,165.73	22.03
Elkton silt loam (Em)	Poorly drained	2,367.25	10.10
Elkton mucky silt loam (Ep)	Poorly drained	1,727.70	7.37
Honga peat (Hg)	Very poorly drained	1,764.64	7.52
Matapeake silt loam , wet (MkA)	Well drained	23.63	0.10
Mattapex silt loam (MsA)	Moderately well drained	204.78	0.87
Mattapex silt loam (MsB)	Moderately well drained	26.67	0.11
Othello silt loam (Oh)	Poorly drained	1,477.14	6.30
Othello and Kentuck soils (Ok)	Poorly drained	2,009.32	8.57
Sunken Mucky silt loam (Su)	Very poorly drained	2,671.80	11.40
Other Minor Inclusions	N.A.	18.21	0.08
Water	N.A.	5,987.06	25.54
Totals		**23,443.93**	**100.00**

Bestpitch and Transquaking soils formed in moderately decomposed organic deposits from salt tolerant herbaceous plants that overlie clayey mineral estuarine sediments (Brewer 1995:26). Bestpitch and Transquaking soils have a thick, highly organic

[10] Anonymous 1963: General Soil Map

surface layer; in the Transquaking series this can be up to 51 inches (130 cm) thick. On the refuge this soil type is found on the tidal marshes along Blackwater River. Elkton soils formed in aeolian silt deposits overlying sandy fluvio-marine sediments (Brewer 1995:32). On the refuge this soil type is found on most of Parsons Creek Neck, on most of Buttons Neck, on a large area in the center of Green Brier Swamp, and surrounding the Othello and Kentuck soils on Gum Swamp. Honga soils formed in moderately decomposed organic deposits from salt tolerant herbaceous plants overlying silty mineral sediments (Brewer 1995:47). Honga soils have a thick organic surface layer (approximately 22 inches [56 cm]). This soil type is found on large areas adjacent to Parsons Creek, and along most of the tidal marshes of Blackwater River.

Marsh deposits on Blackwater NWR began about 3,800 years ago. Many deposits are almost 4 meters thick in the oldest areas of the marsh, but average deposits are between 2 and 3 meters thick. Most of the material is loose, organic muck. The Blackwater and Little Blackwater Rivers are the major sources of inorganic sediments for most of the marshes on the refuge, with occasional storm deposition from Fishing Bay being important for marshes in the southeastern part of the refuge. The emergent marsh is noticeably being replaced by open water through erosion, subsidence, sea-level rise, increasing salinities, and eat-outs from muskrats, nutria, and geese. In the last 100 years, effective sea-level rise (land subsidence added to sea-level rise) has been 12 inches in the Chesapeake Bay area (Leatherman et al. 1995).

Matapeake, Mattapex, Othello, Kentuck, and Sunken soils all formed in loess (silty) deposits overlying sandy fluvio-marine sediments (Brewer 1995:56, 58, 62). On Blackwater, Matapeake soil is found on the banks of Buttons Creek and Little Blackwater River. Mattapex soils are found on the banks of Buttons Creek and Little Blackwater River, and on an island between Wolfpit Marsh and Goose Pond (Middle Ridge). Othello soils are found on the bank of the unnamed tributary to Corsey Creek and on most of Kentuck Swamp. Kentuck soils are found always in combination with Othello soils, and are on the more elevated area above the unnamed tributary to Corsey Creek, on Kentuck Swamp, on most of Green Brier Swamp, on Dragon Swamp, and on small areas of Gum Swamp. Sunken soils are found in large areas surrounding the Honga peat along Parsons Creek, Corsey Creek, and Blackwater River, and on all of McGraw Island.

Metapeake silt loam, mattapex silt loam, and othello silt loam are considered prime farmland. These soil types are found primarily on Hog Range and in the existing farm field along Key Wallace Drive. The U.S. Department of Agriculture recognizes that responsible levels of government should encourage and facilitate the wise use of our Nation’s prime farmland because of the importance in meeting the Nation’s short- and long-range needs for food and fiber. Elkton loam and elkton silt loam are also very good soil types for farmland if properly drained.

Prior converted (PC) wetland soils, i.e., Class 3 soils, are primarily the wetter Elkton and Othello series. PC wetlands having these soil types can be readily converted to freshwater impoundment systems and forested wetlands. The potential productivity is moderately high for loblolly pine and some hardwood trees (swamp chestnut oak, willow oak, and water oak) on the Elkton and Othello soils. Engineering, recreational, and facility development properties of these soils is found in the Soil Survey Update for Dorchester County.

Chesapeake Island Refuges.— Honga soils are found along the low shorelines of Barren Island, on almost the entire Bishops Head Division, and on all of Spring Island. Matapeake soils are found on central Barren Island and the interior of southern Barren Island, reconfirming the importance of Barren Island as an agricultural community in the 18th and early 19th centuries. Sunken soils are found on some elevated portions of Barren Island, and in small, isolated places on the Bishops Head Division. The Natural Resources Conservation Service has not mapped the soils on Battery Island, due to its small size. The Natural Resources Conservation Service has not mapped the soils on Battery Island, due to its small size.

Nanticoke Protection Area .—The associated Nanticoke watershed is underlain by a seaward-dipping wedge of unconsolidated and semi-consolidated sediments ranging in age from Jurassic to Holocene. Overlying the older deposits is a series of gravels with minor amounts of sandy and silty materials that form steps or terraces in the coastal plain. Two of these terraces form the bulk of the watershed. The Wicomico terrace is found at elevations between 45 and 90 feet above sea level in the upper watershed, while the Talbot terrace forms the lower lands from 10 to 45 feet above sea level.

The upper Nanticoke watershed has mostly well drained soils with some areas of excessively drained sandy soils. Some of the areas of sandy soil are of limited use for agriculture due to drought and low fertility. Agricultural land use includes farm yards, orchards, pasture and cropland. Row-cropped corn and soybeans are planted extensively for use as feed for poultry, which is one of the largest components of the agricultural economy. Most of the lower watershed's soils are poorly drained with large areas of swamp and marsh that are subject to tidal flooding, except for some large areas of very sandy soils in Wicomico County. Poor drainage limits the agricultural value of soils and drainage ditches have been constructed and maintained to drain the area.

Within the Wicomico County portion of the Preliminary Project Proposal focus area, there are four major soil types: Tidal Marsh, Muck, Plummer loamy sand, and Klej loamy sand. Tidal Marsh occupies about 7 percent of Wicomico County, and most of the tidal marsh in the county is found along the Nanticoke within the protection area, principally south of Maryland Route 50. This series is obviously unsuited for agriculture and forestry.

Muck consists of very poorly drained to ponded, extremely acid, organic soils that lie along the upper Nanticoke above Route 50. In most places, they are forested with a mixture of sweet gums, black gums, and red maples, and are also unsuited for agriculture.

The Plummer series consists of level or nearly level, deep, sandy soils that are poorly drained. These soils formed in sandy marine sediments or very old alluvium. The surface layer of these soils has been darkened by organic matter, and the underlying sand contains mottles, which indicate that air is lacking for long periods each year when the soil is wet. Where the soils are wooded, the native trees are wetland hardwoods and conifers, including red maple, gums, holly, and loblolly and pond pines. In areas that are reforested following clear cutting, loblolly pine grows in nearly pure stands. Because of the wet nature of the Plummer soils and their high water table, there is little agriculture. Ponding is not uncommon during the winter months and early spring. These soils are naturally acid and low in fertility, and primarily suited to maintaining forests.

The Klej series soils are deep, level to gently sloping, coarse textured soils that are somewhat poorly drained or moderately well drained. These soils lie on upland flats and in similar areas where they formed in sandy marine sediments or very old alluvial sediments, commonly underlain by finer textured material. The native vegetation consists of mixed oaks, sweetgum, maple, holly, and some loblolly pine. Most of the series in the focus area is forested. Like Plummer soils, they have seasonally high water tables, but they can be drained by either tile or open ditches. These soils are also naturally acid, and lime and fertilizer are needed if crops are to be grown successfully. Maintaining productivity is very difficult.

Almost every soil type found within Dorchester County exists on that portion of the Preliminary Project Proposal focus area located in Dorchester County. It is particularly interesting to note the large diversity of soil types found at the confluence of the Marshy Hope and Nanticoke Rivers.

Refuge Complex soils	Polygon count	Hectares	Acres
Barren Island			
ELKTON SILT LOAM	1.0	1.4	3.4
HONGA PEAT	14.0	27.9	69.0
MATTAPEX SILT LOAM, 0- TO 2-PERCENT SLOPES	4.0	1.9	4.8
MATTAPEX SILT LOAM, 2- TO 5-PERCENT SLOPES	8.0	16.9	41.7
SUNKEN MUCKY SILT LOAM	7.0	11.6	28.7
UDORTHENTS	1.0	3.4	8.4
Unit totals	35.0	63.1	155.9
Honga Focus Area			
BEACHES	12.0	8.2	20.3
BESTPITCH AND TRANSQUAKING SOILS	17.0	18.1	44.6
CHICONE MUCKY SILT LOAM	3.0	35.6	87.9
DOWNER SANDY LOAM, 0- TO 2-PERCENT SLOPES	2.0	4.9	12.2
DOWNER SANDY LOAM, 2- TO 5-PERCENT SLOPES	2.0	5.1	12.6
ELKTON MUCKY SILT LOAM, VERY WET	65.0	1,989.6	4,916.4
ELKTON SILT LOAM	98.0	2,656.7	6,564.6
GALESTOWN LOAMY SAND, 2- TO 5-PERCENT SLOPES	3.0	5.3	13.1
HAMBROOK LOAM, 2- TO 5-PERCENT SLOPES	1.0	2.2	5.5
HONGA PEAT	159.0	5,627.4	13,905.4
INGLESIDE SANDY LOAM, 0- TO 2-PERCENT SLOPES	1.0	13.9	34.4
INGLESIDE SANDY LOAM, 2- TO 5-PERCENT SLOPES	1.0	1.2	2.9
KEYPORT SILT LOAM	46.0	189.6	468.5
KLEJ-HAMMONTON COMPLEX	2.0	15.4	38.0
MATAPEAKE SILT LOAM, WET SUBSTRATUM, 0% TO 2%	13.0	48.0	118.6
MATAPEAKE SILT LOAM, WET SUBSTRATUM, 2% TO 5%	6.0	13.1	32.5
MATTAPEX FINE SANDY LOAM, 0- TO 2-PERCENT SLOPES	1.0	3.1	7.5
MATTAPEX SILT LOAM, 0- TO 2-PERCENT SLOPES	70.0	385.1	951.5
MATTAPEX SILT LOAM, 2- TO 5-PERCENT SLOPES	29.0	67.0	165.5
OTHELLO AND KENTUCK SOILS	95.0	1,713.6	4,234.2
OTHELLO SILT LOAM	58.0	1,339.9	3,311.0
PUCKUM MUCK	3.0	21.6	53.3
SUNKEN MUCKY SILT LOAM	242.0	2,128.9	5,260.6
UDORTHENTS	3.0	13.4	33.2
WATER	737.0	741.7	1,832.7
WOODSTOWN LOAM, 0- TO 2-PERCENT SLOPES	1.0	1.8	4.4
Unit totals	1,670.0	17,050.4	42,131.6

Refuge Complex soils	Polygon count	Hectares	Acres
Bishop's Head and Spring Island			
HONGA PEAT	8.0	236.0	583.0
SUNKEN MUCKY SILT LOAM	9.0	18.6	46.0
WATER	75.0	5.1	12.6
Unit totals	92.0	259.7	641.6
Blackwater NWR			
BESTPITCH AND TRANSQUAKING SOILS	52.0	1,968.1	4863.2
ELKTON MUCKY SILT LOAM, VERY WET	23.0	630.5	1,557.9
ELKTON SILT LOAM	50.0	888.1	2,194.6
GALESTOWN LOAMY SAND, 0- TO 2-PERCENT SLOPES	1.0	5.1	12.7
HONGA PEAT	60.0	676.8	1,672.4
KEYPORT SILT LOAM	2.0	7.4	18.3
MATAPEAKE SILT LOAM, WET SUBSTRATUM, 0% TO 2%	1.0	0.2	0.6
MATTAPEX SILT LOAM, 0- TO 2-PERCENT SLOPES	11.0	54.6	135.0
MATTAPEX SILT LOAM, 2- TO 5-PERCENT SLOPES	1.0	0.9	2.2
OTHELLO AND KENTUCK SOILS	47.0	784.1	1,937.5
OTHELLO SILT LOAM	27.0	556.4	1,374.8
SUNKEN MUCKY SILT LOAM	73.0	1,055.1	2,607.1
UDORTHENTS	1.0	0.9	2.2
WATER	292.0	2,416.4	5,971.0
Unit totals	641.0	9,044.7	17,486.2

Source: Soil Survey Geographic (SSURGO) Data Base, Dorchester County,USDA, NRCS. SURRGO soils data are not yet available for Somerset and Wicomico Counties

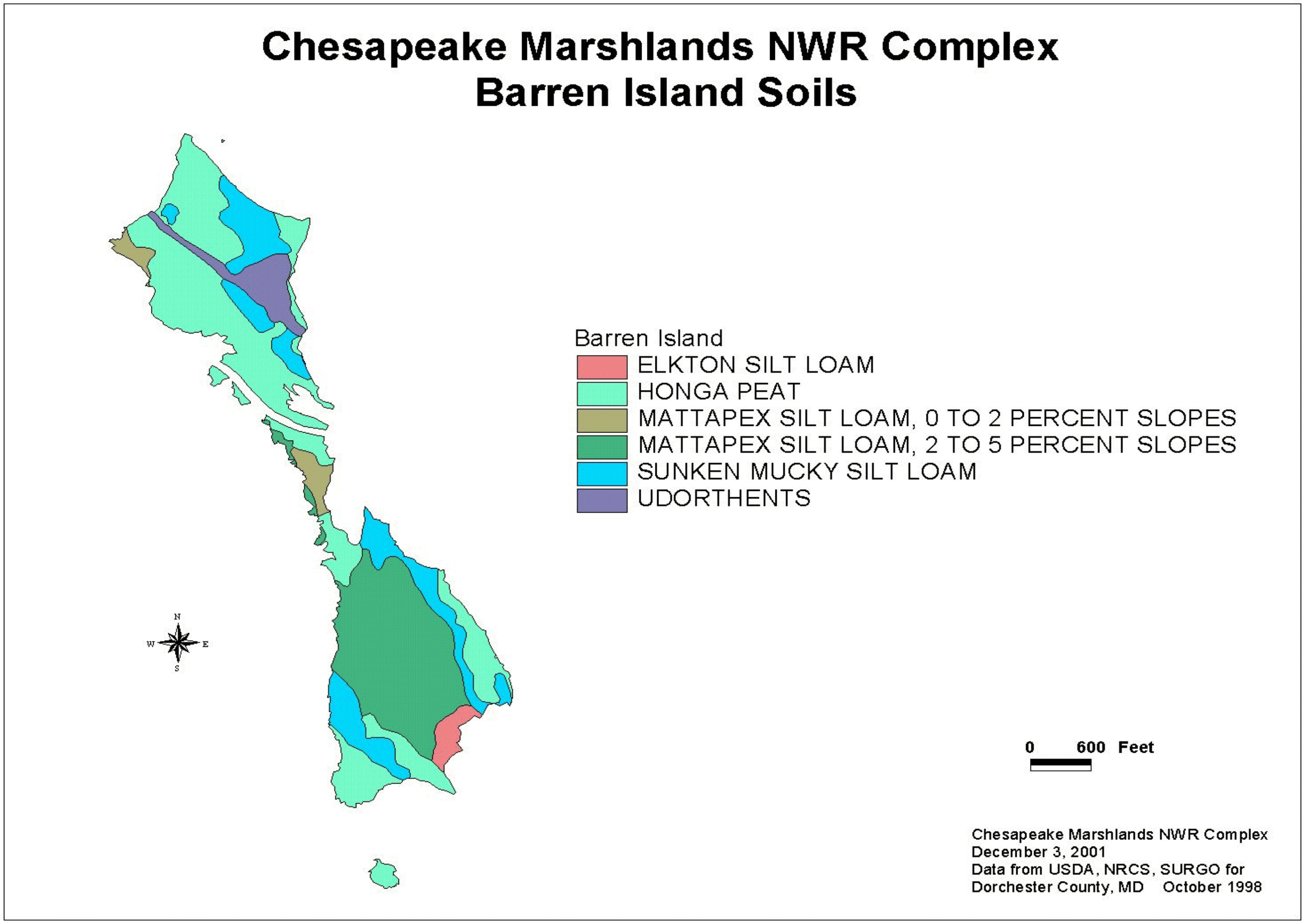


Figure 8. Barren Island Soils (color plate)

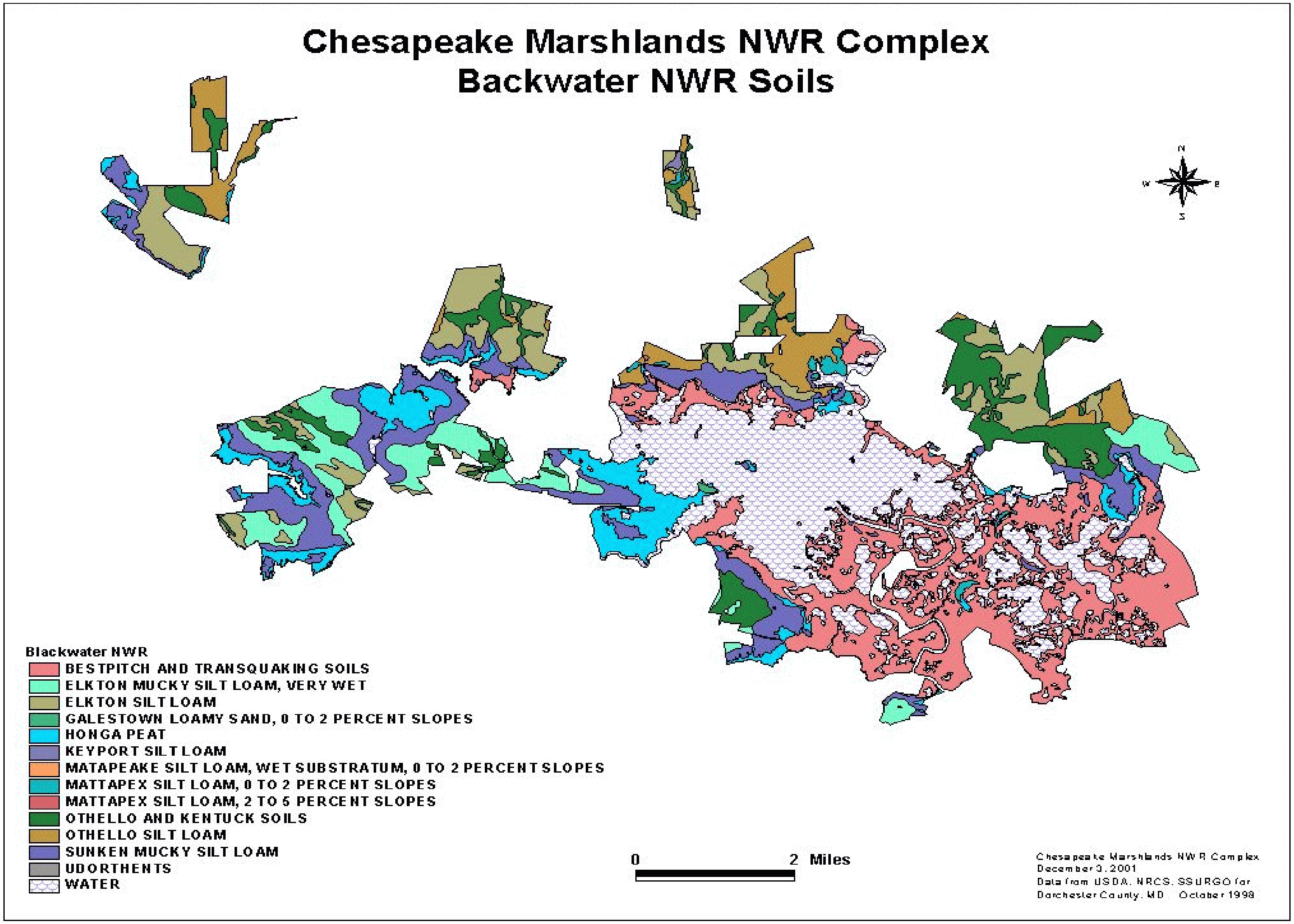


Figure 9. Blackwater NWR Soils (color plate)

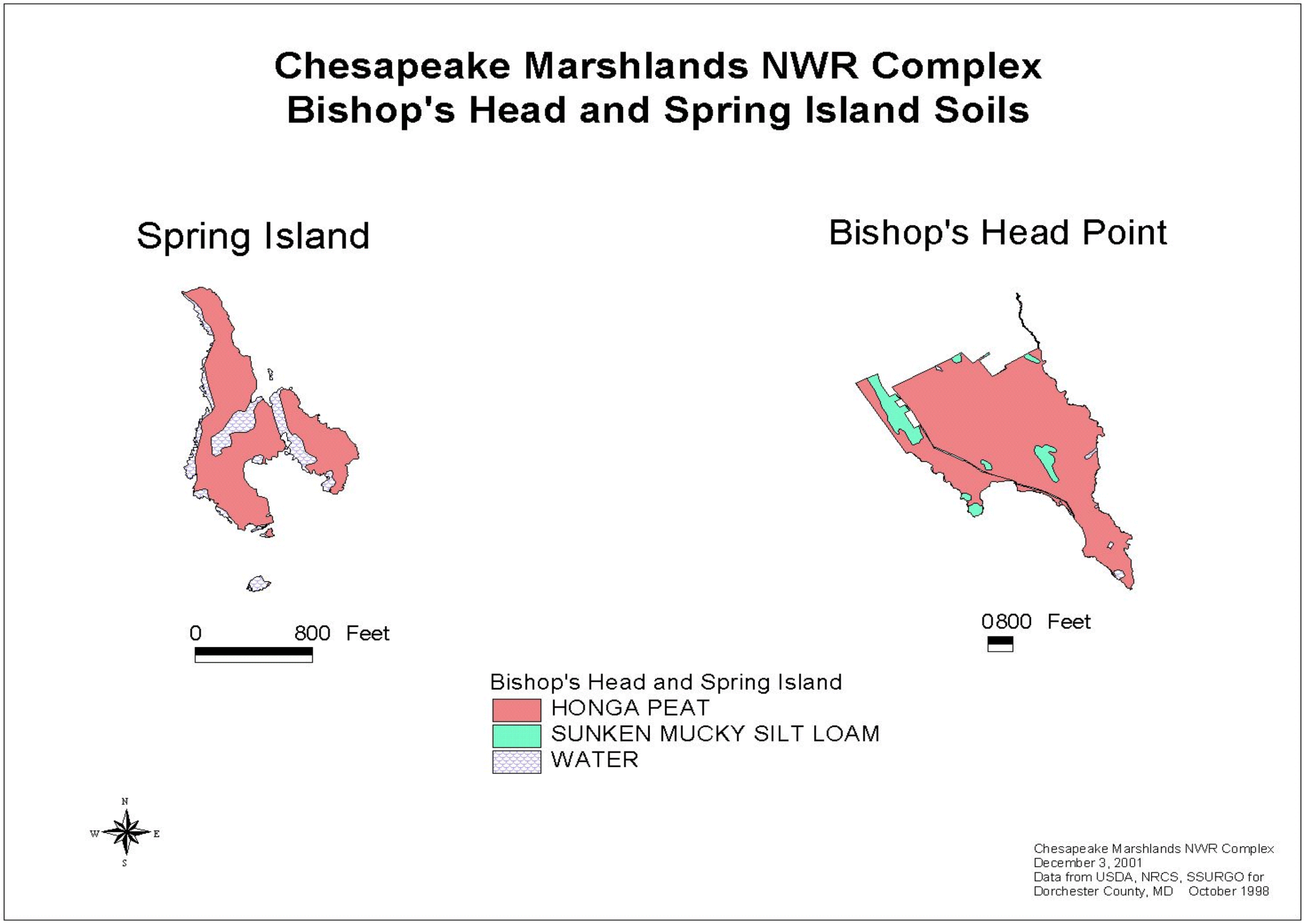


Figure 10. Bishop’s Head and Spring Island Soils (color plate)

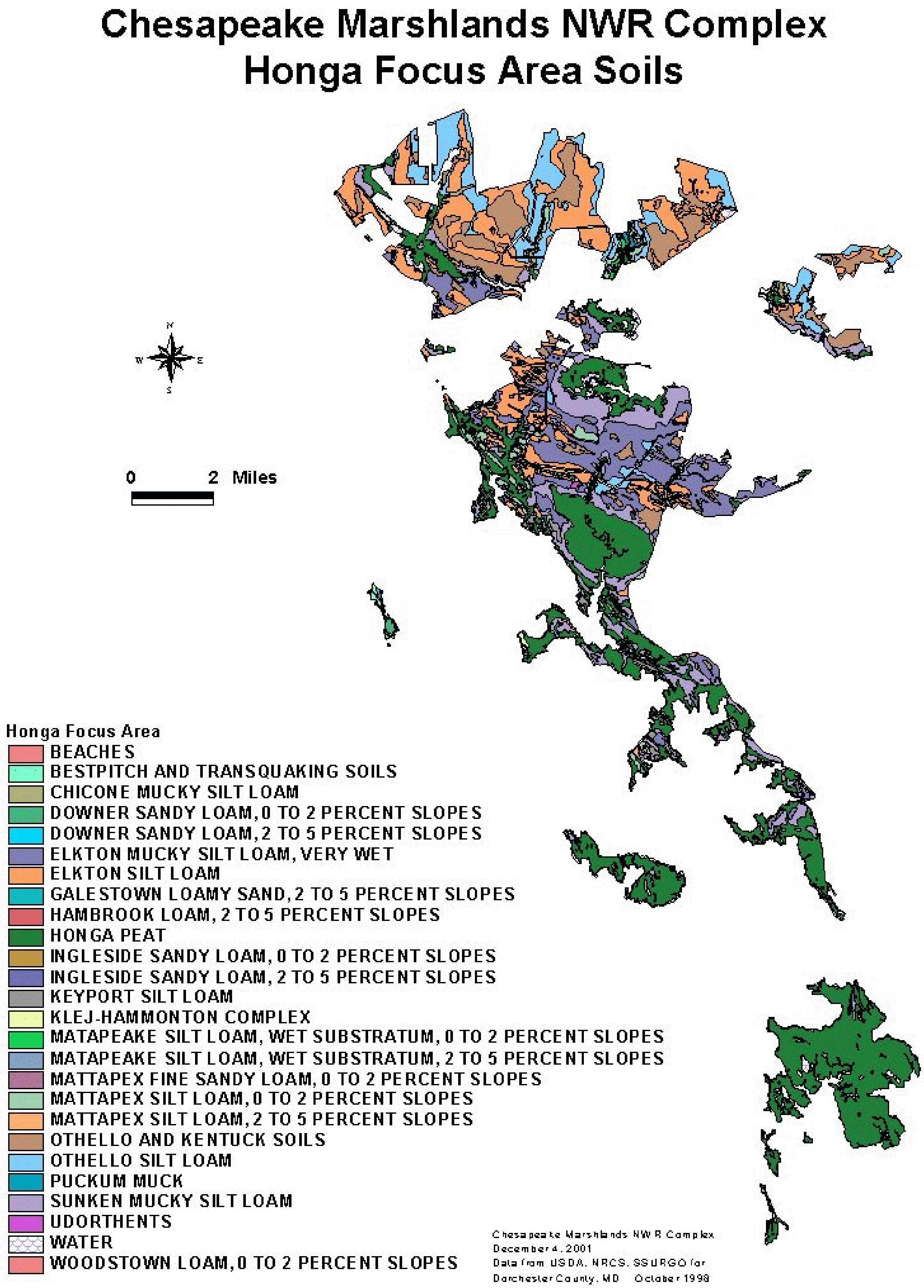


Figure 11. Honga Focus Area Soils (color plate)

Water Resources and Hydrology

Unconsolidated sediments underlie the Coastal Plain, including all of the estuarine wetlands. The area derives its groundwater recharge mainly through infiltration of precipitation. Discharge occurs through seepage to streams, estuaries, and the ocean. Coastal wetlands are in these discharge zones. These wetlands have complex hydrology, in which stream flow, groundwater flow, and tidal flow all play a part. Forested wetlands occur along the stream channels, and are sustained by local and regional groundwater flow and flooding during storms. The poorly drained interior of the Delmarva Peninsula has a system of depressional palustrine wetlands, narrow bands of palustrine wetlands along rivers and ditches that drain from inland to the coasts.

Susquehanna NWR.—The small, 1.5-acre Edmondson Island (Battery Island/Shad Battery) is surrounded by the waters of the upper Chesapeake Bay. The island and surrounding ‘flats’ are influenced greatly by the Susquehanna River. Surface water is derived from local precipitation.

Blackwater NWR.—The main section of the refuge is drained by the Blackwater River, which empties into Fishing Bay to the southeast, a large shallow embayment at the north end of Tangier Sound. Major tributaries of the Blackwater River include Buttons Creek, Little Blackwater River, and Backgarden Creek on the north flank, and Meekins Creek, Coles Creek, and Raccoon Creek on the south flank.

The upper two-thirds of the Blackwater River is separated from the lower third by Maple Dam Road, which is a substantial barrier for water, sediment, and chemical transport. Maple Dam Road, also called Shorters Wharf Road, runs north and south along the west side of Green Brier Swamp and then through the marshes for approximately 6.1 miles (10 km) with no culverts. The road was first established in the early 1900's, and sometime before World War II was built up with oyster shells and dredge spoil (Pendleton and Stevenson 1983:143). The north and south ends of Maple Dam Road are first depicted on Martenet’s 1865 map, but are separated by Keenes Ditch. A 1934 map shows the north end of the road, from Cambridge to a point directly east of Church Creek, as an improved county connecting road; the section that continues to Shorters Wharf is shown as a state road; and the section from Shorters Wharf to Lakesville was an unimproved county connecting road (Hoen & Co. 1934). The road was paved and raised several times, and Pendleton and Stevenson (1983:145) reported that in the mid-1960's the road was at an elevation where it was no longer flooded on a regular basis. However, the road currently continues to flood during most spring tides at several places from Wolfpit Marsh to the Blackwater River bridge at Robbins.

Historically, Blackwater River and Parsons Creek were not connected. According to the cartographic evidence, sometime between 1850 and 1865 Parsons Creek was channelized to accommodate the removal of timber (Cowperthwait 1850; Martenet 1865). An 1850 map does not depict a channel extending off of Parsons Creek. The next map of this area found during a recent archaeological and geomorphological reconnaissance (USFWS Contract No. 50181-7-C062) is the 1865 map by Martenet, which shows “Stewart’s” Canal connecting Parsons Creek and Big Blackwater. Sometime between 1865 and 1877 another canal or ditch was excavated to facilitate boat travel following Corsey Creek up to Tobacco Stick Bay, now Madison Bay. After this point, only the marshes between the headwaters of Blackwater River and Parsons Creek provided a filter protecting Blackwater River from the influx of salt water from the Little Choptank River. Marsh loss, caused by excessive herbivory by nutria and accompanying salt water intrusion, has recently allowed a connection between Parsons Creek and the head of Blackwater River, so the river is now tidally influenced from both ends. This breach was first noticed in 1989.

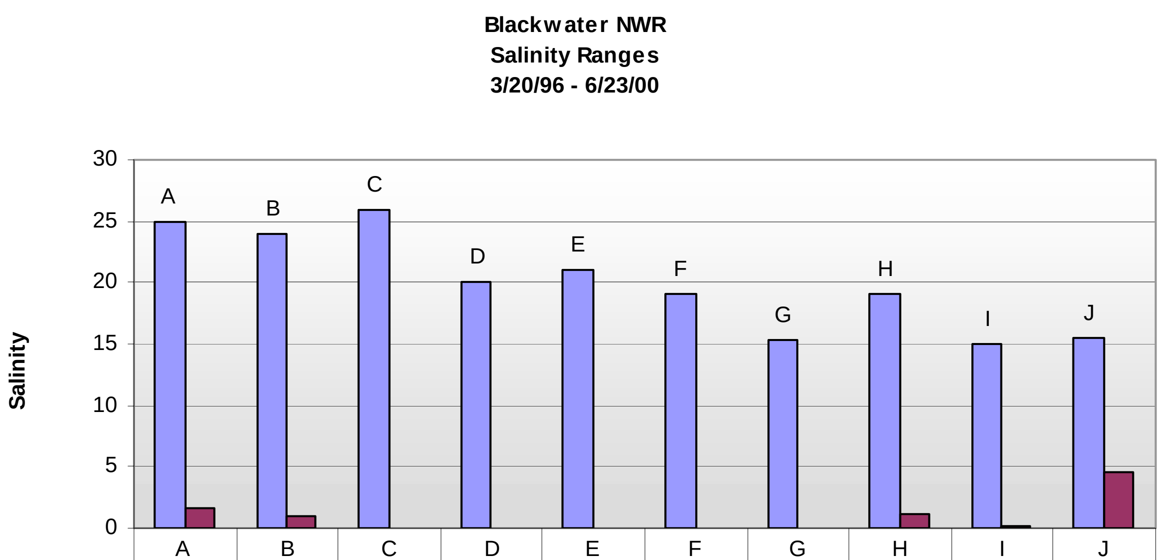
The tides are asynchronous at the opposite ends of Blackwater River. A 4-hour tidal delay between the two connections to the Bay creates a pumping action that increases the salinity of the Blackwater River channels and swamps. According to salinity tests performed by the refuge staff, the freshest water is consistently found near the mouth of Buttons Creek (Glenn Carowan, personal communication 1997). A study conducted in June 1931 found that most of Blackwater River was brackish, but that salinity decreased to the northwest in the vicinity of Little Blackwater River (Uhler and Nelson 1931).

Salinity monitoring during the Pendleton and Stevenson (1983:74) study indicated that salinity rates fluctuate seasonally. During a winter with high freshwater runoff, the entire river system within the refuge was essentially fresh. Salinity trends are also associated with climatic episodes, particularly storm surges and runoff fluctuations. Storm tides can flood refuge wetland areas with saltwater, which results in salt-saturated soils and tree mortality. Severe drought conditions, like those that occurred in 1997 and 1999, can also cause severe tree mortality, particularly in the transitional zones where forests meet marshlands.

The figure below indicates salinity trends at locations on Blackwater NWR. The salinity data from 1944–1946 were derived from chlorosity (g Cl- / L) using this formula: Salinity = 0.07 + (1.805 * chlorosity).

Legend

A Stewart's Canal	B Smithville Road
C Headwaters–Blackwater R.	D Footbridge–Blackwater R.
E. Buttons Creek	F Route 335–Blackwater R.
G Little Blackwater R.	H Shorters Wharf
I Bestpitch Ferry	J Fishing Bay



	A	B	C	D	E	F	G	H	I	J
Maximum	25.0	24.0	26.0	20.0	21.0	19.0	15.3	19.0	15.0	15.5
Minimum	1.7	1.0	0.0	0.0	0.0	0.0	0.0	1.1	0.1	4.5

Station

Figure 12. Blackwater NWR salinity ranges A–J

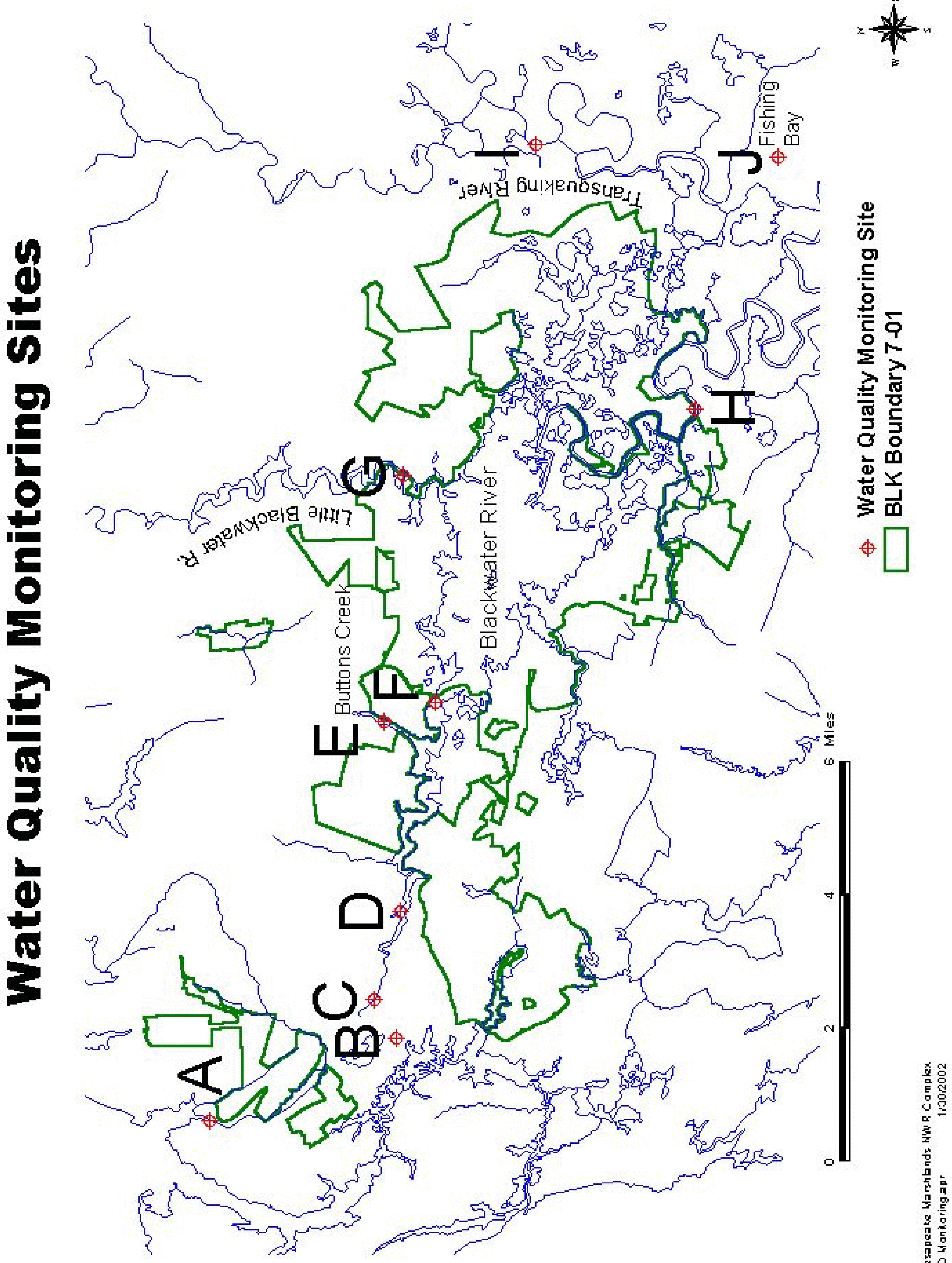


Figure 13. Water quality monitoring sites (color plate)

The figures below indicate salinity trends at two locations on Blackwater NWR. The salinity data from 1944–1946 were derived from chlorosity (g Cl- / L) using this formula: Salinity = 0.07 + (1.805 * chlorosity).

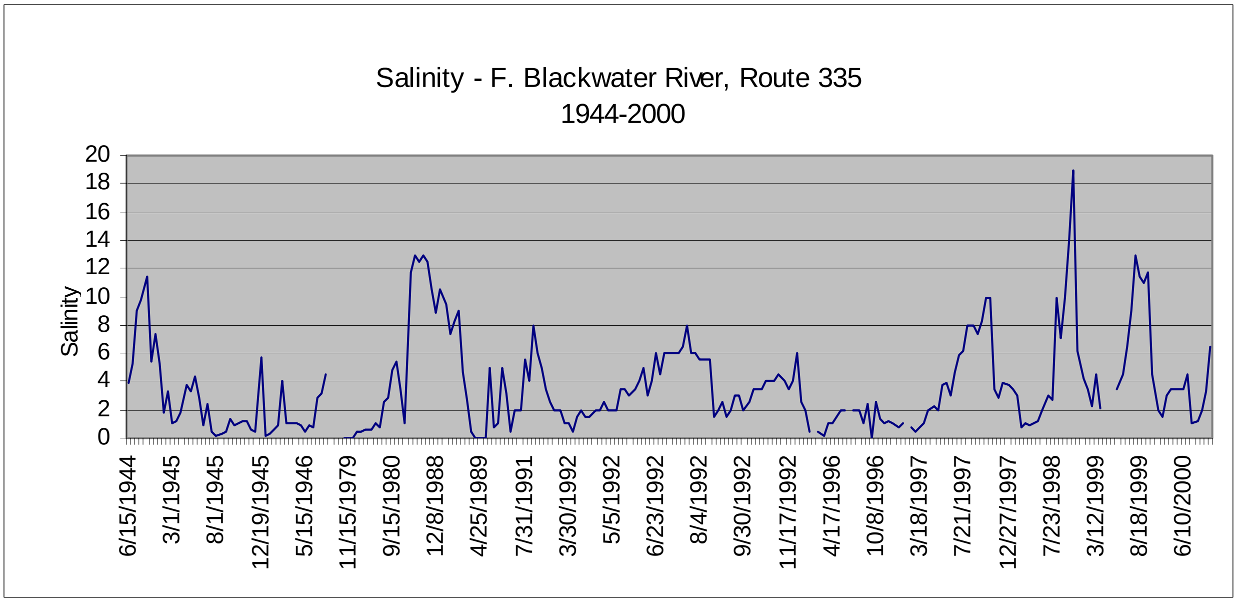


Figure 14. Salinity at Route 335

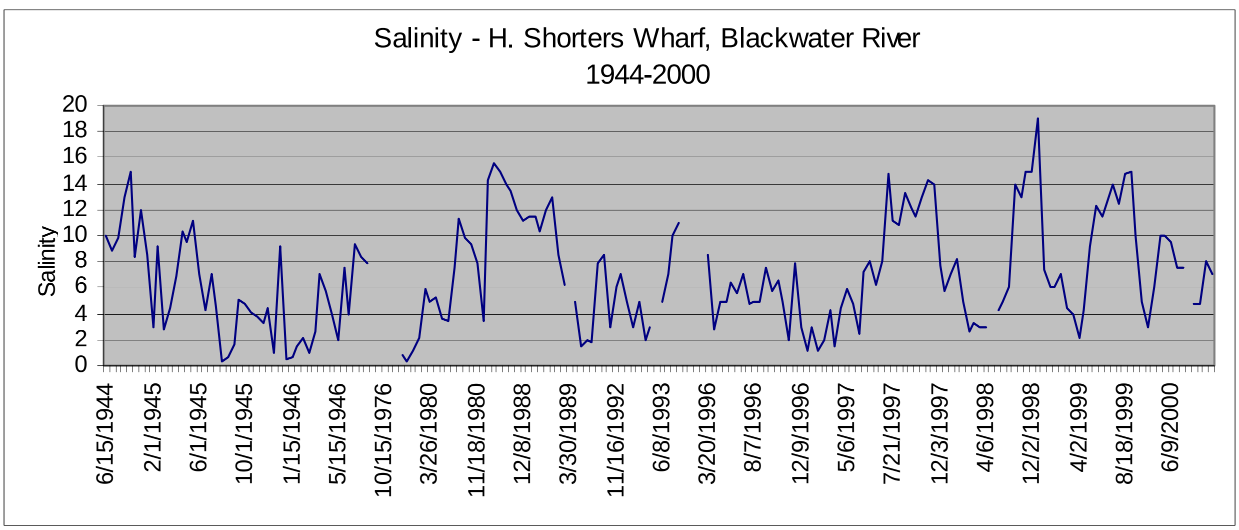


Figure 15. Salinity at Shorter's Wharf

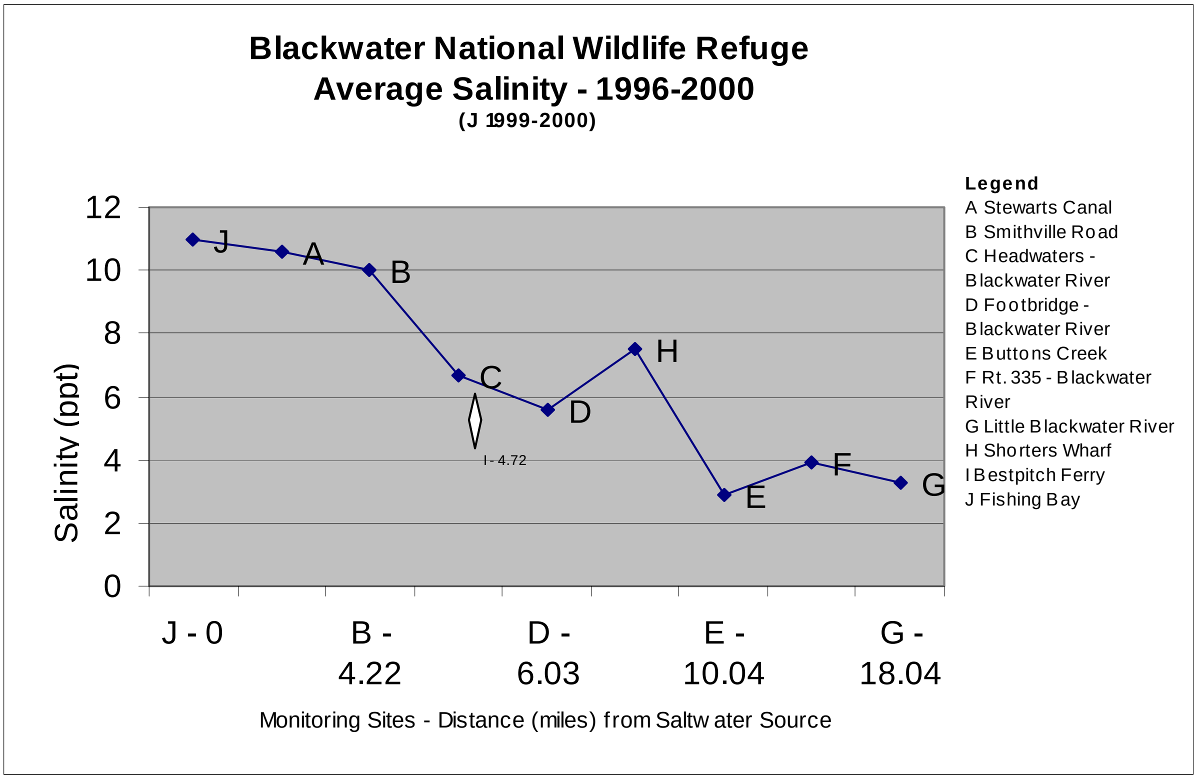


Figure 16. Average salinity (Blackwater NWR)

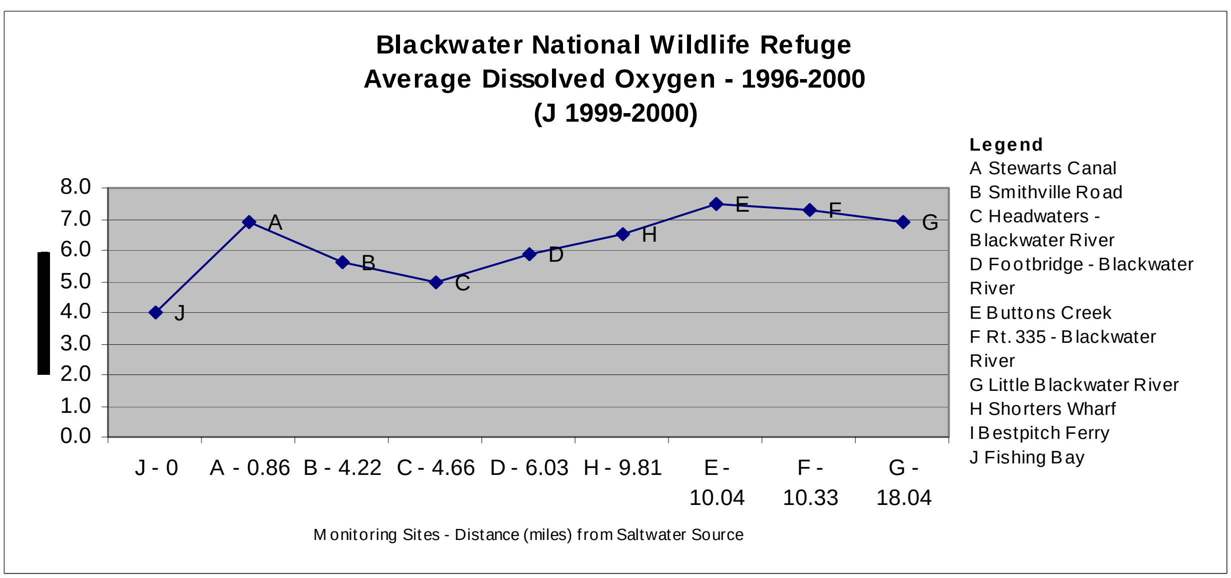


Figure 17. Average dissolved oxygen (Blackwater NWR)

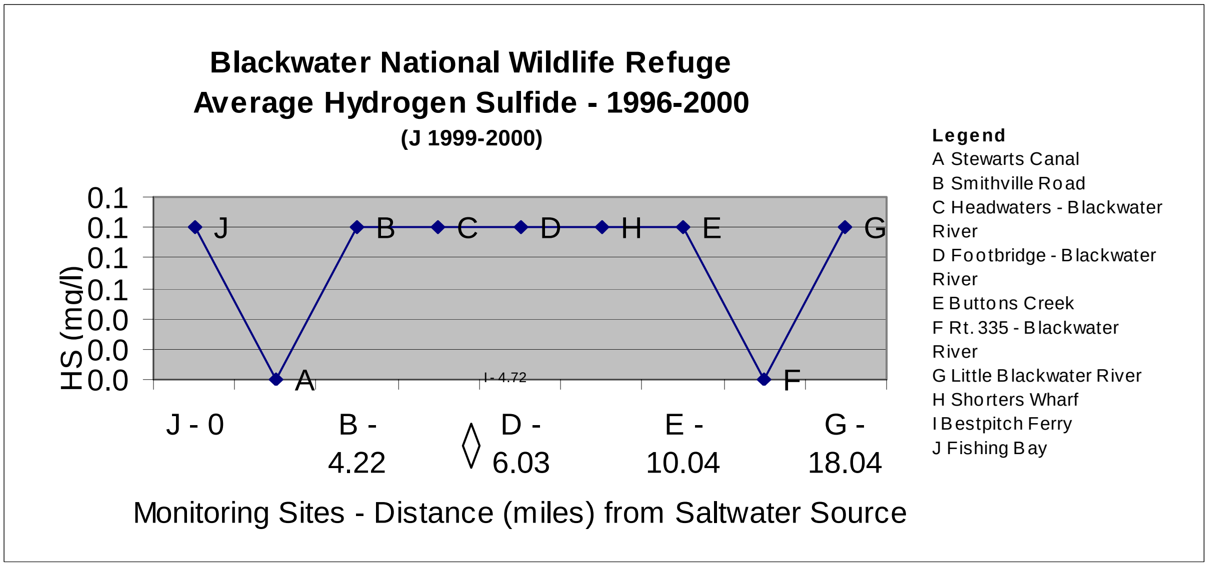


Figure 18. Average hydrogen sulfide (Blackwater NWR)

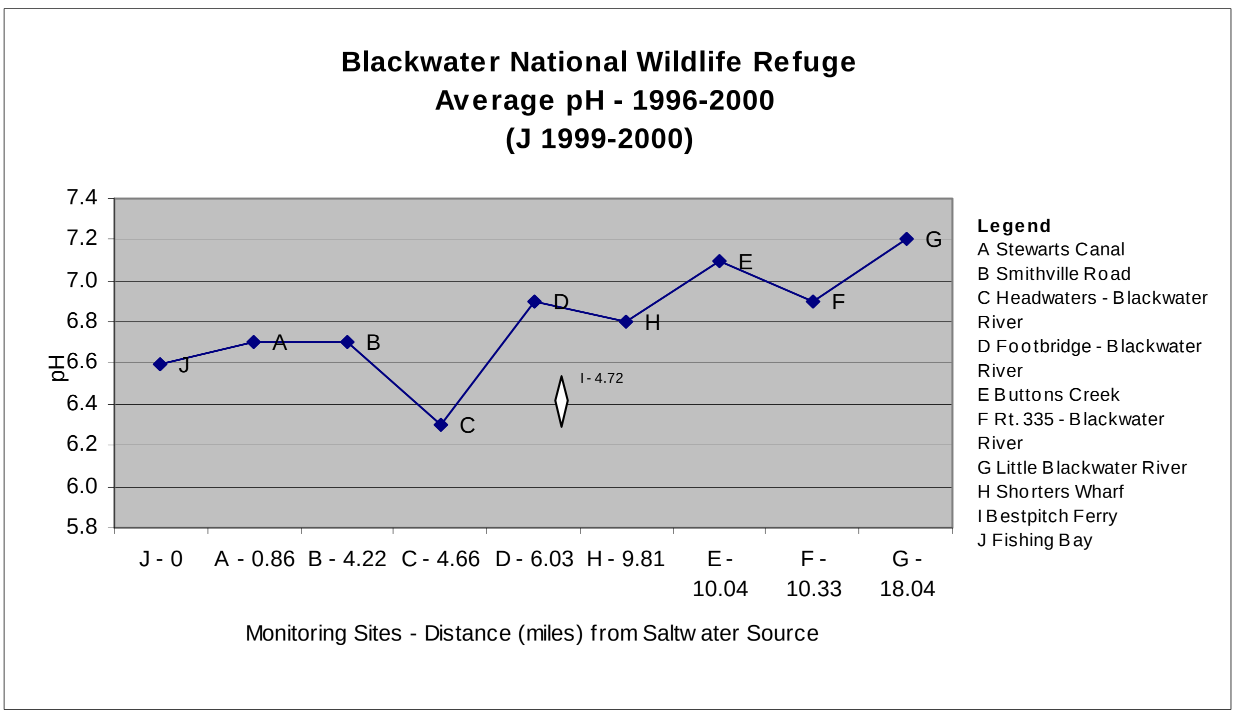


Figure 19. Average pH (Blackwater NWR)

Blackwater NWR Impoundments

Surface water on the refuge derives primarily from local precipitation. Blackwater NWR has a relatively large and efficient watershed, and receives substantial runoff from Green Brier, Kentuck, Gum, and Moneystump Swamps. Refuge impoundments are strategically located to intercept runoff from these swamps, which provide their primary source of freshwater. Refuge wells, all approximately 400 feet deep, can supply these systems with some moisture in drought emergencies, but their volume is insufficient for most moist soil management purposes and as sources for flooding in the fall.

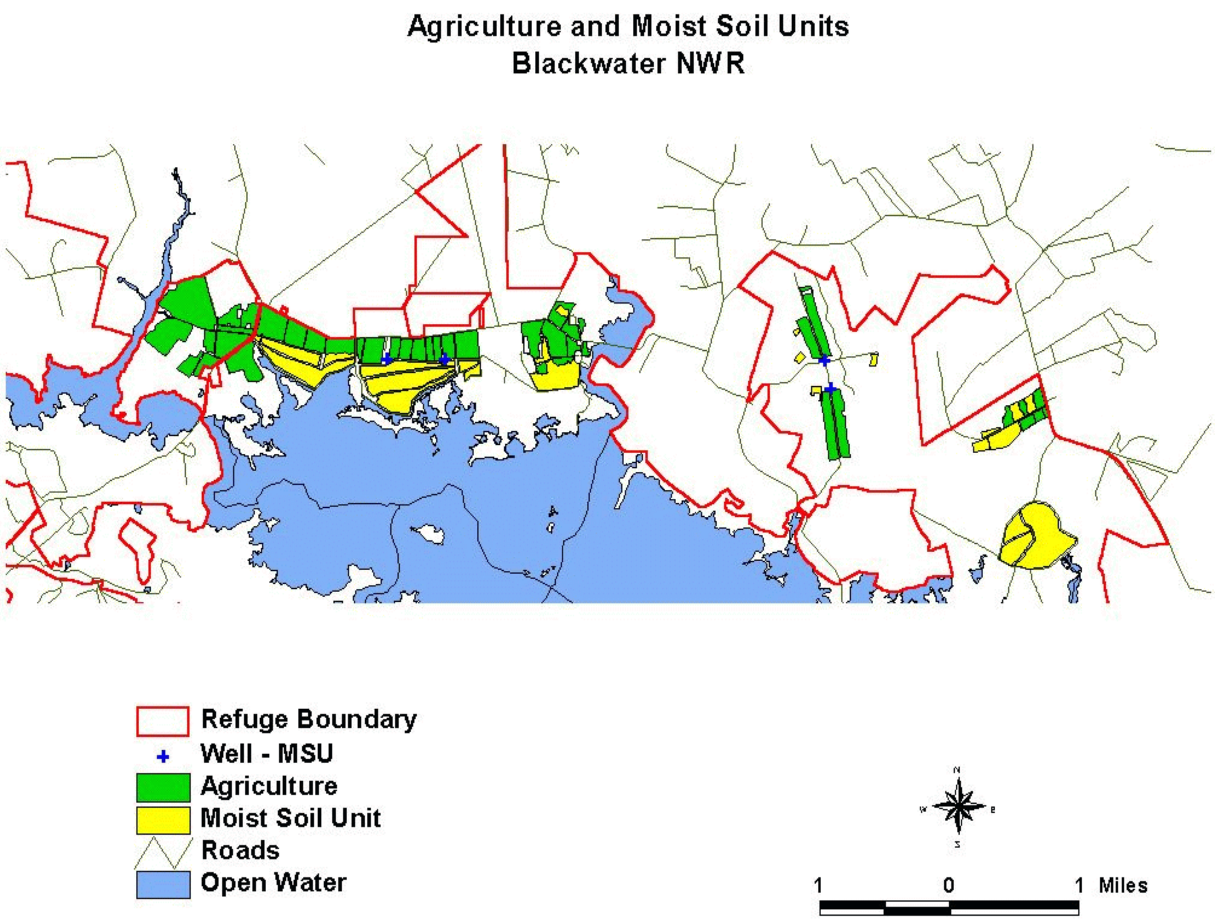


Figure 20. Agriculture and moist soil units (Blackwater NWR) (color plate)

Freshwater impoundments are located along Key Wallace Drive (Kentuck Swamp) and in Green Briar Swamp. These systems take advantage of the slight contour of the land, natural drainages, and the complicated and intricate anthropogenic drainage ditches that have been constructed over the millennia. Because of the flatness of the terrain, refuge staff must be constantly aware of the ability of these systems to flood important endangered species habitats and private lands if they are improperly managed. Note: A more detailed description of the existing impoundment systems is contained in alternative A.

Historical Hydrology on Blackwater NWR

From 10,000 to 6000 years B.P., sea level rose relatively rapidly, from 200 to 30 feet (60 m to 10 m) below present-day sea level. During that period the mainland portions of the refuge were most likely freshwater ecosystems, because elevation kept the area above the influence of the sea. Relative sea-level rise curves for the Chesapeake Bay show a long-term rate of approximately 1.6–1.7 mm/yr for the period from 6000 to 1000 B.P. This rate includes the additive effects of global sea-level rise due to melting glaciers and thermal expansion of sea water (due to sea floor spreading), post-glacial rebound (which is a subsidence for the Delmarva Peninsula), coastal shelf downwarping due to the loading of sediments derived from the erosion of the Appalachian mountains, and sediment compaction/subsidence.

As the rising sea encroached farther onto the low-lying coastal plain, conditions became favorable for the establishment of tidal marshes in the lower Chesapeake Bay, including Blackwater NWR. Continued sea-level rise, coupled with accumulation of organic peats, drove vertical marsh growth and lateral marsh expansion. The exact sequence and timing of the transition of the Blackwater River from nontidal freshwater to tidal freshwater has not been established, but based on dates for this peat layer it began ca. 4000 B.P. (Rizzo 1995). Periods of marsh drowning or marsh emergence were likely to have occurred (e.g. Nydick et al. 1995), but at present, the Chesapeake Bay sea-level rise curves are not high enough in resolution to reveal such dynamics.

Modern Marsh Loss and Sea-level Rise

Marsh loss is a major concern for the refuge; approximately 7,000 acres of marsh have been lost since 1940 through the formation and enlargement of interior ponds (Hester 1994:36; Leatherman et al. 1995; Pendelton and Stevenson 1983:15). This loss has been attributed to a hypothesized increased rate of relative sea-level rise this century and decreased sediment input to the system (Pendleton and Stevenson 1983; Rizzo 1995). However, the existing research and theories on the status of Blackwater NWR marshes contain some flaws.

One problem is that the timing and degree of the hypothesized (perhaps anthropogenically induced) increased inundation rate remain uncertain because sea-level rise estimates from scientific methodologies at dramatically different time scales (e.g., tide records versus stratigraphic reconstructions) may not be directly comparable. Frequently cited high estimates of modern relative sea-level rise are based on short tidal gage records, such as those from stations around Chesapeake Bay, including Baltimore, Annapolis, Solomons, and Washington, D.C.

From 1903 to 1980, the Baltimore gage registered a relative sea-level rise rate of 3.2 mm/yr, while from 1920 to 1983 the Annapolis gage registered a rate of 2.6 mm/yr (Braatz and Aubrey 1987; Hicks et al. 1983). Froomer (1980) reported a high relative sea-level rise rate of 2.74 mm/yr for Chesapeake Bay over the past 325 years based on stratigraphic and radiocarbon dating evidence.

imilarly, Nydick et al. (1995) used stratigraphic, radiocarbon, and foraminiferal evidence to obtain a high relative sea-level rise rate of 3.0 mm/yr for Connecticut marshes beginning in

A.D. 1600. Thus, strong evidence indicates that any increased rate of sea-level rise began more than 300 years ago, before European settlement and the industrial revolution. In that case, the tidal marshes at Blackwater NWR have been able to keep up with accelerated sea-level rise until recently, suggesting that a different cause of marsh loss must be at work.

Another problem with the assertion that tidal marshes at Blackwater NWR are being lost due to sea-level rise is that tidal marshes in nearby Monie Bay (southeast of Blackwater NWR at the mouth of the Wicomico River) show no significant marsh loss or deterioration. Ward, et al. (1988) studied Monie Bay and reported “unlike the lower Nanticoke area, the marshes at Monie Bay show little evidence of increases in open water or other major signs of marsh deterioration despite the low accretion rates.” They found that the average rate of marsh accretion at Monie Bay over the last 200 years was 3.0 mm/yr, with a range of 1.5–6.3 mm/yr. This rate is statistically indistinguishable from the long-term accretion rate of 3.6 mm/yr reported for Blackwater NWR by Rizzo (1995). Thus, none of the regional or global components of relative sea-level rise for Chesapeake Bay that play a role in marsh accretion can be responsible for localized marsh loss at Blackwater NWR.

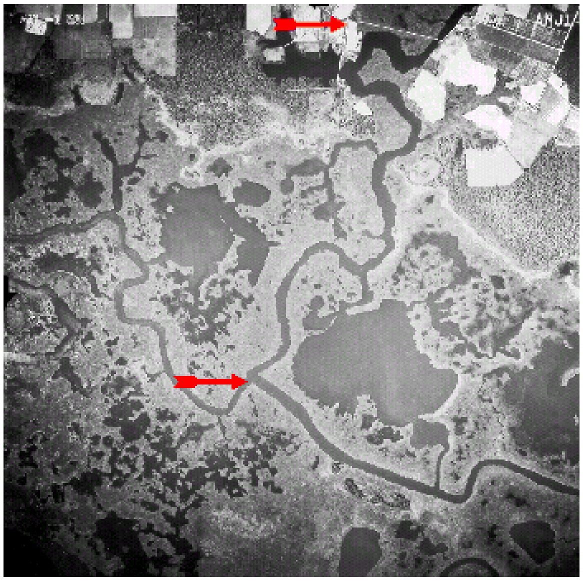


Figure 21. Comparative marsh 1939

Recent studies of coastal mangrove swamp loss in southwestern Florida (Tedesco and Wanless 1997) and salt marshes in North Carolina (Robert Young, personal communication 1998) demonstrate that while accelerated sea-level rise represents a stress on the coastal system, it takes a major disturbance, such as a series of hurricanes or a major coastal forest fire, to stop the coastal system from growing and allow inundation to result in terminal drowning. Also, where such disturbances occur over a large area, the system is unable to flush out the massive amounts of decaying organic matter, thereby inhibiting regeneration of the ecosystem in time to stave off inundation (Tedesco and Wanless 1997). At Blackwater NWR, several major stresses, including hurricanes, waterfowl population bursts, wildlife infestations, human interference, and groundwater withdrawals (Glenn Carowan, personal communication 1997) correspond with the recent period of patchy, rapid death of the marsh ecosystem reported by Rizzo (1995).

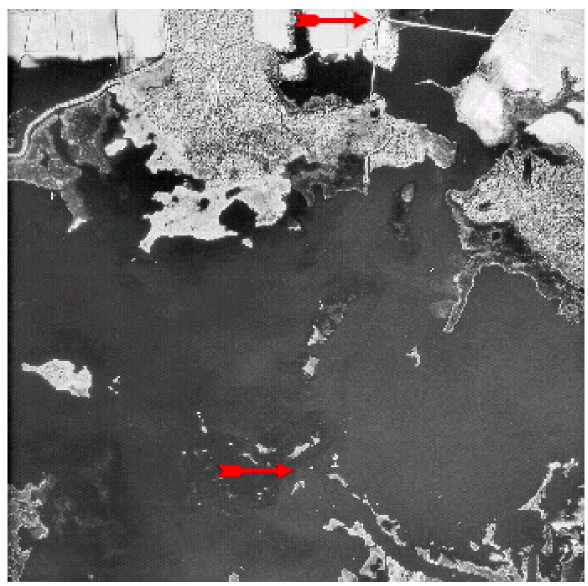


Figure 22. Comparative marsh 1989

Pendleton and Stevenson (1983) investigated the potential impacts of marsh plant production, grazing by overwintering Canada and snow geese, muskrats, and nutria, prescribed annual marsh burning, salinity, herbicides, rising sea levels, and effects of Maple Dam Road on marsh loss at Blackwater NWR. While they concluded that sea level is the dominant factor, their study does not address the ecological impacts of major hurricanes. Refuge Manager Carowan reports the surface muck present where Blackwater NWR marshes have been drowned has the consistency of chocolate pudding, which is virtually the same description used to characterize the surface muck in rotting, hurricane-destroyed mangrove swamps of Florida.[11]

Based on the more recent work illuminating the role of major disturbances in Atlantic coast and Gulf coast marsh inundation, an alternate hypothesis can be forwarded for the cause of marsh loss at Blackwater NWR. The three key elements of the hypothesis are (1) major disturbances destroy patches of vegetation and induce peat decay, (2) low tidal flushing inhibits ecosystem recovery, and (3) inundation is caused by enhanced subsidence of decaying substrates along with sea-level rise.

Pendleton and Stevenson (1983) report that 99 percent of total suspended solids flushing out by Shorters Wharf is from intertidal and subtidal (i.e., open water) sources. Furthermore, they state that Shorters Wharf Road (also called Maple Dam Road) inhibits inflow of fresh sediment during storms. These findings suggest that the system is attempting to flush out the decaying substrates, but the sediment-damming effect of the road is limiting this natural process. Without complete flushing of the decayed matter and eventual replacement by new inorganic substrates, it is unlikely that the marsh ecosystem will be able to recover. Further sea-level rise will continue the trend of marsh loss as long as the effects of past disturbances are not mitigated.

[11] Lenore Tedesco, personal communication 1997

Table 1
Eastern Shore Island Losses in the Middle Portion of Chesapeake Bay (From Historic and Recent National Ocean Survey Chart Data)

	Historic Acreage		Recent Acreage		
Island	Year	Acres	Year	Acres	Erosion, acres
Barren	1664	700	1989	250	-450
Bloodsworth Series	1849	6,051.7	1942	5,243.3	-808.4
Bodkin	1742	1,286	1990	0.9	-1,285.1
Cockey's[1]	1846	5.7	1990	0	-5.7
Cows[1]	1901	6.2	1990	0	-6.2
Deal	1849	2,168.1	1942	1,882.5	-285.6
Deep Banks	1849	31.9	1942	4.6	-27.3
Eastern Neck	1846	2,435.9	1942	2,001.8	-434.1
Great Marsh[1]	1846	6.4	1990	0	-6.4
Hambleton[1]	1775	85	1990	0	-85
Herring[1]	?	?	1990	0	?
Hog	1854	38.3	1942	27.5	-10.8
Holland	1843	253	1980	140	-113
Hooper Series	1848	3,928.1	1942	3,085.4	-842.7
James	1664	1,350	1990	269	-1,081
Johnson	1854	57.4	1942	22.9	-34.5
Kent	1848	21,094.8	1942	19,302.1	-1,792.7
Little	1854	19.1	1942	6.4	-12.7
Little Deal	1849	357.1	1942	257.1	-100
Long[1]	?	?	1990	0	?
Long Marsh	1854	31.9	1942	18.3	-13.6
Parson	1854	172.2	1942	128.5	-43.7
Philpots	1899	25.5	1942	8.3	-17.2
Poplar Series	1846	752.5	1942	238.8	-513.7
Powell[1]	1755	55	1990	0	-55
Punch[1]	1848	1.3	1990	0	-1.3
Royston[1]	1755	41	1990	0	-41

Note: Source: Dave Gelenter. (1990). "Eastern shore island losses," Unpublished report prepared by University of Maryland's Center for Global Change, Laurel, MD, for the U.S. Fish and Wildlife Service, Chesapeake Bay Field Office, Annapolis, MD, Project Manager, John W. Gill.
[1] Erosion resulted in entire island being lost.

(Continued)

Figure 23. Eastern Shore island losses (middle portion of the Bay)

Table 1 (Concluded)

Island	Historic Acreage		Recent Acreage		Erosion, acres
	Year	Acres	Year	Acres	
Sharps[2]	1812	631	1990	0 (at high tide)	-631
Sherwood[1]	1755	41	1990	0	-41
South Marsh	1849	3,590.2	1942	2,910.9	-679.3
Swan[1]	1848	6.4	1990	0	-6.4
Taylors	1848	7,894.6	1942	7,621.7	-272.9
Tilghman	1847	2,015	1983	1,262	-753
Turtle Egg[1]	1849	15.9	1990	0	-15.9
Wrotten	1901	505.1	1942	433.6	-71.5
Totals 35 (12 islands lost)	55,653.3		45,115.6		-10,537.7
The following islands are former points that were cut off the mainland by water. The specific date of separation is unknown, but occurred sometime after 1848.					
Hills Point	1848	Attached	1942	36.7	
Ragged	1848	Attached	1942	128.6	

[1] Erosion resulted in entire island being lost.
[2] Seen at low tide.

Figure 24. Eastern Shore island losses (conclusion)

Chesapeake Island Refuges.—The effects of the changing hydrology of the Chesapeake Bay are best exemplified by an examination of the Island Refuges. These areas are artifacts of the changing course of the Susquehanna River. They have been substantially reduced in size, or even drowned, and sharp decreases in land area led to widespread abandonment of settlements on many of these areas in the first decades of this century. Rising sea levels caused progressive erosion, submergence, or both, eventually eliminating habitats and habitation. Under the present scenario of sea-level rise, this group of lands has a limited future without mitigation.

Nanticoke Protection Area.—The Nanticoke River drains the heart of the Delmarva Peninsula, including the southwestern third of Delaware and more than 100,000 acres at the center of Maryland's Eastern Shore. Countless small headwater streams channel water from coastal plain fields and forests into the upper reaches of the few major tributaries of the Nanticoke: Deep Creek and Broad Creek in Delaware and Marshyhope Creek in Maryland. In Delaware, the main stem of the river winds a meandering path above Seaford, with dense riparian forest overhanging the river. The tidal influence extends just north of Middleford, Delaware along the main stem; Federalsburg on the Marshyhope; the Laurel spillway on Broad Creek; and the Concord dam on Deep Creek, ultimately widening even further into a brackish bay just above its mouth at the Chesapeake Bay.

In an article published in "The Sun," titled "A Family for All Seasons," Mr. Tom Horton writes "From around Vienna, where the Nanticoke leaves its wooded swamps and turns from fresh to brackish, it sashays for 15 miles in a series of great bends and straights to around Tyaskin, where its riverine nature broadens into a sub-estuary of Tangier Sound and the Chesapeake. In this middle distance, along the Wicomico shore, each curve of the river embraces vast marshes, run through by hundreds of miles of 'cricks', 'guts', sloughs, 'dreens', ditches, canals, inlets, thoroughfares and assorted drainageways."

Near its mouth, the Nanticoke River merges with the Blackwater River from the west, forming a vast area of tidal marsh and shallow open water habitats known as "Fishing Bay" and "Tangier Sound." Because its tidal waters extend well upriver into Delaware, the Nanticoke River is navigable by large vessels (primarily tugs and barges) up to Seaford. Depths range from 35–40 feet at the mouth to approximately 10 feet at Seaford. Portions of the river are periodically dredged to ensure navigability. Currents in the lower tidal reaches vary in direction and strength with the tidal stage. The upper nontidal portion of the river has a consistent downstream flow typical of coastal plain rivers.

The Nanticoke is extensively bordered by wetlands, and damaging floods are rare, with little if any flood damage reported. At the mouth of the river, where it forms a brackish estuary, water salinity is highest in the fall (15–20 ppt) and lowest in the spring (10–15 ppt.; EPA 1989). The freshwater boundary (i.e., where salinity drops below 0.05%) migrates north and south in a predictable seasonal pattern, typically extending down the river in late winter or spring when the freshwater flow is highest, and up the river in late summer when downstream freshwater flow is lowest.

The limited data available from sampling in the river itself suggests that overall water quality in the Nanticoke River is fair to poor, with levels of nutrients and other chemicals reflecting the agriculture-dominated landscape of the Delmarva peninsula (Hamilton and Shedlock 1992). However, the river does not support its designated uses in Delaware, due to high levels of nutrients and fecal coliform bacteria (DNREC 1996). In 1996, researchers from Salisbury State University and the Nanticoke Watershed Alliance began a long-term study to monitor water quality of the river. The Maryland Biological Stream Survey program published a comprehensive report in December 1997 that includes water quality data for the Nanticoke River and Marshyhope Creek.

Beds of submerged aquatic vegetation (SAV) in the lower Nanticoke, like vast expanses of SAV's in the Chesapeake Bay, were decimated by water pollution and excessive sedimentation prior to the late 1970's (Kearney et al. 1988, Orth et al. 1993). The upper Nanticoke basin is known to support the largest tidal-freshwater SAV beds in Delaware (DNREC 1996). Significant portions of the upper tributaries of the river (particularly in Delaware) have been channeled to provide for agricultural drainage. Typically, the stream channel is cleared of vegetation on both sides of the stream, and the stream bed is straightened and deepened by bucket dredge.

Initial channeling in the past has been funded by the U.S. Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) with maintenance dredging left to tax ditch associations made up of landowners adjacent to the streams. Side ditches are generally dug in the surrounding agricultural lands to feed into the tax ditches. Channeling the upper reaches of the river is thought to have significant impacts on the hydrology and water quality of its main stem.

Agricultural ditching has changed the characteristic flow and timing of discharge of runoff from the watershed into the main stem river. This rapid discharge of runoff limits the ability of the stream and surrounding wetlands to remove nutrients and sediments coming off the uplands, and may substantially alter the seedbed conditions that provide for the germination and establishment of wetland vegetation. In addition, the deepening and straightening of small stream channels and the more rapid discharge of water from the minor tributaries has impacted both the areal extent and the characteristics of the headwater and palustrine nontidal wetlands in these areas.

Water is withdrawn from the river by both industrial and agricultural interests. Industrial uses are locally significant, but infrequent. The Delmarva Power & Light Company power plant in Vienna and the E.I. DuPont de Nemours nylon plant in Seaford are two principal water users. The total volume of water withdrawn by these and other industries, and the proportion of that water consumed, i.e., not returned to the river, is currently unknown. Similarly, an unknown number of farms withdraw water from the river. Although the total amount of water withdrawn for farming may be a much smaller volume than that taken for industrial uses, a significant proportion of irrigation water is lost from the local system, through evapotranspiration. At the same time, excess irrigation water pumped from deep aquifers but infiltrating into the ground after application may help artificially maintain surface flow in small streams and seasonal channels that otherwise would dry out during the summer when natural precipitation is low. Much more research is needed into the impact of irrigated agriculture on patterns of local groundwater flow.

Most, if not all, domestic needs and most agricultural water needs in the watershed are met by groundwater. Groundwater resources are reported to be abundant. Groundwater is available from wells in the unconfined water table aquifer up to 100 feet deep, or deeper wells in the confined aquifers of the Choptank, Yorktown and Cohansey formations (Cushing et al. 1973; Andres 1994). Increased agricultural usage of the surface water aquifer for irrigation may cause localized groundwater supply problems affecting both natural communities and human needs, and this depletion process may be increasing over time (Brand and Huber 1997). Groundwater discharge is also a primary source of streamflow, supplying as much as 75 percent of the freshwater flow for the upper main stem Nanticoke and many of the tributaries (Johnston 1976; Staver and Brinsfield 1990).

Water quality is degraded in the surface aquifer on the Delmarva Peninsula as a whole because of contamination from agricultural activities in the watershed (Hamilton and Shedlock 1992; Staver and Brinsfield 1993). Nitrate concentrations are high from chemical fertilizers and from septic systems in areas with high populations. Pesticide levels in wells are also elevated in some areas. Excess nutrients and other chemicals in groundwater may take several decades to appear in local surface waters (creeks and streams), so the impacts of past land use activities can still be recorded today. Similarly, groundwater contamination due to current land use practices will persist long after evidence of those practices has disappeared from the landscape.

Modern Climate

Modern climatic conditions vary somewhat from the continental climate of the Coastal Plain. The influence of the Atlantic Ocean and the Bay gives the Eastern Shore generally milder winters, and summers with high humidity and relatively warm days and nights. Summer temperatures normally reach the upper 80's and occasionally climb into the 90's, although 102 ˚F has been recorded. The daily high temperature in July averages 87 ˚F. Winters are usually short, with an average daily low temperature in February of 26 ˚F. The watershed has a frost-free period of approximately 183 days.

From October through March, frequent high- and low-pressure systems alternate cold dry air from the north with warm humid air from the south. That pattern tends to break down in the summer, as warm moist air spreads northward from the south and southwest and remains over the area for much of the season. Intense low-pressure areas (hurricanes and northeasters) can bring torrential rains and winds of hurricane force to the Eastern Shore, especially during August, September, and October. Thunderstorms occur on about 28 days each year; most occur in July. Annual rainfall averages 43 inches. Of that, about 23 inches, or 53 percent, usually falls from April through September. The growing season for most crops falls within that period. The heaviest 1-day rainfall during that period was 7.00 inches, recorded at Vienna on September 27, 1985. Normally, August is the wettest month, and October the driest.

At Blackwater NWR, the lowest annual precipitation was 28.21 inches, recorded in 1942. The highest annual precipitation was 67.27 inches recorded in 1948. Average snowfall is 15 inches, and has ranged from 2 inches in the 1948–49 winter to 37.5 inches in the 1966–67 winter season. The heaviest 1-day snowfall in the past 40 years was 19 inches recorded on February 19, 1979. The average relative humidity in mid-afternoon is about 55 percent. Humidity is higher at night, and the average at dawn is about 74 percent. The sun shines 63 percent of the time in summer and 47 percent in winter. The prevailing wind is from the south. Average wind speed is highest, 11.0 miles per hour, in March.

Under the Clean Air Act, Dorchester County is classified as a Class II area, with air quality that is generally good. Dorchester County meets the National Ambient Air Quality Standards for emissions. Visibility in the county is good, generally averaging 3 to 5 miles. Facilities within the county that could be sensitive to smoke include Dorchester General Hospital, 9 miles from the refuge; City of Cambridge, 8 miles; Dorchester Airport, 8 miles; and Eastern Shore Hospital Center, 8.5 miles. All of these facilities are north of Blackwater NWR and Fishing Bay WMA, where marsh burning has been used as a management tool in the past.

Contaminants

The Chesapeake Bay Program has published Targeting Toxics: A Characterization Report that consolidates data previously collected by various groups, including Federal and state agencies, research institutions, and Bay Program-funded monitoring activities. The information is provided for 27 tidal rivers, including the Blackwater and Nanticoke rivers and their tributaries.

While most of the study area has a low probability for adverse effects from contaminants, field tests from 1984 to 1988 revealed a high larval mortality in striped bass in the Nanticoke River. Comparison tests between the Nanticoke and several rivers in Virginia in 1989, demonstrated that mortality of larvae was highest in the Nanticoke River. In fact, all larvae died in 8 of the 12 tests conducted on the Nanticoke. In contrast, survival ranged from 62 percent to 67 percent in 7 of the 8 tests conducted in Virginia rivers. Concentrations of lead, cadmium, chromium, nickel, arsenic, and selenium were consistently higher in the Nanticoke River.

Wetland Communities

I. Intertidal Wetland Communities
   - A. Open Water Habitat (including mudflats, sandbars, beach, and SAV beds)
     1. Brackish Low Marsh
     2. Brackish High Marsh
     3. Freshwater Intertidal Wetlands
        - a. Freshwater Intertidal Marsh (including mud flats and sand flats)
        - b. Freshwater Intertidal Shrub Swamp
        - c. Freshwater Intertidal Swamp Forest
     4. Atlantic White Cedar–Red Maple Swamps (also palustrine)

II. Riverine Wetlands Community

III. Palustrine Wetland Communities
   - A. Floodplain Forested
     1. Mixed Hardwood–Pine Forested Swamps
     2. Atlantic White Cedar–Red Maple Swamps (also intertidal)
     3. Atlantic White Cedar–Mixed Hardwood Swamps
   - B. Non-floodplain Forested
     1. Mixed Hardwood–Pine Forested Swamps
     2. Atlantic White Cedar–Red Maple Swamps
     3. Coastal Plain Ponds
   - C. Open Canopy Herbaceous Wetlands
     1. Open Water Habitats (millponds)
     2. Coastal Plain Bogs
     3. Wet Meadows

IV. Upland Communities
   - A. Xeric Dunes
   - B. Rich Woods
   - C. Forest Lands
   - D. Agricultural Lands

V. The Rivers

Table 4. Acres of wetland habitat types

National Wetlands Inventory Subsystem	Blackwater NWR	Barren Island	Bishop's Head and Spring Island	Martin NWR and Watts Island	Nanticoke Protection Area	Honga Focus Area	Subsystem Subtotals
Estuarine intertidal	9,761.8	108.7	616.4	4,676.2	6,003.3	22,820.4	43,986.8
Estuarine subtidal	5,354.1	1.2	17.4	2,852.8	2,963.0	2,841.7	14,030.2
Lacustrine littoral	68.8	0.0	0.0	0.0	0.0	0.0	68.8
Palustrine wetland	5,007.5	42.7	6.4	0.0	5,613.9	13,523.8	24,194.3
Riverine tidal	0.0	0.0	0.0	0.0	268.0	0.0	268.0
Wetlands subtotals	20,192.2	152.6	640.2	7,529.0	14,848.2	39,185.9	82,548.1
Upland components	1,259.9	11.4	1.4	35.0	9,203.3	6,879.1	17,390.1
Totals	**21,452.1**	**164.0**	**641.6**	**7,564.0**	**24,051.5**	**46,065.0**	**99,938.2**

Source: USFWS, Delaware Bay Estuary Program Office, "GAP-enhanced" NWI data
Note: CCP boundary was used for Blackwater NWI acres

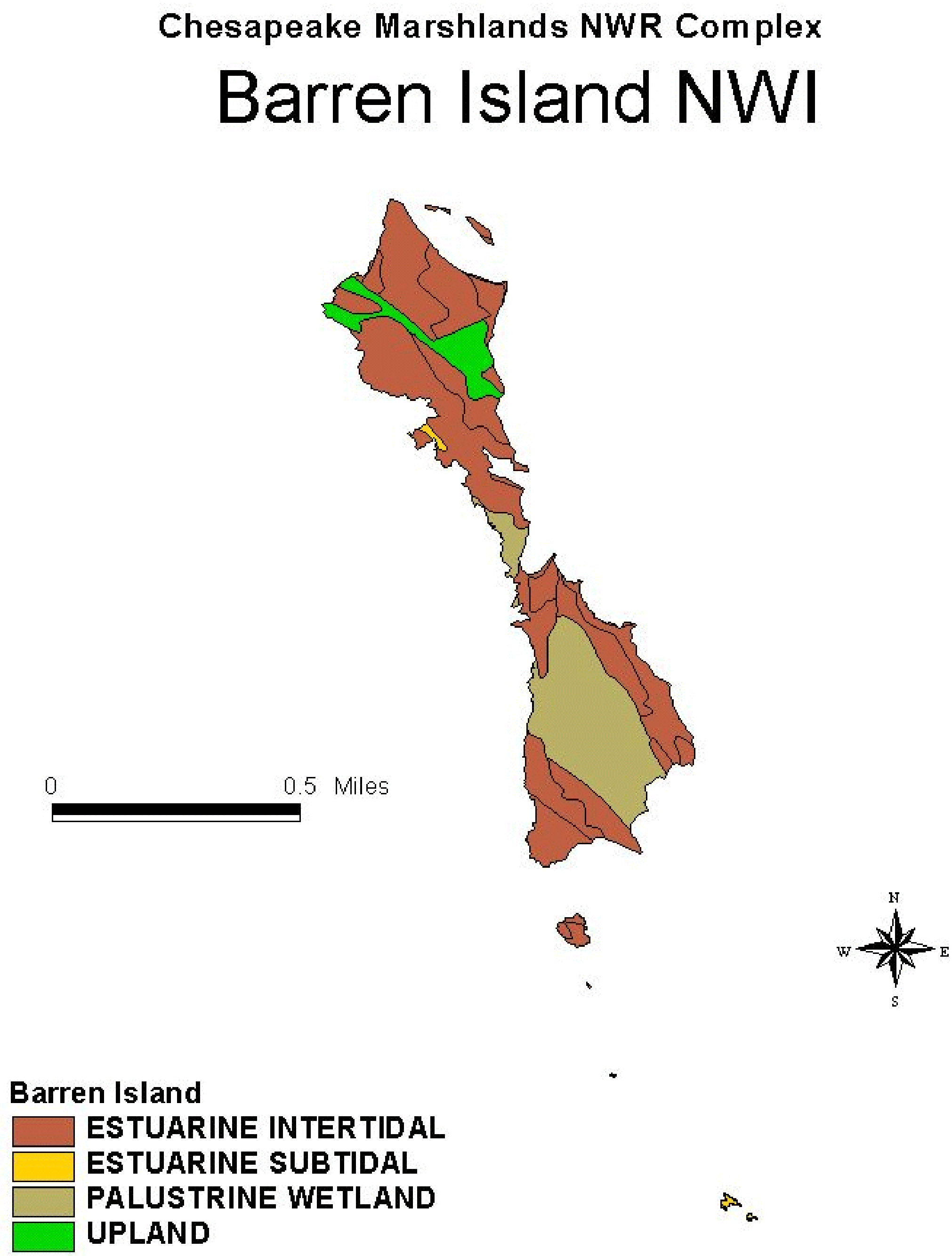


Figure 25. Barren Island NWI (color plate)

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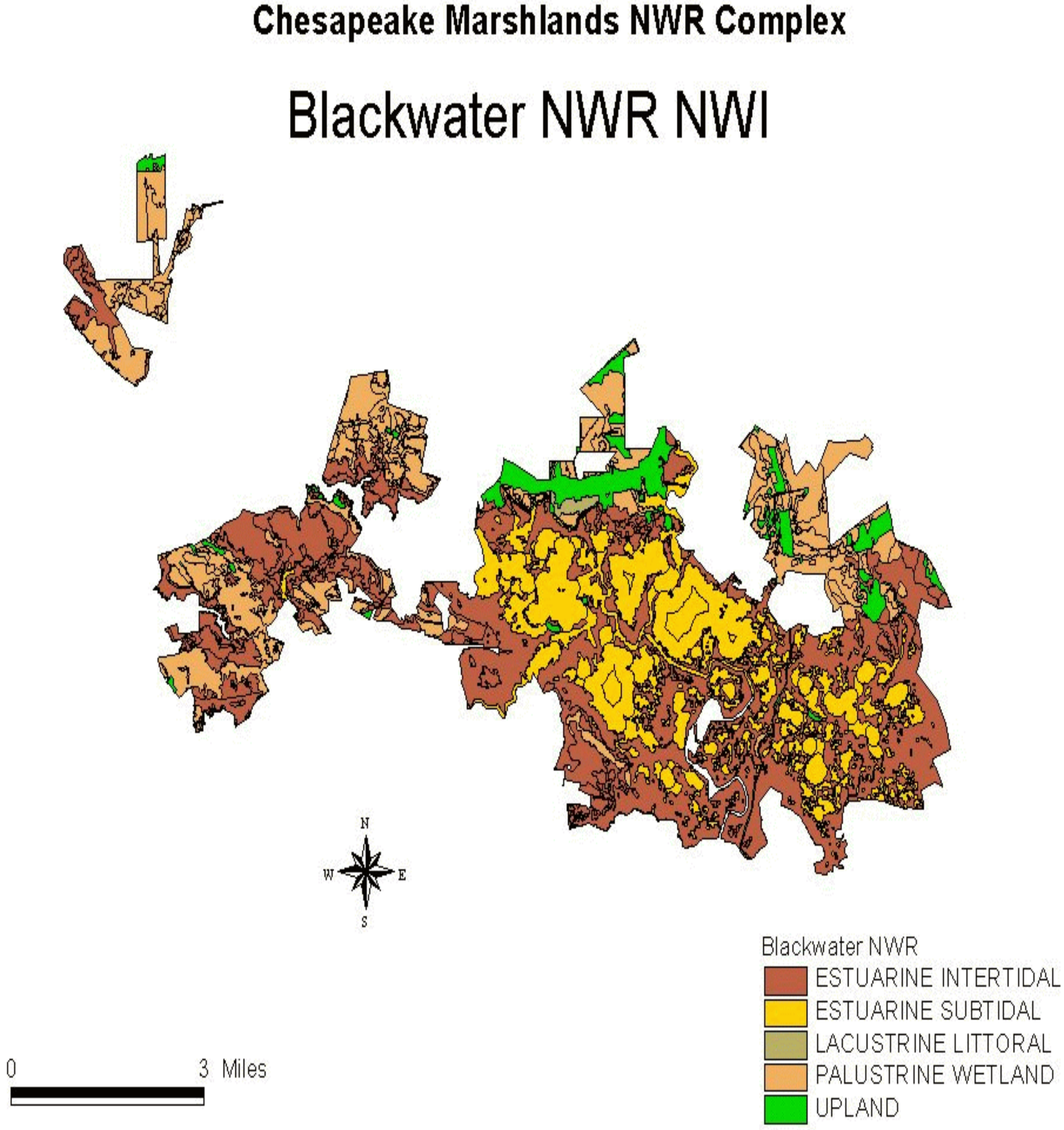


Figure 26. Blackwater NWR NWI (color plate)

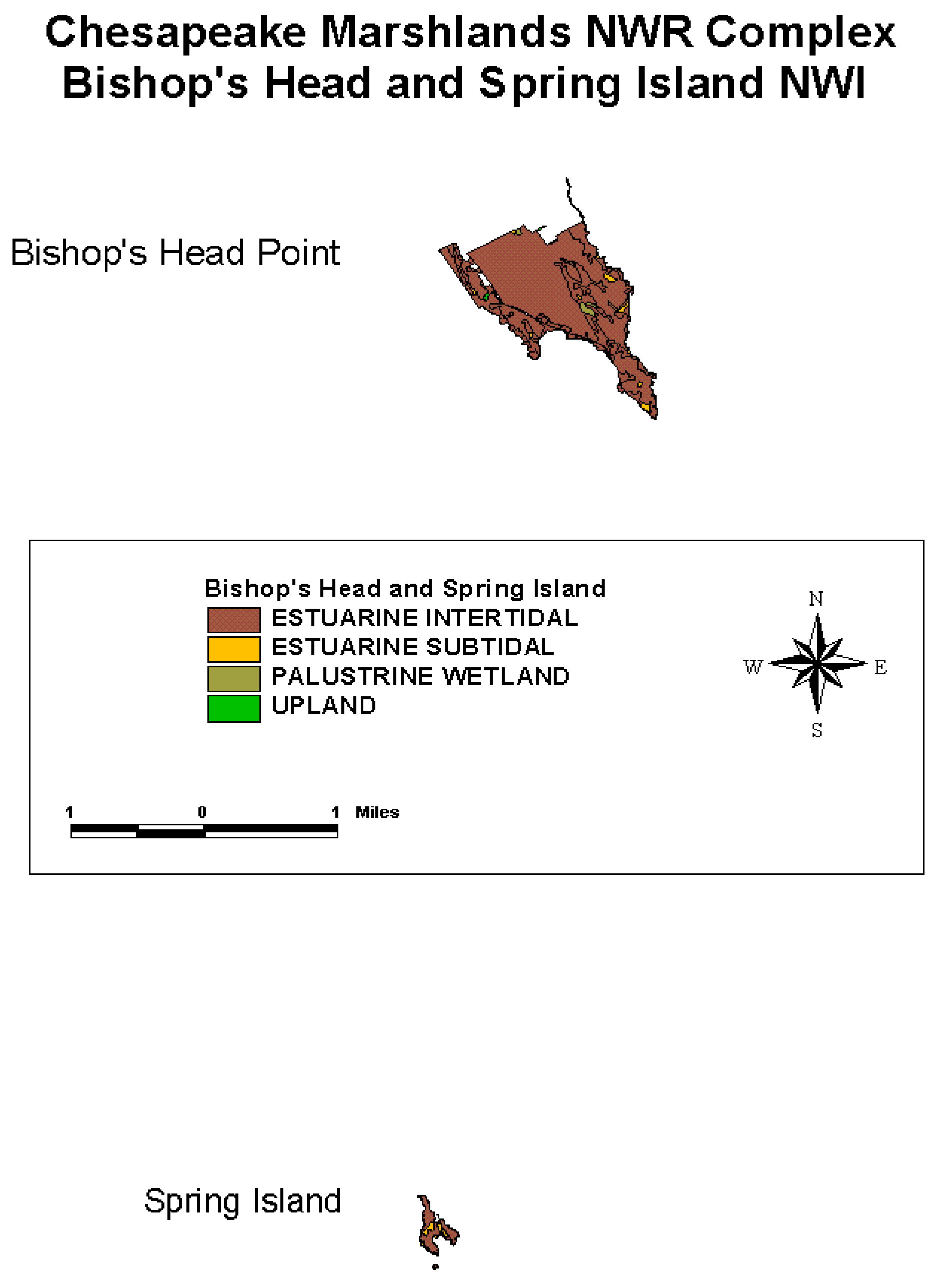


Figure 27. Bishop’s Head and Spring Island NWI (color plate)

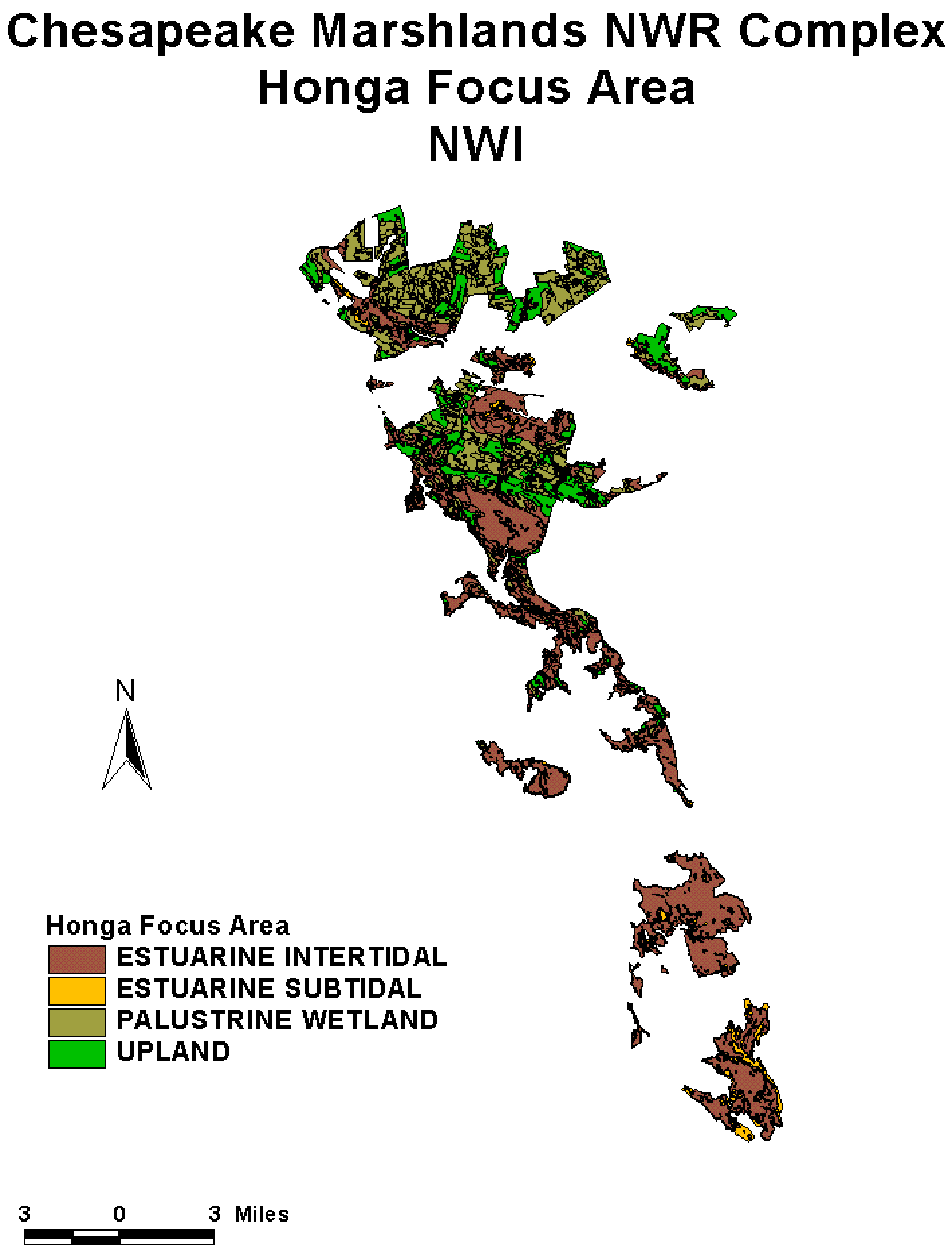


Figure 28. Honga Focus Area NWI (color plate)

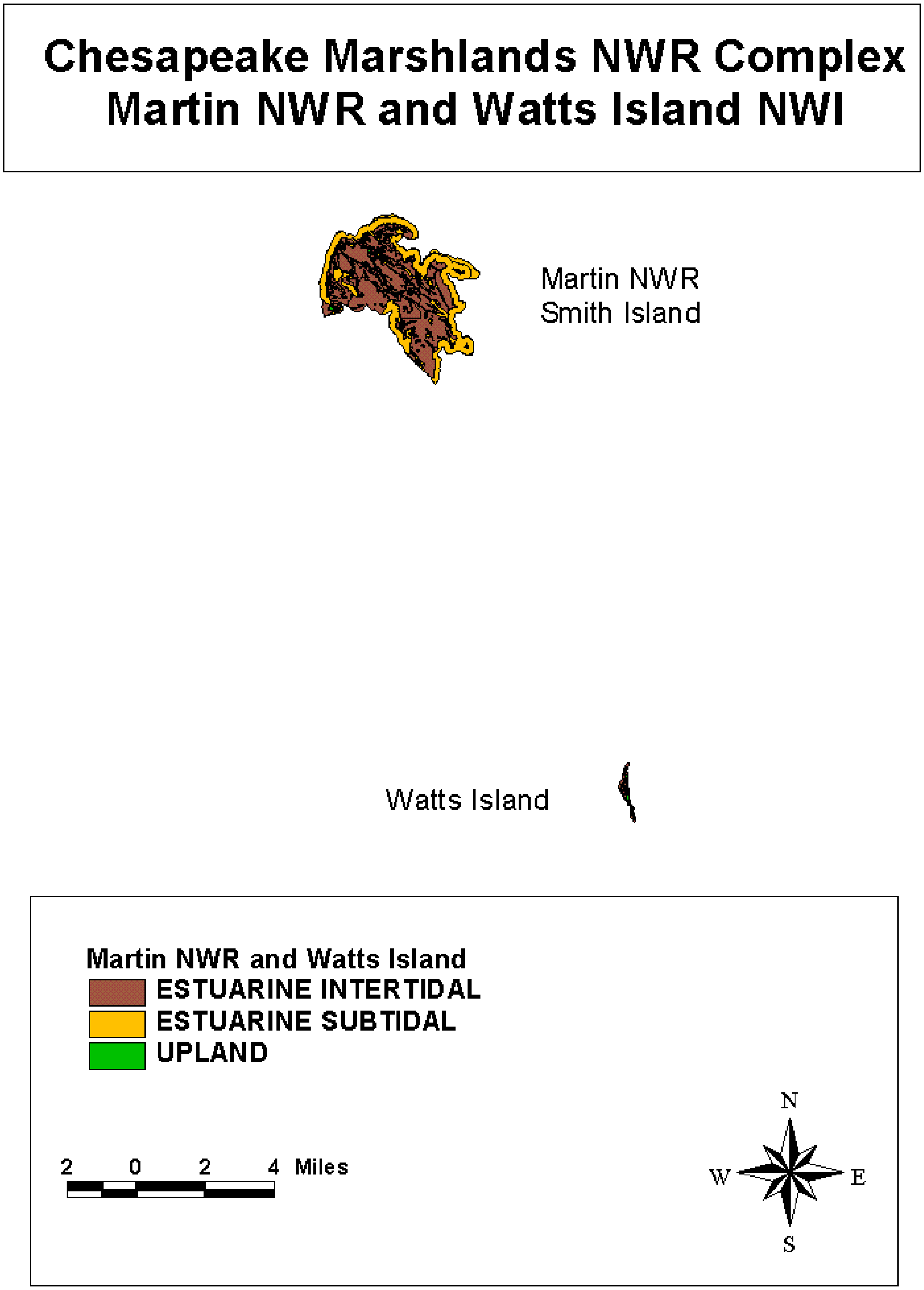


Figure 29. Martin NWR and Watts Island NWI (color plate)

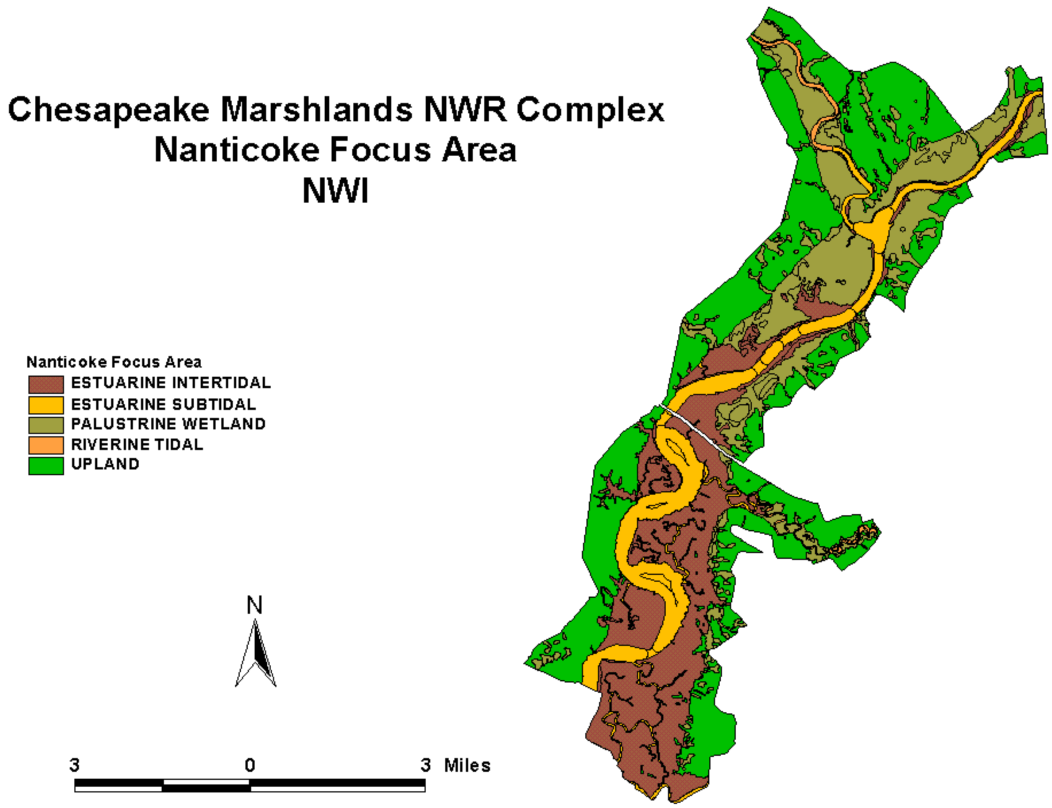


Figure 30. Nanticoke Protection Area NWI (color plate)

Intertidal Wetlands

The Intertidal Wetland Community represents one of the most important and dominant components of the Blackwater–Nanticoke system and the study area, comprising almost 80,000 acres and making up one-third of all the tidal wetlands in Maryland. Almost all of the tidal wetland communities found in the Chesapeake Bay, except for the saline high and low marshes, can be found in this extremely diverse watershed. The intertidal wetland community includes six different categories:

1. Open Water, mudflat, sandbar/beach, and SAV beds;
2. Brackish Low Marsh;
3. Brackish High Marsh;
4. Freshwater Intertidal Marsh;
5. Freshwater Intertidal Swamp Forest; and
6. Freshwater Intertidal Shrub Swamp.

Each type is described in more detail below, and rare species found in this community type are listed in each respective community table. The intertidal wetland classification is based on community descriptions used by McCormick and Somes (1982). It should also be noted that these community descriptions apply to the entire study area, and not just to the strict confines of the Blackwater and Nanticoke rivers watershed. The non-tidal community classification is based on Cowardin's (1979) classification. The upland community descriptions are taken from Maryland Heritage information.

Open water, mudflats, sandbar–beach, and SAV habitats are found throughout the intertidal zone, and occupy more than 8,000 acres of the study area. The most important open water habitats are the large expanses of open water less than 5 feet deep. These shallow water areas occur primarily along the edge of the lower Nanticoke and Blackwater rivers, the upper part of Fishing Bay, shallow water areas and beaches surrounding the islands, and the embayments in the brackish low and high marsh communities, like those on Blackwater NWR.

Submerged aquatic vegetation (SAV) historically has dominated these habitats, and even though SAV abundance has dropped 66 percent in the Chesapeake Bay since the late 1960's, some good stands of sago pondweed, widgeon grass, eelgrass, and horned pondweed still can be found in the Nanticoke system. It should be noted, however, that only small amounts of SAV can be found in the Blackwater system, due to degraded water quality and turbidity associated with marsh loss and erosion.

The Chesapeake Island Refuges are the most productive area for SAV in the Chesapeake Bay, and Martin NWR is the most productive area for SAV in the Refuge Complex. Eel grass (*Zostera marina*) and wigeon grass (*Ruppia maritima*) are the dominant species, with wigeon grass occurring in waters generally less than 3 ft. deep MLW, and eel grass occurring in waters greater than 3 ft. MLW, but still within the photic zone. These grass beds are an important ecological component of the estuary. They provide food and cover for juvenile fishes, molting blue crabs, and many other crustaceans and mollusks, and are an important food for many species of waterfowl. It has been estimated that one square yard of SAV provides habitat for a minimum of 50 juvenile crabs. Assuming a 10-percent survival rate, each acre of SAV would produce approximately 24,000 individuals, or 160 bushels of marketable crabs per year. The beds also support a locally based crab scrape (soft-shell crab) fishery on Smith Island. The distribution of SAV in and around Martin NWR is shown below.

Table 5. Martin NWR SAV

Acres of SAV	**Tier 1**[1]	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**Reduction**
Back Cove[2]	508	469	474	480	444	351	307	40%
Big Thorofare	1427	1223	1348	1355	1342	1193	610	57%
Fog Point Cove	82	70	66	98	89	31	42	49%
Rhodes Point	337	286	341	333	336	54	27	92%
Terrapin Sand	1013	841	854	846	791	658	667	34%
Tylerton	422	338	404	409	320	101	94	78%
Total	**3789**	**3227**	**3487**	**3521**	**3322**	**2389**	**1747**	**52%**

Intertidal mud flats are highly important as foraging areas for waterfowl, sport and commercial fishes, and many other species of food web value in the marine ecosystem. The mud flats along the upper tidal creeks and rivers are a unique ecotonal habitat that supports several rare plant species, including subulate arrowhead (*Sagittaria subulata*), and river bark quillwort (*Isoetes riparia*). The sandbar and beach habitats at the mouth of the Nanticoke River and on the Chesapeake Island Refuges provide foraging areas and nesting habitat. These areas are particularly important to certain species of shorebirds.

Brackish low marshes are characterized by only one wetland type: the smooth cordgrass (*Spartina alterniflora*). These brackish low marshes are extensive, covering about 16,000 acres and representing about 19 percent of all tidal wetlands in the study area. Because they are lower in elevation than the other brackish marshes, the low marsh is partly or wholly inundated during most periods of high tide. Smooth cordgrass marshes are found primarily on the Chesapeake Island Refuges of the Refuge Complex.

Brackish high marshes are by far the largest category of intertidal wetland in the watershed, and cover almost 50,000 acres in the study area. These marshes compose more than 80 percent of the intertidal wetlands and approximately 50 percent of the Blackwater and Nanticoke rivers watershed in Maryland. It is also a very diverse category with nine different wetland types. These wetland types tend to occur in nearly monotypic stands. In order of abundance, they include needlerush, threesquare, meadow cordgrass, spikegrass, big cordgrass, cattail, marsh elder–groundsel bush, switch grass, common reed, and rose mallow. The open water and brackish intertidal communities do not have significant numbers of threatened or endangered species, except for the plant, elongated lobelia. These marshes are very common on Blackwater NWR and the Chesapeake Island Refuges. The Virginia Institute of Marine Science provided the segment maps below.

Source: VIMS SAV Mapping web page: http://www.vims.edu/bio/sav/sav97/figure9.html

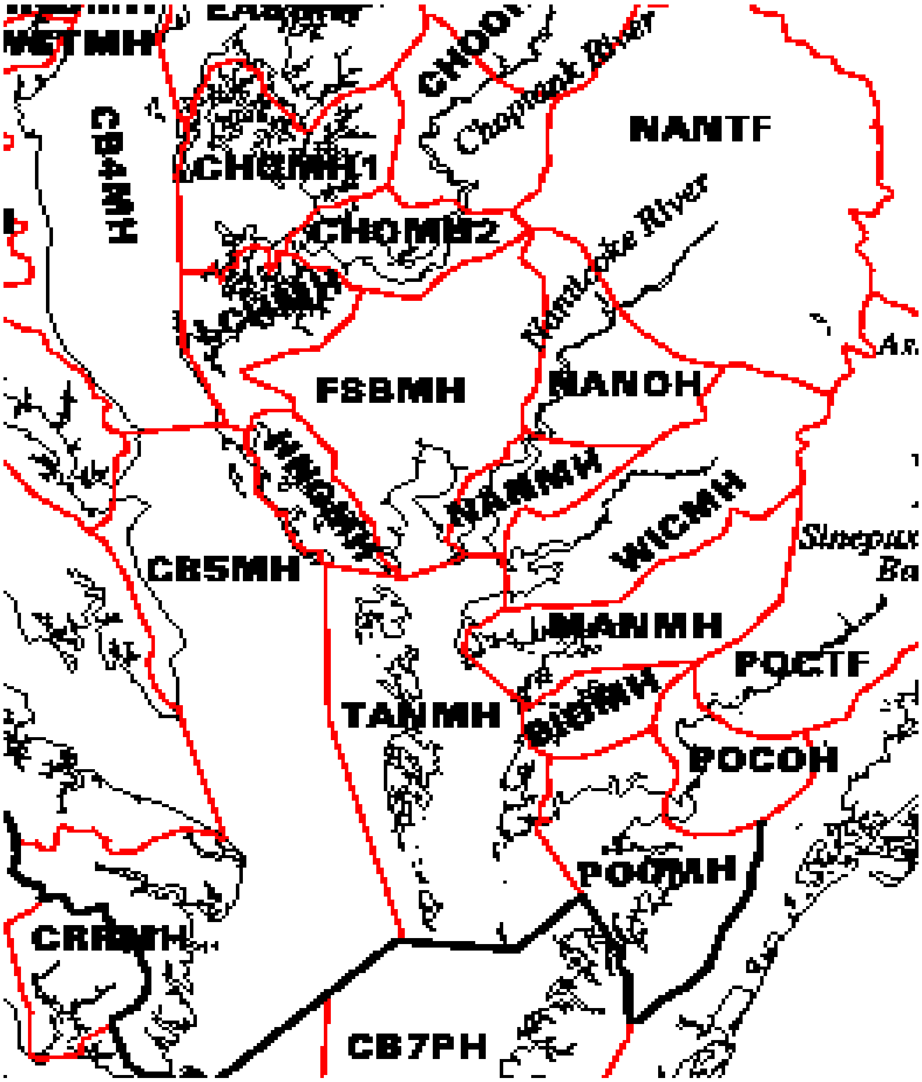
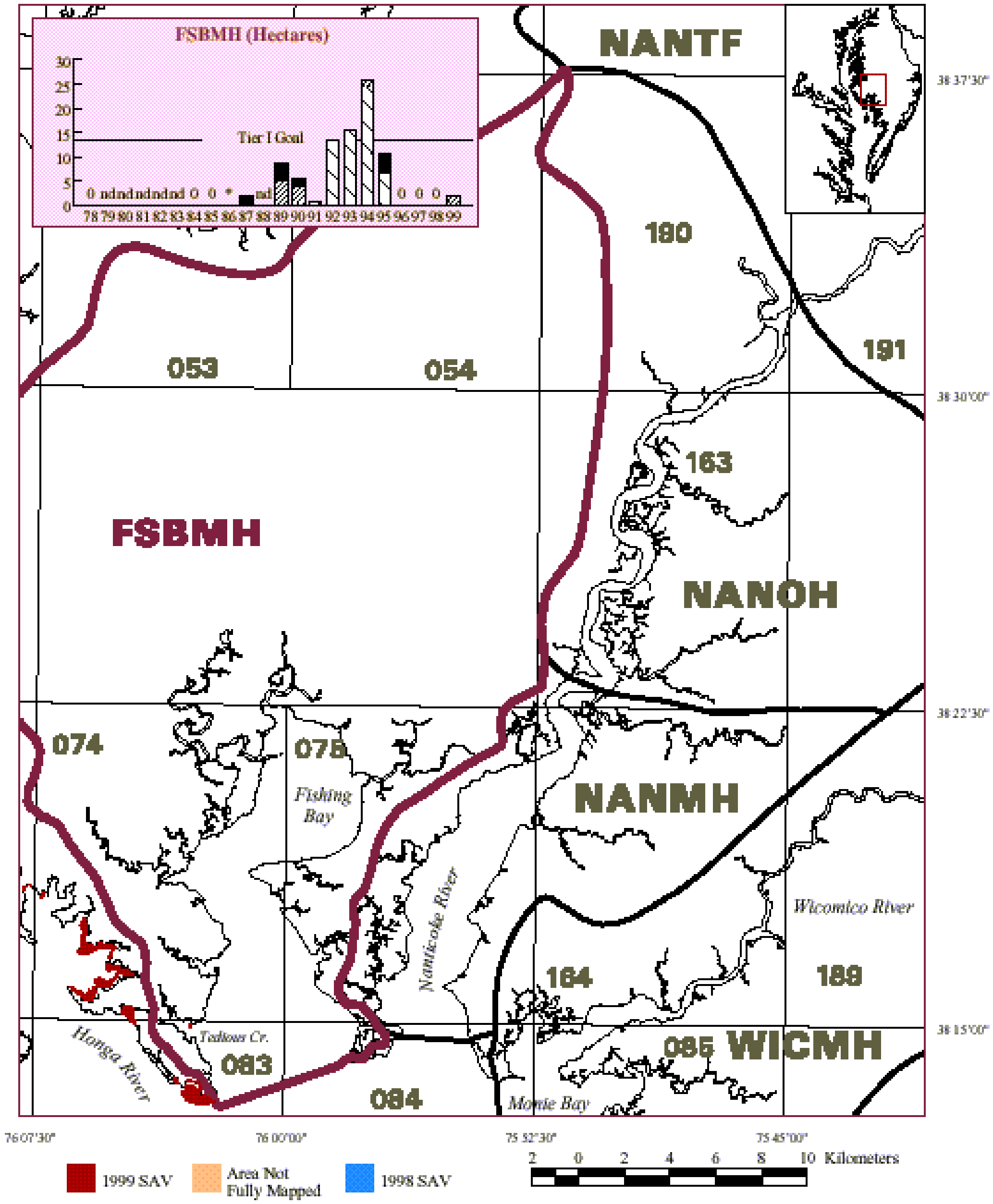


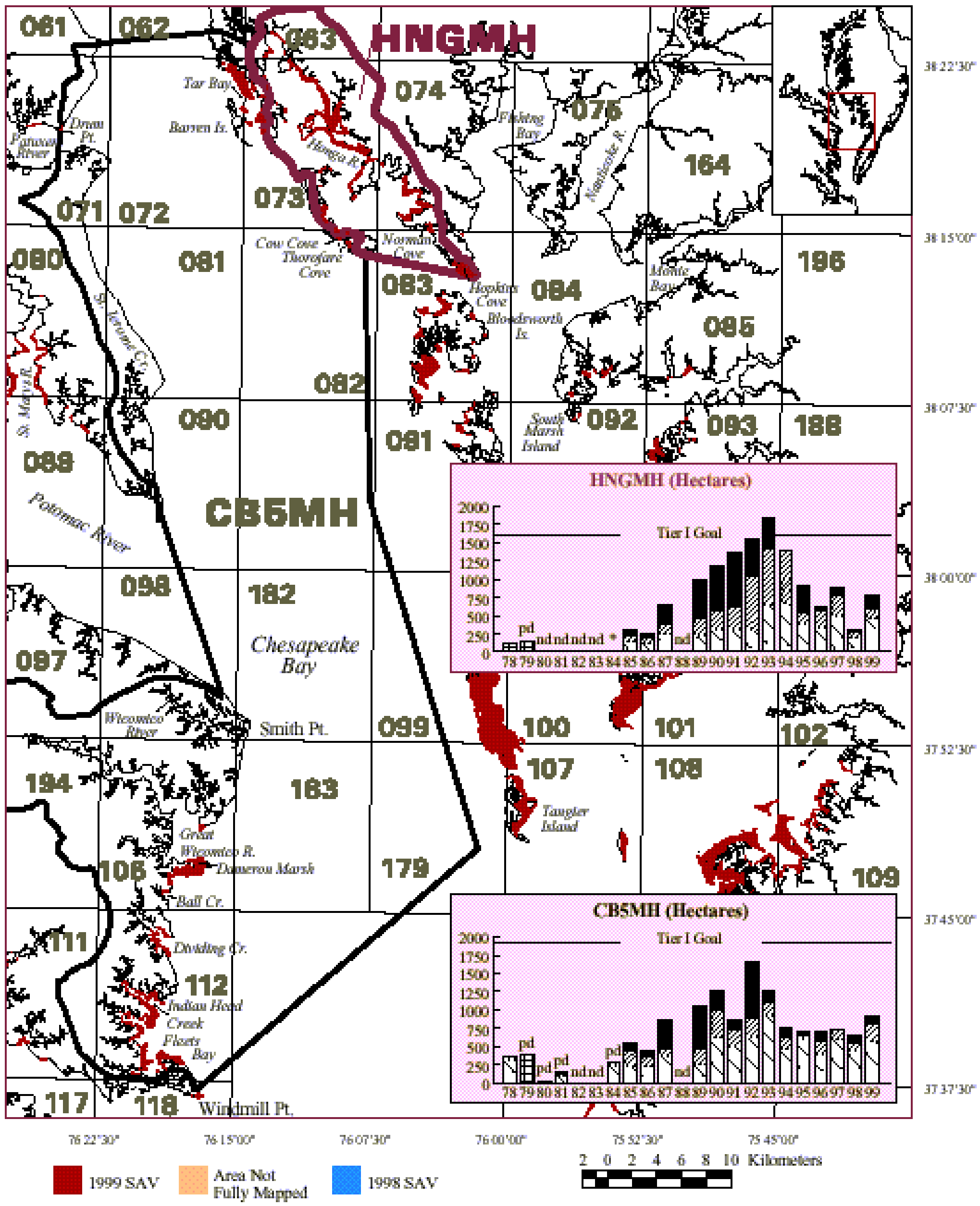
Figure 31. Chesapeake Bay Program segments in the Middle Chesapeake Bay (1978) (color plate)

Key to segment maps
LCHMH–Little Choptank River
HNGMH–Honga River
FSBMH–Fishing Bay
NANMH–Lower Nanticoke River
NANOH–Middle Nanticoke River
TANMH–Tangier Sound
Source: http://www.vims.edu/bio/sav/sav99/downloads/middlezone.pdf



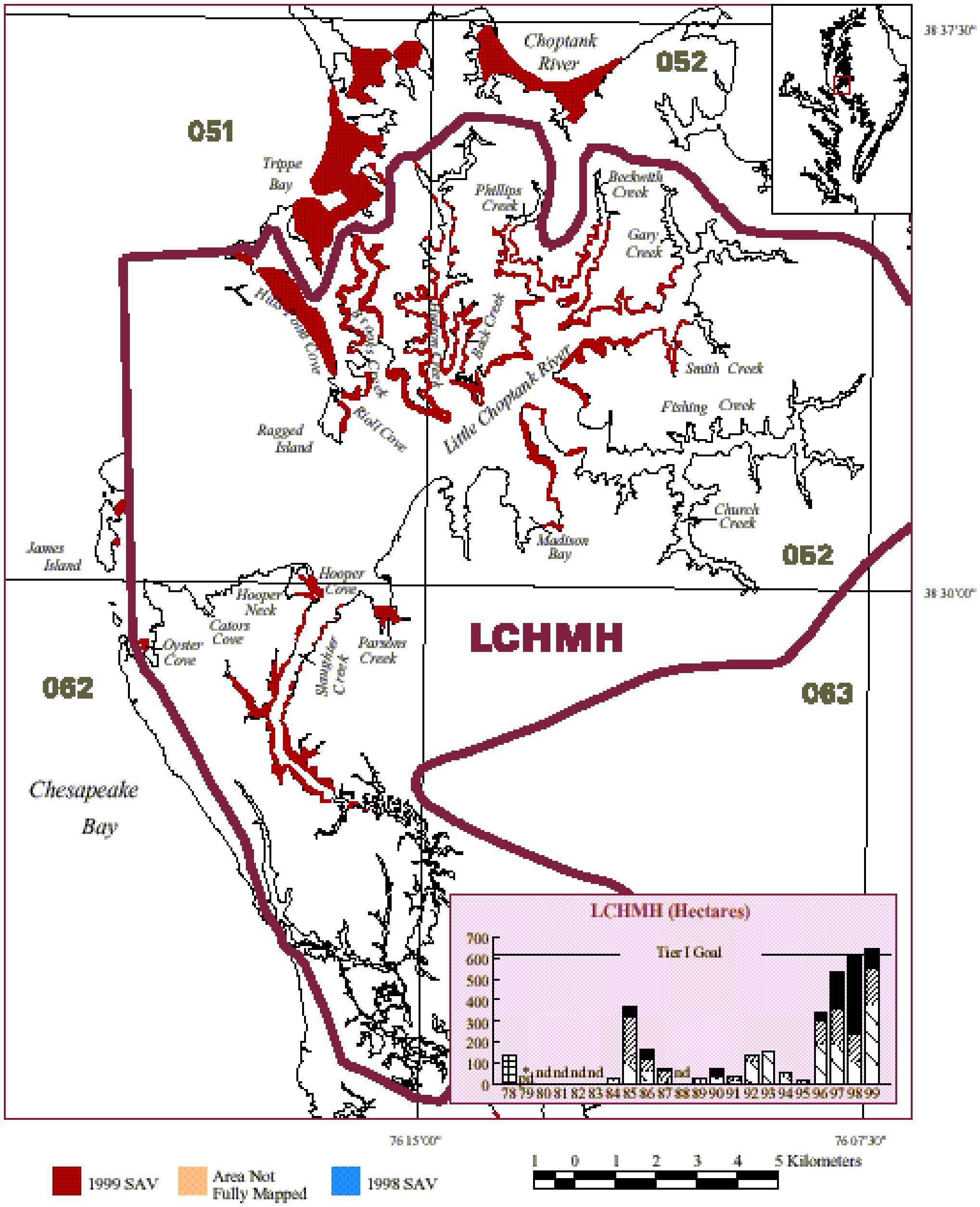
SAV distribution in Fishing Bay (FSBMH); the Lower (NANMH), Middle (NANOH), and Upper (NANTF) Nanticoke River; and the Wicomico River (WICMH) in 1999. NANMH, NANOH, NANTF, and WICMH are not graphed as no SAV was mapped from 1971-1999. (See Figure 11 for key.)

Figure 32. Segment FSBMH (hectares) (color plate)



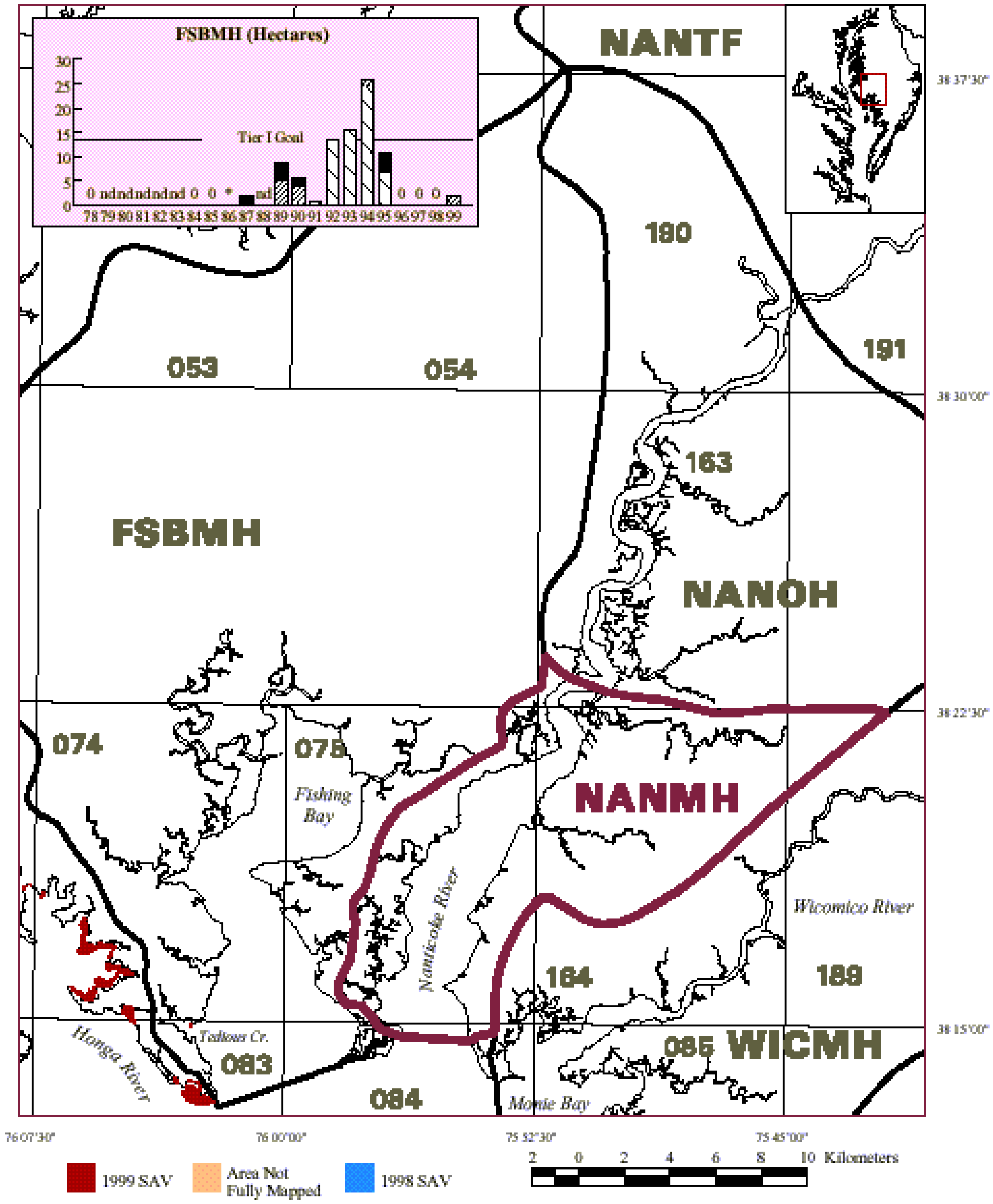
SAV distribution in the Lower Central Chesapeake Bay (CB5MH) and the Honga River (HNGMH) in 1999. (See Figure 11 for key.)

Figure 33. Segments CB5MH and HNGMH (hectares) (color plate)



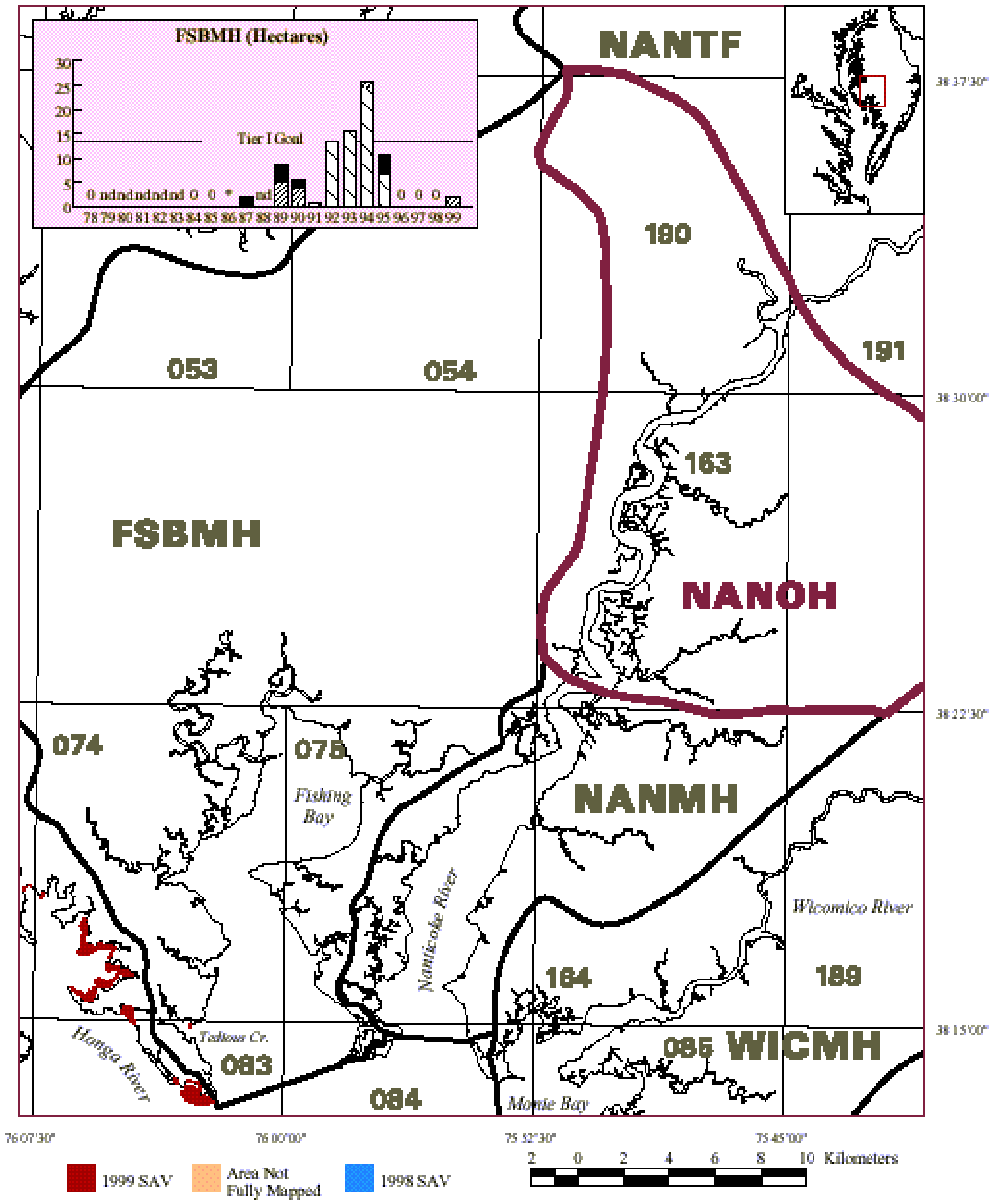
SAV distribution in the Little Choptank River (LCHMH) in 1999. (See Figure 11 for key.)

Figure 34. Segment LCHMH (hectares) (color plate)



SAV distribution in Fishing Bay (FSBMH); the Lower (NANMH), Middle (NANOH), and Upper (NANTF) Nanticoke River; and the Wicomico River (WICMH) in 1999. NANMH, NANOH, NANTF, and WICMH are not graphed as no SAV was mapped from 1971-1999. (See Figure 11 for key.)

Figure 35. Segment NANMH (hectares) (color plate)



SAV distribution in Fishing Bay (FSBMH); the Lower (NANMH), Middle (NANOH), and Upper (NANTF) Nanticoke River; and the Wicomico River (WICMH) in 1999. NANMH, NANOH, NANTF, and WICMH are not graphed as no SAV was mapped from 1971-1999. (See Figure 11 for key.)

Figure 36. Segment NANOH (hectares) (color plate)

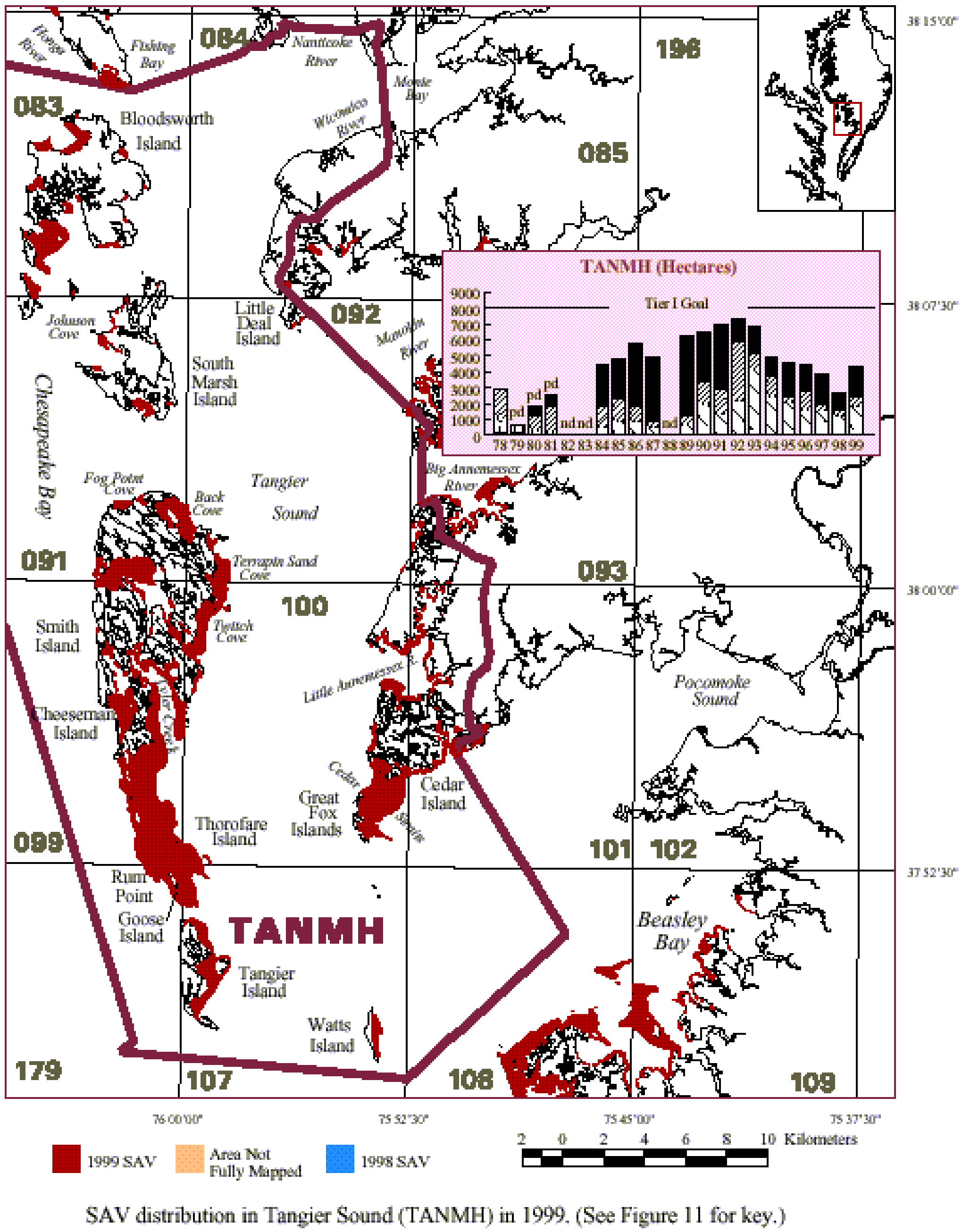


Figure 37. Segment TANMH (hectares) (color plate)

The dominant plant community types in the brackish high marsh are needlerush (*Juncus roemerianus*) and threesquare (*Shoenoplectus spp.*). Each of these community types occupies about 20,000 acres of the study area, and each represents about 18 percent of the total tidal wetlands. The Olney threesquare marshes are what has historically made Blackwater NWR world famous and the haven it has been to waterfowl for centuries. Olney threesquare (*Shoenoplectus americanus*) is the predominant species in the threesquare marshes, but common threesquare (*Scirpus americanus*) and stout bulrush (*Scirpus robustus*) may be more abundant in the landward sections of the marshes. Net aerial primary production of *Shoenoplectus americanus* at Blackwater NWR was found to average 639.4 grams of dry weight per square meter, which is in the middle of the range for Chesapeake Bay marshes (Pendleton and Stevenson 1983).

Within the study area, meadow cordgrass (*Spartina patens*) and spikegrass (*Distichlis spicata*) marshes occupy more than 10,000 acres of the study area (11.7 percent); big cordgrass (*Spartina cynosuroides*) occupies more than 4,000 acres (5.1 percent); and cattail (*Typha spp*.) occurs on approximately 2,000 acres (2.7 percent). Stands of big cordgrass tend to occur along the banks of the rivers, creeks and guts; the meadow cordgrass and spikegrass occupies the most saline areas; and cattail is found in the least saline areas.

Other wetland community types in the brackish high marsh category are those dominated by marsh elder (*Iva frutescens*), groundsel bush (*Baccharis halimifolia*), switch grass (*Panicun virgatum*), common reed (*Phragmites communis*), and rose mallow (*Hibiscus spp.*). The shrubby marsh elder–groundsel bush wetlands occupy sites along the upland margin of the wetlands on natural levees and turf banks. Unlike the other brackish high marsh plant communities, the marsh elder–groundsel bush and rose mallow do not occur in pure stands of the predominant species. In stands of marsh elder and groundsel bush, the undergrowth commonly is formed by meadow cordgrass. Rose mallow is commonly found with switch grass, Olney threesquare, narrowleaf cattail and smartweeds.

According to McCormick and Somes (1982), the average areal biomass production of brackish high marshes exceeds that of the low marsh. As with the low marsh. most of this biomass is used by consumers as detritus. The exception to this rule would be the use by some bird species of the seeds and roots of certain plants. The seeds of species such as the bulrushes and panicgrasses are important food sources tor waterfowl, shorebirds, and songbirds. The roots of *Scirpus* spp. are food for waterfowl, particularly Canada geese, muskrats, and nutria.

Freshwater intertidal marsh is one of the most important marsh types, based on total ecological value, and covers more than 5,600 acres in the study area. It is among the highest in wildlife productivity and waterfowl utility, and is closely associated with fish spawning and nursery grounds. This community is highly valued as a natural shoreline stabilizer and sediment trap for upland runoff. The 3–5 tons of plant biomass produced per acre each year is fully accessible to the estuary.

The predominant wetland types are cattail (*Typha spp*.), pickerel-weed (*Pontederio cordata*), arrow arum (*Peltandra virginicum*), bulrush (*Scirpus* spp.), and spatterdock (*Nuphar advera*). These four types make up about 80 percent of the wetlands of this category. Other wetland types in this category include big cordgrass (*Spartina cynosuroides*), smartweed (*Polygonum spp.*), rice cutgrass (*Leersia oryzoides*), wildrice (*Zizania aquatica*), sweetflag (*Acorus calmus*), rose mallow (*Hibiscus* spp.) and common reed (*Phragmites communis*).

This habitat community also has at least two State-listed species, the spongy lophotocarpus (*Sagittaria calycina*), threatened, and the marsh wild senna (*Chamaecrista fasciculata*), endangered. The latter is also a candidate for Federal listing; the only known population in Maryland is the one at Mill Creek, in the Nanticoke protection area. Other rare plant species in this community include elongated lobelia (*Lobelia elongata*), and a beggars tick (*Bidens discoidea*). The large number of wetland types (10) in the freshwater marshes is a reflection of the tendency of marshes to increase in plant diversity with decreased salinity (Anderson, 1968; Gabriel and de la Cruz, 1974). Phragmites, an exotic species, is an aggressive colonizer and displaces many other marsh plant species in this community.

Freshwater intertidal swamp forests are contiguous with the freshwater intertidal marshes, and cover about 8,000 acres within the study area. These swamp forests are composed of red maple–ash swamp forests (called ‘cripples’ on the Nanticoke) and the loblolly pine swamp forest (found principally on the Blackwater). The deciduous swamp forests occur in the upper reaches of the main stem river and creeks on the Nanticoke River, and tend to merge almost imperceptibly into the inland palustrine swamp forest, as do the loblolly pine swamp forests of the Blackwater NWR. They are noticeably smaller than the palustrine forests of the same species, and tend to shed their leaves earlier.

The most extensive intertidal swamp forest in the watershed is the red maple–ash (*Acer rubrum–Fraximus spp.*) type, which covers about 7,000 acres (5.4 percent) of the study area, mostly within the Nanticoke protection area. Other trees within this broadleaf forest type include green ash (*Fraxinus pennsylvanica subintegerrima*), blackgum (*Nyssa sylvatica*), and sweetbay (*Magnolia virginiana*) (McCormick and Somes, 1982). The loblolly pine swamp forests occupy about 900 acres (1 percent) of the study area, and generally occur adjacent to brackish marshes. They may be either pure stands or mixed with broadleaf trees. Collins sedge, Mitchell's sedge, a beggars tick, and false hop sedge are rare plant species found in the freshwater intertidal swamps.

Freshwater intertidal shrub swamps are similar to the swamp forests in species composition, but represent an earlier stage of forest regrowth and may also be characterized by dogwood, poison ivy, black willow, smartweeds, royal fern and water hemp. The intertidal shrub swamp comprises about 897 acres (1.1 percent) of the watershed.

Riverine Wetland

Riverine systems are defined by Cowardin (1979) as areas in which moving water flows through a channel at least periodically, and salinity is less than 0.5 ppt (parts per thousand). The boundaries of riverine wetlands are further defined as the area from the channel of non-tidal rivers and streams up to the channel bank or to wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens (Cowardin et al. 1979). Riverine wetlands make up a minor component of the total wetland complex within the watershed, and are restricted to a narrow band of wetlands along the upper reaches of the main stem of Marshyhope Creek and the Nanticoke River, and some of the Delaware tributaries. The upper Blackwater River historically could have been considered as riverine wetlands, but salinities are currently to high. The riverine wetlands are habitat for the rare subulate arrowhead (*Sagittaria subulata*) which colonizes the muddy banks.

Palustrine Wetland

A significant proportion of the land area of the Delmarva Peninsula is occupied by nontidal or palustrine wetland communities of one type or another. The sandy soils that characterize most of the lower Peninsula allow rapid draining of surface water, but the combination of low elevation and little or no relief and moderate annual precipitation produces a landscape that features large areas that have saturated soils or which hold standing water during several months of the year. These communities include forested swamps lining streams and rivers (floodplain forested swamps), extensive low swamp areas (nonfloodplain forested swamps) that may or may not drain into (or act as the headwaters for) small creeks and streams, seasonally flooded ponds (“Delmarva” or “Carolina” bays) with open or closed canopies, small bog habitats, open water millponds with bordering vegetated wetlands, and a number of other wetland types (natural and man-made) intermediate in character between these primary types.

Palustrine wetlands play a very important role in protecting the water quality of the Blackwater and Nanticoke river systems. These communities provide the basic “ecosystem services”: filtering nutrients and chemicals from surface and groundwater, trapping excess sediments, and moderating floodwaters and storm effects. Floodplain forested swamps form a protective corridor that buffers streams and tributaries from both natural and anthropogenic impacts and disturbances. Similarly, forested wetlands at the headwaters of streams play a major role in determining both the amount of flow in the streams, and how clean that water will be.

Taken together, palustrine wetland communities in the watershed support a host of rare plant and animal species. This is especially true for habitats that are intrinsically rare on the Coastal Plain (e.g., bogs), as well as for those that have suffered dramatic reductions in abundance and distribution on the Delmarva Peninsula (e.g., seasonally flooded ponds) as a result of human activity. Palustrine forested wetlands also provide some of the best wildlife habitat in the watershed (and on the Peninsula). Because these woods have been much less disturbed than upland forests, the retain the structural and ecological characteristics that promote high species diversity and efficient ecosystem cycling.

Within the palustrine forested wetlands on Blackwater NWR, two existing “green tree reservoirs,” totaling approximately 10 acres, are managed, monitored, and maintained to provide seasonal sources of flooded hard mast and macro invertebrates as food resources for migratory birds, principally wood ducks, black ducks, and mallards. Drawdown occurs in early March to maintain living or “green” timber that will live year after year to produce hard and soft mast and detritus for macro invertebrate production. Reflooding occurs in late September or whenever there is sufficient rainfall. Water levels are monitored biweekly during the winter, and maintained in accordance with the Annual Water Management Program.

Most of the 40 types of palustrine communities described by the USFWS National Wetlands Inventory (NWI) are found in the Blackwater NWR and Nanticoke protection area. However, most of the NWI community types can be grouped into one of the following categories.

Floodplain Forested Swamps.—Floodplain forested swamps occur along many of the small creeks and larger streams. The forested swamps along the Marshyhope Creek are good examples of these habitats that are dominated by red maple, black gum, some scattered loblolly pine, and an understory of holly and sweet bay. Shrub cover within these types of forested swamps is dominated most often by sweet pepperbush and highbush blueberry, and can also include rhododendron, serviceberry, and fetterbush. Several different types of ferns are common in the herbaceous layer, as well as various species of sedges. On some floodplain terraces, ash, river birch, and oaks form part of the canopy.

Non–Floodplain Forested Swamps.—Non-floodplain forested swamps are forested swamps in closed basins or not closely associated with a flowing stream. While the plant composition is very similar to that of the Floodplain Forested Swamps, the canopy is often dominated by very large (2- to 3-foot DBH) and widely spaced red maples, with some sweet and black gums. These are “old growth” swamps.

One unique type of non-floodplain forested swamp is the Atlantic white cedar swamp found in Nanticoke protection area. This community type is found above the intertidal swamp zone along rivers, as well as in palustrine wooded wetlands away from the rivers. In pure stands, Atlantic white cedar may occupy half of the canopy, with red maple, black gum, loblolly pine, and sweet gum making up the remainder.

Palustrine Forest on Blackwater NWR

Practically no virgin forests remain in Dorchester County. Almost all of the woodland in the county has been cut several times, much of which had been permanently cleared for agriculture, and to a lesser extent, development. Most of the remaining woodlands exist in small isolated patches surrounded by agricultural fields. Blackwater NWR currently contains some of the largest contiguous forests in Dorchester County, and has been identified as a major forested hub by the Maryland Green Infrastructure Program.

The forested habitats that occur on Blackwater NWR are primarily palustrine forested wetlands and, to a lesser extent, forested uplands, estuarine intertidal forests, and palustrine scrub forests, as defined by National Wetlands Inventory Standards. The four major forest cover types delineated on Blackwater NWR are Loblolly Pine, in which loblolly pine comprises at least 80 percent of the basal area of the stand; Loblolly Pine–Oak, in which loblolly pine comprises 20–79 percent and oak species account for 20 percent or more of the basal area; Loblolly Pine–Mixed Hardwood, in which loblolly pine comprises 20–79 percent and hardwoods other than oak comprise at least 20 percent of the basal area of the stand; and Mixed Hardwoods, in which various hardwood species account for at least 80 percent of the stand (Whiteman and Onken 1994).

For the purpose of our CCP and our forest management plan, we have combined the Loblolly Pine–Oak type and the Loblolly Pine–Hardwood type into the "Loblolly Pine–Hardwood" type. Harvested or regenerating stands and planted sites containing trees up to 15 years of age are pooled to form the "Regeneration" cover type classification. Areas dominated by stunted and dying trees are combined with stands dominated by dead trees to form the "Stunted/Inoperable" cover type classification. The final subclassification of the forest habitat is referred to as "Miscellaneous Forests"; it includes all of the wooded islands scattered throughout the marsh and all of the narrow wooded fringes that border ditches and small patches of trees (<2 acres) that are not part of any other forest habitat. Blackwater NWR now contains 8,374 acres of forested habitats.

Table 6. Forest cover types (Blackwater NWR)

Forest Type	Acres
Regeneration	1,270.26
Loblolly Pine	1,328.15
Loblolly Pine–Hardwood	2,958.11
Mixed Hardwoods	1,232.68
Stunted/Inoperable	1,458.18
Miscellaneous	98.63
Total†	**8,346.01**

†plus small islands in wooded compartments

The most dominant tree species on Blackwater NWR is loblolly pine (*Pinus taeda*). Well adapted to the Atlantic Coastal Plain of Maryland's Eastern Shore, loblolly pine grows well on soils with imperfect to poor surface drainage. It is shade-intolerant, so some form of disturbance is necessary to maintain the species. Most view the "climax" forest for the loblolly pine type as several possible combinations of hardwood species and loblolly pine. Some evidence indicates that, within the range of loblolly pine, several different tree species could potentially occupy a given area for an indefinite period of time, and that disturbance is a naturally occurring phenomenon. If this is so, then the climax for this forest might best be termed the "southern mixed hardwood–pine forest" (Baker and Langdon 1990).

The common hardwoods include sweet gum (*Liquidambar styraciflua*), black gum (*Nyssa sylvatica*), red maple (*Acer rubrum*), swamp chestnut oak (*Quercus michauxii*), willow oak (*Quercus phellos*), black oak (*Quercus velutina*), white oak (*Quercus alba*), American beech (*Fagus grandifolia*) and American holly (*Ilex opaca*). Shrub species found in association with these forest types include high bush blueberry (*Vaccinium corymbosum*), sweet pepper bush (*Clethra alnifolia*), maleberry (*Lyonia ligustrina*), swamp sweet bells (*Leucothoe racemosa*), poison ivy (*Toxicodendron radicans*), and various species of green briar (*Smilax spp.*).

Of all the hardwood species found, the most important are the oaks. Oaks are the life support system for many animals. Acorns are eaten by many species of birds and mammals, including deer, bear, squirrels, mice, rabbits, foxes, racoons, grackles, turkey, grouse, quail, bluejays, woodpeckers, and waterfowl. The population and health of wildlife often rise and fall with cyclic production of acorns. Acorns' importance to wildlife is related to several factors, including their widespread occurrence, palatability, nutritiousness, and availability during the critical fall and winter period (Johnson, 1994).

Due to the low elevation of much of the forested habitats and the underlying layers of impermeable clay in the soil horizon, it is not uncommon for entire forest tracts to be flooded throughout much of the winter and spring. Those areas characterized by longer periods of ponding or flooding tend to have extremely sparse understories and little to no regeneration.

Forest Communities

Loblolly Pine TNC Vegetation Classification Types

I.A.8.C.x.9 Pinus Taeda Planted Forest Alliance

I.A.8.N.b.16 Pinus Taeda Forest Alliance; Pinus taeda / Liquidambar styraciflua–Acer rubrum var. rubrum / Vaccinium stamineum Forest; Pinus taeda / Myrica cerifera / Vitis rotundifolia forest.

I.A.8.N.g.300 Pinus Taeda Saturated Forest Alliance; Pure loblolly pine stands occur throughout the refuge at all elevations, but often bordering marsh habitats. Pure pine stands not yet affected by rising sea levels comprise 1,328 acres (16 percent) of the total forest acres. Pine stands along marsh transition zones in general make up the stunted forest type, and comprise 1450 acres (17.4 percent) of the forest area. When loblolly pine predominates, it forms the Society of American Foresters Forest Type 81, Loblolly Pine (Baker and Langdon, 1990), and the following Nature Conservancy Forest Alliances: A. 30 Pinus Taeda Forest Alliance. In immature stands, the pines are generally very dense with a dense understory of various shrubs, grasses, and hardwood saplings. The understory in mature stands is usually more open, with wax myrtle, holly, grasses, and other hardwoods. These stands represent an early stage of succession; hardwoods dominate the sub-canopy and will eventually dominate the stand.

In general, loblolly pine begins to decline around age 80, and will be mostly eliminated from a stand by the age of 100 to 150 years (BRefuge 1984; Giese, Rider, Daniels, 2000). This occurs at an earlier age on wetter sites where trees become more stressed and susceptible to insect and disease outbreaks due to greater frequency and duration of flooding. The primary cause of pine mortality in this region is red rot disease or heart decay caused by numerous species of fungi. Also associated with frequent flooding is the risk of salt water intrusion, which has affected many of the forested habitats on the refuge.

On the more upland sites, as loblolly pine declines, it will be replaced by dense stands of red maple and sweet gum with little to no oak component. Red maple (*Acer rubrum*) and sweet gum (*Liquidambar styraciflua*) are major components of all forest types present on the refuge, and are positioned to take advantage of any gaps in the canopy. Due to their faster growth rates and hardiness, they generally out-compete all other tree species, especially slower-growing oaks. Also on upland sited pure loblolly pine stands may occur as plantations or stands of natural origin that were managed for pine production early in there development. Near pure pine stands also exist as newly regenerating stands where woody shrubs are the pine's primary competition for nutrients. The understory within these stands can range from fairly sparse in mature stands to very dense in young or more open stands. Common understory species include *Smilax spp.*, wax myrtle, poison ivy, and switchgrass.

Loblolly pine–mixed hardwood TNC Vegetation Classification Types

I.B.2.N.d.16 Quercus (Michauxii, Pagoda, Shumardii)–Liquidambar Styraciflua Temporarily Flooded Forest Alliance, Pinus taeda–Quercus (michauxii, falcata) Liquidambar styraciflua temporarily flooded forest.

Pine–hardwood associations in this region represent a more intermediate stage of succession towards a climax hardwood forest. Loblolly pine is the dominant canopy species in this community type, with red maple, sweet gum, holly, and black gum dominating the sub-canopy. Various oak species as well as American beech also occur throughout most of these stands. The occurrence of specific species of oak or beech is directly related to micro topography, elevation, and soil moisture. Where willow oaks are most frequent on the lower elevations, the presence of beech indicates the highest and driest sites in the stand.

Upon reaching maturity, canopy closure eventually shades out intolerant young loblolly pine which are replaced by shade tolerant hardwoods such as oak and beech. As in the pure pine stand, heart rot will eventually succeed in removing pine from the upper canopy as well. On these marginally drier sites, loblolly pine may live to 120 to 150 years. However, growth rates, mast production, and overall health begins to decline dramatically between 80 and 100 years. Increment cores from several 120-year-old loblolly pines revealed negligible growth for almost the last 20 years. Again, the gaps created in the canopy will most likely be filled by maple and gum. Oaks and beech will persist in the sub-canopy inching their way to dominance and, eventually, the climax species of the stand.

Selective thinning of red maple and sweet gum to release oaks at an early stage of succession would ensure a greater prevalence of oaks in the canopy. Then as gaps are created, the oaks would be the first to capitalize by expanding their crowns. Wider crowns result in higher rates of photosynthesis, growth rates and ultimately mast production. Perpetuating oak survivability versus red maple or sweet gum would greatly enhance Delmarva fox squirrel habitats.

Mixed Hardwoods TNC Vegetation Classification Types

I.B.2.N.a.22 Liquidambar Styraciflua Forest Alliance

I.B.2.N.d.16 Quercus (Michauxii, Pagoda, Shumardii)–Liquidambar Styraciflua Temporarily Flooded Forest Alliance

I.B.2.N.e.6 Liquidambar Styraciflua–(Acer Rubrum) Seasonally Flooded Forest Alliance

I.B.2.N.e.15 Quercus Phellos Seasonally Flooded Forest Alliance

I.B.2.N.g.2 Acer Rubrum–Nyssa Sylvatica Saturated Forest Alliance

Natural, pure hardwood stands are limited to narrow bands along low wet drainage ways. However, mixed hardwood stands occur throughout Blackwater NWR as a result of various anthropogenic forces. Hardwood fringes border agricultural lands and ditch banks, and serve as wooded corridors that connect otherwise fragmented habitat. Green tree reservoirs exist adjacent to seasonally flooded moist soil units, and provide an invertebrate food source for wintering waterfowl. The most dramatic force resultant in mixed hardwood forest types was the selective removal of more valuable pine from pine–hardwood stands, also known as high grading.

The residual stands created by this harvest method are generally characterized by having an over-mature canopy of poor quality hardwoods, little to no mid-story, and dense shrub understory. The remnant hardwoods, especially oaks, tend to be stunted and stressed from being suppressed their entire life by overtopping pines; therefore they are more susceptible to forest insect pests and disease. On rare occasions, high graded stands flourished as mature oak dominated stands of good health and quality. The remnant trees were vigorous enough to take advantage of the release, and increased crown diameter to fill in the gaps and maintain a sparse understory. Several factors may have caused such a dramatic contrast in tree response such as time of harvest, soil type, hydrology, and percentage of overstory removed.

Stunted/Inoperable TNC Vegetation Classification Type

I.A.8.N.g.300 Pinus Taeda Saturated Forest Alliance

These stands are generally portions of loblolly pine stands that border marsh habitats and grow on Sunken soils. The potential productivity is low for loblolly pine on Sunken soils. Because of the sodium salts in the upper layers of the soils, the trees are stunted and seedling mortality rates are increased (USDA 1998). Therefore, these stands are dominated by stunted, mature loblolly pine of small diameter and height. The understory consists primarily of grasses and sedges along with wax myrtle and green briar. Due to rising sea levels, these stands are inundated for several months of the year by tidal waters, during which they are exposed to varying concentrations of salt which causes the stunting and ultimately widespread mortality and conversion to marsh.

Most of these stunted pine stands buffer estuarine tidal wetlands and are protected by the Critical Areas Commission, and in some cases Natural Heritage Area designations. Please consult the Forest Management Plan for a more thorough description of the forest classifications and types in each refuge compartment.

Coastal Plain Ponds (Delmarva Bays).—Among the most unique wetland habitats in the study area are the seasonally flooded ponds known as “Delmarva bays.” These wetlands fill with water in the winter as ground water levels increase, then gradually dry in July and August. The plant species are specially adapted to these fluctuating conditions. Many of these areas have been drained and converted to agricultural lands, timber plantations, or residential development, and for this reason these wetlands and their dependent species are quite rare in Maryland, Delaware, and regionally. The Coastal Plain Ponds contain some of the rarest species in the study area, and accordingly have been the focus of conservation efforts by many agencies and conservation organizations.

Open Canopy Herbaceous Wetlands

Open Water Habitats (Ponds and Impoundments).—On the Delmarva Peninsula, conditions that support an open water habitat with a constant freshwater inflow and outflow are restricted primarily to man-made ponds. Sand and gravel "borrow" pits and old millponds along the Nanticoke River, created by damming small streams many years ago to provide water power for mills, provide excellent habitats for spatterdock, waterlily, bladderwort, pink bog-bottom, bur-reed, St. John's wort, buttonbush, and water hemlock.

Twenty-four freshwater ponds, the largest being 6 acres, have been created by refuge staff or previous landowners on Blackwater NWR. These ponds are maintained and managed to support wildlife and a diversity of plant and animal life, and most importantly serve as a source of fresh water to supply nearby moist soil units. Two of these ponds are equipped with dry hydrants to supply emergency sources of water during wildland suppression fire operations. Periodic dredging to maintain pond depth, and mechanical or chemical control to treat woody vegetation and other invading species is performed as necessary.

Twenty-four fresh water impoundments, totaling 368 acres, are managed and maintained on Blackwater NWR principally to provide food and habitat for migratory birds (waterfowl, shorebirds, and wading birds). Most of the existing impoundments have been constructed on "prior converted or farmed wetlands." A management technique, known as "moist soil management," is the current management practice in these impoundments.

When implementing moist soil management, pool drawdowns typically occur between mid-March and early June, depending on the wildlife objectives and moist soil plant/invertebrate response desired. Drawdown is initiated in most pools first by gravity flow, but pumping is often required in most of the impoundments to remove all the water. Several permanent and seasonal pumping stations, utilizing gasoline, diesel, and electric pumps, are operated and maintained. Rates of drawdown are critical, and, depending on the pool bottom topography and soil type or organic content, can occur rapidly or must be prolonged. All drawdowns are completed by mid-June, and pool bottoms are maintained as moist as weather conditions will allow to facilitate the germination, growth, and production of a wide diversity of emergent moist soil plants such as smartweeds, beggartick, red-root cyperus, Panicum, Walters' and barnyard millets, dwarfed spike rush, etc.

Water levels, pH, conductivity, and salinity are monitored and recorded weekly during the growing season and biweekly during periods of flooding. Exact water level management plans are described in an Annual Water Management Program, and used as an annual management guide (rainfall dependent). Vegetative transects are conducted between mid-June and mid-July, and again in early September, to determine success or failure of vegetative response. When preferred emergent vegetation has failed to grow and weeds like cocklebur and fleabane are dominant, these areas are disced and a small grain crop, such as millet or sorghum, is planted. Gradual reflooding begins in September, depending on having the necessary fresh water which is supplied through rainfall, snow melt, runoff through Kentuck and Green Briar Swamps, adjacent freshwater ponds, or by a limited number of small wells.

The waters of the Blackwater and Little Blackwater Rivers and the adjacent marshes (once fresh and used for these purposes) are currently too salty for this use. When used for flooding in the past, waters from these sources have significantly contributed to increased soil salinity (and subsequent soil sterilization) in several impoundments, particularly sub-impoundment 5b. Runoff can be significant at times (particularly during hurricanes and tropical storms) from adjoining private land in Kentuck and Green Briar Swamps. This is particularly true for the lands adjacent to impoundments 3 and 5, which are separated from Kentuck Swamp by Key Wallace Drive, and it is not uncommon to observe water sheeting across 2 miles of Key Wallace Drive and several places along State Route 335 after major weather events. Appropriate consideration must, therefore, always be given to ensure that dikes and water control structures are properly constructed, sized, and maintained so as not to inadvertently result in flooding private lands.

Because of the flat topography of most of the refuge, many opportunities are lost to create additional impoundments or maintain water reserves since the presence of supporting impoundment infrastructures can severely restrict historical drainage patterns and create flooding of private lands. Periodic disturbance, mowing and discing, are utilized to destroy monicultures and set back succession. Moist soil wetlands that are normally dominated by seed-producing annuals, may shift to less desirable perennials after several years and need to be rejuvenated. Undesirable plants that have little or no wildlife value need to be controlled so that they do not outcompete plants with greater values. When manipulation is required, it is timed so that the resultant decomposing vegetation can be used effectively by wetland invertebrates.

Manipulation of managed wetland areas is often better described as a learned craft or art, rather than strictly as applied science. Each impoundment and subimpoundment has its own unique characteristics, and preliminary assessments include the following considerations when managing these wetlands.

1. Site location to assess salinity and pH;

2. Determination of topography to better understand subtle elevational differences within specific managed wetland sites and to better predict vegetational responses to disturbances and water regimes;

3. Maintaining systematic records of water level changes to assess vegetation response and determine availability of optimum foraging depths (also included will be a monitoring program to record amounts of water from the flooding sources);

4. Monitoring water quality;

5. Site inspections and monitoring to evaluate site use and to identify manipulations needed to enhance or prevent certain vegetative conditions;

6. Plant identification to ensure proper timing and type of manipulation;

7. Effects of burrowing animals to maintain integrity of levees and dikes;

8. Equipment capabilities, availability, and readiness will be determined; and finally

9. Critical time periods will be identified for implementing preferred management strategies (Fredrickson and Reid, 1988).

Coastal Plain Bogs.—True bogs are most common in the mountain region of western Maryland, but several important examples of bog communities occur in the watershed, principally along the Nanticoke River. Because they are somewhat different than the true bogs of western Maryland, they are referred to here as “Coastal Plain bogs.” These habitats are relatively rare on the Eastern Shore, and most that do exist are the result of human modification of the environment. Old millponds that have been dammed for many years or stream areas crossed by power lines have accumulation of peat and herbaceous plants. These areas are often colonized by carnivorous plants and other rare plant species.

Wet Meadows.—Another artificial open canopy herbaceous wetland community type located on Blackwater NWR and within the Nanticoke protection area is wet meadows. Many wet meadow habitats were created as a result of power transmission line construction, which removed the tree canopy from areas that were formally forested wetlands. Several wet meadows are maintained at Blackwater NWR (e.g. Stanley and Slacum Fields).

The alteration, disturbance, degradation, dredging, or filling of these freshwater wetlands, most particularly those activities affecting naturally occurring wetland systems, are closely regulated by local, State, and Federal agencies. Management actions designed to convert one freshwater wetland type to another are regulated by the U.S. Army Corps of Engineers and discouraged by the Service (excluding actions to convert “prior converted wetlands” to more functional wetland systems). For example, conversion of a naturally occurring inland palustrine forested wetland to a green tree reservoir, where water levels are regulated and controlled flooding is practiced during the winter months, is not permitted by the regulatory agencies. Similarly, actions that alter the existing hydrology in such a way as to convert palustrine wetland communities to freshwater swamps also are regulated, and not permitted.

While protecting wetlands from loss and degradation, today’s strict laws have precluded many types of wetland restoration and enhancement actions, and limited these activities to the following.

1. Control of noxious and invasive weeds in both man-made and naturally occurring freshwater areas;

2. Restoration or conversion of “prior converted wetlands” and uplands to freshwater systems, principally shallow and deep water ponds, impounded wetlands, inland palustrine forests, and wet meadows;

3. Management or restoration of these man-made ponds, millponds, impoundments, inland palustrine forests, and existing green tree reservoirs; and

4. Silvicultural management of forests in inland palustrine forested wetlands.

Therefore, these activities must be sensitive to two very important needs. First, wetland losses must be avoided wherever possible, and unavoidable losses must be compensated to ensure that "no-net-loss" of wetlands is maintained. Second, wildlife managers must achieve their objectives with minimum adverse impacts on wetland values and functions. A major issue discussed during the scoping process was to what extent "prior converted wetlands" will be maintained in agriculture or restored or converted to one of the freshwater systems mentioned above. This issue will be specifically addressed in each alternative.

Upland Communities

Xeric Dunes.—The ancient xeric dunes are dry sandy ridges formed 13,000 to 30,000 years ago out of the underlying Parsonsburg Sand formation. This geologic strata is particularly well developed along the east side of the Nanticoke River in both Maryland and Delaware, and ranges in height from 3 to 12 meters. Where they have not been converted to agriculture, timber plantations, or residential developments, Virginia pine is the dominant forest cover, with oaks, hickories, and some loblolly present and scattered with sweet gum, beech, and tulip popular. The understory is usually quite open, and highbush blueberry, low blueberry, huckleberry, and bayberry are present. The herbaceous layer is typically sparse, with green moss, reindeer moss, spotted wintergreen, and panic grasses. Rare species include the Pinkland tick-trefoil, Torrey beakrush, low frostweed, box huckleberry, pine barren gerardia, and Common's panicgrass.

Rich Woods Community.—The rich woods community is a subgroup of the ancient dune community, and is unusual because soil pH is circumneutral. This anomaly with the combination of well drained sandy soil and high pH has resulted in a mixed deciduous community with Piedmont affinities found along the east side of the Nanticoke River. Two state-listed species, the endangered cream-flowered tick-trefoil and the threatened wild lupine are associated with these habitats. Fire is an important disturbance factor that promoted the suitability of these habitats for the dune-adapted species.

Upland Forestlands.—The study area stands apart from other portions of the Delmarva Peninsula because of the extensive unbroken upland and palustrine forests. Thirty-eight percent of the study area is forested, including the largest continuous pine forest left on the Delmarva peninsula. Pine (mainly loblolly), hardwood, and mixed pine and hardwood are the main forest types. Loblolly pine is the principle timber tree. The continued presence and expansion of the forest land base in the watershed can be attributed largely to the existence of an economic incentive for private landowners to retain forests.

The Valiant and Linthicum or Buttons Neck Tracts contain the only upland forests on Blackwater NWR. Plantation loblolly pines are the dominant tree species on these upland sites.

Agricultural Lands.—About 43 percent of the land in the study area is used for agriculture. The study area supports about 1,300 animal production farms with poultry being the most common. In fact, the Nanticoke has more animal production units than any other river basin in Maryland. One result of this high level of livestock density is huge quantities of manure, a potential source of nutrients. Major crops include corn, soybeans, sorghum, wheat, and barley. Vegetable crops, including sweet corn, green beans, peas, tomatoes, and potatoes, also are commonly grown. Irrigation is common, and often a necessity for consistent production and high yields. Conservation tillage and no-till farming are widely practiced.

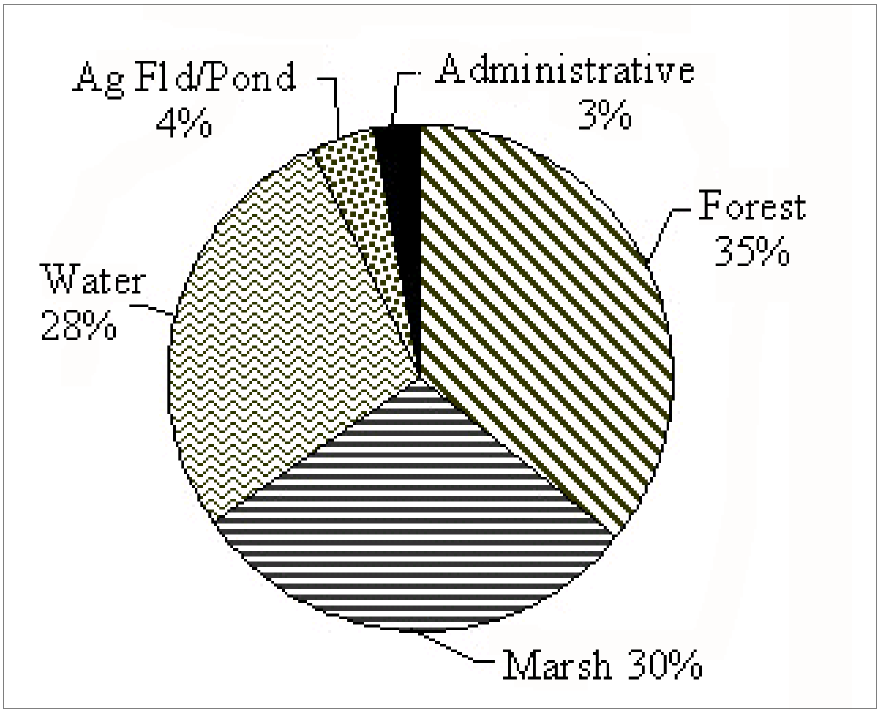


Figure 38. Land cover types as a percent of total area on Blackwater NWR

Agricultural lands on the Refuge Complex are limited to Blackwater NWR. Refuge staff currently plant approximately 567 acres in croplands (principally sorghum and corn) with funds received from grants, private donations, and force account monies directly from the refuge’s budget. Annual Service funding to support this critically important management program has been reduced from $43,000 in 1989 to $00 in 2000. Unlike cooperative farming where the refuge would only receive a 20- to 25-percent share of the crops produced, this management option allows the refuge to leave all crops unharvested and thereby make 100 percent of all crops grown available to wildlife.

Since the objectives are more directed towards wildlife and their needs, rather than the economics of a private farmer, no insecticides and very limited herbicides are used. The program also allows for more creative and innovative low impact tillage practices, liberal use of filter strips, longer crop rotations utilizing legumes to reduce nitrogen applications, and most importantly, a diversified cropping program directed at meeting the nutritional needs (seasonal carbohydrate demands) of waterfowl, high energy food sources for endangered species, and food resources for migrating songbirds and resident game.

The refuge also plants approximately 320 acres in high protein cool season grasses and forbs (consisting of rye, ladino clover, and wheat, the later acreage often double-seeded with high protein buckwheat), which are browsed heavily by migrating and wintering waterfowl. The refuge's best management practices continue to earn praise and support from local government officials, the general public, hunters, and adjacent landowners, and are often used to demonstrate to local farmers and students how best to “farm for wildlife.”

Bay Island Uplands.—The uplands of the Bay Islands within the study area vary from island to island. Battery Island on Susquehanna NWR is 80 percent lawn surrounded by a few pines and hardwood trees. The uplands of Barren Island are predominantly loblolly pines with a few mixed hardwoods, surrounded by marsh. Watt Island is forested with loblolly pines and mixed hardwoods, surrounded by a fringe of marshland.

The upland hammocks of Smith Island are important nesting sites for wading birds. Twelve hammocks on the Smith Island complex currently contain wading bird rookeries. Generally these hammocks constitute isolated ridges surrounded by marsh or open waters, or are former dredged spoil disposal sites which are also adjacent to marsh or open water. Hammock vegetation is characterized by shrub and tree species such as wax myrtle (*Myrica cerifera*), groundsel bush, black cherry (*Prunus serotina*), sassafras (*Sassafras albidum*), and hackberry (*Celtis occidentalis*). Understory vegetation is comprised of vine species such as Japanese honeysuckle (*Lonicera japonica*), poison ivy (*Toxicodendron radicans*) and blackberry (*Ribes* spp.).

Inland Island Uplands.—Inland island uplands within the study area are found only on Blackwater NWR, and represent most of the refuge uplands, except for approximately 90 acres of loblolly pine uplands on the Linthicum Tract, and 200 acres of loblolly pines on the Valiant Tract. These islands are dominated principally by a mixture of loblolly pine and hardwood with an open understory, and support most of the refuge's American bald eagle nest sites.

Unique Communities

The following sites have been identified by their respective Heritage Programs as being of special significance as natural heritage areas. Most sites currently have no protection, while others are partly or completely owned by conservation organizations or the Federal or state governments.

Maryland.—Big Creek Swamp, Boy Scout Divided Pond, Bradley Road Wetlands, Brookview Ponds, Butlers Beach, Chicone Woods, Gales Creek, Harrison Ferry Wetlands, Harrison Ferry South, Ingem Gut, Little Creek Upland and Floodplain, Lower Gales Creek, Marshyhope Spared Ridge, Marshyhope Floodplain, Mill Creek Natural Heritage Area, Nutters Neck, Savannah Lake Natural Heritage Area, Sharptown Dunes (Plum Creek Swamp) Taylors Trail, Upper Blackwater River Natural Heritage Area,and Upper Nanticoke River Macrosite Preserve.

Delaware.—Broad Creek, Ellendale Wet-Meadow, James Branch, Red House Landing Area, Robbins, Trapp Pond, and Wright Creek.

Brief descriptions of the Maryland sites and their ecological significance follow. Please note that, in some cases, the Heritage Program has not released the specific species in order to protect these sites. Descriptions of the Delaware sites are not included in this report.

Maryland Sites

Big Creek Swamp.—One of the least disturbed swamp–marsh complexes in Maryland, this protection area in Dorchester County near the confluence of the Nanticoke River and Marshyhope Creek encompasses a vast complex of undisturbed brackish-to-fresh tidal swamp and tidal marsh communities, as well as an extensive zone of ecotonal wetland habitats. The protection area supports two rare and one uncommon woody species, and almost a dozen rare or uncommon herbaceous species. One rare woody species is quite abundant along the Nanticoke River, but aside from one disjunct location in the Midwest, occurs nowhere else in the Country. The other rare tree species is known from fewer than 10 other sites around the State. A rare orchid, known from only about a dozen other sites in Maryland, also grows in the transitionzone habitat.

Boy Scout Divided Pond.—This ½–acre seasonal pond (Delmarva bay) in Dorchester County is a good example of a wetland habitat type that is now extremely rare in Maryland. Three rare and uncommon species; one State-listed as endangered, one State-listed as rare, and the third on Maryland's Watch List, grow in this pond. All are sedges. The endangered sedge is found in fewer than 10 other locations around Maryland; the State-listed (rare) sedge occurs at fewer than 20 other sites.

Bradley Road Wetlands.—This high quality tidal and nontidal wetland site is located near Stump Gut in Wicomico County. This site is among the most extensive and least disturbed examples of Atlantic White Cedar along the River. Three Watch List plant species and a small, but apparently native, population of a State-listed (threatened) plant occurs in the swamp. An uncommon orchid species is scattered about the swamp on raised sphagnum hummocks and around mossy tree trunks. The fresh upper tidal marsh around Stump Gut supports at least four rare plant species.

Brookview Ponds.—The Brookview Ponds Preserve in Dorchester County includes nine naturally occurring seasonal ponds that support 16 rare plant species and the State-listed (rare) carpenter frog. Five plant species that grow here are especially significant; lance-leaved sabatia (which had not previously been seen in Maryland since the early 1940's), capitate beakrush (also not previously recorded since 1972), wrinkled jointgrass, and Canby's lobelia (which are known from only one and two other Maryland locations, respectively.) Moreover, the occurrence of Canby's lobelia at this site represents the largest and most viable population of this species in the Maryland. Finally, the only known Maryland population of showy aster occurs on this area.

Chicone Creek.—A complex of tidal and non-tidal wetlands and a very unique mixed deciduous community with Piedmont affinities support two State-listed species, the cream-flowered tick-trefoil (endangered) and the wild lupine (threatened). At least seven species of FIDs use the area, including the Kentucky warbler and worm-eating warbler.

Gales Creek.—The nontidal wetlands along Gales Creek support at least 24 rare or uncommon plant species, 15 of which are State-listed (endangered). Based upon the number and quality of rare plant populations, Gales Creek is among the most significant rare species sites in the State. The most significant rare plant community along the nontidal portions of the creek is the bog that occurs at Galestown Millpond. All but four of the rare plant species inhabit this bog and the adjacent open water. Few other areas of comparable size on Maryland's Coastal Plain have such a concentration of rare species. Irving Millpond, a mile upstream from Galestown Millpond, also supports at least six rare plant species.

Harrison Ferry Wetlands.—This wetland complex supports at least four rare plant species. The fresh tidal marsh supports a large population of a rare shrub known only from the Delmarva Peninsula and one small area in Oklahoma. The open marsh–forested swamp ecotone supports a widespread population of a State-listed (endangered) vine. Here, this woody vine approaches the northern limit of its natural range.

Harrison Ferry South.–This tidal wetland along Marshyhope Creek supports at least five rare plant species, four of which are State-listed (endangered).

Ingem Gut.—A complex of tidal, seasonally tidal, and nontidal marshes and swamps support two State-listed (endangered) plant species.

Little Creek Upland and Floodplain.—This site supports several distinct, high-quality habitats bordering a small tributary of Rewastico Creek.

Lower Gales Creek.—This tidal creek and adjoining tidal freshwater marsh and swamp support at least 11 rare plant species and one rare animal. Together, Galestown Millpond and Lower Gales Creek support what may be the greatest concentration of rare species on the Eastern Shore of Maryland.

Marshyhope Spared Ridge.—Located on an ancient sand dune formed during the Pleistocene period, this type of plant community is now very rare on Maryland's Eastern Shore. To date, only one uncommon species of terrestrial sedge has been found in the protection area, but other rare or endangered plants are likely to be discovered once the area has been completely surveyed.

Marhsyhope Floodplain.—This complex ecological system supports numerous diverse habitats and natural communities, including a mature floodplain forest of exceptional quality, xeric pine–oak uplands, high quality aquatic habitat, remnant oak savanna, etc. These habitats support at least four State-listed (endangered) and three Watch List plant species. A State-listed (endangered) fish occurs at several spots in the waters of Marshyhope Creek. A plant in the mint family was last reported from the State more than 50 years ago, and was considered extirpated by the Heritage Program until was discovered here. The waterleaf, a southern species, has never before been reported for Maryland. If determined to be a natural occurrence, this population represents a northern range extension of more than 150 miles.

Mill Creek.—Mill Creek is an expansive complex of tidal and nontidal wetlands that support the State-listed (threatened) spongy lophotocarpus and the State-listed endangered marsh wild senna. The latter is also a candidate for Federal listing, and the population at Mill Creek is the only one known in the State.

Nutters Neck.—is large site incorporates several significant natural communities and populations of eight rare and uncommon plant species.

Savannah Lake.—This area encompasses nine types of natural tidal wetland communities and nine nontidal wetland types that are among the best examples of their kind in the State. The area supports three Species in Need of Conservation: Black rail, Henslow's sparrow, and sedge wren; and one State-listed (rare) species, the northern harrier; all which have been documented as breeding in the area. The carpenter frog, another Species in Need of Conservation, historically occurred on the site until 1984. Increased salinity is thought to have displaced this species, which would recolonize the area if wetland restoration activities were undertaken.

Taylors Trail.—This sandy ridge supports three rare and uncommon plant species in habitats that are remnants of an ancient sand dune.

Upper Blackwater River Natural Heritage Area.—This area, most of which is protected by the existing Blackwater NWR and the proposed additions, represents one of the best examples of a complex of tidal saltwater wetlands, tidal freshwater wetlands, contiguous non-tidal wetlands, upland islands, and Delmarva bays in Maryland. Wetland communities extending from the Ewing (Madison) Tract at the headwaters of the Little Choptank River, east to the Seward Tract, include ten different major tidal types and approximately 15 types of non-tidal wetlands that support a number of rare, threatened, and endangered species, including the rare skipper (*Problema bulenta*) and American bald eagles (*Haliaeetus leucocephalus*).

Both estuarine and palustrine wetlands are well represented. Within the palustrine wetlands, palustrine forested, palustrine scrub–shrub, palustrine emergent, and open water are the major types. Within the estuarine wetlands, estuarine emergent, intertidal forested, estuarine scrub–shrub, and aquatic bed are represented. All of these habitats are considered priority wetlands. The whole gamut of hydraulic regimes, ranging from seasonally saturated soils to permanently flooded areas, can be found in the palustrine wetlands, and the estuarine wetland regimes, ranging from tidal to irregularly flooded, are equally well defined. The tidal wetland communities within these parcels make this complex extremely diverse and important for preservation and protection: Salt Marsh Cordgrass, Saltmeadow, Saltbush, Black Needlerush, Freshwater Mixed, Arrow Arum–pickerel Weed, Cattail, Narrowleaf Cattail, Yellow Pond Lily, and Tidal Mudflat.

- The Salt Marsh Cordgrass Community, found on the fringes of the Ewing, Mills, and Valiant Tracts, is one of the most productive communities worldwide. Annual primary productivity averages about 4 tons per acre, and most of this detritus becomes available to the estuarine food web by tidal flushing. This type of marsh also provides nursery and spawning areas for fish. Roots and rhizomes are eaten by waterfowl, stems are used in muskrat lodge construction, and nesting material is used by bird species such as terns, willet, and rails. This community is also important as a buffer to shoreline erosion and a sediment trap for upland runoff.

- The Saltmeadow Community, also found on the edges of the Ewing, Mills, and Valiant Tracts adjacent to Parsons and Beaver Creeks, provides nesting habitat for birds and mammals, and seeds for the former. Because of its high vegetative density and accumulation of peat, the Saltmeadow Community also functions as a sediment trap and erosion deterrent.

- The Saltbush and Black Needlerush Communities, along the waterways of Parsons Creek and Stewart's Canal, add habitat diversity to the area. They are especially important as nesting areas for non-game birds.

- The Tidal Freshwater Mixed Community is the most represented along the entire Blackwater River, and is among the most diverse communities in the State. It and the Arrow Arum–Pickerel Weed Community are among the most important marsh types based on total ecological value. They are among the top three tidal wetlands for productivity, wildlife and waterfowl use, and are associated with fish spawning and nursery grounds. These communities are also highly valued as natural shoreline stabilizers and sediment/nutrient/chemical traps for upland runoff. Furthermore, the 3–5 tons of detritus produced annually per acre are accessible to the estuary on a daily basis, and help to make Fishing Bay the Chesapeake Bay's number one producer of blue crabs.

- The Narrowleaf Cattail and Cattail Communities along the upper Blackwater waterway adjacent to the Ewing, Valiant, Linthicum, and Howard properties, provide habitat and food for both game and non-game wildlife.

- The Yellow Pond Lily Community along the Blackwater River waterways and Buttons Creek provides excellent cover and attachment sites for aquatic invertebrates and algae which are consumed by a variety of fish and aquatic birds. Although lacking the stiffness of grasses and sedges, this community does reduce wave action from wind and boats. In addition, the flow of flood water is slowed somewhat with some sediment settling from the water column.

- The Tidal Mudflat Community is a very important foraging area for waterfowl, marsh birds, shore birds, and sport fishes. This community interacts significantly with adjacent vegetated areas in the cycling of nutrients, and both are mutually dependent ecologically.

The upland islands and upland agricultural and forested areas add additional levels of species diversity. Being dominated by non-wetland species and providing transition zones which usually are higher in diversity, they provide excellent pine tree nesting and perching sites for the more than 160 American bald eagles and 10 golden eagles that winter on or immediately adjacent to the refuge. The hardwoods, as well as the pines, also provide excellent habitat for the Delmarva fox squirrel and numerous other species.

Upper Nanticoke River Macrosite.—This site contains expansive tidal marshes, forested and unforested non-tidal wetlands, and ancient xeric dunes. The area's tidal marsh communities are among the most productive in the State, are heavily used by waterfowl and other wildlife, and provide fish spawning an nursery habitat. The seaside alder, a regionally rare species, occurs in at least two locations. Forested non-tidal wetlands support the red-berried greenbriar (endangered), giant sedge (endangered), and Torrey's rush (endangered). Other wetland types support the northern pitcher plant (threatened). American bald eagles breed and forage in the area's tidal and non-tidal wetlands. In the ancient xeric dunes, the regionally rare Pine Barren gerardia and the State-listed (highly rare) Commons' panicgrass can be found.

Other Maryland Sites in Need of Protection

- Wheatley Marsh, east of the Nanticoke River and adjacent to Jack's Creek, is a 612-acre area noted as one of the last expanses of three-square bulrush marshes, and has been included in the National Wetlands Priority Conservation Plan (NWPCP).

- Hurley Neck, south of Cokeland and east of Elliott Island Road, is identified as an Area for Preservation or Restoration per the Federal Coastal Zone Management Act (FCZMA).

- Plum Creek Bog, south of Sharptown, is a high quality sphagnum bog exhibiting a diverse flora, and has been identified as a Geographical Area of Particular Concern per FCZMA.

- Round Island Gut, on the eastern shore of the Nanticoke south of Vienna, consists of high value marshes, and has been included in the NWPCP.

- Pole Point–Marshall Point Marshes, likewise identified in the NWPCP, encompass prime wetland areas important for waterfowl located on the eastern shore of the Nanticoke.

Fauna

In 1606, Captain John Smith reported abundant animal life on the lower Eastern Shore, including deer, squirrels, badgers, opossums, rabbits, bears, beavers, otters, foxes, martins, minks, weasels, and numerous fish and bird species (Hughes 1980:66). Other large animals that inhabited the region at that time were elk, bison, panthers, and wolves. During Pleistocene times an entirely different fauna would have inhabited the region, including mammoth, mastodon, caribou, saber-toothed tiger, and other species that became extinct with the advent of human predation and rapid climate change at the end of the ice ages. European settlement and clear-cut forests dramatically altered the amount and sometimes type of animal life sustainable in this region.

The Refuge Complex provides habitat for a rich diversity of wildlife. More than 282 species of birds, 38 species of mammals, and 45 species of reptiles and amphibians occur on the Refuge Complex for at least part of the year. The shallow bays, creeks, and marshes are also famous for their fishery resources. The study area supports significant populations of threatened American bald eagles and endangered Delmarva fox squirrels, and has been specifically recognized in recovery plans for these species. The Nanticoke portion of the watershed has been designated as a TNC Bioreserve, based on the area’s rare, threatened and endangered plant and animal species and ecologically significant communities (also consult Section 2.4.6). The refuges within the Refuge Complex were designated as “Important Bird Areas” (IBA) by The American Bird Conservancy in 1996 as part of an international effort to recognize and protect such areas on a global, national, and state basis.

Migratory Birds

Waterfowl

The Refuge Complex is recognized as one of the most significant areas for migratory waterfowl in Maryland. As one of five NAWMP focus areas in Maryland, the Refuge Complex provides habitat for 26 species of ducks, 5 species of geese, and 3 species of swans (including the reintroduced trumpeter swam). Of the duck species, the redhead, canvasback, and wood duck are identified by the NAWMP as high priority species; and the black duck, mallard, northern pintail, and blue-winged teal as priority species. Of these priority species, wood duck, mallard, black duck, gadwall, and blue-winged teal nest on the Refuge Complex, along with the northern shoveler, Canada goose, and mute swan. In addition to providing protection and habitat to the seven high priority and priority species identified in the NAWMP, the Refuge Complex is also noted for supporting the Southern James Bay Canada goose, Atlantic brant, greater and lesser scaup, ring-necked duck, American wigeon, and common eider, which, together with the NAWMP species, are species of Special Management Concern in Region 5.

Approximately 35 percent of the Atlantic Flyway's waterfowl population uses the Chesapeake Bay, and the Refuge Complex is among the most important areas to waterfowl on the Bay. For example, according to the 1993 Midwinter Survey, the study area accounted for almost 40 percent of all puddle ducks and more than 5 percent of all diving ducks observed statewide. The table below shows the average number of waterfowl counted during the Midwinter Waterfowl Inventory of the Blackwater NWR, Chesapeake Island Refuges, and Nanticoke protection area survey units. The study area supports 10 percent of the Chesapeake Bay canvasback population, and 22 percent of Maryland’s wintering black duck population. Our Chesapeake Bay Field Office provided the data shown below.

Table 7. Waterfowl counts on the Refuge Complex (45-year means) and their percentage of Maryland's total[ab]

Species	Blackwater NWR		Chesapeake Island Refuges		Nanticoke Protection Area	
	Count	Percent	Count	Percent	Count	Percent
Canada goose	16,648 ± 520	5.6 ± 0.8	4,318 ± 634	1.6 ± 0.3	6,230 ± 800	2.0 ± 0.2
Snow goose[c]	958 ± 1,840	31.1 ± 6.0	†		1,164 ± 579	4.0 ± 1.9
Tundra swan	356 ± 72	1.6 ± 0.3	1,469 ± 138	5.8 ± 0.5	1,055 ± 209	5.0 ± 1.0
American black duck	2,673 ± 481	7.5 ± 0.7	2,042 ± 307	5.7 ± 0.5	1,944 ± 204	7.0 ± 0.8
∑ dabblers	7,496 ± 1,304	8.8 ± 1.1	4,207 ± 943	4.5 ± 0.5	4,276 ± 478	6.0 ± 0.7
∑ divers	281 ± 105	0.2 ± 0.1	2,525 ± 372	2.6 ± 0.4	4,919 ± 965	4.0 ± 0.6
∑ sea ducks	55 ± 12	0.6 ± 0.1	547 ± 172	6.0 ± 1.8	148 ± 41	2.0 ± 0.4

[a]Forty-five-year means (±1 SE) of Midwinter Waterfowl Inventories on the Refuge Complex and their percentage of Maryland State totals.

[b]Blackwater NWR is Zone 7, Segment 19; Nanticoke protection area is Zone 7, Segment 26; Chesapeake Island Refuges include Zone7, Segments 20, 27, 29.

[c]Counts at Blackwater NWR are of lesser snow geese; counts elsewhere in Maryland primarily are of greater snow geese.

[†]Data missing

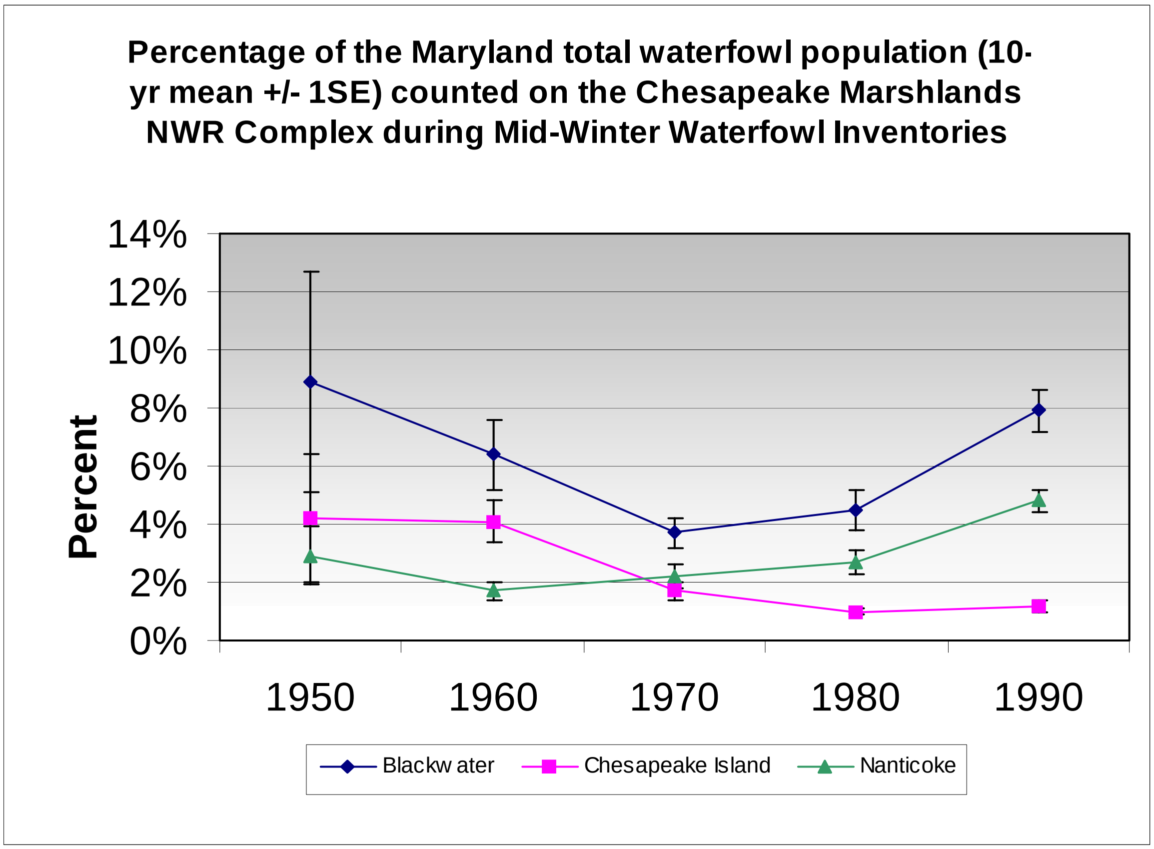


Figure 39. Midwinter waterfowl counts on the Refuge Complex as a percent of Maryland's total

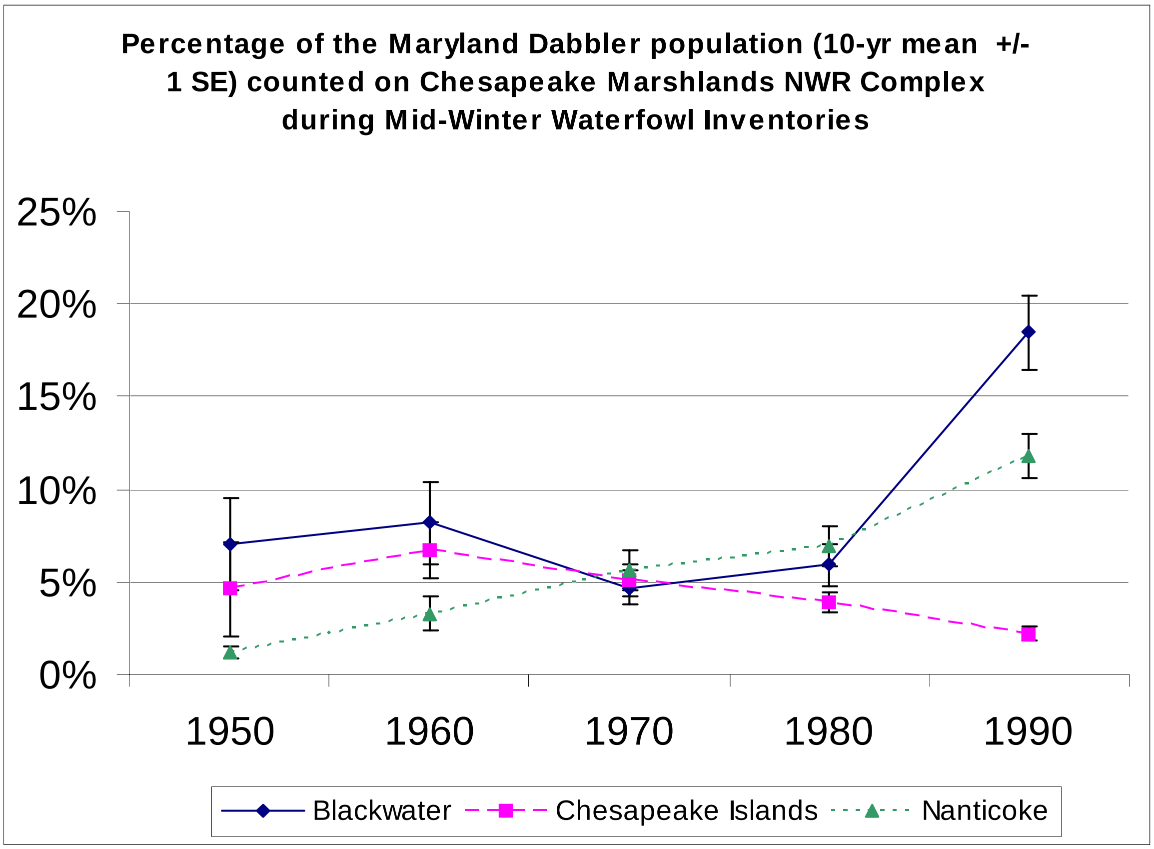


Figure 40. Midwinter dabbler counts on the Refuge Complex as a percent of Maryland's total

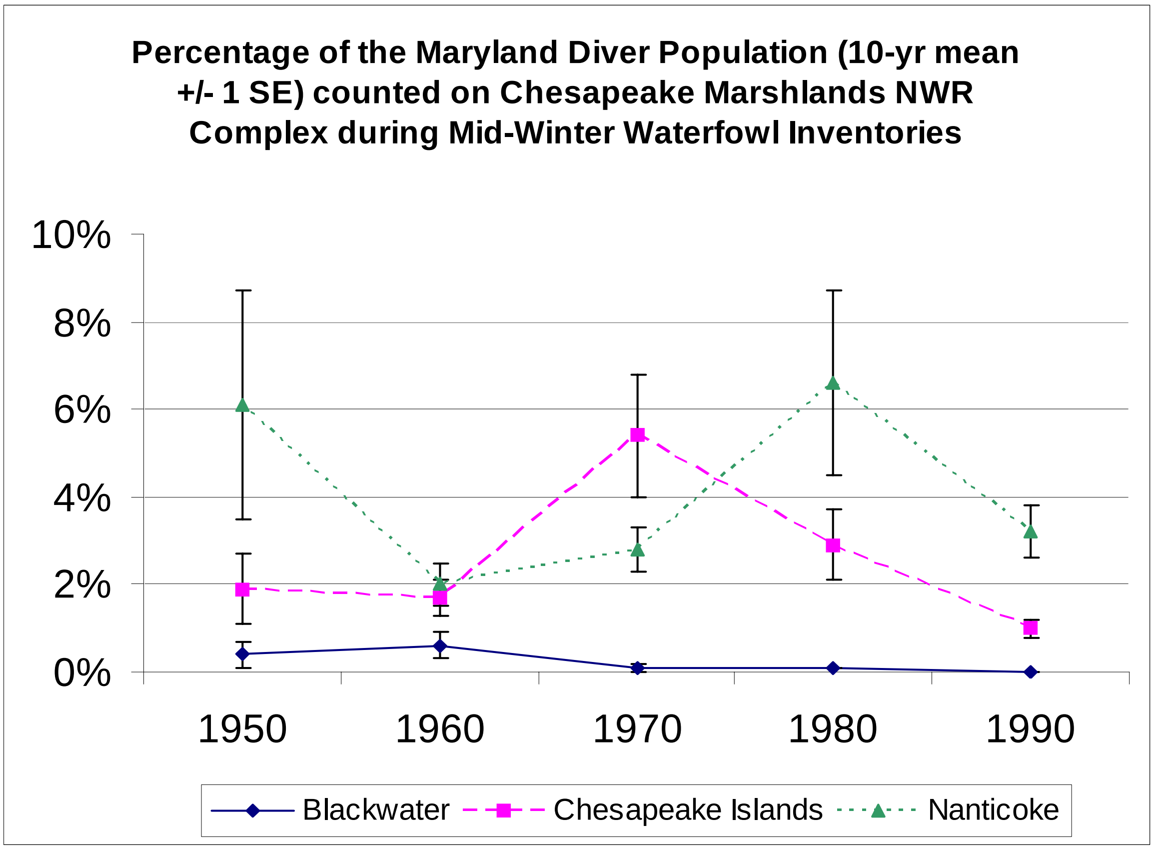


Figure 41. Midwinter diver counts on the Refuge Complex as a percent of Maryland's total

The Atlantic Midwinter waterfowl survey is flown along standardized flight paths along the major rivers and water bodies in the Atlantic flyway, including the Chesapeake Bay. The survey is conducted during the first 2 weeks of January, and provides a comparative index of midwinter waterfowl populations along the flyway. Numbers of species of waterfowl counted on Blackwater, the Chesapeake Island Refuges, and the Nanticoke protection area are tabulated below. The average count for each species for the intervals 1956–1965, 1966–1975, 1976–1985, and 1986–1996 is shown as a percentage of average Chesapeake Bay counts for those time intervals.

The Refuge Complex contains extensive shallow-water habitats, SAV beds, tidal mudflats, miles of fringing low marsh, freshwater moist soil management units, croplands, and cool season grasses and forbs. Each of those provides important wintering forage for a variety of waterfowl. The large eelgrass and wigeon grass beds in the Big Thoroughfare, Terrapin Sand Cove, Shanks Creek, and Back Cove on Smith Island (Martin NWR) are important to migrating and wintering waterfowl as feeding and resting areas. Because of their importance to wintering waterfowl, these areas were closed to the taking of waterfowl by a 1960 Presidential Proclamation Order. Eelgrass is an important food source for American black duck, wigeon, Canada goose, redhead, and brant.

Ducks

Blackwater NWR.—Twenty-four species of ducks use Blackwater NWR annually, and six species reside year-round. Large numbers of migrating ducks use the wetlands of the area during the spring and fall, particularly black duck, blue-winged teal, wood duck, green-winged teal, pintail, wigeon, gadwall, ring-necked duck, and common merganser. In recent years, peak populations of 20,000 to 25,000 have occurred on the refuge from mid-November to late December.

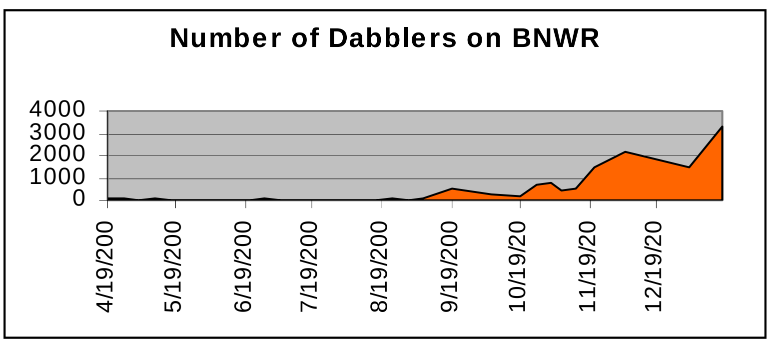


Figure 42. Numbers of dabblers on Blackwater NWR

One species of particular interest is the Atlantic blue-winged teal. In an article appearing in the Auk (1932), journal of the American Ornithologists' Union, Oliver Austin of the U.S. Biological Survey reported the first evidence of the Atlantic blue-winged teal in Maryland. Austin's report was based on information obtained in the Blackwater marshes during the period 1929–31. This proved an interesting discovery, as this small species of waterfowl was thought to be only a spring and fall migrant and occasional winter visitor in the Chesapeake Bay, with breeding populations mainly in the pothole region of the Prairie States and the Prairie Provinces of Canada. Austin recorded the events leading to the discovery of the young and nests of the blue-winged teal at Blackwater: On July 13, 1929, W.G. Tregoe of Cambridge, a warden with the Maryland Game and Inland Fish Commission, found several young that he believed were teal, whose identification was later confirmed by Talbot Denamead, an ornithologist with the U.S. Biological Survey. Additional nests were located and broods were observed during the summers of 1930 and 1931.

In the early 1950's, Robert E. Stewart and John W. Aldrich, Service ornithologists, suspecting that the Chesapeake Bay birds might be morphologically different enough from western or interior breeding populations of blue-winged teal to be a distinct subspecies, collected specimens from Dorchester marshes in May, June, and July. Upon comparing them with museum specimens of breeding birds from the interior, it became apparent that Dorchester County specimens were much darker than those from the Midwest and Prairie Provinces of Canada. In the course of their examinations, they found that all breeding blue-winged teal in the Atlantic Coastal region extending from North Carolina to the Maritime Provinces of Canada were much darker than birds from the interior. Therefore, the men described and named a new geographic race or sub-race of the species, *Anas discors orphna*, the Atlantic blue-winged teal. The center of abundance of the Atlantic blue-winged teal breeding population is in the brackish tidal marshes of New Jersey, Delaware and Maryland, particularly in Dorchester County, and the Delaware Bay marshes of Delaware and New Jersey. (Stewart and Aldrich, 1956).

Table 8. Lesser snow goose monthly high counts

	Sept	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**
1998-99	0	3,504	0	2,000	5,816	4,000	1,500	
1997-98	673	50	9,352	0	4,502	9,501	8,000	
1996-97		700		2,500	3,800	5,000	3,800	
1995-96	0	28	0	3,500	3,000	0	0	
1994-95		220	1,800	6,010	1,900	0	38	

Source: Blackwater NWR Aerial Waterfowl Surveys 1994–1999

Duck roost counts on Blackwater NWR usually are conducted from mid-August to early October, mainly as an index to numbers of roosting wood ducks. Counts have been conducted in the late evening at two locations on the upper Blackwater River and one location on the Little

Blackwater River. Roost counts were not conducted in 1999, due to insufficient staffing and adjustments in workloads and priorities. Blackwater NWR historically has maintained approximately 200 wood duck boxes, and an average of approximately 600 wood ducks have been fledged annually.

Table 9. Wood ducks and Canada geese roosting at two locations (Blackwater NWR)

Location	Date	Wood Ducks	Canada Geese	Unidentified
Blackwater River (upper)	9/24/97	290		
	10/9/97	25		
	10/22/97	65	82	
	8/27/98	177	17	4
	9/8/98	170	49	7
	9/25/98	119	10	305
	10/6/98	590	162	6
Little Blackwater River	9/23/97	1306		
	10/7/97	684	639	
	10/21/97	664	1715	
	8/25/98	725		
	9/9/98	1062		4
	9/24/98	718		2
	10/7/98	57	1634	

Data: Blackwater NWR 1997–1998

Martin NWR.—On Martin NWR (Smith Island), wigeon, pintail, black duck, and mallard are the principal species that peak from 10,000 to 15,000 in early December. Black ducks and mallards frequently nest on Martin. A breeding pair count, completed in April 1988, yielded a breeding population index of 734 black ducks and 57 mallards. Smith Island harbors an important proportion of the midwinter population of dabbling ducks on the Chesapeake Bay: 2.27 percent of the counts for the entire Chesapeake Bay between 1956–1996. Over this time period, the islands contained more than 1 percent of the Chesapeake Bay midwinter counts for the following species: black duck, gadwall, widgeon, and pintail. Also, Smith Island contained more than 1 percent of the Chesapeake Bay midwinter counts for five other species of waterfowl: redhead, bufflehead, scoter, old squaw, brant, and tundra swan. It concentrates a major portion of the midwinter waterfowl population on about 0.0001 percent of the shoreline of the entire Chesapeake Bay.

Atlantic Population (AP) Canada Geese

Prior to 1940, it was considered rare for Canada geese to winter on Blackwater NWR or other units of the Refuge Complex. However, with the introduction of the mechanical corn picker and a shift in agriculture from truck farming to row crops (corn and soybeans), AP Canada geese began wintering on the Eastern Shore of Maryland in numbers greater than any other locality in North America. According to Bellrose, the mid-Atlantic population of wintering Canada geese during the period 1970–1975 was as follows: central and western New York, 8,000; western Pennsylvania, 26,000; Delaware and Maryland (Delmarva Peninsula), 537,000; coastal Virginia, 60,000; North Carolina, 58,000; and South Carolina, 10,500.

A large segment of the goose population wintering in the Chesapeake Bay formerly wintered farther south, particularly along the Outer Coastal Plain of North Carolina. The so-called “short-stopping” of many geese somewhat farther north of the former range occurred as the more inefficient mechanical corn picker began leaving as much as 10 percent of the crop in the field for the birds to forage on. Farmers began planting more corn and soybeans as truck farming was being discontinued. More food equated to more geese, and for the next 30 years the trend continued to increase. An example of the increase in Canada geese is seen in population figures at Blackwater NWR. In the 1940's, approximately 5,000 geese visited the refuge in the winter, but by the mid-1970's the annual population increased to about 100,000 at the peak of migration.

In an attempt to make geese move to their historical wintering areas, wildlife management agencies extended seasons and bag limits. It was thought that if enough “gunning” pressure could be applied, then the geese would simply fly south. But the geese did not fly south, and in the following decade, when production was at record lows, over-harvest occurred and the population plummeted. For example, in 1983 hunters harvested more than 280,000 Canada geese in Maryland, more than occurred in the entire state by the mid-1990's. Winter counts of AP Canada geese in Maryland declined from about 608,000 in 1980 to a low of 217,700 in 1997 before they started to rebound slightly. As previously noted, this decline was caused by overharvest, combined with reduced gosling production. Alarmed by these declines in wintering populations and the lack of production on the breeding grounds, it became necessary in 1995 to close the hunting season on Canada geese.

Geese that winter at Blackwater NWR and other areas of the Refuge Complex nest along the eastern margin of James Bay and Hudson Bay as well as the interior of Ungava. Following the breeding season and summer molt, geese begin to stage in areas near the coast of James and Hudson Bays preparatory to migration southward. The main migration corridor south is through southern Quebec, across Lake Ontario, into central New York, and down through eastern Pennsylvania to Chesapeake Bay. The first birds arrive at Blackwater in late September, historically with numbers increasing through October, until a peak population is reached in November. The table below shows roost counts of Canada geese and wood ducks for 1997–1998 at two locations on Blackwater NWR.

Following the season closure in 1995, the number of AP geese breeding in northern Quebec increased from 29,000 pairs in 1995 to 77,500 pairs in 1999. This increase in breeding population is largely the result of a shift in age structure (i.e. young geese reaching breeding age). The annual breeding pair survey of AP geese on the Ungava Peninsula provides the most reliable measurement of this population, an estimate free from contamination by other populations of Canada geese. In 1996, the Atlantic Flyway Council approved an Action Plan to address the immediate survey and research needs to rebuild the AP flock to its former level of abundance. The goal of this Plan is to reestablish 150,000 breeding pairs in the Ungava Region. It explains that no additional harvest of AP geese will be considered until the population index reaches 60,000 pairs with evidence of a sustained recovery. In 1999, managers agreed that sufficient recovery of AP geese had occurred to warrant a limited harvest of about 35,000 birds or a harvest rate of 5 percent. Maryland was offered 12,000 of the 35,000 flyway harvest, but Maryland hunters requested that the season remain closed until a more liberal season could be implemented.

During the past 10 years, the Refuge Complex has played an important role in assisting the State to recover AP geese. Unquestionably, one of the most important contributions has been Blackwater NWR’s cropland management program, and the 1989 decision to eliminate cooperative farming in lieu of force account farming, thereby leaving 100 percent of the crops available for the wintering waterfowl.

Lesser Snow Geese

Although both greater and lesser snow geese (*Anser caerulescens c.*) winter on Blackwater NWR, the lesser snow goose is found in greater abundance. It is rather rare for lesser snow geese to winter in the Atlantic Flyway, since the traditional winter grounds are in the Lower Mississippi Valley, along the Texas coast, and in the Central Valley of California. The lesser snow goose flock at Blackwater is also unique in that almost 50 percent of the flock is of the blue phase.

Swans

Tundra swans, destined for Chesapeake Bay wintering grounds, migrate south from the northwest arctic and subarctic tundra breeding areas, by way of northern Alberta and Saskatchewan, the Devils Lake area of North Dakota, across the Great Lakes to the Middle Atlantic area. Some come from as far as the Alaskan Northern Slope near the Prudhoe Bay oil fields. During fall migrations, swans make tremendous long-distance flights. Tundra swans can be found on all the units of the Refuge Complex except Susquehanna NWR. The species is particularly attracted to the Chesapeake Island Refuges because of the abundance of SAV and several species of mollusks (the Baltic macoma clam and the long clam). Mute swans, an exotic species, are discussed in “Exotic and Invasive Species,” below.

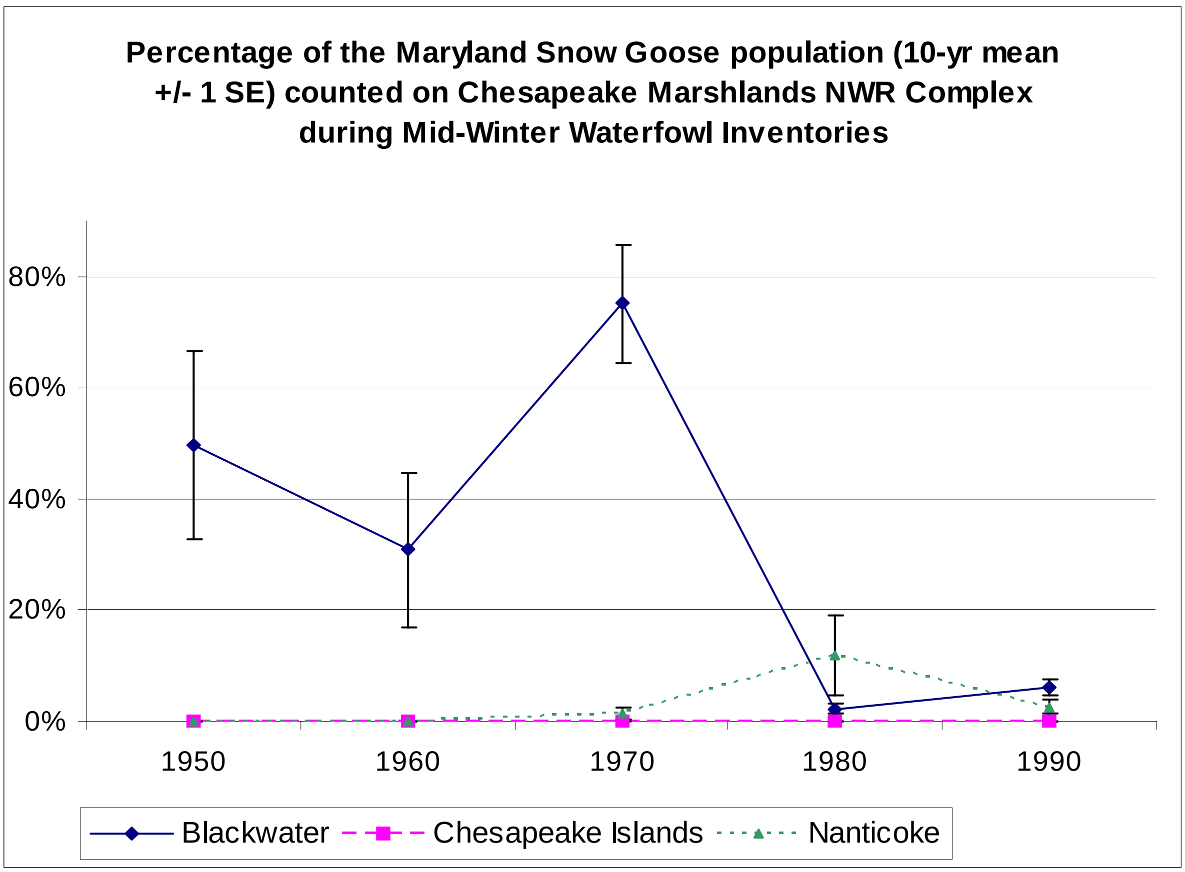


Figure 43. Midwinter snow goose counts on the Refuge Complex as a percent of Maryland's total

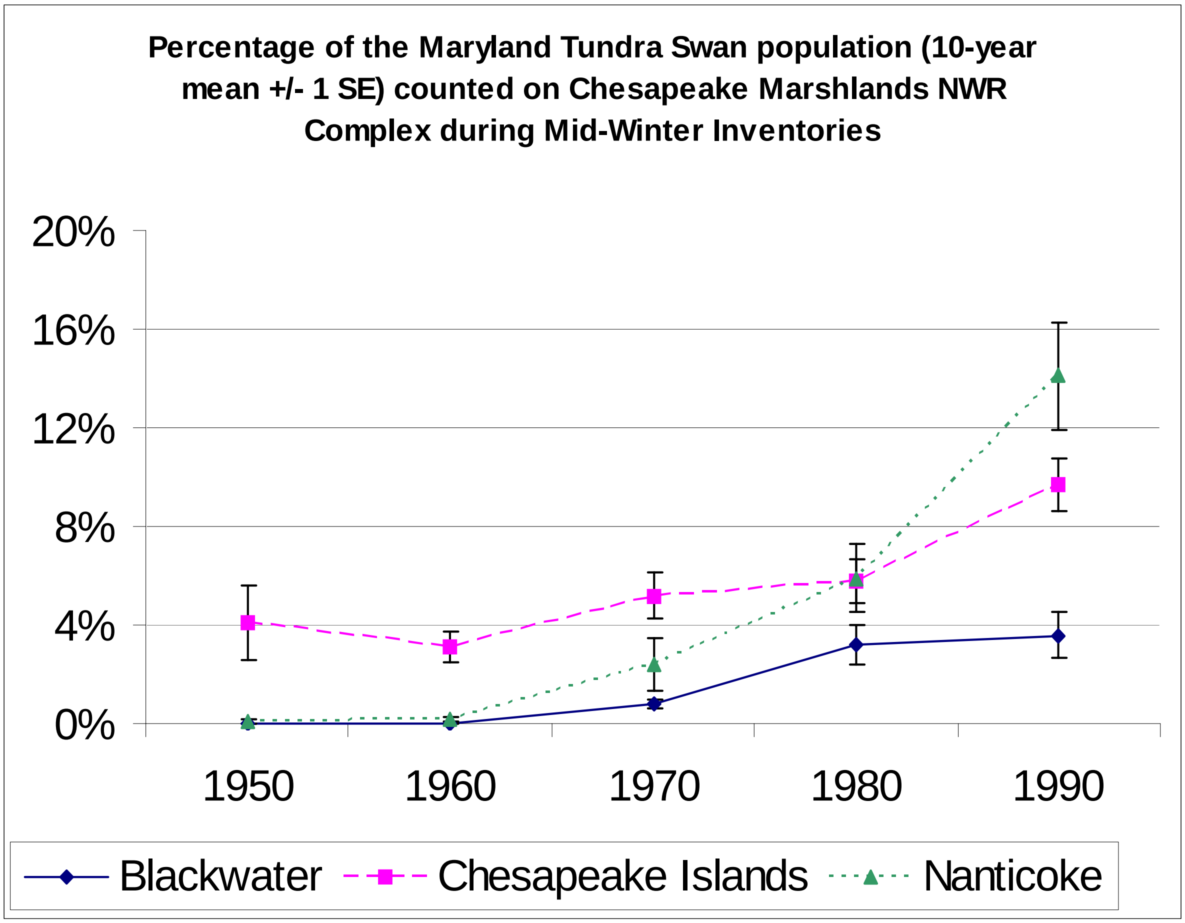


Figure 44. Midwinter tundra swan counts on the Refuge Complex as a percent of Maryland's total

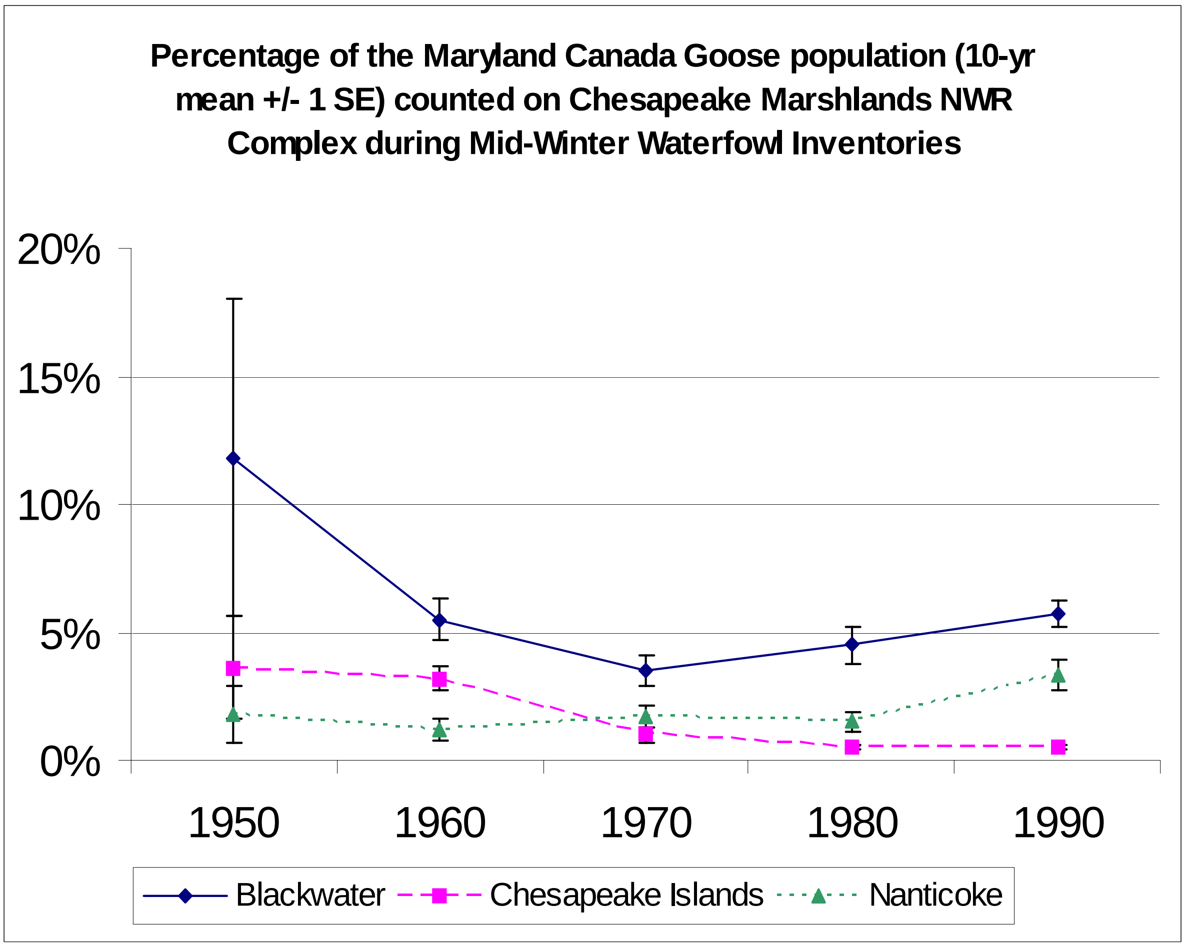


Figure 45. Midwinter Canada goose counts on the Refuge Complex as a percent of Maryland's total

Forest Interior Dwelling Species (FIDs)

Forest interior dwelling birds (FIDS) require large forest areas to breed successfully and maintain viable populations. This diverse group includes colorful Neotropical migrant songbirds, such as tanagers, warblers, and vireos, that breed in North America and winter in the Caribbean and Central and South America, as well as residents and short-distance migrants, such as woodpeckers, hawks, and owls. FIDS are an integral part of Maryland's landscape and natural heritage. They have depended on large forested tracts, including streamside and Bayside forests, for thousands of years (A Guide to the Conservation of Forest Interior Dwelling Birds in the Chesapeake Bay Critical Area, June 2000).

FIDS act as "umbrella species" for a wide range of forest benefits, and are an important component of a natural forest system. They spread seeds through their droppings, help control insect numbers, and provide food to those higher on the food chain. The habitat needs of FIDS overlap those of many other plant and animal species including large mammals, many wildflower species, wood frogs, and wild turkey. When sufficient habitat is protected to sustain a diversity of forest birds, other important components and microhabitats of the forest will be encompassed and be protected. These may include the small, forested streams and headwaters critical for fish populations and the vernal pools necessary for the survival of amphibians. Forest birds are also an important link in a complex food web. Warblers and other insectivores eat untold numbers of insects such as spruce budworms and caterpillars, helping to keep these defoliators in check (Yahner 1995).

Although most of these birds are still fairly common, populations of some forest bird species have been declining during the last 30–40 years. According to the Breeding Bird Survey (BBS), there was a 63-percent decline in occurrence of individual birds of Neotropical migrant species (many of which are FIDS) in Maryland between 1980–1989. While many factors have contributed to the decline of FIDS populations, including the loss of habitat on wintering grounds and loss of migratory stopover areas for Neotropical migrants, the loss and fragmentation of forests on the breeding grounds here in North America appear to play a critical role. FIDS generally are more successful at survival and reproduction in large, older, hardwood-dominated forests. However, there has been a loss of quality habitat through the conversion of hardwood and mixed-hardwood forests to pine and the reduction of "old growth" forest to small isolated patches. Prior to European settlement it is estimated that old-growth forest covered approximately 95 percent of the Chesapeake watershed (Kraft and Brush, 1981). Forest coverage in Maryland today is about 44 percent (USDA Forest Service 1996) and about 40 percent of the remaining deciduous forest in the East today consists of small, isolated woodlots of relatively immature trees in agricultural and suburban landscapes. When European settlers arrived in eastern North America in the 1600's, the average height of a hardwood tree was 100 feet or more. The average height of trees in the Chesapeake Bay region today is only 60-80 feet (USDA Forest Service 1996).

The fragmented, younger forest found in the Chesapeake Bay region has several negative effects on FIDS. The direct loss of forest habitat results in smaller forest tracts that may no longer be adequate to accommodate a bird's territory, to provide an ample supply of food, or to provide the necessary forest structure for breeding. Many forest tracts are too small to support species with large breeding territories such as the red-shouldered hawk, barred owl, and pileated woodpecker. For example, a breeding pair of red-shouldered hawks require from 250-625 acres to sustain them. Most FIDS, even those species that have small breeding territories, will only select larger forest tracts for breeding: They are area-sensitive. In addition to area requirements, many FIDS have additional habitat requirements for nesting. Reduction of forest size often results in the loss of specialized habitats/microhabitats.

Forest fragmentation also leads to indirect effects on FIDS that are associated with an increase in edge. Edges are commonly associated with higher rates of nest predation, increased brood parasitism by brown-headed cowbirds, increased rates of human disturbance (including noise), and invasion by exotic flora. Edge is most detrimental when a forest adjoins a lawn, agricultural field, pasture, or wide road. We have defined “edge” as forest within 100 m of the forest edge, which is consistent with the definition used by the Chesapeake Bay Critical Area Commission (A Guide to the Conservation of Forest Interior Dwelling Birds in the Chesapeake Bay Critical Area, June 2000), recommended widths of riparian forests (Keller et al. 1993), and the criteria used by Robbins et al. (1989) to distinguish forest patches. The area within this 100-m edge is defined as “interior” habitat and is measured by changes in “effective area”; i.e., total forested area minus the area within the forest edge. Interior habitat functions as the highest quality breeding habitat for FIDS.

Blackwater NWR currently contains much of the remaining large, contiguous tracts of forested lands on the Delmarva Peninsula. Twenty-five species of forest interior dwelling (FID) birds potentially breed in the Mid-Atlantic Coastal Plain (A Guide to the Conservation of Forest Interior Dwelling Birds in the Chesapeake Bay Critical Area, June 2000). Twenty of the 25 species are Neotropical migrants, species which nest in temperate North America and winter in Central and South America. The cerulean warbler, veery, and black-throated green warbler were eliminated from this list because they are unlikely species to be breeding on Blackwater NWR (H. Armistead, D. Dawson, J. McCann, pers. comm). Consequently, twenty-two of these FIDs are potential breeders on Blackwater NWR and 20 species have been documented during the breeding forestbird survey in the past 5 years (table 8).

Forestry practices need not be detrimental to FIDs. Forests can be thinned and harvested in ways that FID habitats are not harmed, and in many cases are actually improved. Conservation of FID habitat is required by law within the Chesapeake Bay Critical Area and recommended in all other parts of the state. To minimize the impact of forestry practices on FIDs, silvicultural prescriptions for different forest types will generally follow those outlined by the FIDS/Forestry Task Force (June 1999) unless it specifically conflicts with critical habitat requirements of the Delmarva fox squirrel.

Table 10. Twenty-two FIDs potentially breeding on Blackwater NWR[1]

Species[a]	Status in mid-Atlantic Coastal Plain[b]	PIF rank[c]	% occurrence at BNWR[d]	Minimum area (ha) for breeding[e]
Swainson's warbler (*Limnothlypis swainsonii*)	B	26	nd	*350
Wood thrush (*Hylocichla mustelina*)	B	24	27.9	1
Kentucky warbler (*Oporornis formosus*)	B	23	8.2	17
Worm-eating warbler (*Helmitheros vermivorus*)	B	23	50.8	150
Acadian flycatcher (*Empidonax virescens*)	B	22	47.5	15
Louisiana waterthrush (*Seiurus motacilla*)	B	22	3.3	350
Prothonotary warbler (*Protonotaria citrea*)	B	22	13.1	*100
Yellow-throated vireo (*Vireo flavifrons*)	B	22	6.6	*100
Hooded warbler (*Wilsonia citrina*)	B	21	†	*35
Scarlet tanager (*Piranga olivacea*)	B	21	13.1	12
Whip-poor-will (*Caprimulgus vociferus*)	B	21	1.6	*125
Northern parula (*Parula americana*)	B	19	1.6	520
Black-and-white warbler (*Mniotilta varia*)	B	18	1.6	220
Ovenbird (*Seiurus aurocapillus*)	B	18	65.6	6
Brown creeper (*Certhia americana*)	D	15	†	na
Red-shouldered hawk (*Buteo lineatus*)	R	15	8.2	225
Red-eyed vireo (*Vireo olivaceus*)	B	15	62.3	3
American redstart (*Setophaga ruticilla*)	B	14	†	*35
Broad-winged hawk (*Buteo platypterus*)	B	14	nd	na
Hairy woodpecker (*Picoides villosus*)	R	14	26.2	7
Pileated woodpecker (*Dryocopus pileatus*)	R	14	54.1	165
Barred owl (*Strix varia*)	R	13	3.3	*100

[1] "The status of 22 forest interior dwelling bird species potentially breeding on Blackwater NWR and their rankings as species of concern in the draft Mid-Atlantic Coastal Plain Bird Conservation Plan by Partners In Flight (PIF)."

[a] Species list from A Guide to the Conservation of Forest Interior Dwelling Birds in the Chesapeake Bay Critical Area (draft 6 Oct 1999). Species in **boldface** are considered highly area-sensitive.

[b] Local status refers to migratory status in the mid-Atlantic Coastal Plain. Codes are: B=species that breed in the region but do not winter (these species primarily are Neotropical migrants, but may also include some temperate-zone migrants), D=species that breed and winter in the region, and R=resident or nonmigratory species (Watts 1999). Supplemental data from Robbins and Blom (1996).

[c] Total concern scores for species breeding within the mid-Atlantic Coastal Plain (appendix V *in* Watts 1999); presented in decreasing order of concern (maximum value=30).

[d] Species detected during 5-min counts (variable distance) on 61 points distributed at 500-m intervals in estuarine and palustrine forest (NWI data from Delaware Bay Estuary Program); sampled during 23 May–18 July in 1996–2000; †=known to occur on the refuge (H. Armistead, pers. comm.) but not detected during surveys; nd=not known to occur on the refuge.

[e] Values without asterisks are from Robbins, et al. (1989); values with asterisks are from Bushman and Therres (1988); na=data not available.

Migratory Nongame Species of Management Concern

The Refuge Complex hosts 68 of the 70 migratory nongame birds of management concern in Region 5.

Raptors

The Refuge Complex provides habitat for 24 raptor species. Direct management now focuses on peregrine falcons, osprey, and barn owls.

Arctic Peregrine Falcon.—Peregrine falcons (*Falco peregrinus tundrius*) regularly use the Refuge Complex, particularly the Chesapeake Island Refuges. Martin NWR historically has been noted for its concentration of peregrine falcons during the migration period, when six or more regularly can be observed. Peregrine falcons nest on two artificial towers on Martin NWR, a tower on Watts Island, and a tower placed on Spring Island in 1998 by Navy personnel and our Chesapeake Bay Field Office to replace the nest on Adams Island (see production table).

Osprey.—Both Blackwater and Martin NWRs maintain artificial osprey nesting platforms: 70 on Martin NWR, and 30 on Blackwater NWR (see production tables, below).

Barn Owl.—See production table, below.

Table 11. Peregrine falcon production (Martin NWR)

Year	Siners Tower		Anderson Tower		Watts Island
	Eggs	Fledged	Eggs	Fledged	Fledged
1986	4	3			
1987	4	4			
1988	4	4			
1989	4	2	structure	built	
1990	4	3	no nest		
1991	4	3			
1992	2	2	2	1	
1993	4	4	4	3	
1994	5	3	3	2	
1995	5	2	5	5	
1996	3	1	4	4	
1997	3	1	5	5	
1998	2	1	4	3	
1999	2	0	4	0	
2000		0		3	3
Total	**50**	**33**	**31**	**26**	**3**

Source: Martin NWR annual narrative reports, except 1999 and 2000, Mike Harrison pers. comm. Siners and Anderson Towers are on Smith Is.

Table 12. Osprey production (Blackwater NWR) 1973–2001

Year	Occupied Nest[1]	Active Nest[2]	Successful Nest[3]	Eggs	Fledglings	Fledglings / Eggs[4]
2001	25	25	25	60	54	0.90
2000	28	28	28	75	65	0.87
1999		28			57	
1998	32	32	29	72	68	0.94
1997	34	34	34	77	71	0.92
1996	36	36	30	90	71	0.79
1995	28	28	25	68	61	0.90
1994	36	36	31	81	65	0.80
1993	30	29	26	69	58	0.84
1992	29	28	19	69	40	0.58
1991	24	24	22	60	47	0.78
1990	28	25	20	51	43	0.84
1989	23	23	16	51	37	0.73
1988	30	28	22	60	45	0.75
1987	22	22	19	49	37	0.75
1986	25	21	12	48	26	0.54
1985	20	19	14	37	29	0.78
1984	18	18	11	21	28	1.33
1983	17	17	10	20	21	1.05
1982	13	13				
1981	15	15	6	16	15	0.41
1980	9	9	4	15	8	0.53
1979	8	8				
1978	6	6	3	6	5	0.83
1977					9	
1976						
1975					10	
1974						
1973					3	

Source: Blackwater NWR data and annual narrative reports.
Blanks indicate missing data.

[1]Nests with adults present

[2]Nests that contained eggs

[3]Nests with fledglings

[4]Due to some incomplete egg counts, fledglings may exceed eggs.

Table 13. Osprey production (Martin NWR) 1974–2001

Year	Nesting Structures	Occupied Nests[1]	Active Nests[2]	Successful Nests[3]	Eggs	Fledglings	Fledglings / Eggs[4]
2001	32	30	29		78	67	0.86
2000	28	28	28	58	69	65	0.87
1999		57	31	30		49	
1998		53	45	36	130	58	0.45
1997		51	39	29	101	44	0.44
1996						67	
1995		55			117	38	0.32
1994		56	41	33	114	60	0.53
1993		54	28	17	71	21	0.30
1992		49	8	7	14	9	0.64
1991		58	21	15	53	30	0.57
1990		55	36	15	98	28	0.29
1989		53		4		6	
1988		55	48	30	134	50	0.37
1987		53	45	32	123	70	0.57
1986		56	34	18	90	36	0.40
1985		55	31	25	86	44	0.51
1984		49	30	16	77	31	0.40
1983		44	34	21	81	37	0.46
1982		44	32	26	87	45	0.52
1981		37	29	18	69	31	0.45
1980		44	35	26	86	50	0.58
1979	54		42	39	40	36	0.90
1978	50		26	18	46	36	0.78
1977	47		32			39	
1976	47		25			51	
1975	48		29			60	
1974						39	

Source: Martin NWR data and annual narrative reports. Blanks indicate missing data.
[1]Nests with adults present
[2]Nests that contained eggs
[3]Nests with fledglings
[4]Due to some incomplete egg counts, fledglings may exceed eggs.

Table 14. Barn owl nest box productivity (Blackwater NWR) 1959–2000

Year	Nests	Young	Fledglings
2000	11	78	73
1999	10	29	29
1998	13	50	50
1997	13	53	44
1996	10	50	50
1995	11	54	54
1994	11	50	49
1993	13	15	15
1992	14	30	30
1991	13	66	66
1990	10	67	70
1989	12	61	59
1988	14		46
1987			10
1986			
1985			
1984			
1983			
1982			
1981			
1980			
1975		4	
1964	3	14	
1963	2	7	7
1962	2	4	
1961	2	4	
1960	2	11	
1959	1	4	

Estimated numbers from original data sheets and Annual Narrative Reports

Blanks indicate missing data

Shorebirds, Gulls, Terns, and Allied Species

The Refuge Complex provides diverse shallow water habitats that support 52 species of shorebirds, gull, terns, and allied species. Rare and State-listed threatened species include the black-necked stilt and least tern. The following species nest on the Refuge Complex: laughing gull, herring gull, great black-backed gull, royal tern, common tern, Forster’s tern, least tern, black skimmer, killdeer, American oystercatcher, willet, and woodcock. Shorebird surveys of the moist soil management units on Blackwater NWR have been conducted weekly since May 31, 1996 (see charts, below).

Marsh and Water Birds

The shallow waters and marshes of the Refuge Complex provide excellent feeding areas for 30 species of marsh and water birds. The Chesapeake Bay’s most important heron and egret rookeries are located on Martin NWR, Watts Island, Bishops Head, Barren Island, and within the Nanticoke protection area. Little blue, tricolored, and green-backed herons; black-crowned and yellow-crowned night-herons; great, snowy, and cattle egrets; glossy ibis; clapper, king, Virginia, and black rails; common moorhen; least and American bitterns; and double-crested cormorants all nest on the Refuge Complex. Spring Island contains the northernmost brown pelican colony in the United States; it produced more than 1,200 young in 2000.

The Chesapeake Island Refuges

The Coastal Plain is the most important physiographic region in Maryland for breeding colonial water birds. Chesapeake Bay islands within this region provide particularly important habitats for bird colonies. According to Maryland surveys, in 1995, Somerset County contained 20 percent of the state's total colonial water bird colonies, and 23 percent of the total breeding pairs (Brinker, et al. 1996).

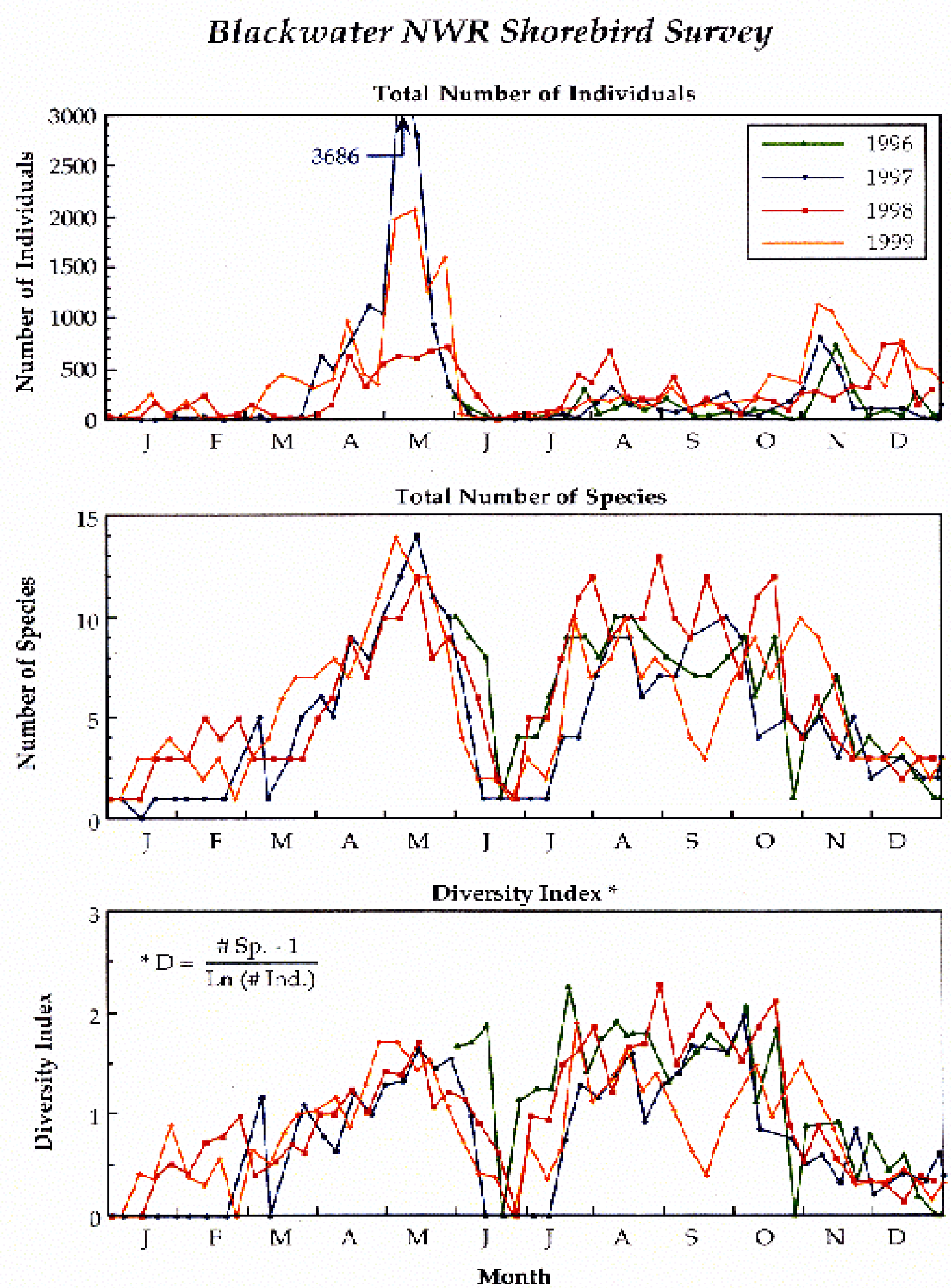


Figure 46. Shorebird survey charts, Blackwater NWR (color plate)

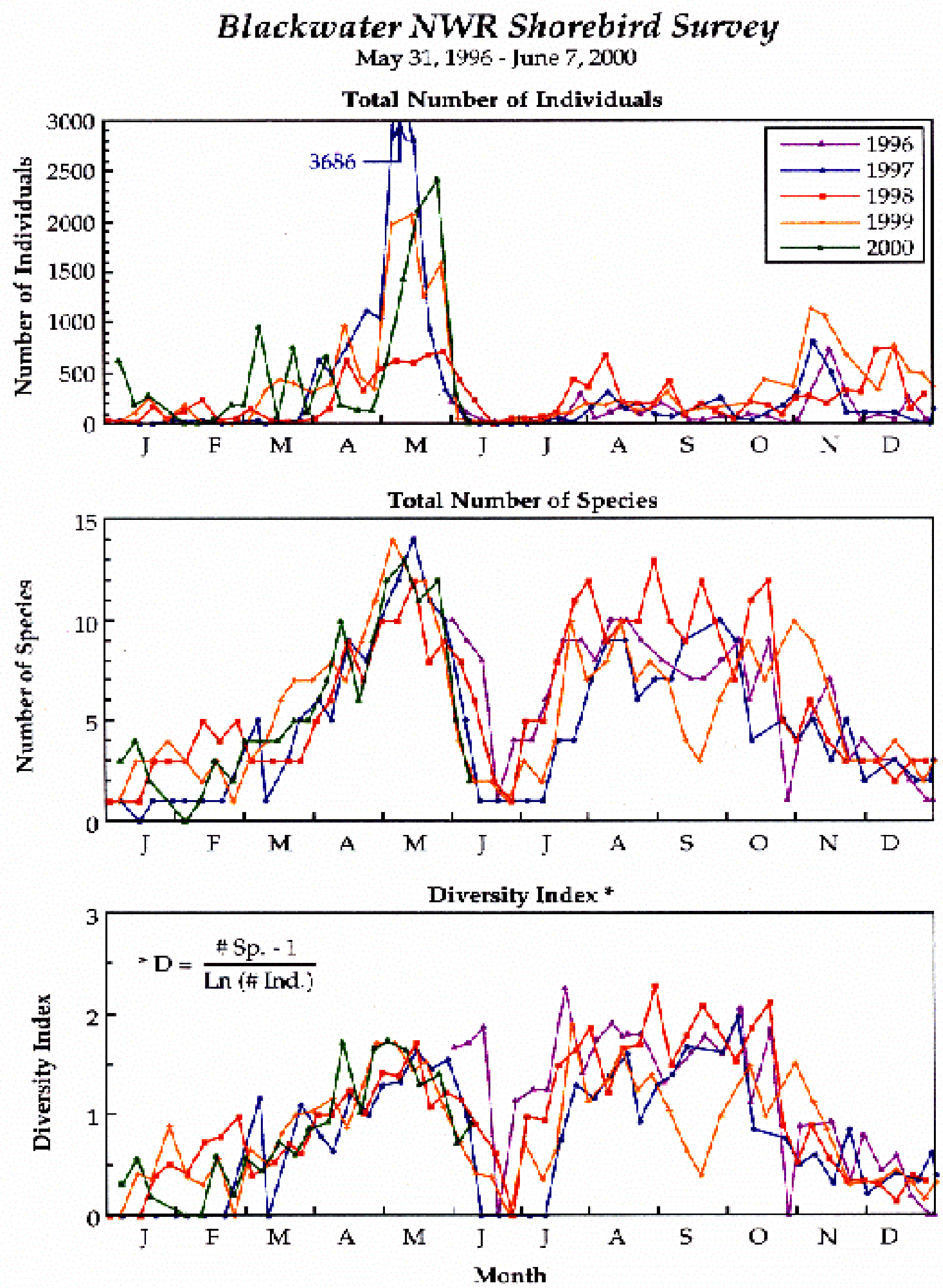


Figure 47. Shorebird survey charts, Blackwater NWR (color plate)

Source: Erik Smith and Karen Sundberg, refuge volunteers

Smith Island has one of the highest numbers of colonial water bird colonies per area in the State: 12 active breeding colonies for wading birds were recorded there in 1995. Five species of heron, three species of egret, and glossy ibis breed at Smith Island, according to State surveys. This census does not include green herons, which have also been recorded breeding on Smith Island (Amistead 1974).

Brinker, et al. (1996) reported that four of the nine species of wading birds that breed at Smith Island have shown significant declines in Maryland between 1985 and 1995 (snowy egret, tricolored heron, black-crowned night-heron, and glossy ibis). Declines for these species may be the result of a variety of factors, including habitat disturbance or loss, altered prey bases, increases in competing species, increases in predators, or exposure to contaminants. Because colonial water birds concentrate reproductive efforts at a few, discrete locations, these populations are particularly sensitive to habitat disturbance or loss. The Maryland population of glossy ibis has declined by approximately 50 percent since 1985, primarily attributable to a major disturbance at the Point Comfort colony on Smith Island. The Maryland Department of Natural Resources, Wildlife and Heritage Division has placed a high priority upon protection from human disturbance and erosion for colonial water bird rookeries (Brinker et al. 1996).

Rookeries at Smith Island are located on isolated ridges surrounded by marsh (hammocks), vegetated primarily with woody shrubs, i.e. wax myrtle (*Myrica cerifera*), groundsel tree (*Baccharis halimifolia*), and marsh elder (*Ivafrutescens*); trees, e.g., black cherry (*Prunus serotina*), sassafras (*Sassafras albidum*), and hackberry (*Celtis occidentalis*); and vines, e.g., japanese honeysuckle (*Lonicera japonica*), poison ivy (*Toxicodendron radicans*), and blackberry (*Ribes spp.*). Hammocks are generally small sites (1–20 acres), isolated from larger land masses by extensive tracts of black needlerush (*Juncus roemerianus*) marsh and tidal creeks. Some hammocks are topographic high points in the landscape that have become isolated due to land subsidence and sea level rise; others are dredged material disposal areas that were originally, in part, tidal marsh.

About 12 hammocks on Smith Island now contain important wading bird rookeries. Three of these, Cherry Island, Wellridge Creek, and Lookout Tower, are part of Martin NWR. The other areas are privately owned wooded islands scattered across the southern half of Smith Island, south of the Big Thoroughfare navigation channel.

Wooded island habitats in the Chesapeake Bay, exposed to little disturbance by humans or mammalian predators, provide important breeding sites for migratory birds such as colonial water birds (Erwin and Spendelow 1991), waterfowl, and certain raptors. These sites also provide important resting and staging areas for migratory songbirds. Habitats for many of these species have been severely limited on the mainland surrounding the Bay because of development, human disturbance, cultivation, and exposure to predation by domestic animals.

Recent studies have demonstrated that erosional loss of Chesapeake Bay island habitats has accelerated during the last century, due to sea-level rise and land subsidence (Wray, et al. 1995, Kearney and Stevenson 1991). Recent studies on three wooded islands in the Chesapeake Bay (Barren, James, and Poplar Islands) suggest that these habitats are eroding along western shorelines at an average rate of 4.96 m/yr = *:0.12 (Wray et al. 1995). Erosion on Eastern Shore islands in the middle portion of the Bay (Galenter 1990) has reduced nesting habitats, which has a negative impact on colonial water birds, waterfowl, and migratory songbirds. Habitat loss for wading birds breeding in the Bay region increases risks of predation, disease, and natural disasters (storms, oil spills, etc.) (Erwin and Spendelow 1991). Waterfowl researchers have correlated the loss of isolated islands, along with increased shoreline development, with the decline of black ducks in the Chesapeake Bay (Krementz et al. 1991).

Erosion poses the greatest threat for water bird colonies on Smith Island. For example, one hammock now used by black-crowned and yellow-crowned night-herons is threatened by erosion near Rhodes Point. Erosion has been slowed by placing dredged material and geotextile tubes along the shoreline adjacent to this shrub community. However, the shoreline is still eroding, especially at the north end of the geotextile tubes.

Some of the rookery sites are associated with dredged material disposal sites. Also, red foxes (*Vulpes vulpes*) populate the island. While they generally do not pose a threat to wading birds nesting high in trees, they may now limit the ability of those birds to breed in shrub communities on the hammocks.

Table 15. Breeding pairs of colonial nesting water bird species for eight years*

Species	Alpha	Colony	ID	Location	1975	1976	1977	1985	1986	1987	1988	1995
Cattle Egret	CAEG	Barren Is	DOR002	Barren Is	0	0	51	0	0	0	0	
Glossy Ibis	GLIB	Barren Is	DOR002	Barren Is	0	0	6	0	0	0	0	
Great Blue Heron	GBHE	Barren Is	DOR002	Barren Is	160	340	390	161	465	368	360	400
Great Egret	GREG	Barren Is	DOR002	Barren Is	140	125	180	60	35	60	162	175
Snowy Egret	SNEG	Barren Is	DOR002	Barren Is	0	0	90	0	0	0	0	
Black-crowned Night-Heron	BCNH	Fin Creek	DOR004	Bloodsworth Is	0	0	5	0	2	0	0	
Great Blue Heron	GBHE	Fin Creek	DOR004	Bloodsworth Is	209	263	101	128	124	130	121	90
Great Egret	GREG	Fin Creek	DOR004	Bloodsworth Is	8	0	0	0	1	0	0	
Green-backed Heron	GRHE	Fin Creek	DOR004	Bloodsworth Is	0	0	15	2	0	0	0	
Yellow-crowned Night-Heron	YCNH	Fin Creek	DOR004	Bloodsworth Is	0	0	1	0	0	0	0	
Black-crowned Night-Heron	BCNH	Adam Is	DOR005	Adam Is	8	0	7	0	0	0	0	
Great Blue Heron	GBHE	Adam Is	DOR005	Adam Is	20	15	10	15	1	6	14	8
Great Egret	GREG	Adam Is	DOR005	Adam Is	4	6	1	0	0	0	0	2
Green-backed Heron	GRHE	Adam Is	DOR005	Adam Is	2	0	3	0	1	0	0	
Little Blue Heron	LBHE	Adam Is	DOR005	Adam Is	6	0	0	0	0	0	0	
Snowy Egret	SNEG	Adam Is	DOR005	Adam Is	4	0	0	0	0	0	0	
Tricolored Heron	TRHE	Adam Is	DOR005	Adam Is	3	0	0	0	0	0	0	
Yellow-crowned Night-Heron	YCNH	Adam Is	DOR005	Adam Is	7	0	3	0	0	0	0	2
Black-crowned Night-Heron	BCNH	Holland Is	DOR006	Holland Is	156	39	38d	0	0	2	0	12
Cattle Egret	CAEG	Holland Is	DOR006	Holland Is	36	15	40d	0	0	0	0	35
Common Tern	COTE	Holland Is	DOR006	Holland Is			21	0	0	0	0	
Glossy Ibis	GLIB	Holland Is	DOR006	Holland Is	46	1+	16d	0	0	0	0	16
Great Blue Heron	GBHE	Holland Is	DOR006	Holland Is	48	13	50	3	0	1	4	54
Great Egret	GREG	Holland Is	DOR006	Holland Is	73	22	27c	0	0	6	8	88
Green-backed Heron	GRHE	Holland Is	DOR006	Holland Is	19	AA	5d	1	0	5	0	
Herring Gull	HEGU	Holland Is	DOR006	Holland Is			5	0	0	0	0	
Little Blue Heron	LBHE	Holland Is	DOR006	Holland Is	56	22c	22c	0	0	0	0	90
Snowy Egret	SNEG	Holland Is	DOR006	Holland Is	292	115	100	0	0	0	0	202
Tricolored Heron	TRHE	Holland Is	DOR006	Holland Is	46	13	23d	0	0	0	0	104
Yellow-crowned Night-Heron	YCNH	Holland Is	DOR006	Holland Is	37	8c	8c	10	18	3	18	8

Species	Alpha	Colony	ID	Location	1975	1976	1977	1985	1986	1987	1988	1995
Black-crowned Night-Heron	BCNH	N Holland Is	DOR008	Holland Is	201	32	37d	0	0	0	0	
Cattle Egret	CAEG	N Holland Is	DOR008	Holland Is	14	6	40d	0	0	0	0	
Glossy Ibis	GLIB	N Holland Is	DOR008	Holland Is	14	0	17d	0	0	0	0	
Great Blue Heron	GBHE	N Holland Is	DOR008	Holland Is	43	27	50	0	0	0	0	
Great Egret	GREG	N Holland Is	DOR008	Holland Is	40	35	28c	0	0	0	0	
Green-backed Heron	GRHE	N Holland Is	DOR008	N Holland Is	A	AA	5d	0	0	3	0	
Little Blue Heron	LBHE	N Holland Is	DOR008	Holland Is	17	23c	23c	0	0	0	0	
Snowy Egret	SNEG	N Holland Is	DOR008	Holland Is	85	60	100	0	0	0	0	
Tricolored Heron	TRHE	N Holland Is	DOR008	Holland Is	15	3	22d	0	0	0	0	
Yellow-crowned Night-Heron	YCNH	N Holland Is	DOR008	Holland Is	2	7c	7c	5	0	7	12	20
Black-crowned Night-Heron	BCNH	Piney Is Pt	DOR013	Bloodsworth Is	0	8		0	6	7	0	
Great Blue Heron	GBHE	Piney Is Pt	DOR013	Bloodsworth Is	0	25	A					25
Great Egret	GREG	Piney Is Pt	DOR013	Bloodsworth Is	0	25	A	0	0	4	0	
Green-backed Heron	GRHE	Piney Is Pt	DOR013	Bloodsworth Is				0	5	2	0	
Snowy Egret	SNEG	Piney Is Pt	DOR013	Bloodsworth Is				0	0	3	0	
Tricolored Heron	TRHE	Piney Is Pt	DOR013	Bloodsworth Is				0	0	3	0	
Great Blue Heron	GBHE	Bloodsworth Pt	DOR015	Bloodsworth Is								2
Great Egret	GREG	Bloodsworth Pt	DOR015	Bloodsworth Is				20	14	0	0	
Black-crowned Night-Heron	BCNH	Bishop's Head Pt	DOR028	Bishop's Head								2
Green-backed Heron	GRHE	Bishop's Head Pt	DOR028	Bishop's Head						6	5	
Common Tern	COTE	Whitewood Cove	DOR029	Barren Is				0	0	0	48	234
Forster's Tern	FOTE	Whitewood Cove	DOR029	Barren Is								285
Laughing Gull	LAGU	Whitewood Cove	DOR029	Barren Is								4
Great Black-backed Gull	GBBC	Spring Is	DOR031	Spring Is								20
Herring Gull	HEGU	Spring Is	DOR031	Spring Is								376
Black-crowned Night-Heron	BCNH	Cherry Is	SOM002	Martin NWR	200	AA	110	A	A	10	22	3
Cattle Egret	CAEG	Cherry Is	SOM002	Martin NWR	80	AA	145	0	0	0	0	15
Glossy Ibis	GLIB	Cherry Is	SOM002	Martin NWR	120	AA	A	A	A	9	9	63
Great Blue Heron	GBHE	Cherry Is	SOM00	Martin NWR	60	AA	60	230	185	250	177	54

2

Species	Alpha	Colony	ID	Location	1975	1976	1977	1985	1986	1987	1988	1995
Great Egret	GREG	Cherry Is	SOM002	Martin NWR	80	AA	25	80	A	43	119	50
Green-backed Heron	GRHE	Cherry Is	SOM002	Martin NWR	14	AA	A	A	A	A	A	
Little Blue Heron	LBHE	Cherry Is	SOM002	Martin NWR	20		0	A	A	1	0	10
Snowy Egret	SNEG	Cherry Is	SOM002	Martin NWR	125	AA	72	A	A	3	4	20
Tricolored Heron	TRHE	Cherry Is	SOM002	Martin NWR	80	AA	0	A	A	5	0	41
Yellow-crowned Night-Heron	YCNH	Cherry Is	SOM002	Martin NWR	25	AA	3	A	A	21	17	41
Great Egret	GREG	Noah Ridge	SOM003	Martin NWR	2			0	0	0	0	
Green-backed Heron	GRHE	Noah Ridge	SOM003	Martin NWR	10							
Tricolored Heron	TRHE	Noah Ridge	SOM003	Martin NWR	2			0	0	0	0	
Yellow-crowned Night-Heron	YCNH	Noah Ridge	SOM003	Martin NWR	18			0	0	0	0	
Yellow-crowned Night-Heron	YCNH	Wop Is	SOM005	Martin NWR				12	9	2	8	
Yellow-crowned Night-Heron	YCNH	Otter Creek	SOM010	Martin NWR				0	0	0	0	
Black-crowned Night-Heron	BCNH	Wellridge Creek	SOM025	Martin NWR								1
Cattle Egret	CAEG	Wellridge Creek	SOM025	Martin NWR								3
Glossy Ibis	GLIB	Wellridge Creek	SOM025	Martin NWR								3
Great Blue Heron	GBHE	Wellridge Creek	SOM025	Martin NWR	27	22	A	0	0	0	0	16

Species	Alpha	Colony	ID	Location	1975	1976	1977	1985	1986	1987	1988	1995
Great Egret	GREG	Wellridge Creek	SOM025	Martin NWR								64
Little Blue Heron	LBHE	Wellridge Creek	SOM025	Martin NWR								2
Snowy Egret	SNEG	Wellridge Creek	SOM025	Martin NWR								5
Tricolored Heron	TRHE	Wellridge Creek	SOM025	Martin NWR								24
Yellow-crowned Night-Heron	YCNH	Wellridge Creek	SOM025	Martin NWR				8	A	2	9	6
Great Black-backed Gull	GBBC	Sawney Cove	SOM030	Martin NWR								12
Herring Gull	HEGU	Swaney Cove	SOM030	Martin NWR				127	111	181	250	176
Cattle Egret	CAEG	Lookout Tower	SOM041	Martin NWR								271
Glossy Ibis	GLIB	Lookout Tower	SOM041	Martin NWR								65
Great Egret	GREG	Lookout Tower	SOM041	Martin NWR								3
Little Blue Heron	LBHE	Lookout Tower	SOM041	Martin NWR								61
Snowy Egret	SNEG	Lookout Tower	SOM041	Martin NWR								61
Tricolored Heron	TRHE	Lookout Tower	SOM041	Martin NWR								169
Yellow-crowned Night-Heron	YCNH	Lookout Tower	SOM041	Martin NWR								58
Great Black-backed Gull	GBBC	Terrapin Sand Pt	SOM044	Martin NWR								9
Herring Gull	HEGU	Terrapin Sand Pt	SOM044	Martin NWR								134
Great Black-backed Gull	GBBC	Drum Pt Is	SOM048	Martin NWR								3

Species	Alpha	Colony	ID	Location	1975	1976	1977	1985	1986	1987	1988	1995
Herring Gull	HEGU	Drum Pt Is	SOM048	Martin NWR								13

*1975–1977, 1985–1988, and 1995

Sources: Maryland Water bird Study Final Report, Project FW-8-P, Univ. MD, Center for Environmental and Estuarine Studies, Appalachian Environmental Laboratory (1975-1977 and 1985-1988 data) and Population Trends of Colonial Nesting Water birds on Maryland's Coastal Plain, Final Report, MD DNR, September 1996 (1995 data)

Legend

Blanks represent data not available or no census on that site that year.

A Colony site active, but no census

AA Based upon colony site history, colony site assumed active.

c Previous investigators combined the two colony sites on Holland Is into one count. Here that count is evenly divided between the two sites.

d Erwin & Korschgen (1979) combined the two colony sites on Holland Is into one count. Here that count is evenly divided between the two sites.

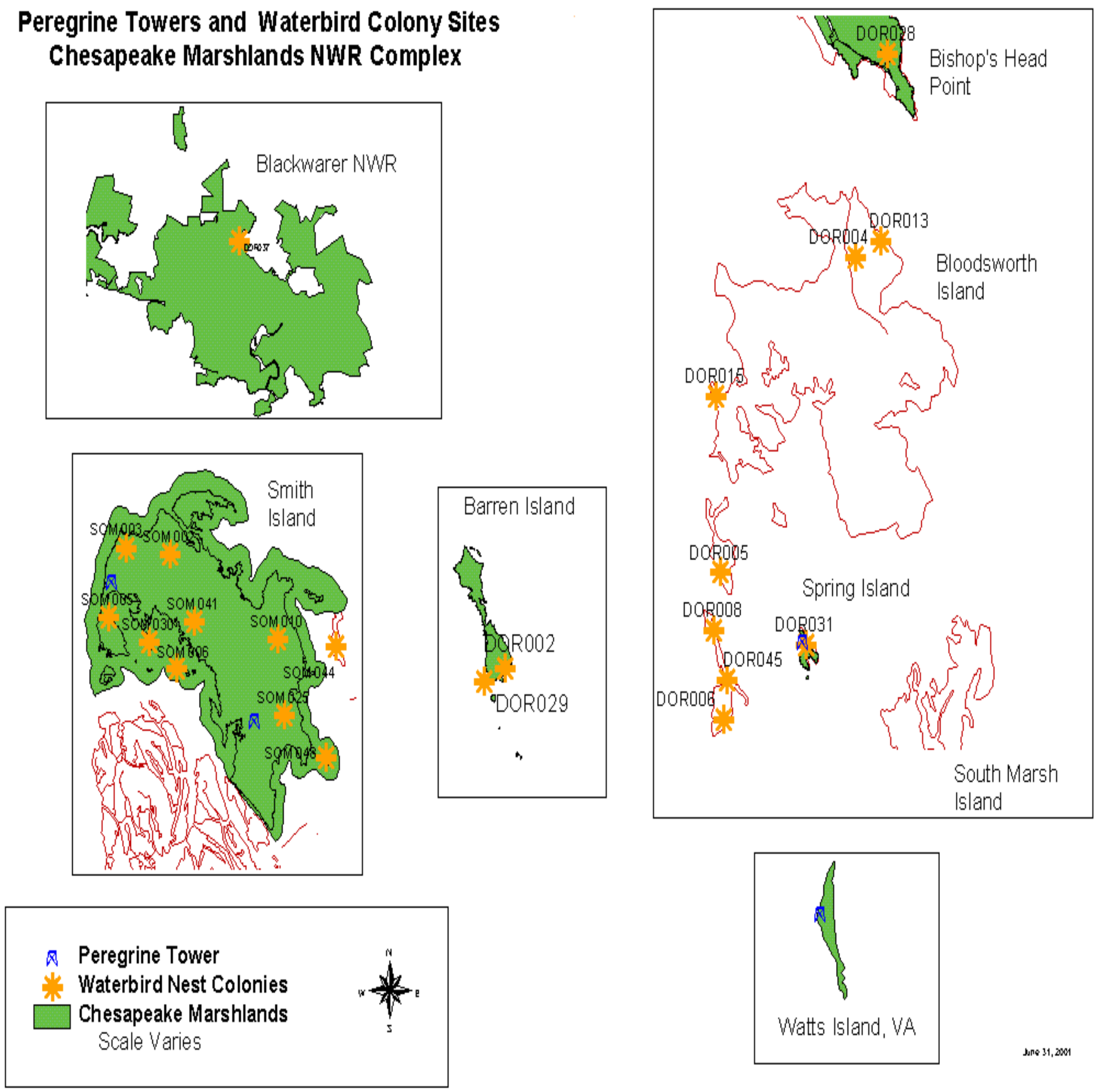


Figure 48. Peregrine towers and water bird colony sites

Breeding Songbirds

Eighty-five different species of songbirds nest in Blackwater NWR’s forested wetlands. Five years of breeding bird surveys began in 1996 on the Greenbriar Swamp, Moneystump, and Gum Swamp Tracts. We maintain eastern bluebird boxes on the refuge; recently, the box program has fledged as many as 147 young annually. Information is not available for the other units of the Refuge Complex or for the Nanticoke protection area.

Table 16. Relative frequency of occurrence of 104 bird species (Blackwater NWR)[1]

Latin name	Common name	% Occurrence
Ammodramus maritimus	Seaside sparrow	*
Catharus minimus	Gray-cheeked thrush[a]	*
Melospiza melodia	Song sparrow	*
Rallus longirostris	Clapper rail	*
Sterna forsteri	Forster’s tern	*
Caprimulgus vociferus	Whip-poor-will	0.24
Ceryle alcyon	Belted kingfisher	0.24
Certhia americana	Brown creeper	0.24
Chaetura pelagica	Chimney swift	0.24
Circus cyaneus	Northern harrier	0.24
Dendroica striata	Blackpoll warbler[a]	0.24
Dendroica virens	Black-throated green warbler[a]	0.24
Dumetella carolinensis	Gray catbird	0.24
Empidonax minimus	Least flycatcher[a]	0.24
Hirundo rustica	Barn swallow	0.24
Icterus galbula	Baltimore oriole	0.24
Ixobrychus exilis	Least bittern	0.24
Mniotilta varia	Black-and-white warbler	0.24
Parula americana	Northern parula	0.24
Sayornis phoebe	Eastern phoebe	0.24
Sturnella magna	Eastern meadowlark	0.24
Anas rubripes	American black duck	0.48
Butorides virescens	Green heron	0.48
Caprimulgus carolinensis	Chuck-will's-widow	0.48
Seiurus motacilla	Louisiana waterthrush	0.48
Strix varia	Barred owl	0.48
Bubo virginianus	Great horned owl	0.71
Egretta thula	Snowy egret	0.71
Ammodramus savannarum	Grasshopper sparrow	0.95
Cistothorus palustris	Marsh wren	0.95
Coccyzus erythropthalmus	Black-billed cuckoo	0.95

Latin name	Common name	% Occurrence
Dendroica discolor	Prairie warbler	0.95
Dendroica petechia	Yellow warbler	0.95
Larus atricilla	Laughing gull	0.95
Melospiza georgiana	Swamp sparrow	0.95
Pandion haliaetus	Osprey	0.95
Progne subis	Purple martin	0.95
Vireo flavifrons	Yellow-throated vireo	0.95
Buteo lineatus	Red-shouldered hawk	1.19
Oporornis formosus	Kentucky warbler	1.19
Mimus polyglottos	Northern mockingbird	1.43
Anas platyrhynchos	Mallard	1.67
Cathartes aura	Turkey vulture	1.67
Vireo solitarius	Blue-headed vireo[a]	1.67
Buteo jamaicensis	Red-tailed hawk	1.90
Haliaeetus leucocephalus	American bald eagle	1.90
Melanerpes erythrocephalus	Red-headed woodpecker	2.14
Piranga olivacea	Scarlet tanager	2.14
Turdus migratorius	American robin	2.14
Tyrannus tyrannus	Eastern kingbird	2.14
Aix sponsa	Wood duck	2.38
Protonotaria citrea	Prothonotary warbler	2.38
Sturnus vulgaris	European starling	2.38
Bombycilla cedrorum	Cedar waxwing	2.86
Dendroica dominica	Yellow-throated warbler	2.86
Icteria virens	Yellow-breasted chat	2.86
Corvus ossifragus	Fish crow	3.10
Meleagris gallopavo	Wild turkey	3.10
Spizella pusilla	Field sparrow	3.10
Calidris alba	Sanderling[a]	3.33
Charadrius vociferous	Killdeer	3.57
Sitta carolinensis	White-breasted nuthatch	3.57
Archilochus colubris	Ruby-throated hummingbird	4.76
Ardea herodias	Great blue heron	4.76
Picoides villosus	Hairy woodpecker	5.48
Sialia sialis	Eastern bluebird	5.71
Spizella passerina	Chipping sparrow	5.71
Tachycineta bicolor	Tree swallow	5.71
Guiraca caerulea	Blue grosbeak	6.19
Branta canadensis	Canada goose	6.43
Hylocichla mustelina	Wood thrush	7.14

Latin name	**Common name**	**% Occurrence**
Vireo griseus	White-eyed vireo	7.38
Zenaida macroura	Mourning dove	7.38
Sitta pusilla	Brown-headed nuthatch	7.38
Icterus spurius	Orchard oriole	8.57
Piranga rubra	Summer tanager	9.29
Empidonax virescens	Acadian flycatcher	10.48
Pipilo erythrophthalmus	Eastern towhee	11.19
Carduelis tristis	American goldfinch	11.90
Passerina cyanea	Indigo bunting	12.14
Dryocopus pileatus	Pileated woodpecker	12.86
Polioptila caerulea	Blue-Gray gnatcatcher	12.86
Colaptes auratus	Northern flicker	13.10
Colinus virginianus	Northern bobwhite	13.10
Cyanocitta cristata	Blue jay	13.33
Helmitheros vermivorus	Worm-eating warbler	14.76
Thryothorus ludovicianus	Carolina wren	14.76
Troglodytes aedon	House wren	18.57
Vireo olivaceus	Red-eyed vireo	21.19
Picoides pubescens	Downy woodpecker	21.90
Melanerpes carolinus	Red-bellied woodpecker	23.33
Molothrus ater	Brown-headed cowbird	23.81
Seiurus aurocapillus	Ovenbird	25.95
Agelaius phoeniceus	Red-winged blackbird	23.44
Quiscalus quiscula	Common grackle	26.19
Cardinalis cardinalis	Northern cardinal	28.33
Contopus virens	Eastern wood-pewee	28.57
Dendroica pinus	Pine warbler	31.43
Geothlypis trichas	Common yellowthroat	31.90
Corvus brachyrhynchos	American crow	32.38
Poecile carolinensis	Carolina chickadee	32.86
Coccyzus americanus	Yellow-billed cuckoo	37.86
Myiarchus crinitus	Great crested flycatcher	38.33
Baeolophus bicolor	Tufted titmouse	54.52

[1]Found at 84 points sampled during 1996–2000
*Detected on stations that were not sampled all 5 years.
[a]Almost certainly migrants (D. K. Dawson, H. T. Armistead, pers. comm.).

FIFTY-YEAR SUMMARY

Southern Dorchester County Christmas Count. High & Low Counts and 5-year Means

Note: In comparing totals across the years, be sure to take into account the differences in coverage, especially party-hours and party-miles on foot. In some years the coverage was poor because of icy roads or small numbers of observers.

Species	High	2nd	Low	1947-1951	1952-1956	1957-1961	1962-1966	1967-1971	1972-1976	1977-1981	1982-1986	1987-1991	1992-1996
Common Loon	8	6	0	0.0	0.0	0.2	0.0	0.6	1.2	1.0	1.8	1.8	4.2
Pied-billed Grebe	20	17	0	1	11	1	1	4	6	2	2	5	2
Horned Grebe	304	229	0	16	66	146	14	69	72	2.8	1.0	4	7
Western(?) Grebe	1	0	0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0
Northern Gannet	1	0	0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0
Am. Bittern	13	7	0	1	2	2	2	1	3	1	2	0.4	0.4
Gt. Blue Heron	139	99	11	15	37	25	21	39	88	82	54	61	54
Great Egret	35	8	0	2	2	3	1	3	2	2	1	3	9
Snowy Egret	2	1	0	0.0	0.0	0.0	0.0	0.0	0.6	0.2	0.0	0.0	0
Little Blue Heron	2	1	0	0.0	0.0	0.0	0.0	0.4	0.2	0.0	0.0	0	0
Tricolored Heron	1	0	0	0.0	0.0	0.0	0.0	0.2	0.0	0.4	0.2	0.0	0
Green Heron	1	0	0	0	0	0	0	0	0	0	0.2	0	0
Blk-cr. Nt-Heron	28	17	0	2	7	9	1	3	7	3	1	1.2	0.6
Glossy Ibis	1	1	0	0	0	0	0	0.2	0.2	0	0	0.6	0
Tundra Swan	2770	1865	0	40	55	101	1055	683	638	648	784	745	928
Mute Swan	68	67	0	0	0	0	0	0	0	0	1.2	3.2	41
Gr White-frt Goose	1	1	0	0	0	0	0	0	0.2	0.4	0.2	0.2	0.2
Snow Goose (white)	4670	2750	0	5	7	13	163	167	855	440	457	2245	1128
(blue)	4950	4000	0	1	4	10	143	220	523	2040	1421	646	1416
(whiteXblue)	1	0	0	0.2	0	0	0	0	0	0	0	0	0
Ross' Goose	2	0	0	0	0	0	0	0	0	0	0	cw	0.4
Brant	1300	60	0	0.2	0	0	260	20	0	0	0	0	0
Canada Goose	47000	47000	1570	2427	11100	7106	35065	32580	28348	25862	16388	12525	7831
Wood Duck	5	5	0	1	1	0	0	0.2	0.4	0.4	1.6	0.6	0.8
Green-winged Teal	1170	810	0	189	452	79	6	12	54	111	75	66	271
Am. Black Duck	10125	5620	160	1599	3960	2565	1512	692	749	1315	621	779	515
Mallard	16650	8370	70	327	2712	3362	5192	2036	1387	2974	1785	4497	2459
No. Pintail	3625	2060	0	115	1319	757	455	249	214	210	18	45	578
Blue-winged Teal	39	38	0	9	10	2	1	1	10	1	0	2	3
No. Shoveler	162	60	0	6	13	2	0	12	20	3	1	1	49
Gadwall	556	316	0	138	136	46	6	8	5	13	21	66	40
Eurasian Wigeon	1	1	0	0.4	0	0	0	0	0	0	0	0	0
Am. Wigeon	1425	545	0	149	396	100	32	62	20	125	17	4	26
Canvasback	9090	8800	0	822	3010	3322	1993	527	896	1002	2309	3128	1957
Redhead	865	492	0	5	207	46	97	5	154	4	9	0	0
Ring-necked Duck	3500	3000	0	153	894	1762	343	12	0.4	3	0.2	1.2	6
Greater Scaup	1010	120	0	0	0	0.4	0	22	1.6	208	26	0.4	0
Lesser Scaup	5060	4490	0	394	810	970	1048	97	54	39	151	9	5
scaup sp.	709	400	0	0	0	0	8	268	17	50	2	3	4
Oldsquaw	375	124	0	16	28	87	11	35	18	47	17	28	3
Black Scoter	4	3	0	0	0.8	0.8	0	0	0	0	0	0.6	0
Surf Scoter	89	28	0	2	9	0	1	0.2	3	26	0	1.4	0
White-wing Scoter	50	8	0	0.2	11	0	0	0.2	0.8	1.6	1.6	0	0
Common Goldeneye	1200	670	0	198	418	203	53	166	49	114	72	35	56
Bufflehead	561	511	0	30	23	16	56	229	230	103	84	153	135
Hooded Merganser	70	59	0	21	29	5	5	9	5	18	6	18	90
Common Merganser	1171	355	0	343	94	61	8	7	20	30	9	9	54
Red-breasted Merg	134	113	0	5	8	32	20	37	10	40	3	7	35
Com or Red-br	13	0	0	0	0	0	0	0	0	0	0	0	2.6
Ruddy Duck	1500	1500	0	134	142	286	192	749	125	407	0	7	2
Black Vulture	48	45	0	0	2	2	9	1	4	23	14	17	18
Turkey Vulture	412	265	0	80	160	219	172	140	119	152	121	167	162
Bald Eagle	117	96	0	16	21	12	11	13	21	33	29	54	69
Northern Harrier	91	87	19	33	55	56	62	48	70	95	85	72	46
Sharp-shinned Hawk	13	11	0	2	3	4	4	3	5	8	9	8	5
Cooper's Hawk	7	6	0	3	3	2	2	1	2	1	1	1	2
No. Goshawk	1	1	0	0	0	0	0	0	0.4	0	0	0	0
Red-shoulder Hawk	18	16	1	7	9	8	9	5	6	11	8	7	4
Red-tailed Hawk	41	34	2	9	12	11	16	15	16	21	16	26	25
Rough-legged Hawk	27	21	1	2	4	5	11	10	8	12	14	9	5
Golden Eagle	3	3	0	0	0.8	0.2	1.2	1.0	1.8	1.2	1.4	1.6	0.2
Am. Kestrel	38	36	1	7	11	18	19	19	26	30	18	17	10
Merlin	2	1	0	0.2	0.2	0.2	0.4	0.4	0	0.4	0	0	0.2
Peregrine Falcon	1	1	0	0	0.2	0.2	0.4	0	0.4	0.2	0	0	0.2
Ring-neck Pheasant	30	14	0	0	0	0	0	0	0	1	0.4	6	7
Wild Turkey	41	23	0	0	0	0.2	0	0	0	0	0	0	14
No. Bobwhite	222	174	0	7	32	38	187	78	110	96	102	32	26
Black Rail	1	0	0	0	0	0	0	0	0.2	0	0	0	0
Clapper Rail	11	9	0	0.8	0.6	0.8	0.4	2	4	0	1.2	0	0
King Rail	32	23	0	5	12	0.8	0	0.4	13	0.4	0.8	0	1
Virginia Rail	115	66	0	15	22	22	10	6	50	7	9	4	4
Sora	4	3	0	1.2	0.4	0	0	0.2	1	0	0	0	0

Figure 49. Fifty-Year Summary, Southern Dorchester County Christmas Count

50-YEAR SUMMARY, Southern Dorchester County Christmas Count. High & Low Counts and 5-year Means

Species	High	2nd	Low	1947-1951	1952-1956	1957-1961	1962-1966	1967-1971	1972-1976	1977-1981	1982-1986	1987-1991	1992-1996
Common Moorhen	1	1	0	0	0	0	0	0	0.20	0	0	0	0.4
Am. Coot	58	40	0	3	9	1	1	16	7	11	0	0	2
Blue Crane	1	0	0	0	0	0	0	0.2	0	0	0	0	0
Black-belly Plover	5	3	0	0	0.2	0	0	0	0	1	1	1.2	0
Killdeer	526	208	0	13	74	63	20	45	69	63	27	62	145
Am. Oystercatcher	2	0	0	0	0	0	0	0	0	0	0.4	0	0
Greater Yellowlegs	55	47	0	7	9	3	3	4	15	24	7	15	25
Lesser Yellowlegs	15	14	0	2	3	1	0.4	0	7	6	1	3	4
Sanderling	2	2	0	0	0.4	0	0	0	0	0.4	0	0	0
Western Sandpiper	7	1	0	0	0	0	1	0	0.2	0	0	0.2	0
Least Sandpiper	18	4	0	0	0.2	0	0	0	0	0	0	4	0
Dunlin	1065	655	0	8	48	4	1	3	212	305	236	117	186
Long-bill Dowitcher	1	0	0	0	0	0	0.2	0	0	0	0	0	0
dowitcher sp.	8	3	0	0	0	0.2	0	0	0	0.6	0.2	0	1.6
Common Snipe	97	96	0	2	19	8	12	27	43	36	15	14	9
Am Woodcock	25	24	0	1	1	4	4	6	19	5	3	2	3
Laughing Gull	1	1	0	0	0.2	0.2	0	0.2	0	0	0	0	0
Bonaparte's Gull	90	2	0	0	0	0	0.4	0	0	0	0	18	0
Ring-billed Gull	2654	2500	15	147	318	364	283	222	339	459	1494	1003	866
Herring Gull	1365	626	18	100	191	240	197	197	175	393	474	459	499
Gt Black-back Gull	60	33	0	2	2	8	8	15	17	30	12	7	11
Forster's Tern	1	1	0	0	0	0	0	0.2	0.2	0	0	0	0
Rock Dove	27	18	0	--	--	--	--	--	8	13	9	4	4
Mourning Dove	747	500	0	19	88	97	190	137	388	252	112	197	79
Barn Owl	10	4	0	2	0.4	3	1	0.4	1	0.8	0.4	3	1.4
E. Screech-Owl	24	23	0	0	1	7	8	3	11	16	11	9	7
Gt Horned Owl	47	42	0	5	17	24	20	12	21	25	17	24	16
Barred Owl	5	4	0	1	2	3	2	1	1	0.8	0.8	0.6	0.6
Long-eared Owl	3	1	0	0	0.2	0	0	0	1	0	0	0	0
Short-eared Owl	23	17	0	1	3	7	6	4	5	7	10	7	7
N. Saw-whet Owl	2	1	0	0.2	0	0.2	0	0	0.4	0.6	0	0.2	0
Belted Kingfisher	65	53	3	6	13	13	21	24	45	17	18	21	20
Red-head Woodpkr	9	1	0	0	0	0.2	0.2	0	0.2	0.2	0.2	0.2	1.8
Red-belly Woodpkr	102	66	0	5	19	22	33	29	38	32	36	37	47
Yel-bel Sapsucker	6	4	0	0	0.2	0.4	0.4	1	0.2	0.4	4	1	2.2
Downy Woodpecker	171	116	15	20	42	56	86	49	57	98	87	67	48
Hairy Woodpecker	37	33	1	4	9	14	17	14	20	19	12	20	12
Red-cockaded Wdpkr	1	0	0	0	0	0.2	0	0	0	0	0	0	0
Yellow-sh Flicker	220	169	5	17	52	75	94	79	126	94	86	91	72
Pileated Woodpkr	32	28	0	6	5	7	13	15	17	21	20	15	16
Eastern Phoebe	7	3	0	0.6	0.6	0	0.2	0.4	0	0	0.4	0.6	2.4
Horned Lark	152	83	0	6	10	7	52	1	11	27	9	24	21
Tree Swallow	1255	1236	0	0	48	542	13	3	75	0	0	0	0
Blue Jay	372	278	1	9	33	27	99	89	175	85	71	73	61
Am. Crow	11870	3545	360	1083	3701	2101	1247	608	614	526	759	1027	826
Fish Crow	2550	1429	0	0	1	5	24	21	31	177	759	961	1121
crow sp.	3100	2100	0	0	0	0	0	0	0	0	0	1045	3819
Blk-cap Chickadee	40	7	0	0	1	8	1	0	0.2	0	0	0	0
Carolina Chickadee	387	368	28	83	141	148	214	186	222	279	259	188	142
Tufted Titmouse	111	96	5	31	56	46	65	63	51	64	80	56	53
Red-br Nuthatch	34	20	0	1	0.2	1	4	3	11	1	3	0.2	1
White-br Nuthatch	34	20	0	0.2	2	6	9	8	2	6	2	2	2.4
Brown-head Nuthtch	482	365	8	63	120	290	186	151	58	54	59	85	27
Brown Creeper	65	52	0	9	19	16	31	23	32	29	32	18	13
Carolina Wren	242	216	3	22	62	53	29	28	169	68	118	76	129
House Wren	6	4	0	0.4	0	0.8	0	2	2	0.4	0.2	0.8	0.4
Winter Wren	79	40	2	8	18	8	6	15	24	6	8	32	20
Sedge Wren	164	70	0	46	35	5	7	4444	6	3	2	0.4	0.6
Marsh Wren	134	127	0	23	43	24	5	4	41	25	34	3	7
Golden-cr Kinglet	352	296	12	37	49	48	174	112	153	82	88	93	60
Ruby-cr Kinglet	149	148	0	7	7	7	68	43	63	26	52	41	25
Blue-gray Gnat	2	0	0	0	0	0	0	0	0	0	0.4	0	0
Eastern Bluebird	255	241	0	44	61	108	22	18	42	12	73	134	151
Swainson's Thrush	1	0	0	0	0.2	0	0	0	0	0	0	0	0
Hermit Thrush	83	79	0	11	29	12	23	18	37	34	55	28	39
Am. Robin	2570	1704	1	17	316	85	297	422	894	365	640	486	804
Gray Catbird	24	20	0	1	5	9	11	8	8	2	6	6	5
No. Mockingbird	109	80	1	3	16	31	63	38	42	42	33	36	28
Brown Thrasher	29	22	0	0.4	8	13	15	9	6	6	2	1.2	1.8
Am. Pipit	288	215	0	59	36	50	5	24	12	8	39	1	44
Cedar Waxwing	601	241	0	2	8	6	18	53	16	52	241	19	50
Northern Shrike	1	1	0	0	0	0.2	0	0.2	0	0	0	0	0
Loggerhead Shrike	14	9	0	1	5	4	3	4	1	1	0.2	0	0
Eur. Starling	3835	2280	60	409	430	762	1612	725	1258	1071	1266	882	1274

Figure 50. Southern Dorchester County Christmas Count (continued)

FIFTY-YEAR SUMMARY, Southern Dorchester County Christmas Count. High & Low Counts and 5-year Means

Species	High	2nd	Low	1947-1951	1952-1956	1957-1961	1962-1966	1967-1971	1972-1976	1977-1981	1982-1986	1987-1991	1992-1996
Orange-cr Warbler	1	1	0	0	0	0.2	0	0	0	0.2	0	0	0.4
Nashville Warbler	1	0	0	0	0	0	0	0	0.2	0	0	0	0
Myrtle Warbler	6500	5835	122	1260	2242	2888	4036	1972	2522	2165	1691	1147	957
Audubon's Warb	1	0	0	0	0	0	0	0	0	0	0	0	0.2
Pine Warbler	21	21	0	0.4	0	1	1.2	0.6	2.4	7	8	7	4
Palm Warbler	6	4	0	0	0.8	0.8	1	0.4	0.4	1.2	0.6	1	0.8
Black-&-white Warb	1	0	0	0	0	0	0	0	0.2	0	0	0	0
Com. Yellowthroat	10	8	0	0.6	1	0.4	1	1	7	0.2	0	1	3.4
Yellow-br. Chat	1	0	0	0	0	0	0	0	0	0.2	0	0	0
No. Cardinal	357	315	22	44	134	144	239	191	180	129	125	86	49
Rufous-side Towhee	127	98	2	15	47	64	53	57	70	27	19	12	27
Bachman's Sparrow	1	0	0	0	0	0.2	0	0	0	0	0	0	0
Am. Tree Sparrow	33	32	0	15	7	11	17	17	8	3	6	0.2	0.4
Chipping Sparrow	11	10	0	0.4	2	1	0.2	0.4	0.8	1.8	0	2	2.4
Field Sparrow	246	239	9	65	108	124	129	106	45	71	66	49	51
Vesper Sparrow	8	6	0	0.4	4	0.6	1	1	3	1	0	0	0
Savannah Sparrow	239	186	7	20	72	109	104	40	57	78	87	95	8.3
Sharp-tail Sparrow	6	5	0	0.2	2	0.6	1	1	3	0.4	2	0.6	1.8
Seaside Sparrow	11	7	0	1	2	0.4	0.8	0.2	0	0	0	0	0
Fox Sparrow	43	33	0	6	7	15	24	20	3	4	14	4	1
Song Sparrow	965	869	85	190	450	312	571	418	558	510	345	297	320
Lincoln's Sparrow	1	0	0	0	0	0	0	0	0	0.2	0	0	0
Swamp Sparrow	1271	1056	86	278	612	419	327	241	421	289	200	196	180
White-thrt Sparrow	1550	1225	83	150	808	451	582	432	555	645	595	266	385
White-crown Spar	23	9	0	0	0	0	0.2	0.6	7	3	0	0.2	1
Dark-eyed Junco	514	449	8	75	233	135	256	178	142	189	173	147	194
Snow Bunting	1	1	0	0	0	0	0.2	0	0	0.2	0	0	0
Lapland Longspur	5	0	0	0	0	0	0	1	0	0	0	0	0
Red-wing Blkbird	500M	130M	1060	4716	7237	106M	65934	7036	14994	21116	29956	14495	12602
E. Meadowlark	633	624	7	247	420	348	396	303	376	267	200	165	159
Rusty Blackbird	58	53	0	3	10	2	33	5	18	11	7	7	0.8
Brewer's Blackbird	1	0	0	0	0	0	0	0	0	0.2	0	0	0
Boat-tail Grackle	842	475	0	0	0	11	32	146	166	314	91	4	56
Common Grackle	251M	150M	2	601	364	33420	7225	130	29376	18465	53574	261	1164
Brown-head Cowbird	2095	1275	0	51	697	271	330	25	146	240	389	54	214
Pine Grosbeak	2	0	0	0	0	0	0	0.4	0	0	0	0	0
Purple Finch	52	12	0	0.4	2	3	1	3	3	7	4	11	0.4
House Finch	1775	162	0	0	0	0	0	0	9	3	40	411	53
Red Crossbill	223	152	0	0	0	0	0	30	55	0	0	0	0
White-wg Crossbill	35	7	0	0	0	0	7	0.2	0	1	0	0	0
Common Redpoll	2	0	0	0	0	0	0	0.4	0	0	0	0	0
Pine Siskin	258	100	0	20	11	1	19	74	6	16	1	1	0
Am. Goldfinch	715	548	0	124	250	161	162	127	95	92	142	248	67
Evening Grosbeak	400	119	0	0	0.6	0.6	3	112	7	4	5	0	0
House Sparrow	670	657	19	93	191	326	468	220	216	219	193	77	43
Total species	132	123	71	93	110	105	106	108.	120	115	106	102	103
Indiv (thousands)	537	358	8	18	49	172	134	55	91	86	139	52	45
Party-hours	196	158	25	40	79	74	89	84	122	138	118	95	77
Party-miles	519	472	57	170	250	281	327	219	305	414	325	265	273
Pty-mi, on foot	143	112	21	22	66	58	72	55	72	90	71	57	43
Miles by boat	40	30	0	11	10	12	2	4	13	9	12	0	2
Miles by air	260	180	0	0	26	19	24	0	10	144	0	0	0
Total parties	22	20	3	4	6	6	6	6	7	11	16	12	9
Total observers	37	35	4	8	20	17	20	14	29	26	25	17	16
% clear days	80	80	10	60	80	80	60	60	10	20	60	40	50
Min. temp	54	45	14	25	33	29	25	28	34	28	23	22	28
Mean wind	20-30	20-25	0	10	13	8	8	13	10	7	11	6	6
% frozen	100	100	0	53	20	37	72	57	19	31	40	38	40

Figure 51. Southern Dorchester County Christmas Count (conclusion)

Source: Dr. Chandler Robbins, USGS, BRD, Patuxent

Threatened and Endangered Species

The Refuge Complex is noted for its abundance of rare, threatened, and endangered species. The Maryland and Delaware Natural Heritage Programs have documented more than 200 plant species and almost 70 animal species that are rare, threatened, or endangered. [See appendix B, “Rare Species in the Nanticoke River Watershed.”] The Federal-listed species on the Refuge Complex include the American bald eagle, Delmarva fox squirrel (DFS), shortnose sturgeon, sensitive joint-vetch, Canby’s dropwort, swamp pink, northeastern beach tiger beetle, and five species of sea turtles. Blackwater NWR forests provide habitat for the largest aggregation and nesting population of American bald eagles along the Atlantic coast north of Florida, and for the Nation's largest protected population of DFS.

Delmarva fox squirrels.—Eastern fox squirrels occur along the Atlantic and Gulf Coastal Plains, from the Delmarva Peninsula in Maryland south to central Florida and west to the Mississippi River flood plain. A subspecies of the Eastern fox squirrel, the DFS (*Sciurus niger cinereus*) was Federal-listed as endangered in 1967. It occurs in only four Eastern Shore counties in Maryland and in one location in Accomack County, Virginia. Within the study area and the Refuge Complex, DFS are found only in the Blackwater and Nanticoke rivers watershed. This subspecies formerly was found in southeastern Pennsylvania, Delaware, New Jersey and, probably, that part of the Delmarva Peninsula in Virginia.

The DFS inhabits open hardwood, hardwood–pine, and hardwood wetland communities, preferring mature stands of large hardwoods such as oaks (*Quercus* spp.), hickories (*Carya* spp.), walnuts (*Juglans* spp.), and beeches (*Fagus* spp.) that are interspersed with mature loblolly pine (*Pinus taeda*) (Moncrief et al. 1993, Bendel and Therres 1994). DFS also are found in deciduous swamps close to pine woodlands (Tesky, 1993). Fox squirrels are most abundant in open forest stands with little understory vegetation; they are not as abundant in stands with dense undergrowth. An ideal habitat is small stands of large trees interspersed with agricultural land (Allen, 1982, and Tesky, 1993). Contrary to this, Weigl (1989) and Paglione (1996) claim that large mature forest stands of loblolly pine and mixed hardwoods are essential for the existence of viable, stable populations of DFS. This is a prime example of the lack of information and conflicts in the literature on this species.

Much more local research must be conducted before definite habitat management recommendations can be made for this species. The size and spacing of pines and oaks are among the important features of fox squirrel habitats. The actual species of pines and oaks themselves may not always be a major consideration in defining fox squirrel habitat (Weigl, et. al. 1989, and Tesky, 1993). Fox squirrels are often observed foraging on the ground several hundred meters from the nearest woodlot. They also commonly occupy forest edge habitat (Dueser, et. al., 1988, and Tesky, 1993).

DFS habitat consists primarily of relatively small stands of mature mixed hardwoods and pines that have relatively closed canopies, open understories, and a high proportion of forest edge. Occupied areas include both groves of trees along streams and bays and small woodlots near agricultural fields. In some areas, particularly in southern Dorchester County, Maryland, occupied habitat includes areas dominated by mature loblolly pine located adjacent to marshes and tidal streams (Tesky, 1993).

In contrast to the gray squirrel (*Sciurus carolinensis*), the DFS often travels on the ground (Moncrief et al. 1993) and has been shown to prefer mature forests with a “minimum of underbrush” (Moncrief et al. 1993), closed canopies, open understories, and a high proportion of forest edge (Dueser et al. 1988). Authors have suggested that habitat for fox squirrels in general may be improved by leaving mature and large-crowned trees in managed forests, encouraging nut-bearing trees, and opening up the forest understory by burning or light grazing (Chapman et al. 1982, Engstrom et al. 1996). Fox squirrels have been found to prefer sites where understory closure is 30 percent or less (Allen 1982). Fire may reduce habitat suitability for the competing gray squirrel (Weigl et al. 1989).

Female fox squirrels normally produce two litters a year. They come into estrus in mid-December or early January and again in June. However, yearling females may produce only one litter, and poor food conditions may prevent some adult females from breeding. Females become sexually mature at 10 to 11 months of age. They usually produce their first litter when they are 1 year old. The gestation period of fox squirrels is 44 to 45 days. Earliest litters appear in late January, with most births occurring in mid-March and July. The average litter size is three, but litter size can vary according to seasonality and food availability. Tree squirrels develop slowly compared to other rodents. Eyes open when fox squirrels are 4 to 5 weeks old, and ears open at 6 weeks. Fox squirrels are weaned between 8 and 10 weeks but may not be self-supporting until 12 weeks. Juveniles usually disperse in September or October, but they may den together or with their mother the first winter.

Fox squirrels generally live up to 6 years in the wild, but have survived 13 years in captivity (Chapman and Feldhamer, 1982). Fox squirrels have two types of shelters: leaf nests and tree dens. They may have two tree cavity homes or a tree cavity and a leaf nest. Tree dens are preferred over leaf nests during the winter and for raising young. When den trees are scarce, leaf nests are used year-round. Forest stands dominated by mature to over-mature trees provide cavities and a sufficient number of sites for leaf nests to meet the cover requirements.

Fox squirrels may make their own den in a hollow tree by cutting through the interior; however, they generally use natural cavities or cavities created by northern flickers (*Colaptes auratus*) or redheaded woodpeckers (*Melanerpes erythrocephalus*). Crow nests have also been used by fox squirrels (Tesky, 1993). Overstory trees with an average d.b.h. of 15 inches (38.1 cm) or more generally provide adequate cover and reproductive habitat. Optimum tree canopy closure for fox squirrels is from 20 to 60 percent. Optimum conditions for understory closure occur when the shrub-crown closure is 30 percent or less (Allen, 1982; Tesky, 1993).

Food habits of fox squirrels depend largely on geographic location. In general, fox squirrel foods include mast, tree buds, insects, tubers, bulbs, roots, bird eggs, seeds of pines and spring-fruiting trees, and fungi. Agricultural crops such as corn, soybeans, oats, wheat, and fruit are also eaten (Allen, 1982; Chapman and Feldhamer,1982; Weigl, et. al., 1989; Tesky, 1993).

The range of fox squirrels in the eastern states has been greatly reduced in the past 100 years Chapman and Feldhamer, 1982; Tesky, 1993). Habitat reduction is one cause. The Delmarva Peninsula is undergoing rapid deforestation and forest modification due to accelerated residential and agricultural development, and intensive management techniques in commercial forests (Weigl, et. al., 1989; Tesky,1993). One of the primary reasons for the decline of the endangered DFS is poor timber management techniques and accelerated rates of timber harvesting. As large trees are removed, so are much of the areas that provide the DFS with an open understory habitat. During this temporary loss of habitat, this subspecies is forced to compete with gray squirrels for food and nesting resources.

Logging practices that include harvesting all the big hardwoods and replacing them with stands of pure loblolly pine are also detrimental to DFS, since stands of pure species do not provide good fox squirrel habitat (Tesky, 1993). Another major cause of fox squirrel population decline is mange mite (*Cnemidoptes sp.*), along with severe winter weather (Chapman and Feldhamer, 1982; Tesky, 1993). The DFS population on Blackwater NWR, estimated at 550, appears to be stable.

Recovery Plan tasks specific to Blackwater NWR:

- **2.3** Field testing and defining applications for the Habitat Suitability Model;
- **4.1** Determining effects of timber management and other land use practices on the DFS;
- **4.2** Developing and refining guidelines for prescriptive habitat management for the DFS;
- **4.3** Developing and implementing guidelines for habitat management on public lands occupied by the DFS; and
- **4.4** Monitoring the outcome of prescriptive habitat management.

The figures below were selected from “Project Report, Analysis of Delmarva fox squirrel (*Sciurus niger cinereus)* benchmark population data (1991–1998)” Dr. Raymond D. Deuser, Utah State University, Logan, UT 84322-5210, January 19, 1999.

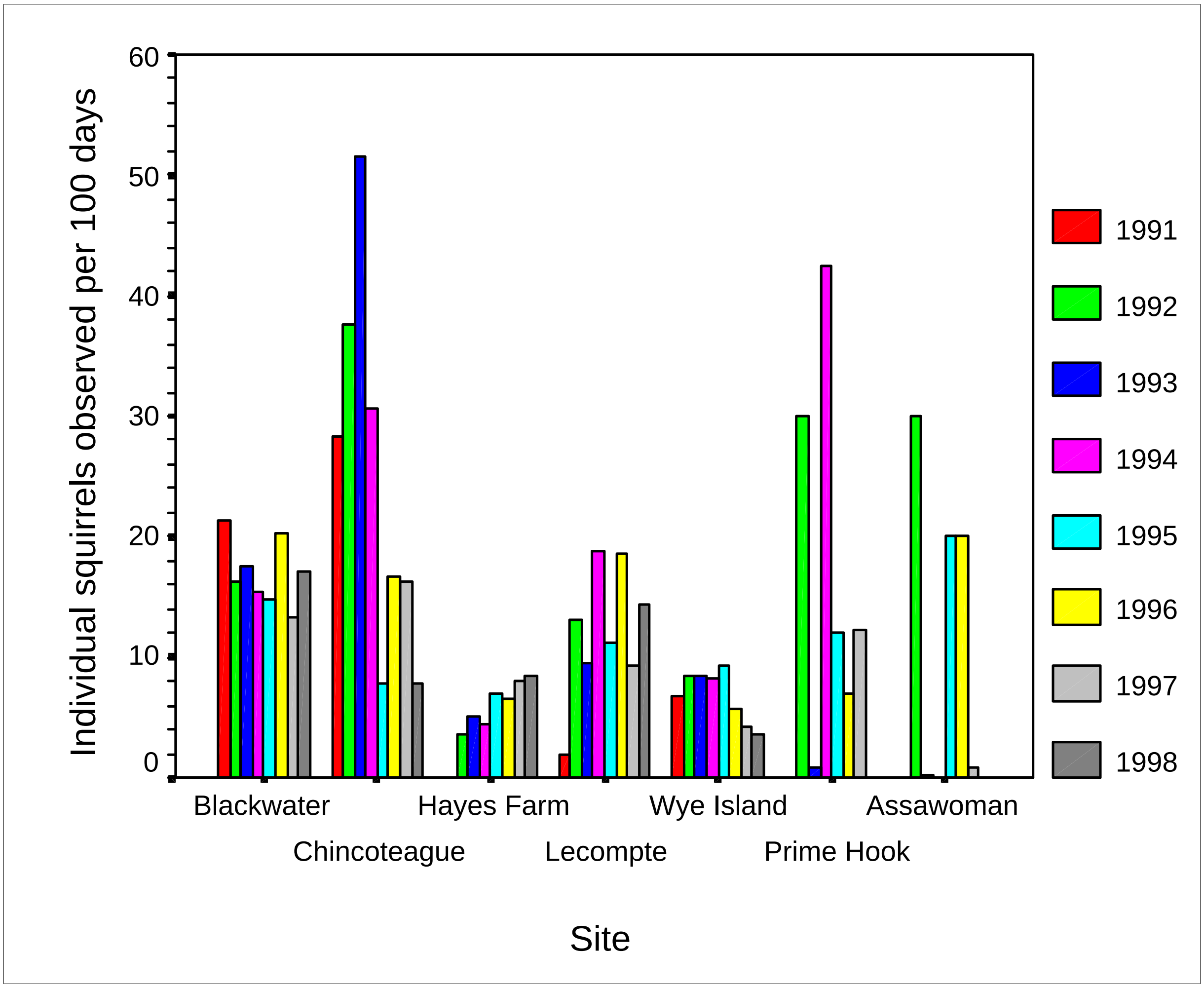


Figure 52. Number of DFS observed per 100 sampling days at seven sites (color plate)

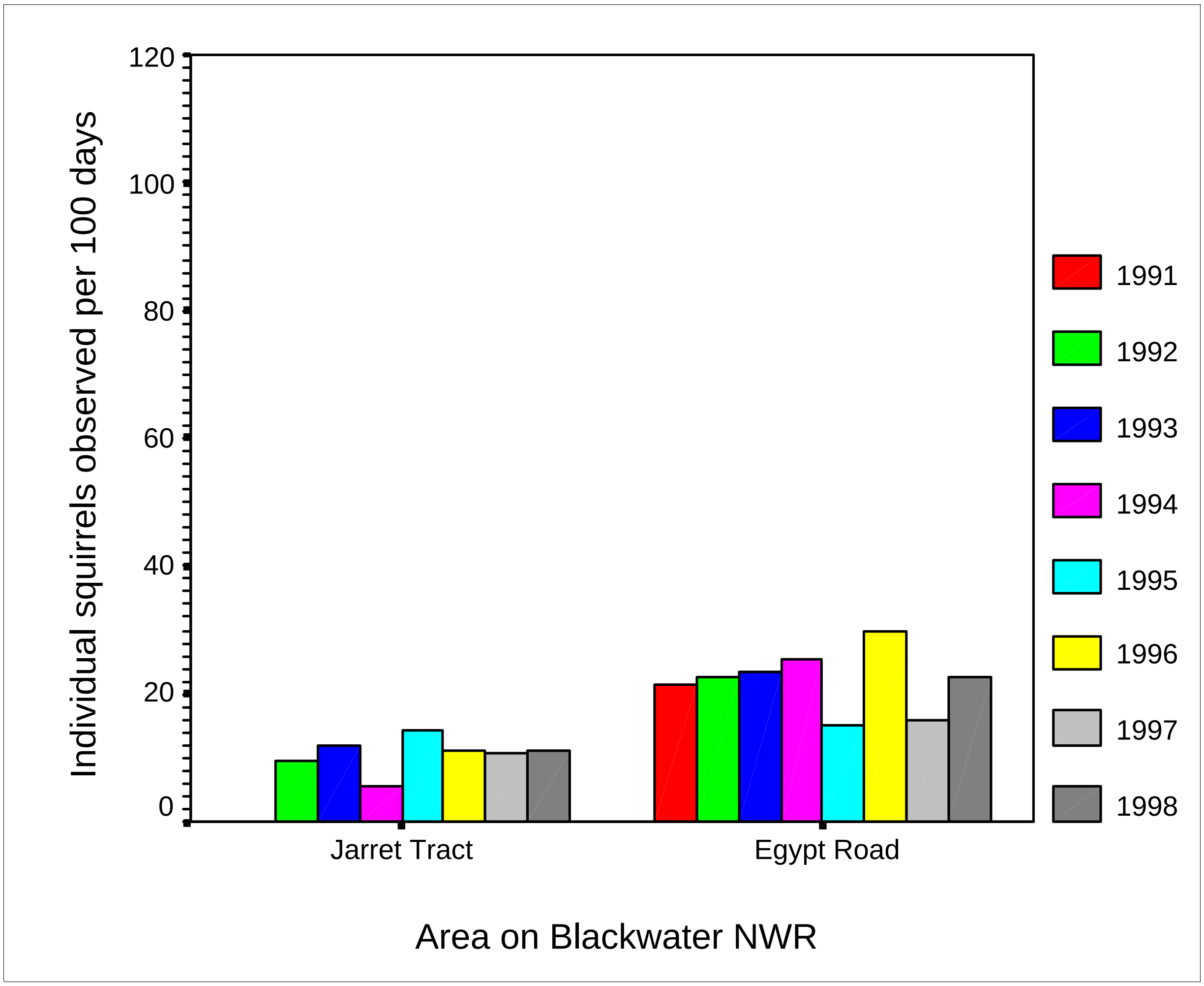
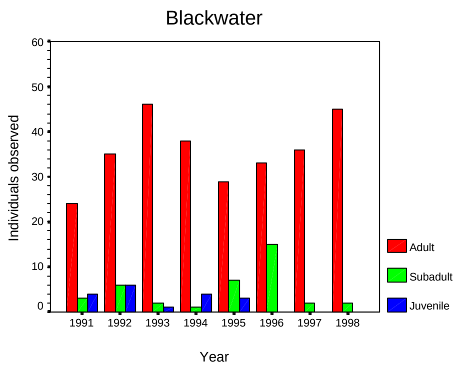
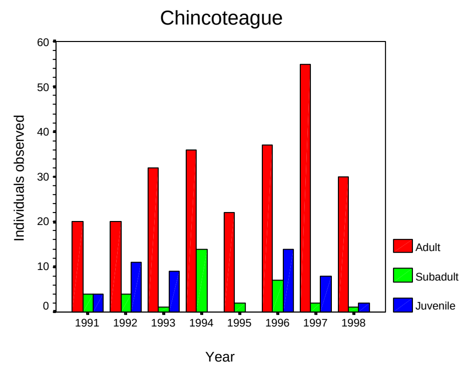
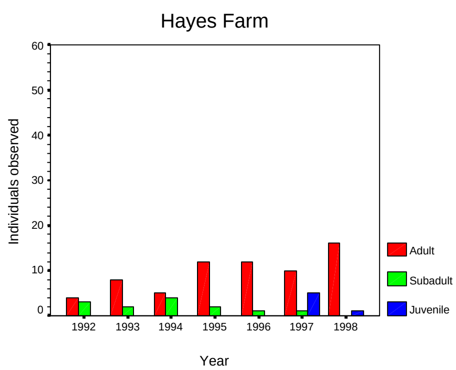


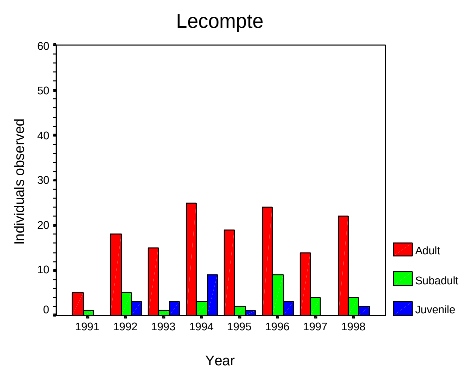
Figure 53. Number of DFS observed per 100 sampling days at two sites (BLK) (color plate)

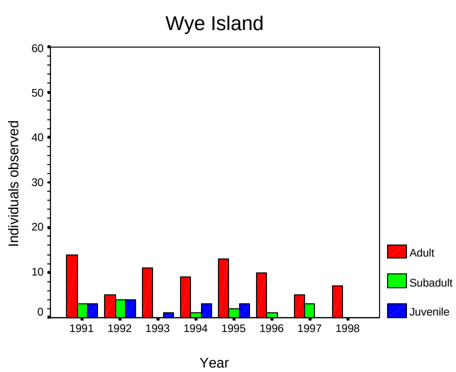
Figures. Seven benchmark sites: DFS population structure (color plate)

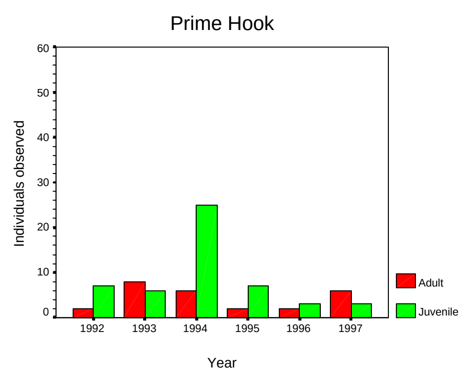


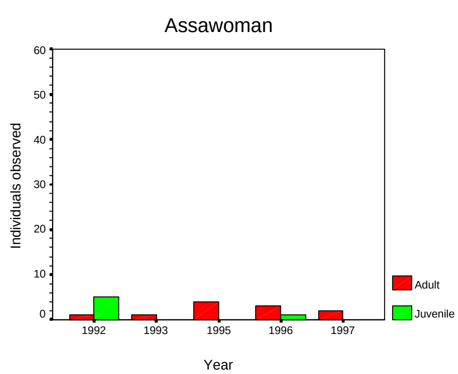












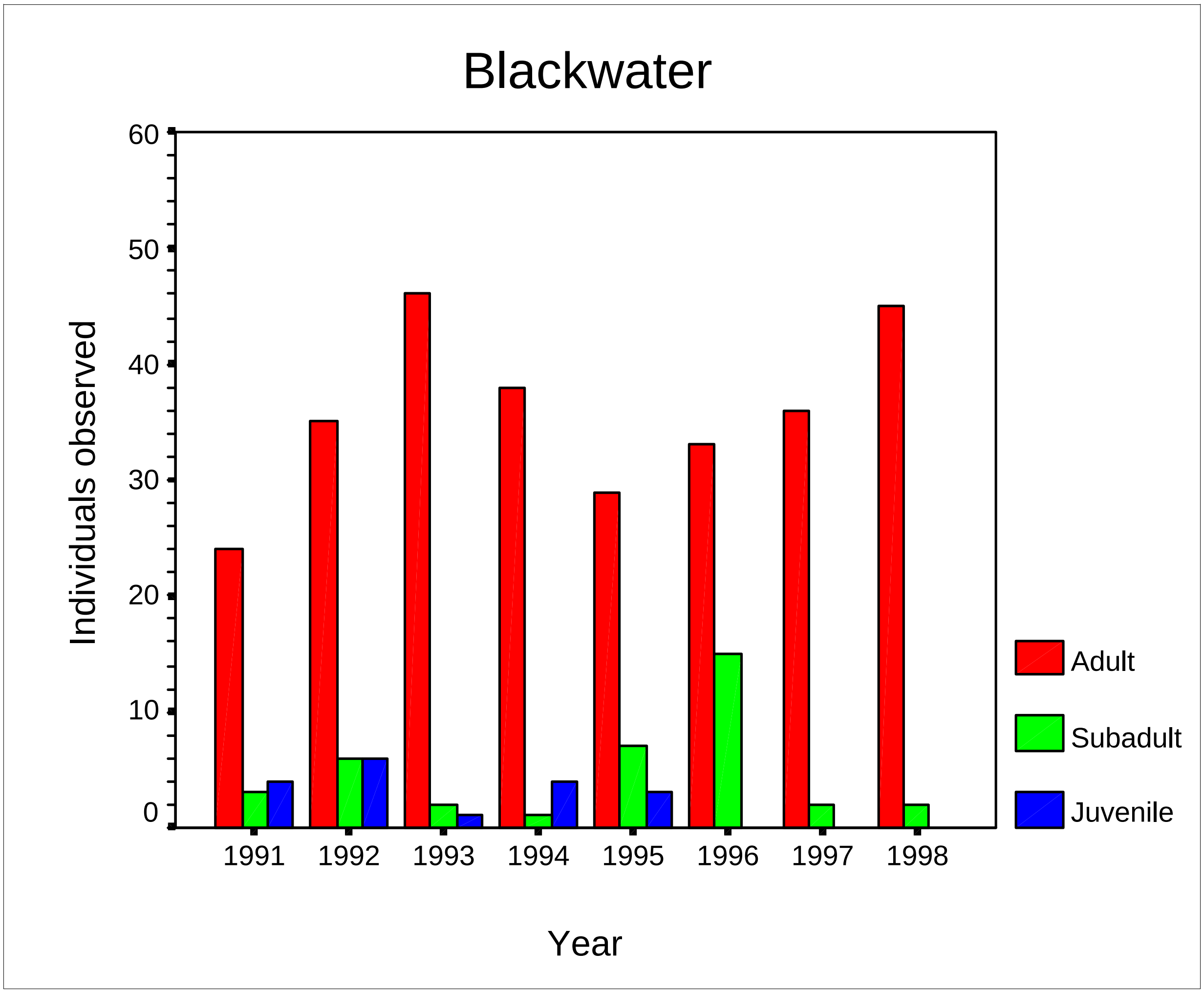


Figure 61. Adult, subadult, and juvenile DFS observed (BLK) (color plate)

Figures. Seven benchmark sites: Observed life spans of DFS

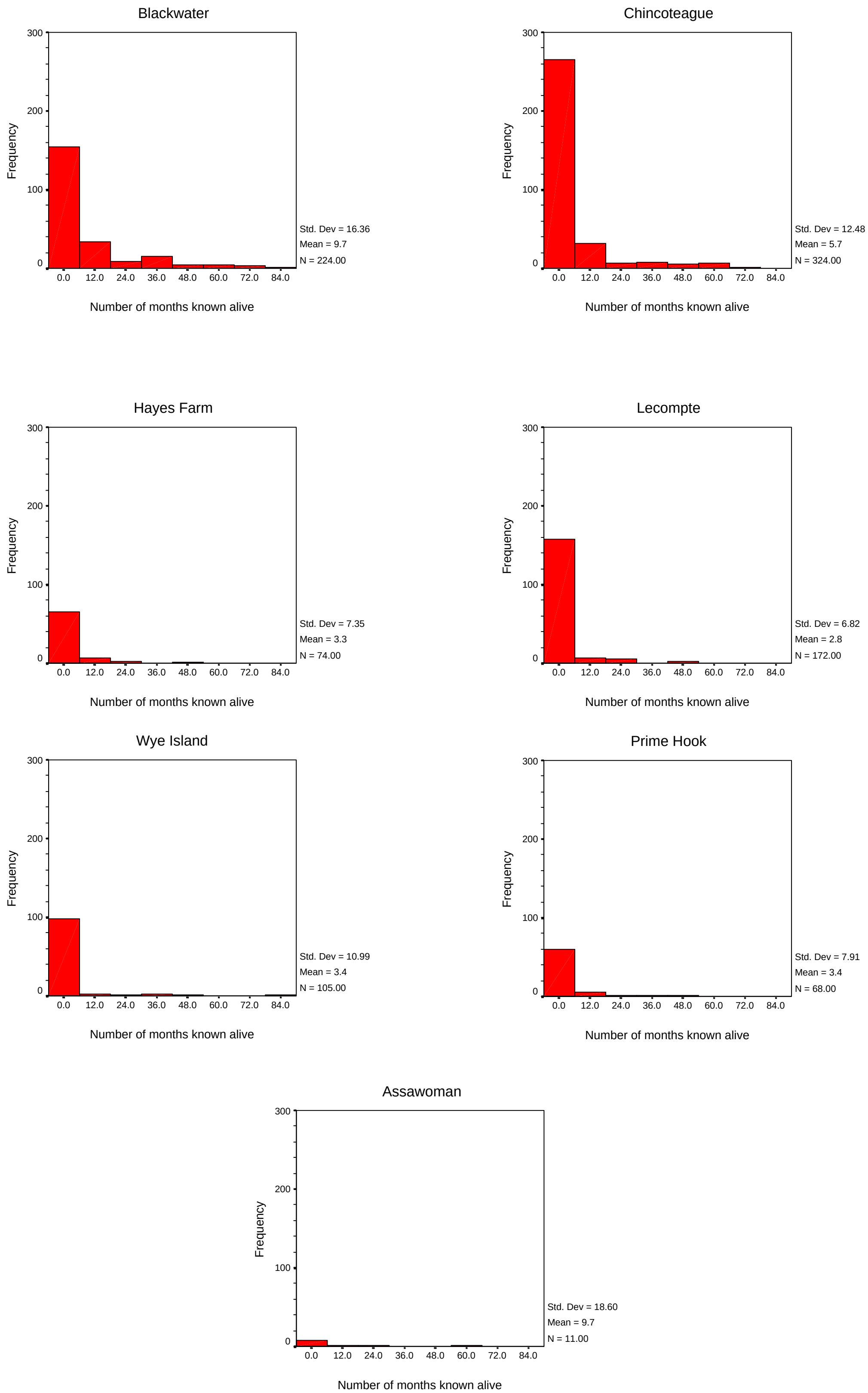


Table 17. Comparison of midwinter eagle surveys (Blackwater NWR and Maryland) 1979–2001

Year	Refuge Bald Eagles	State Bald Eagles	Refuge Golden Eagles	State Golden Eagles
2001	97	336	2	2
2000	93	246	2	2
1999	121	272	1	1
1998	125	238	1	1
1997	88	240	1	1
1996	129	295	0	0
1995	72	194	2	1
1994	53	146	1	1
1993	40	121	0	0
1992	73	185	0	0
1991	50	115	1	2
1990	81	263	1	1
1989	38	132	1	1
1988	29	116	2	2
1987	29	80	2	0
1986	36	100	1	1
1985	36	112	0	1
1984	49	180	1	2
1983	23	109	0	2
1982	38	113	1	4
1981	28	85	2	4
1980	24	65	1	6
1979	48	44	2	2

Sources: Blackwater NWR original data and Annual Narrative Reports; Maryland Dept. of Natural Resources

American bald eagle.—The Complex is known for its nesting and wintering concentrations of American bald eagles (*Haliaeetus leucocephalus*). Eagles use the expansive marshes, open waters, and upland areas to feed throughout the year. Dorchester County and Blackwater NWR support the highest nesting density of eagles in the state of Maryland and in the entire mid-Atlantic region. Migrating eagles from both the north and south use the Chesapeake Bay region as a wintering area. Annual midwinter American bald eagle surveys are conducted in January each year.

Red-cockaded woodpecker.—Once found on Blackwater NWR and Smith Island, the red-cockaded woodpecker (*Picoides borealis*) has not been sighted anywhere on the Refuge Complex since 1976, and is now believed extinct in Maryland.

Northeastern beach tiger beetle.—The northeastern beach tiger beetle (*Cicindela dorsalis*) is believed to have suitable habitat on Barren Island and Martin NWR; however, no specimen has been found to date.

Sea turtles.—Sea turtles like the endangered loggerhead (*Caretta caretta*), Atlantic green (*Chelonia mydas*), hawksbill (*Eretomochelys imbricata imbricata*), leatherback (*Dermochelys coriacea*), and Kemp's ridley (*Lepidochelys kempii*) are found occasionally in the waters surrounding Watts Island, Smith Island, Barren Island, Bishops Head Point, and Spring Island. No sea turtles nest on the Refuge Complex.

Table 18. Comparison of bald eagle nests and productivity (Blackwater NWR and Maryland) 1977–2000

Year	Refuge Nests	State Nests	Refuge Young	State Young
1977	3	41	4	45
1978	3	47	3	37
1979	6	51	3	38
1980	6	53	2	35
1981	4	53	2	51
1982	4	58	3	55
1983	2	59	2	59
1984	4	60	3	70
1985	2	62	5	77
1986	3	66	6	102
1987	3	86	6	121
1988	5	97	4	135
1989	4	97	7	117
1990	6	123	11	164
1991	6	128	13	169
1992	7	152	11	185
1993	9	154	10	168
1994	8	157	11	192
1995	8	182	13	265
1996	12	201	19	265
1997	14	219	24	282
1998	10	232	22	295
1999	13	260	18	370
2000	13	270	21	395

Sources: Original Blackwater NWR data and Annual Narrative Reports; Maryland DNR

Table 19. American bald eagle productivity (Blackwater NWR) 1959–2000

Year	Refuge Nests	Refuge Young	Adjacent Nests	Adjacent Young	County Nests	County Young
1959	0	0				
1960	1	0				
1961	1	0				
1962	1	0				
1963	0	0				
1964	1	0				
1965	0	0				
1966	3	0				
1967	2	0				
1968	3	0				
1969	3	0	6	1		
1970						
1971		1				
1972	2	1				
1973						
1974		4				
1975		4			8	13
1976	4	5	4	4		
1977	3	8	4	5		
1978	3	3	4	7		
1979	6	3	3	6		
1980	6	2	5	6		
1981	4	2	6	7		
1982	4	3	5	7		
1983	2	2	8	11		
1984	4	3	7	13	18	26
1985	2	5	10	17	19	29
1986	3	6	6	9	14	28
1987	3	6	8	13	20	36
1988	5	4	7	15	22	34
1989	4	7	6	11	19	39
1990	6	11	10	18	27	47
1991	6	13	12	17	29	51
1992	7	11	13	20	28	52
1993	9	10	13	23	33	50
1994	8	11	11	20	36	36
1995	8	13	16	29	40	76
1996	12	19	15	26	47	80
1997	14	24	14	26	52	92
1998	10	22	14	22	50	86
1999	13	18	17	23	57	89
2000	13	21	16	30	53	95

Source: Original data sheets and Blackwater NWR Annual Narrative Reports

Table 20. Midwinter eagle surveys (Blackwater NWR) 1950–2001

Year	Bald Eagles	Golden Eagles	Year	Bald Eagles	Golden Eagles
2001	97	2	1975	28	3
2000	93	2	1974	28	5
1999	121	1	1973	22	
1998	125	1	1972	22	2
1997	88	1	1971	25	2
1996	129	0	1970		
1995	72	2	1969	30	1
1994	53	1	1968	11	
1993	40	0	1967	11	2
1992	73	0	1966	11	2
1991	50	1	1965	9	
1990	81	1	1964	20	1
1989	38	1	1963	11	2
1988	29	2	1962	20	1
1987	29	2	1961	30	1
1986	36	1	1960	30	1
1985	36	0	1959	20	1
1984	49	1	1958	30	
1983	23	0	1957	30	
1982	38	1	1956	30	
1981	28	2	1954	25	1
1980	24	1	1953	35	1
1979	48	2	1952	30	1
1978			1951	35	
1977	38	3	1950	25	
1976	30				

Source: Blackwater NWR data and Annual Narrative Reports (unidentified eagles included with American bald eagles)

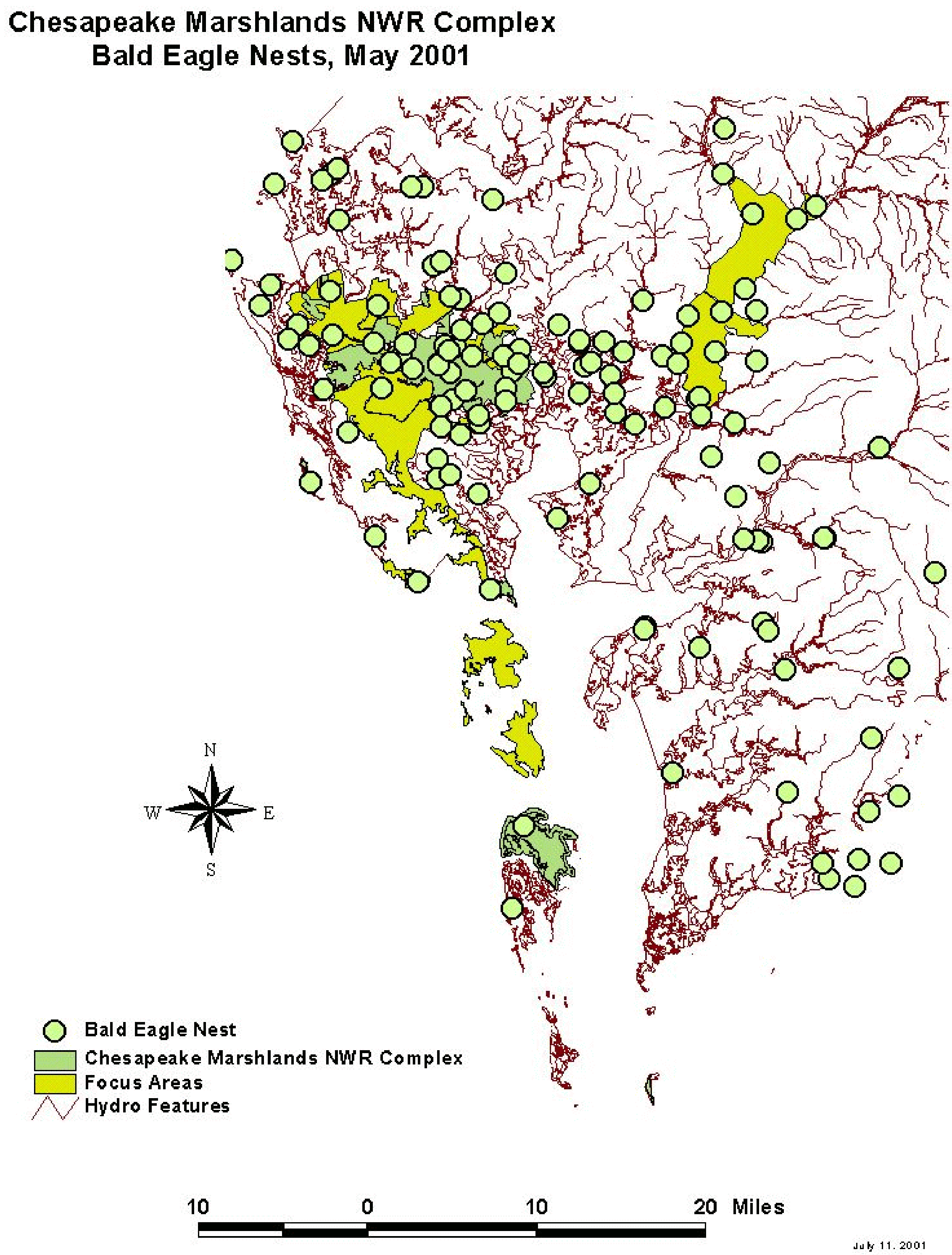


Figure 69. American bald eagle nests (Refuge Complex) May 2001

Benthic Organisms and Invertebrates

The abundance of SAV on the Refuge Complex indicates the value of the bottoms for benthic invertebrates. Although shallow water unvegetated substrate provides important habitat for many nekton species, this habitat has often been found to be relatively depauperate of benthic-oriented epifauna, compared to vegetated shallow water habitat (Heck and Thoman, 1984; Fonseca et al., 1996).

The protected interior shallow waters support a productive community of invertebrate species. Although some invertebrates have importance because of their commercial value, the ecological significance of most invertebrate communities lies in their contributions to the food web. They are a food source for fish, birds, reptiles, and mammals. The freshwater impoundments on Blackwater NWR provide significant populations of macroinvertebrates important for providing protein sources for migrating and wintering waterfowl.

The officially designated crabbing bottoms correlate well with the areas that now support or historically supported SAV. As previously discussed, the submerged vegetation provides cover that is especially attractive to molting blue crabs. Tangier Sound is particularly important as a migratory route for juvenile blue crabs moving northward from spawning grounds in the lower Chesapeake Bay. The commercial harvest of blue crabs is a major source of income for island residents. Smith Island is one of the most important soft-shell and peeler crab-producing areas in the Chesapeake Bay.

The Smith Island–Tangier Sound area also supports other commercial shellfish operations, including the harvest of oysters and clams. As with the rest of the Chesapeake Bay, oyster populations in the vicinity of Smith Island have been decimated by the oyster diseases MSX and Dermo. The nearest charted oyster bar, Church Creek, is located approximately 1.5 miles west of Rhodes Point.

Finfish and Shellfish

The waters within the Refuge Complex support a wide array of fish species, and the associated marshes and estuaries are a spawning and nursery ground for commercial and sport fin and shellfish. Almost 300 species of fishes have been recorded in the Bay and its tributaries; about half are ocean fishes that enter the Bay to feed in warmer months, then return to the ocean. Ocean fishes are more likely to be found south of the study area. While most of these summer visitors spawn in the ocean, their larvae and juveniles enter the Bay at an early age to feed on the dense populations of invertebrates and small forage fishes. Atlantic menhaden (*Brevoortia tyrannus*) is probably the most abundant and most commonly seen fish in the Bay. The most abundant ocean species found in the shallows in the middle to lower parts of the Bay are three species of drum-spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*), and silver perch (*Bairdiella chrysoura*).

Many fish species move into shallow waters in summer and out to deeper Bay waters in the fall. The most common Bay species found in shallow waters are the killifishes, anchovies, and silversides. Mummichogs (*Fundulus heteroclitus*) and banded killifish (*Fundulus diaphanous*) stay close to shore, with the mummichogs entering marshes to feed with the tides. Sheepshead minnows (*Cyprindon variegatus*) are also typical of shallow waters. Needlefish (*Strongylura nuvina*) prey on these small fish close to shore.

Bay anchovies (*Anchoa mitchilli*) and silversides [the Atlantic silverside (*Menidia menidia*), inland silverside (*Menidia beryllina*), and the rough silverside (*Membras martinica*)] are some of the most plentiful fishes in the Bay. Flatfish are common in the shallows, with the most likely in the central Bay area being the small, bony hogchokers (*Trinectes maculatus*), winter flounder (*Pleuronectes americanus*), and in more saline areas, summer flounder (*Paralicthys dentatus*), windowpane (*Scophthalmus aquosus*),and blackcheek tonguefish (*Symphurus plagiusa*). Older flatfish move to deeper waters or the ocean to spawn.

Fish typical of the deeper, open waters include schooling predator fishes, bottom-feeding fishes, reef-type fishes, and small foraging species. The adults of most species found in the shallows are found here, too. Large schools of menhaden and anchovies are preyed upon by schools of striped bass, bluefish, and seatrouts [spotted (*Cyroscion nebulosus*) and weakfish (*Cynoscion regales*)]; all four are avidly sought by sport fishermen. Species of commercial value include the white perch, alewife, river herring, American eel, striped bass, and American shad; the latter two being historically the two most important fish to swim the Nanticoke. Rockfish populations declined severely during the late 1970's and 1980's, a situation probably attributable to over-fishing, pollution, larval sensitivity to toxic metals and pesticides, and reductions in zooplankton that fed the young (USFWS, 1990).

At one time, the Nanticoke contributed 12 percent of the striped bass production in Maryland waters, which historically yielded approximately 10 percent of the entire Chesapeake Bay landings. During peak years, such as 1973 and 1976, the catch during March and April was 186,000 and 202,000 pounds, respectively, in Delaware. The striped bass population has rebounded somewhat following years of catch limits and a 5-year harvest ban. Maryland has imposed a fishing moratorium on shad since 1980. Shad catches are permitted in Delaware, but have been low.

The Refuge Complex also hosts diverse crabs, shrimp, clams, and oysters. The best known of these are the blue crab (*Callinecies sapidus*) and the American oyster (*Crassotrea virginica*). Both are found throughout the area, as is the less sought-after but commercially harvested soft-shelled clam (*Mya arenaria*). Commercially marketed pink (*Pinaius duorarum*), white (*P. setiferus*), and brown (*P. aztecus*) shrimps occur in the Bay, but not in sufficient quantities to harvest. Altogether, about 28 species of mollusks and 25 species of shrimp and crab are likely to be found in this portion of the Bay or its tributaries. Crabs are particularly abundant in the shallow waters around Tangier, Smith, and Bloodsworth islands in the warmer months.

It should be mentioned that fish and shellfish populations in the Bay have been affected by over-fishing of some species, declining acreage of SAV and estuarine marshes, and pollution. In addition, oyster populations have been decimated by two protozoan parasites: MSX (*Haplosporidium nelsoni*) and Dermo (*Perkinsus marinus*) (Lippson and Lippson, 1997). Also, the microbe *Pfeisteria piscidcida* threatens fish with lethal toxins in portions of the Bay, thought to be the result of over-fertilization of Bay waters by farming and livestock production (Warrick and Shields, October 3, 1997).

Anadromous Species

The Refuge Complex and Nanticoke protection area are both nursery and spawning habitat for eight species of Atlantic anadromous fish (species that spawn freshwater and live in the ocean) and nine species of migratory intercoastal or estuarine inland interjurisdictional fish. Every spring, anadromous herrings and shad enter the rivers and streams in large schools to spawn. The Nanticoke River now provides most of the spawning habitat. The waters of the upper Blackwater River, historically significant for spawning anadromous fish, are currently too salty and degraded due to the breach in the marsh that now joins the Blackwater River with the Little Choptank.

Shad species include American (white) shad (*Alosa sapissima*), hickory shad (*Alosa mediocris*) and gizzard shad (*Dorosoma cepedianum*). The closely related river herring species are alewife (*Alosa psuedoharengus*) and blueback (*Alosa aestivalis*). Once plentiful throughout the Chesapeake and harvested in great numbers until the turn of the century, the anadromous Atlantic sturgeon (*Acipenser oxyrhyncus*) is the largest fish to be found in the Bay and the waters of the Refuge Complex. The Atlantic sturgeon has a global ranking of G3 (very rare and local throughout its range), and the shortnose sturgeon is currently listed as endangered.[12]

Striped bass (*Morone saxatilis*) typically spawn downstream of the Delaware state line on the Nanticoke River. However, eggs and larvae are transported into the Delaware portion by tidal currents and young stripers utilize the shoreline as a nursery area. The migratory intercoastal estuarine-inland interjurisdictional species include weakfish, red drum, blue fish, summer flounder, spotted seatrout, spot, Atlantic croaker, Atlantic menhaden, and shortnose sturgeon.

[12] Text and tables below from Nanticoke River Basin Environmental Assessment Report, December 1990, Department of Natural Resources and Environmental Control (Delaware), Nanticoke River Study Committee

FISHERIES RESOURCES

Delaware's portion of the Nanticoke River provides habitat for an impressive list of fishes (Table 1). Many species are year round residents which may make small seasonal migrations within the system. Such is the case for yellow perch and white perch. Other species undergo extensive coastal migrations before returning to their natural river to spawn in the spring. These anadromous species which utilize the upper reaches of the Nanticoke estuary for spawning and nursery habitat include: American shad, blueback herring, hickory shad, alewife, and striped bass.

The upper Nanticoke is both nursery and spawning habitat for most of the anadromous species. Striped bass are more of a pelagic spawner than the other anadromous species. During years of normal stream flow rates, they typically spawn downstream of the Delaware state line. However, eggs and larvae are transported into the Delaware portion by tidal currents and young stripers utilize the shoreline as a nursery area.

Other important fish found in the upper Nanticoke are Atlantic croaker and Atlantic menhaden. Spawning occurs in lower Chesapeake Bay and the adjacent ocean with the larvae and young being subsequently carried in shore waters.

Species of commercial value which are or were landed in the recent past are listed in Table 2. Landings of American shad and striped bass in recent years have declined dramatically compared to historic levels. Much of this decline has been attributed to overfishing and degradation of habitat throughout most Chesapeake Bay drainage areas. Shad landings peaked in the late 1800's at well over a million pounds from the Nanticoke River. The striped bass landings in the mid-70's was in excess of 3500 pounds in Delaware. Maryland's portion of the river historically yielded approximately 10% of the entire Chesapeake Bay landings. During peak years, such as 1973 and 1976, the catch during March and April was 186,000 and 202,000 pounds respectively. During the past several years a moratorium was placed on striped bass fishing in both Maryland and Delaware waters. However, during 1990 both states will have a brief fishing season for the striped bass. As seen in Table 1, the economic value of these fish species in minimal. American eel are harvested commercially; however, catch records are not required and no landings data are available.

Table 1

Fishes Known to Occur in the Delaware Portion of the Nanticoke River

Species	Resident Species	Sport Fish	Commercial Species	Primarily Nursery	Special Status
Alewife	-	X	X	X	-
American Brook Lamprey	X	-	-	-	X
American Eel	-	-	X	X	-
American Shad	-	X	X	X	X
Atlantic Croaker	-	-	-	X	-
Atlantic Menhaden	-	-	X	X	-
Atlantic Needlefish	-	-	-	-	-
Atlantic Silverside	X	-	-	-	-
Atlantic Sturgeon	-	-	-	-	-
Banded Killfish	X	-	-	-	-

Figure 70. Fisheries resources of the Delaware section of the Nanticoke River

Table 1 Continued

Species	Resident Species	Sport Fish	Commercial Species	Primarily Nursery	Special Status
Banded Sunfish	X	-	-	-	-
Bay Anchovy	-	-	-	-	-
Black Crappie	X	X	-	-	-
Blackbanded Sunfish	X	-	-	-	X
Blueback Herring	-	X	X	X	-
Bluegill	X	X	-	-	-
Bluespotted Sunfish	X	-	-	-	-
Brown Bullhead	X	X	-	-	-
Carp	X	-	-	-	-
Chain Pickerel	X	X	-	-	-
Channel Catfish	X	X	X	-	-
Creek Shubsucker	X	-	-	-	-
Eastern Mudminnow	X	-	-	-	-
Gizzard Shad	X	-	-	-	-
Golden Shiner	X	-	-	-	-
Goldfish	X	-	-	-	-
Hickory Shad	-	X	-	X	X
Hogchoker	X	-	-	-	-
Inland Silverside	X	-	-	-	-
Ironcolor Shiner	X	-	-	-	X
Largemouth Bass	X	X	-	-	-
Longnose Gar	X	-	-	-	X
Margined Madtom	X	-	-	-	-
Mosquitofish	X	-	-	-	-
Mud Sunfish	X	-	-	-	X
Mummichog	X	-	-	-	-
Pirate Perch	X	-	-	-	-
Pumpkinseed	X	X	-	-	-
Redbreast Sunfish	X	-	-	-	-
Redfin Pickerel	X	-	-	-	-
Satinfin Shiner	X	-	-	-	-
Sea Lamprey	-	-	-	-	-
Shield Darter	X	-	-	-	X
Shorthead Redhorse	X	-	-	-	X
Silvery Minnow	X	-	-	-	-
Spotfin Shiner	X	-	-	-	-
Striped Bass	-	X	X	X	X
Swallowtail Shiner	X	-	-	-	-
Tadpole Madtom	X	-	-	-	-
Tesselated Darter	X	-	-	-	-
White Catfish	X	X	X	-	-
White Perch	X	X	X	-	-
Yellow Bullhead	X	-	-	-	-
Yellow Perch	X	X	X	-	X

Of the sportfish present in the upper Nanticoke River the largemouth bass is by far the most important. Numerous bass fishing tournaments and thousands of man-days of fishing are directed strictly toward bass. The state is currently conducting a study to determine the relative abundance, population and spawning areas of largemouth bass throughout the river.

Figure 71. Fisheries resources of the Delaware section of the Nanticoke River (conclusion)

Fishes listed under the column "Special Status" in Table 1 include those species that are presently at low population levels, i.e. American Shad, hickory shad, striped bass and yellow perch. Special fishing regulations have been adopted regarding these species. Also included are those species which have a very limited distribution within the State. The Nanticoke River is the only drainage in Delaware where four species: longnose gar, mottled sculpin, shield darter and shorthead redhorse occur. Mottled sculpin are found only in a portion of Butler Mill Branch above Craig's Pond (Map 2). Shield darter have only been collected in the upper portion of Nanticoke Branch near Bridgeville (Map 2). Note Maps 2, 3, 4, 5, and 6 for the local spawning sites of important or rare fish in the Nanticoke River basin.

Table 2

Recent Commercial Fish Landings

Species	Lbs	Value $
American Shad	1774	577
White Perch	642	316
Herrings	13,009	1,652
Catfish	804	305
Other	5	1
Total	16,234	2,851

Figure 72. Recent commercial fish landings

Table 21. Fish collected from the Nanticoke River between its mouth and Sharptown, MD

Alewife	Channel catfish	Northern puffer	Striped anchovy
Amberjack	Cownose ray	Northern sea robin	Striped bass
American eel	Crevalle jack	Oyster toadfish	Striped bass, hatchery
American shad	Gizzard shad	Pigfish	Striped killifish
Atlantic croaker	Golden shiner	Pumpkinseed	Striped mullet
Atlantic menhaden	Harvestfish	Rainwater killifish	Summer flounder
Atlantic needlefish	Hickory shad	Rough silverside	Swallowtail shiner
Atlantic silverside	Hogchoker	Satinfin shiner	Tessellated darter
Banded killifish	Inland silverside	Sheepshead minnow	Threadfin shad
Bay anchovy	Inshore lizardfish	Shorthead redhorse	Unknown kingfish
Black drum	Ladyfish	Silver perch	Unknown minnow
Blackcheek tonguefish	Largemouth bass	Silvery minnow	Unknown shiner
Blueback herring	Longnose gar	Skilletfish	Weakfish
Bluefish	Mosquitofish	Southern kingfish	White catfish
Bluegill	Mummichog	Spanish mackerel	White perch
Brown bullhead	Naked goby	Spot	White sucker
Butterfish	No fish	Spotfin killifish	Yellow perch
Carp	Northern kingfish	Spottail shiner	
Chain pickerel	Northern pipefish	Spotted seatrout	

Source: Eric Durell, MD DNR Fisheries
List generated from the annual juvenile striped bass survey data set 1957–2000

Table 22. Fish collected by location (Blackwater NWR) 1995

Location	Alewife	Anchovy	Banded killifish	Bluegill	Hogchoker	Largemouth bass	Naked goby	Pipefish	Pumpkinseed	Rainwater killifish	Spot	Striped bass	Tidewater silverside	White perch	Yellow perch
Island at mouth of Harper Pond	x	x			x			x					x		
Crow Island			x										x		
Meekins Creek at Bull Point			x						x	x			x	x	
Meekins Creek	x		x				x		x	x			x	x	
Keene's Ditch											x			x	
Blackwater R. Round Pond entry down river to refuge		x			x								x		
Barbadoes Pond channel		x												x	
Barbadoes Pond		x			x								x	x	
Blackwater R. Fishing Bay WMA					x										
Backgarden Creek below trapper cabin		x			x										
Above footbridge		x		x		x			x						x
Along Route 335 bridge*		x											x	x	
Backgarden Pond					x							x		x	
Backgarden Pond upper end	x									x			x	x	

Source: Gary Swihart, USFWS Office of Fisheries Assistance, Gloucester, VA 1995
Species collected using a 50-ft. bag seine, 15-ft. seine, and 10-ft. otter trawl between 09/19/95 and 09/21/95. *Two seine hauls opposite sides of river

Table 23. Fish collected from Parson Creek (Blackwater NWR)

Parson creek*					Length Range MM	
Mo	Da	Yr	Species	Number	Minimum	Maximum
10	25	93	Striped bass	4	80	150
10	25	93	Tidewater silverside	8	45	115
10	25	93	Blue crab	5	29	115
10	25	93	Grass shrimp	2	42	110
10	25	93	Jelly fish	2	110	240
10	25	93	Barnacles	1	165	
10	25	93	Northern pipefish	3	82	97
10	25	93	Hogchoker	3	28	88
11	4	93	Hogchoker	10	62	77
11	4	93	Tidewater silverside	9	30	56
11	4	93	Sheepshead minnow	18	22	150
11	4	93	Blue crab	1	126	
11	4	93	Northern pipefish	2	40	46
11	4	93	Grass shrimp	1	130	
11	4	93	Striped killifish	4	110	115
3	15	94	Tidewater silverside	2	122	130
4	14	94	Blue crab	2	121	132
5	25	94	Blue crab	2	115	126
5	25	94	Striped bass	5	95	118
5	25	94	White perch	3	25	146
6	13	94	Blue crab	1		152
6	13	94	White perch	5	50	110
6	13	94	Jelly fish	8	64	95
6	13	94	Spot	1	70	
6	13	94	Tidewater silverside	1	44	
5	13	94	Striped killifish	2	55	100
7	12	94	Blue crab	1	150	
7	12	94	White perch	2	65	75
7	12	94	Tidewater silverside	2	60	100
7	12	94	Jelly fish	1		
7	12	94	Grass shrimp	5	80	125
8	15	94	Blue crab	1	173	
8	15	94	Striped bass	8	125	237
8	15	94	White perch	1	390	
8	15	94	American eel	2	35	55
8	15	94	Tidewater silverside	2	80	100
8	15	94	Jelly fish	–	–	–
8	15	94	Grass shrimp	75	25	
9	30	94	Blue crab	4	65	152
9	30	94	Pumpkinseed sunfish	2	110	114
9	30	94	Spot	1	108	
9	30	94	Tidewater silverside	5	55	70
9	30	94	White perch	4	125	135
9	30	94	Jelly fish	6		

Source: Leon Fewlass, MD DNR, October 21, 1994, memorandum to refuge manager

*Species collected by otter trawl upstream from Route 16 bridge, 1993 and 1994. No summer flounder were collected.

Catadromous Species

Table 24. Fish collected from the mouth of the Blackwater River, 1959 and 1960

Alewife	Mummichog
Atlantic menhaden	Rough silverside
Atlantic needlefish	Silver perch
Atlantic silverside	Spot
Bay anchovy	Spotted seatrout
Blueback herring	Striped anchovy
Carp	Striped bass
Gizzard shad	Striped killifish
Hogchoker	Weakfish
	White perch

Source: Eric Durell, MD DNR

Elvers, or young catadromous American eels (*Anguilla rostrata*), hatch in the Sargasso Sea east of the Bahamas. They float with currents up into the Bay and its tributaries in great numbers to stay for 5 to 20 years before leaving to spawn in the ocean. American eel populations are declining, possibly due to lower water quality, lack of access to spawning habitats, and mortality in hydro-electric turbines. American eels historically have been harvested commercially on the Blackwater River.

Freshwater Species

Freshwater species that can tolerate low levels of salinity often can be found in shallow streams and protected coves of the larger estuarine rivers of the Refuge Complex. Yellow perch (*Perca flavescens*), the best known freshwater species in the Bay, has become acclimated to brackish water and behaves like the semi-anadromous white perch and gizzard shad.

Other freshwater fishes commonly found in somewhat to barely brackish water include brown bullhead (*Ameiurus nebulosus*); white catfish (*Ameiurus catus*); channel catfish (*Ictalurus punctatus*); white sucker (*Catostomus commersoni*); carp (*Cyprinus carpio*); goldfish (*Carassius auratus*) set free from fish tanks; golden shiner (*Notemigonus chrysoleucas*); silvery minnow (*Hybognathus regius*); spotted shiner (*Notropis hudsonius*); satinfin shiner (*Cyprinella analostana*); pumpkinseed (*Lepomis gibbosus*); bluegill (*Lepomis macrochirus*); black crappie (*Pomoxis nigromaculatus*); smallmouth bass (*Micropterus dolomieu*); largemouth bass (*Micropterus salmoides*); longnose gar (*Lepisosteous osseus*); chain pickerel (*Esox niger*); redfin pickerel (*E. americanus*) and eastern mudminnow (*Umbra pygmaea*). Of the many sportfish, the largemouth bass is by far the most important.

The Nanticoke River is the only drainage in Delaware where four species occur: the longnose gar, mottled sculpin, shield darter, and shorthead redhorse. Mottled sculpin are found only in a portion of Butler Mill Branch above Craig's Pond. Shield darters have only been collected in the upper portion of the Nanticoke near Bridgeville.

The marshes of Smith Island are permeated with tidal creeks which provide spawning, nursery, or feeding habitat for an abundance of finfish. The contiguous waters of Chesapeake Bay and Tangier Sound also support extensive fishery stocks. The Maryland Department of Natural Resources reports commercial fishery landings in Tangier Sound for 1992–1995. Those reflect only commercially sought-after species; they do not reflect the recreational fishery.

The Smith Island–Tangier Sound area does have a significant recreational fishery, with sea trout, croaker, spot, bluefish, striped bass (*Morone saxatilis*), and summer flounder (*Paralichthys dentatus*) commonly being taken. Also, this data base does not cover the interior waters of Smith

Island, or the large diverse assemblage of forage species and shallow water species such as minnows, killifish, and silversides, which are important prey items for larger species, such as striped bass.

Table 25. Anuran species at Blackwater NWR 5/19/99–6/28/00

Date	Northern cricket frog	Common gray treefrog	Cope's gray treefrog	Intermediate gray treefrog	Bullfrog	Carpenter frog	Fowler's toad	Green treefrog	Green frog	Eastern spadefoot toad	Northern spring peeper	New Jersey chorus frog	Southern leopard frog	Wood frog
5/19/99	x	x			x	x								
6/29/99	x				x		x	x	x	x				
3/11/00											x	x	x	
4/15/00						x			x		x		x	
6/28/00	x	x	x	x	x	x		x	x					x
3/17/01					x	x			x		x	x	x	x
5/12/01	x				x				x		x	x		

Source: Refuge data and North American Amphibian Monitoring Program (http://www.mp2-pwrc.usgs.gov/naamp/data/public/)

Reptiles and Amphibians

The vast marshes and river swamps that compose the Refuge Complex offer ideal living conditions for at least 53 species of reptiles and amphibians. There likely are more, but surveys remain incomplete. Some of these creatures often are easily observed, such as a painted turtle basking on a log, while most are shy and elusive. These cold-blooded animals become torpid or dormant and inactive with the onset of winter. But with spring comes the constant sounds of frogs and toads and, throughout the long summer nights, the deep bass voice of the bullfrog resounds. Of those 53 species, the following are State-listed as rare, threatened, or endangered: the Eastern narrow-mouthed toad (*Gastrophryne carolinensis*), Carpenter frog (*Rana virgatipes*), Eastern tiger salamander (*Ambystoma tigrinum*), spotted turtle (*Clemmys guttata*), ground skink (*Scincella lateralis*), Eastern kingsnake (*Lampropeltis getula*), rough green snake (*Opheodrys aestivus*), Northern brown snake (*Storeria dekayi*), Northern redbelly snake (*Storeria occipitomaculata*) and the Northern copperhead (*Agkistrodon contoritrix*), the only poisonous snake found on the Refuge Complex.

The diamondback terrapin (*Malaclemys terrapin*) inhabits salt and brackish waters of the Eastern United States, from Cape Cod south to the Gulf coast of Texas. In the Chesapeake Bay, terrapins utilize multiple habitats during the course of their life cycle. In late summer, the adult diamondback terrapin generally inhabits the deep portions of creeks and tributaries, avoiding near shore waters. Juvenile terrapins inhabit shallow creeks and coves adjacent to salt marshes as nursery areas. During June and July, female terrapins cross the intertidal zone and seek nest sites in open sandy areas (Roosenburg 1991). Diamondback terrapins inhabit the tidal marshes and creeks of Smith Island and other islands of the Chesapeake Island Refuges, and are harvested by the locals. The turtles have been observed nesting on the isolated upland hammocks. The diamondback terrapin is not Federal-listed as an endangered species; however, characteristics of terrapin life history render this species especially vulnerable to overfishing and habitat loss.

These characteristics include low reproductive rates, low survivorship, limited population movements, and nest site philopatry.[13]

Waterfront development has been shown to directly reduce reproductive success in diamondback terrapins (Roosenburg 1991). Shoreline stabilization practices associated with near-shore development, such as wooden bulkheads, gabions, or rip-rap, prevent terrapins from reaching sites above the intertidal zone; the only viable terrapin nesting habitat. Because terrapins are philopatric (Roosenburg 1992), “hard” shoreline stabilization practices may eliminate entire breeding colonies. Other reptile species on Smith Island include box turtle (*Terrapene carolina carolina*), northern water snake (*Natrix sipedon*), and rough green snake (*Opheodrys aestivus*).

Table 26. Anuran species at Mardela Springs 3/31/01–6/27/01

	03/31/01	05/04/01	06/27/01
Bullfrog		X	X
Fowler’s toad		X	X
Green treefrog			X
Green frog		X	X
Northern spring peeper	X		
Southeastern chorus frog	X		
Pickerel frog			X

Source: North American Amphibian Monitoring Program (http://www.mp2-pwrc.usgs.gov/ naamp/data/public/)
Data from NAAMP Route #460708 primary observer only

[13] a high degree of fidelity to nesting sites

Table 27. Muskrat density and harvest (Blackwater NWR) 1984–1999

Year	House Count Index	Muskrat/Ac Marsh	Muskrat Harvest/Ac	Marsh Acreage
1998–99	18	3.0	0.53	6,132
1997–98	22	3.8	0.53*	6,132
1996–97	32	4.2	0.93	6,132
1995–96	31	3.7	0.63**	6,002
1994–95	32	3.8	0.7	6,002
1993–94	30	3.0	0.78	6,002
1992–93	28	3.0	0.59	5,924
1991–92	49	5.6	0.72	5,924
1990–91	39	5.2	0.67	5,372
1989–90	28	3.8	0.71	5,372
1988–89	21	4.4	0.73	5,372
1987–88	40	7.9	1.08	4,987
1986–87	37	5.3	1.18	4,433
1985–86	28	4.4	0.98	4,433
1984–85	22	3.9	0.95	4,124
1983–84	38	4.4	0.96	4,124

* Harvest report was not received from one trapper; his catch and trapping unit acreage was not included in harvest calculation.
** Heavy snow and ice conditions reduced trapper harvest

Mammals

Although the mammals of the Refuge Complex often are overlooked in favor of its more abundant and conspicuous bird life, the Refuge Complex hosts 38 species of mammals, including the endangered DFS.

Furbearers

The extensive wetland habitats of the Refuge Complex support healthy populations of native muskrats (*Ondatra zibethicus*), red and gray foxes (*Vulpes vulpes*), beavers, mink (*Mustela vison*), river otters (*Lutra canadensis*), and raccoons, as well as the exotic nutria. Most, but not all of these species are trapped on Blackwater NWR and the Nanticoke protection area, and provide a fur harvest which is a regionally important source of income. Beavers, often a problem species for many refuges, are not found on Blackwater, but do occur within the focus area. Furbearers are not managed on other units of the Refuge Complex.

The most prized furbearer on the refuge, the muskrat, is found in equivalent numbers in the United States only in the marshes of Louisiana. Blackwater muskrats are known to the mammalogist as the coastal, or Virginia, muskrat. The Virginia muskrat, which has two color phases, (1) brown or red, and (2) black, is about 2 feet long including the tail, and averages a little more than 2 pounds. In the Blackwater area, the muskrat is associated with the Olney three-square bulrush, which is the muskrat's primary source of food.

Muskrats live in dome-shaped houses or lodges that may be 5 or 6 feet in diameter and 3 to 4 feet in height. Houses are usually made from the three-square plants. To prevent an overpopulation of "rats" and consequent "eat-outs" of their habitat, trappers endeavor to keep the marsh trapped to a stable population level. The number of muskrats trapped at Blackwater NWR each year for the commercial trade has varied considerably in the nearly 67 years of trapping there. The catch has varied from approximately 1,000 to 26,000 a year. The years 1936 to 1940 were all high catch years ranging from 19,000 to 26,000 animals. During a peak population year as in 1938, five or more muskrats per acre were trapped in the Blackwater mashes.

Deer

Two species inhabit the Refuge Complex: Sika deer and white-tailed deer. While the former is found only on Blackwater NWR and the Nanticoke protection area, the latter is also found on Barren Island and the Bishops Head Divisions of the Island Refuges. Neither species is found on Susquehanna NWR or the other islands.

Table 28. Deer spotlight counts total/avg. (Blackwater NWR)

Nights	Seasons	White-tailed	Avg./night	Sika	Avg./night	Total Deer	Avg./night
5	89-90	121	24	303	61	424	85
6	90-91	180	30	327	55	507	85
6	91-92	160	27	389	65	549	92
6	92-93	176	29	408	68	584	97
6	93-94	196	33	544	91	740	123
6	94-95	226	38	374	62	600	100
6	95-96	289	48	386	64	675	113
5	96-97	240	48	321	64	561	112
5	97-98	190	38	277	55	467	93
5	98-99	133	27	256	51	389	78

Source: Original data from Blackwater NWR 1989–1999

Overall deer herd health is monitored through the information collected at the check stations during refuge hunts. Each deer is sexed, aged, and weighed. Antler measurements are recorded for yearling bucks, and yearling does are examined for signs of fawning. Tooth wear and replacement indicate the age of each deer. Changes in yearling weights and yearling basal antler diameters will signal any long term shifts in deer herd health. Consistent declines in yearling weights and yearling basal antler diameter would indicate deer numbers too high for the habitat to support. Deer reproductive information is provided through examination of the yearling females and yearling males. Teat lengths indicate nursing, which reveal the productivity of fawn does. The diameter of the yearling buck antler base is directly correlated to the reproductive potential of the deer herd. Large diameters relate to higher deer herd productivity.

All deer are inspected for evidence of hemorrhagic disease, a viral disease spread by biting midges. Deer hemorrhagic diseases commonly appear in late summer and early fall. Deer that have survived hemorrhagic disease and are harvested in late November will exhibit hooves with sloughing tissue. These deer are still suitable for human consumption. The results of this disease survey are reported to the Southeastern Cooperative Wildlife Disease Study (SCWDS) in Athens, Georgia as part of a nationwide survey. Every 5 years, the SCWDS conducts a thorough necropsy of five randomly killed deer on the refuge. The necropsy focuses on the number of abomasal parasites, an indicator of herd health. This study is one of the oldest and most complete nationwide wildlife disease investigations.

Trends in deer abundance are commonly monitored using harvest estimates and age structure of the deer herd as previously described. Deer abundance is also monitored utilizing spotlight counts. Refuge staff are investigating the use of Forward-Looking Infrared (FUR) imaging to monitor deer abundance. FUR detects and differentiates thermal or heat sources, and deer can be easily separated from the background heat under most circumstances.

Sika deer.—Sika deer inhabit marshes, swamps, and associated woodlands and agricultural fields. This species, a native of eastern Asia, became established after being released by Clement Henry on James Island during the early 1900's. Populations exist mainly in Dorchester County and on Assateague Island in Worcester County. Maryland DNR’s sika deer management goal is to maintain this exotic species at current levels so that hunting opportunities are balanced with depredation issues across the lower Eastern Shore.

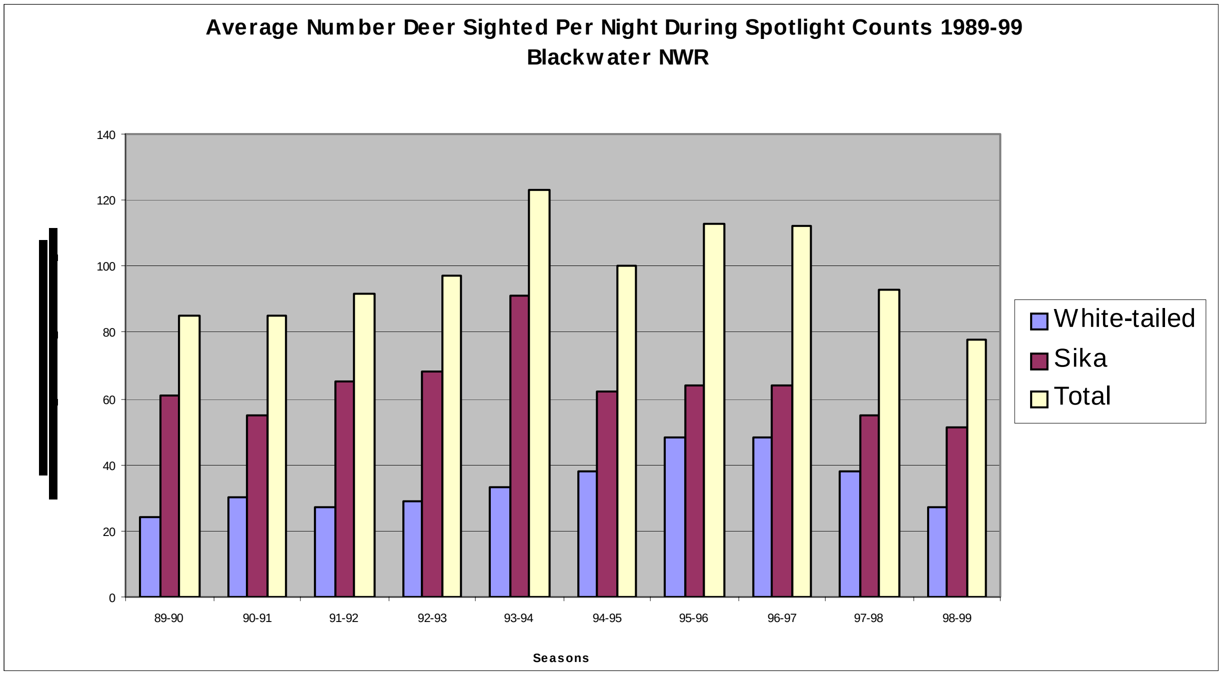


Figure 73. Deer spotlight counts average (Blackwater NWR)

The popularity of sika deer hunting recently has increased. Non-residents and hunters from other areas of Maryland now travel to the lower Eastern Shore with hopes of taking a trophy 6-point sika. In 1999, more than 8,200 hunters pursued sika deer with firearms for an average of 4.2 days. About 4,500 muzzle-loader hunters stalked sika deer for 3.2 days each, and almost 3,200 bow hunters tracked sika deer for an average of 7.2 days each (Maryland DNR Annual Report 1999–2000).

Sika deer management in Maryland changed for the 1998–99 hunting seasons. Only one antlered male could be taken during each hunting season (bow; firearm, muzzle-loader). Maryland DNR implemented this management change in the hope that more males would reach the prime age, while still allowing for appropriate population control.

Data collected in 1999 at big game checking stations by DNR Wildlife and Heritage Division staff indicated that the average field-dressed weight of a 1.5-year-old male sika deer was 53 pounds, while the +3.5-year-old males topped 80 pounds. Sika stags that were +3.5 years of age averaged 5.5 antler points, while 2.5-year-old deer had 4.1 points. Field-dressed yearling (1.5 years old) females averaged 45 pounds, with +3.5-year-old females weighing about 60 pounds. At Blackwater, the average yearling male sika deer field-dressed at 54 pounds, while the +3.5-year-old males weighed an average of 78 pounds.

The University of Maryland Eastern Shore, Fish and Wildlife Research Unit recently studied sika deer habitat, movements, and home ranges in Dorchester County and Blackwater NWR. Preliminary results indicated that average sika deer home ranges cover 2.5 to 3.6 square miles. Previous research conducted by DNR confirmed that sika deer have lower reproductive potential than white-tailed deer. Sika females tend to bear a single young while white-tailed females more than 1.5 years old usually bear twins. DNR research found that about 25 percent of sika female fawns were pregnant, while about 50 percent of white-tailed female fawns breed.

White-tailed deer.—Prior to the arrival of European immigrants, white-tailed deer inhabited all of Mary1and and eastern North America. Native Americans hunted deer during all seasons without bag limits. In Maryland, gray wolves and mountain lions preyed on white-tailed deer. The first European settlers in Maryland found ample white-tailed deer populations. Deer meat and hides provided them with food and clothing. As the colony prospered and human populations multiplied, unregulated market hunting and the destruction of habitat caused deer populations to decline drastically throughout the 1700's. With settlements expanding across the State during the 1800's, deer populations continued to drop, and mountain lions and wolves were exterminated.

By 1900, white-tailed deer only inhabited limited sections of far Western Maryland. Since the birth of wildlife management in the early 1900's, Maryland's deer population has steadily increased. State wildlife biologists, working hand-in-hand with private citizens, restocked the white-tailed deer to all available habitats in the State. Deer stocking efforts ended in the early 1960's. Early hunting seasons of the 1930's and 1940's prohibited the taking of antler-less deer, but soon deer populations expanded to allow more liberal seasons and bag limits. Currently, hunting antler-less deer is encouraged. On average, yearling white-tailed bucks Statewide carry 4.6 antler points and weigh 105 pounds field dressed, while 3.5-year-old white-tailed bucks field dress at about 145 pounds and sport 8.4 points.

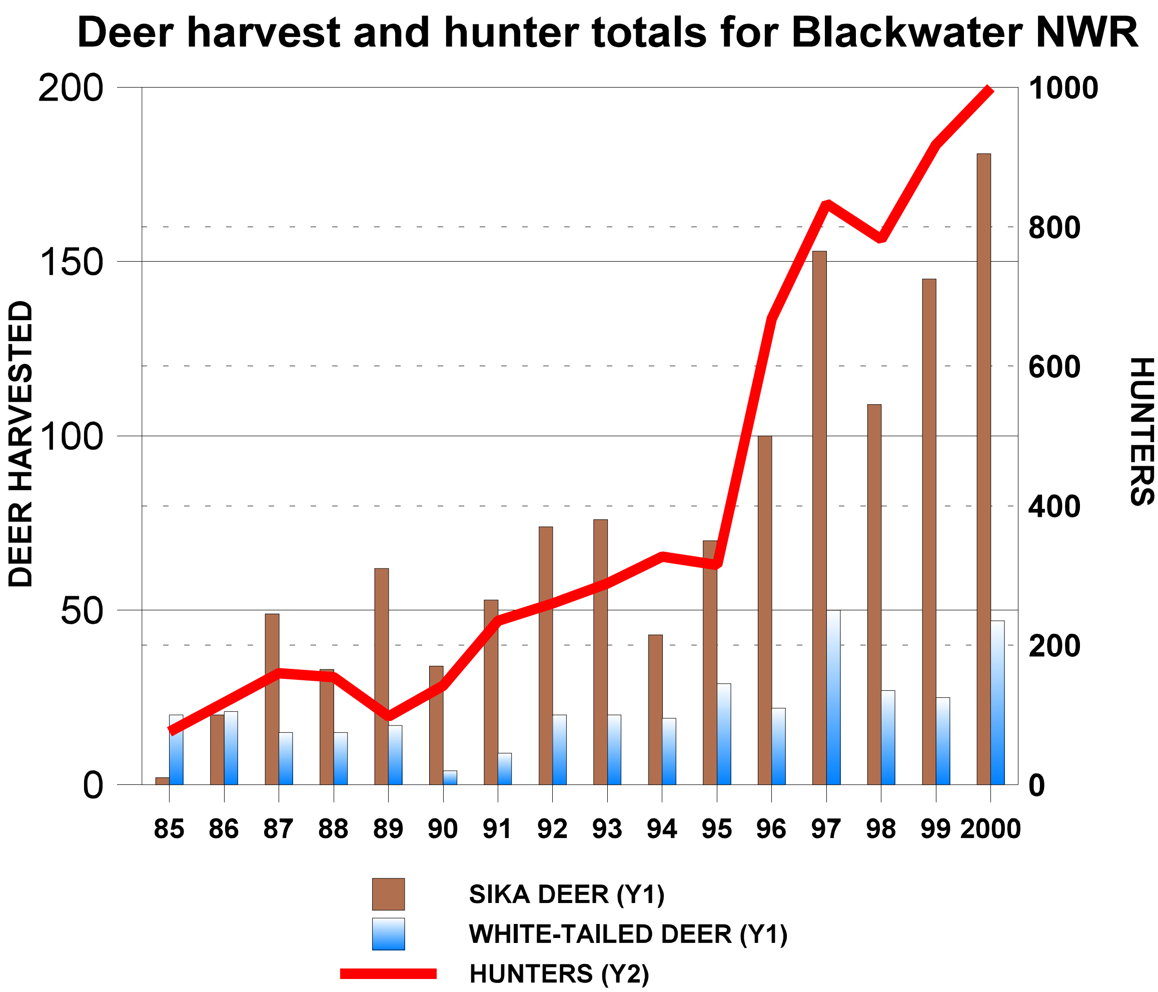


Figure 74. Deer harvest and hunter totals (Blackwater NWR)

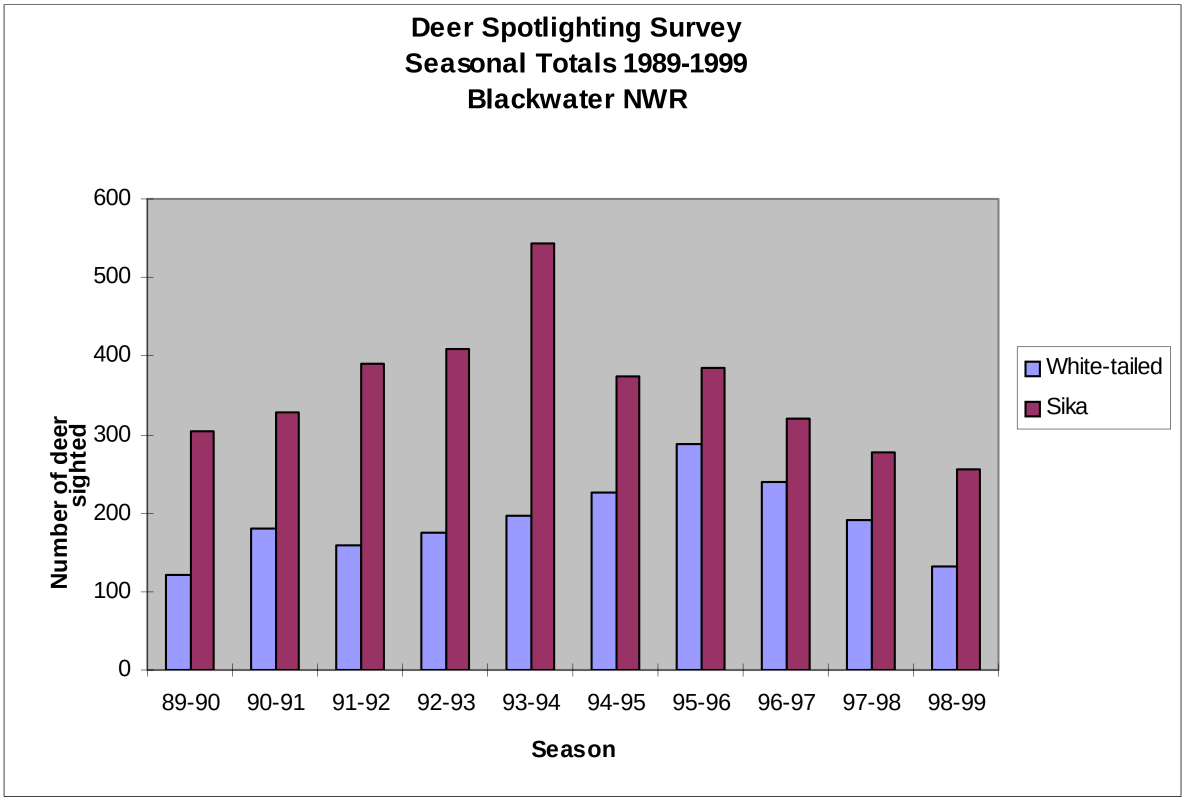


Figure 75. Deer spotlight seasonal totals (Blackwater NWR)

Table 29. Annual furbearer harvests (Blackwater NWR) 1939–1974

Year	Muskrat	Nutria	Raccoon	Red fox	Opossum	Skunk	Gray fox
1939	22,000			10			
1940	19,310		11	5			
1944							
1951							
1952	1,764	1		1			
1953							
1954							
1955							
1956	3,630						
1957	2,010		25	7			
1958	2,000						
1959	2,000						
1960	1,500						
1961	1,189	16	3				
1962	1,281	4	6				
1963	1,410	16					
1964	1,458	11	4				
1965	1,388						
1966	1,336	27	4	4			
1967	1,292	59	225	30	60	15	
1968	1,452	323	50				
1969	1,708	469	75	16	25	25	
1970	1,618	661	5	1	25	20	
1971	2,890	533	36	10	20	10	
1972	2,747	769	4	3			
1973	2,694	1,064	20				
1974	2,377	2,944	17				

Table 30. Annual furbearer harvests (Blackwater NWR) 1975–1999

Year	Muskrat	Nutria	Raccoon	Red fox	Opossum	Skunk	Gray fox
1975	4,119	3,863	36				
1976	5,008	2,894	19	1			
1977	3,809	3,467	24	9			
1978	3,575	83	16	3			
1979	3,996	77	33	0			
1980	7,177	73	45	3			
1981	6,489	74	97	0			
1982	4,474	20	75	0			
1983	4,135	13	109	0			
1984	3,996	65	60	2			
1985	3,919	52		0			
1986	4,362	71	71				
1987	5,238	468	80	2	22		
1988	5,397	870	78	1			
1989	3,926	2,002	42	5	26	0	
1990	3,849	3,400	11	2	16	0	
1991	3,614	2,282	178	3	62	24	
1992	4,300	3,908	221	3	89	22	
1993	3,528	5,558	155	1	36	11	
1994	4,681	4,899	38	1	13	3	0
1995	4,206	4,039	17	1	4	0	0
1996	3,778	5,436	52	3	16	1	0
1997	5,721	8,054	43	0	12	2	
1998	2,888	7,416	42	2	6	0	1
1999	3,275	5,690	58	0	26	0	0

Source: Furbearer Harvest Reports and Annual Narrative Reports

Table 31. Deer harvest summary (Blackwater NWR)

Year	Deer	Youth	Muzzle-loaders	Shotguns	Species Total	Total Deer	Total Hunters	Total Acres (est.)	Shotgun Days	Muzzle-loader Days	Youth Days
1985	WT			20	20	22	76		2		
1985	Sika			2	2						
1986	WT			21	21	41	118		2		
1986	Sika			20	20						
1987	WT			15	15	64	160	3,400	2		
1987	Sika			49	49						
1988	WT			15	15	48	154	3,400	2		
1988	Sika			33	33						
1989	WT			17	17	79	98	3,200	2		
1989	Sika			62	62						
1990	WT			4	4	38	142	3,400	2		
1990	Sika			34	34						
1991	WT			9	9	62	235	4,175	2		
1991	Sika			53	53						
1992	WT			20	20	94	260	4,175	2		
1992	Sika			74	74						
1993	WT			20	20	96	289	4,880	2		
1993	Sika			76	76						
1994	WT			19	19	62	327	4,880	2		
1994	Sika			43	43						
1995	WT			29	29	99	315	6,680	2		
1995	Sika			70	70						
1996	WT		7	15	22	122	668	8,000	2	2	
1996	Sika		25	75	100						
1997	WT	2	20	28	50	203	833		4	2	1
1997	Sika	3	37	113	153						
1998	WT	1	15	11	27	136	782		4	2	1
1998	Sika	1	22	86	109						
1999	WT	4	11	10	25	170	918		4	2	1
1999	Sika	1	33	111	145						
2000	WT	4	19	24	47	228	999	17,000	4	2	1
2000	Sika	5	29	147	181						

1984 Annual Narrative Report (p.1) states "There has been no hunting on the refuge since the last deer hunt in 1972." Hunting resumed in 1985.

Exotic and Invasive Species

Executive Order No. 13122 authorizes and directs the Service to protect native wildlife and their habitats on national wildlife refuges from damage associated with invasive and injurious species, including damage related to migratory birds.

Nutria.—Nutria are an exotic, invasive, semi-aquatic South American rodent introduced on Blackwater in 1943. Because they are a foreign addition to Maryland's natural communities, no inherent biofeedback mechanisms exist to naturally control their populations. Consequently, successive population increases and range expansions have established populations in at least eight counties on the Eastern Shore. Populations on Blackwater NWR estimated at fewer than150 nutria in1968 have grown to an estimated 35,000–50,000 today.

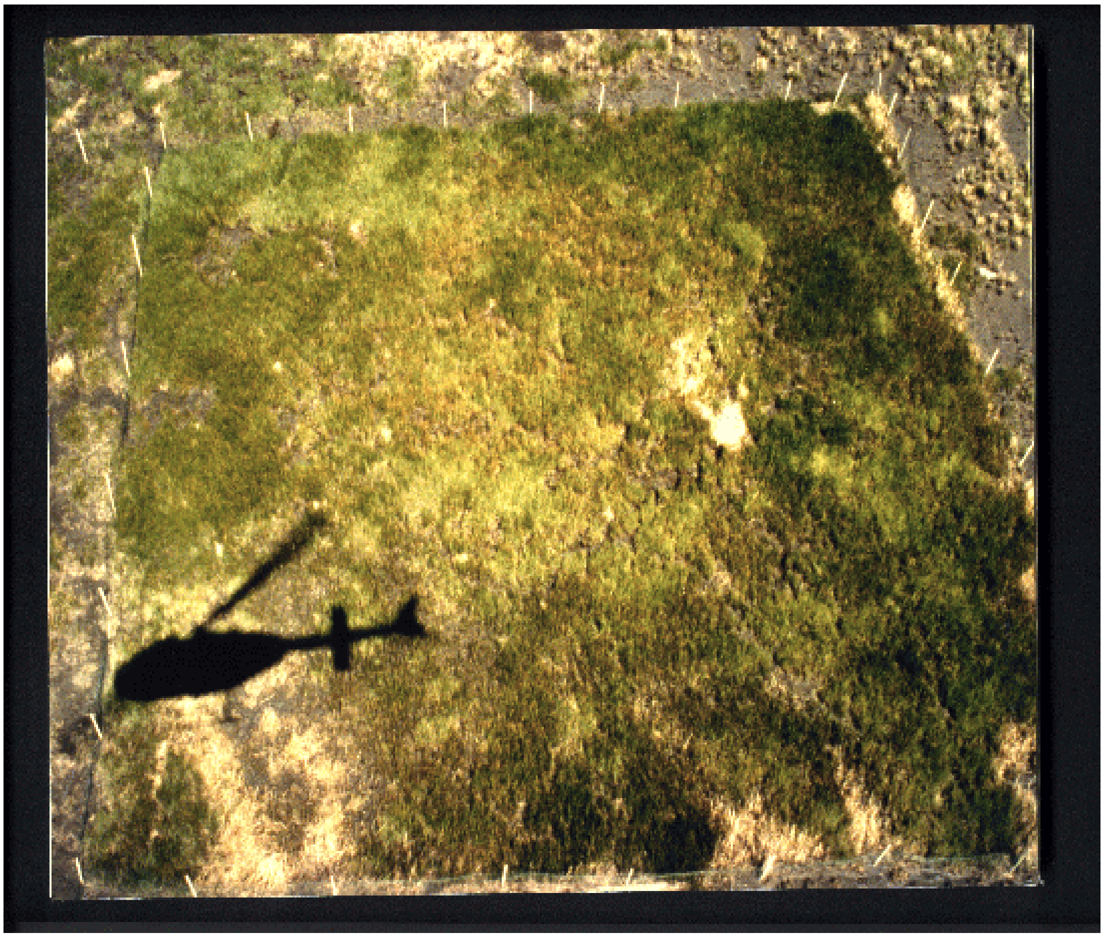


Figure 76. One year of nutria exclusion from marshes (color plate)

Loss or degradation of Maryland's coastal wetlands has reached alarming proportions. It is estimated that 65 percent of those fragile ecosystems have been lost since the 1700's. Nutria digging behavior damages or destroys the existing root mat that binds and secures structural components of functional marshlands. When this fibrous network is compromised by nutria activity, emergent marsh is quickly reduced to unconsolidated mudflats. These areas in turn are highly susceptible to erosion, and eventually convert to open water. While nutria are not the sole reason for marsh loss, they have been implicated as the catalyst that has greatly accelerated losses during the last decade.

Fourteen other states also are experiencing, in varying degrees of severity, the problems associated with the nutria populations established in Maryland. Likewise, localized harvest schemes do not adequately meet most management concerns. No pragmatic, effective means now exists to meet these challenges.

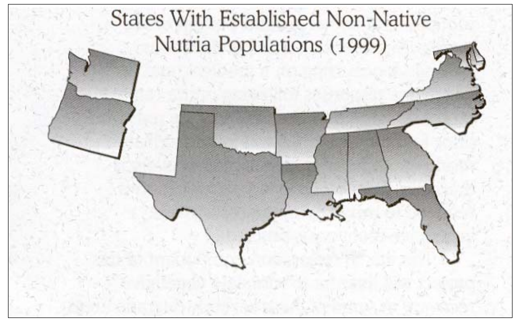


Figure 77. States with nutria populations

Nutria display phenomenal reproductive characteristics. As a result of these capabilities, conventional commercial or recreational harvest has proven ineffectual in reversing population growth trends. Although nutria are relatively easy to harvest in large numbers by experienced trappers, it has become apparent that this, in and of itself, is not enough.

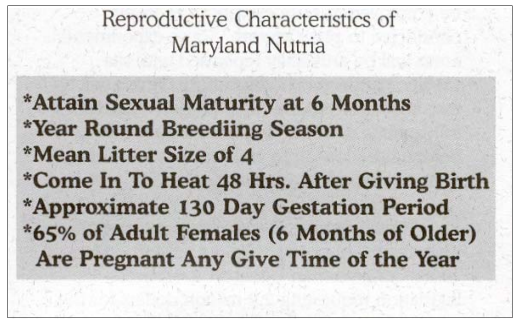


Figure 78. Nutria reproduction

Successful eradication efforts in Great Britain have demonstrated that it is how, when, and where nutria are harvested that contributes to their ultimate demise. Understanding behavioral and reproductive traits, and how they change in response to intense harvest pressure, will allow researchers to identify weak links or exploitable behavioral manifestations. This, in turn, will enable control personnel to develop harvest strategies and techniques that capitalize on those idiosyncrasies, thus ensuring maximum reduction values.

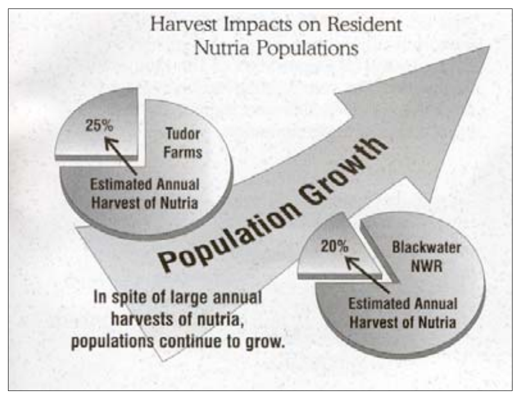


Figure 79. Nutria harvest impacts

Mute swans.—Native to Europe, mute swans were brought to this country in the late nineteenth century to grace the ponds of country estates. The mute swan is an introduced species in Maryland. From the escape of five captive swans from a Talbot County waterfront estate in 1962, Maryland's feral mute swan population has increased to 3,955 birds in 1999 (figure 9). The 1999 mute swan estimate was 46 percent greater than the 2,100 swans counted during the 1996 survey.

The 1999 mute swan population included 594 breeding pairs; 2,115 nonbreeders, and 646 young (cygnets). Mute swans reside primarily in estuarine river habitats with smaller numbers on inland lakes and ponds. The largest number of mute swans occurs in the lower Chester River south to the Little Choptank River along the Eastern Shore. Lesser numbers of mute swans were observed in lower Eastern Shore tributaries, with 1ocal concentrations in the vicinity of Hoopers and Bloodsworth Islands and Western Shore tributaries, like the Patuxent River. Mute swans are not federally protected. However, by virtue of their genetic link to the family of swans, they are given State protection in Maryland as wetland game birds. Population growth and range expansion of this species has increased the number of swan-related problems.

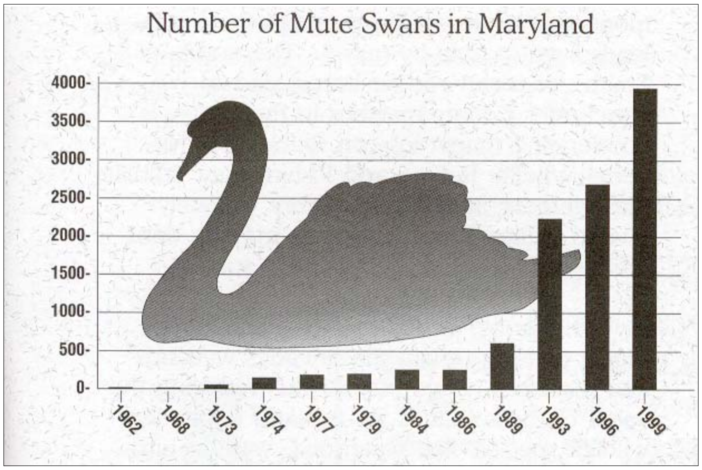


Figure 80. Mute swans in Maryland

Although valued for their aesthetic qualities, mute swans pose a potential ecological threat to certain native species of wildlife. Since this species did not evolve in the Chesapeake Bay region and develop genetic mechanisms to coexist with native bay wildlife, conflicts between mute swans and native wildlife have emerged. Of greatest concern is the impact of mute swans on native tundra swans, which winter in Maryland. Mute swans have been observed driving tundra swans from preferred feeding and resting habitats. Since the mid-1970's, Maryland's wintering tundra swan population has declined by about 30 percent. However, research is needed to tell whether this decline is related to increased competition from mute swans.

In the early 1990's, a large molting flock (>600) of mute swans prevented colonial water birds (terns and skimmers) from nesting on Barren Island. The swans used the islands for loafing, and inadvertently trampled the nests, eggs, and chicks of the terns and skimmers. Those swans also displaced nesting Forster's and common terns, declining species in Maryland. In response, personnel from the Maryland DNR and Refuge Complex reduced the mute swan flock in this area to alleviate the problem.

In other areas of the State, mute swans have also killed mallard ducklings, Canada goose goslings, and cygnets belonging to other mute swan pairs. However, they appear to tolerate adult birds of other species nesting nearby. The Refuge Complex has zero tolerance for mute swans, and takes appropriate actions to keep swans from becoming established on Service lands and waters. Often, however, Refuge Complex staff cannot control swans if they are on State-owned waters.

Citizens have complained that mute swans reduce the availability of submerged aquatic vegetation to native wildlife, reducing recreational crabbing and fishing opportunities. Presently, Maryland's mute swan flocks consume an estimated 9 million pounds of submerged aquatic grasses annually. In some instances, concentrations of mute swans have over-grazed bay grasses, eliminating habitats for crabs, fish; and other wetland-dependent species.

Some mute swans are aggressive, and will attack humans, especially small children, in defending their nest and young. Although the potential for injury is low, their territorial behavior is a nuisance and renders some land or water areas inaccessible to people during the breeding season.

The mute swan is a highly visible species that provides aesthetic values to some people. However, the growth of the feral mute swan population must be managed to prevent harm to native species and habitats. In the absence of population control measures, we expect the number of mute swans in Maryland to continue to increase. Eventually, this exotic species could occur throughout the Chesapeake Bay region and cause additional ecological harm and problems for humans.

In response to public interest, the Governor appointed a citizens advisory committee in 1999 to identify pubic concerns and suggest strategies related to the management of mute swans in Maryland. The project leader for the Refuge Complex is a member of the committee. We hope recommendations now pending will be implemented to keep the Bay's mute swan population from expanding to uncontrollable numbers.

Phragmites.—Phragmites is an aggressive colonizer that has displaced other marsh species in many other parts of the Chesapeake Bay. Also known as "common reed", it is a large coarse perennial grass. Phragmites, like loosestrife, reduces the diversity of plant and wildlife species in the wetlands (Cross and Fleming 1989). Although scattered clumps provide cover for small mammals and birds, it usually forms large, monotypic, impenetrable stands that provide little value for wildlife. The exact abundance and current rate of spread of Phragmites on refuge lands is unknown; but it is documented that it is increasing in abundance and distribution. Phragmites has a thick stalk that can reach 13 feet in height, and a large, plume-like flower. The plant reproduces both by seeds and extension of long creeping rhizomes.

Phragmites is currently not being treated except in the impounded wetland systems; thus, it has great potential to spread to natural systems and seriously destroy natural freshwater wetland ecosystems if not properly controlled (Cross and Fleming 1989). Rodeo™ is one of the most environmentally acceptable herbicides used for treatment. When used at the recommended rates and in conformance with the procedures and methods described above, it has very minor effects on the environment. Biological control is rarely a practical option for controlling Phragmites, because those organisms known to feed on this plant cause only incidental damage, with a few rare exceptions (Cross and Fleming 1989). The post-treatment burning removes the mats of dead vegetation, allowing the native forms of vegetation to quickly recolonize infected areas.

The approximate acreage of Phragmites on the Refuge Complex is now unknown, but conservative estimates from aerial photographs and anecdotal information suggest that several thousands of acres are infested with this exotic species. Efforts to accurately map acreage are presently underway. This highly invasive plant is readily apparent in most of the wetland systems, and can be found throughout Blackwater NWR, the Island Refuges, and to a lesser extent, the Nanticoke protection area. Susquehanna NWR has no Phragmites.

Phragmites is now treated with Rodeo at the prescribed rate of 6 to 10 lbs./acre, using hand and aerial application. As previously noted, treatments are presently limited to infestations within the freshwater impoundment system. Size, accessibility, and proximity of Phragmites to other vegetation or wetlands dictates the most appropriate application technique. On small beds, backpack sprayers are used. If areas are very large or are inaccessible from the ground, aerial spraying by an experienced helicopter pilot is used. A marker system is placed before flying transects to maintain a reference point during refilling. Infrared photographs of treated areas are viewed to locate missed spots. Equipment used for aerial spraying is free of leaks and has complete cut-off capabilities to prevent treatment of nontarget areas. The cost of aerial spraying averages approximately $40 per acre.

As well as chemical control, other techniques include physical treatments like mowing, discing, flooding, draining, and burning, although these have not proven very successful when used alone. Once a stand has become established, the key to controlling the plant involves destroying the underground rhizome system. The rhizome mat can often be more than 3 feet thick, and one can imagine how difficult and impractical it would be to mechanically remove the rhizome mat. Multiple treatments, therefore, often are required to effectuate control.

The most practical method is the spraying of glyphosate herbicide when plants are actively growing and at mid-to-full bloom (late August or September, but before a killing frost). The plants die within 6–8 weeks, and are then burned or mowed to eliminate shading of preferred vegetation. Burned areas regenerate in more favorable vegetation quicker than unburned areas (Jones 1995). For best results, the same area is sprayed in two successive years, then spot-treated in succeeding years to prevent reestablishment. A toxic chemicals application permit is needed from the Maryland Department of the Environment’s Industrial Discharge Permits Division to spray Phragmites in wetlands.

Gypsy moth.—The gypsy moth (*Lymantria dispar L.*) is one of the most notorious pests of hardwood trees in the Eastern States. Brought to Massachusetts from Europe in 1869 to interbreed with silkworms, this devastating forest defoliator can be found in all Maryland counties today. The larvae prefer hardwoods, but may feed on several hundred different species of trees and shrubs. In the East, the gypsy moth prefers oaks, apple, sweetgum, speckled alder, basswood, gray and white birch, poplar, willow, and hawthorn, although other species are also affected.

The effects of defoliation depend primarily on the amount of foliage that is removed, the condition of the tree at the time it is defoliated, the number of consecutive defoliations, available soil moisture, and the species of the host. If less than 50 percent of their crown is defoliated, most hardwoods will experience only a slight reduction in radial growth. If more than 50 percent of their crown is defoliated, most hardwoods will refoliate or produce a second flush of foliage by midsummer. Healthy trees can withstand one or two consecutive defoliations of greater than 50 percent. Trees that have been weakened by previous defoliation or been subjected to other stresses such as drought are frequently killed after a single defoliation of more than 50 percent.

Trees use energy reserves during refoliation and eventually are weakened. Trees weakened by consecutive defoliations are vulnerable to attack by disease organisms and other insects. For example, the Armillaria fungus attacks the roots, and the two-lined chestnut borer attacks the trunk and branches. Affected trees will eventually die 2 or 3 years after they are attacked. Although not preferred by the larvae, pines and hemlocks are subject to heavy defoliation during gypsy moth outbreaks and are more likely to be killed than hardwoods. A single, complete defoliation can kill approximately 50 percent of the pines and 90 percent of the mature hemlocks (McManus, 1999).

Natural predators, parasites, and diseases that normally feed on the egg masses and caterpillars are not as prevalent in the United States or are not as effective as in their native habitats. However, natural enemies may play an important role during periods when gypsy moth populations are sparse. Natural enemies include parasitic and predatory insects such as wasps, flies, ground beetles, and ants; many species of spider; several species of birds such as chickadees, blue jays, nuthatches, towhees, and robins; and approximately 15 species of common woodland mammals, such as the white-footed mouse, shrews, chipmunks, squirrels, and raccoons.

Diseases caused by bacteria, fungi, or viruses also help contribute to the decline of gypsy moth populations, especially during periods when gypsy moth populations are dense and are stressed by lack of preferred food sources. Wilt disease caused by the nucleopolyhedrosis virus (NPV) is specific to the gypsy moth and is the most devastating of the natural diseases. NPV causes a dramatic collapse of outbreak populations by killing both the larvae and pupae. Larvae infected with wilt disease are shiny and hang limply in an inverted "V" position.

Weather may also have a significant effects on the survival and development of gypsy moth life stages regardless of population density. For example, temperatures of -20 °F (-29 °C) lasting from 48 to 72 hours can kill exposed eggs; alternate periods of freezing and thawing in late winter and early spring may prevent the overwintering eggs from hatching; and cold, rainy weather inhibits dispersal and feeding of the newly hatched larvae and slows their growth.

A number of more direct tactics have the potential to minimize damage from gypsy moth infestations and to contain or maintain gypsy moth populations at levels considered tolerable. These tactics include monitoring gypsy moth populations, maintaining the health and vigor of trees, discouraging gypsy moth survival, and treating with insecticides to kill larvae and protect tree foliage (McManus, et. al. 1999).

Since 1991, Region 5 refuges have requested and received forest pest management funding from the USDA Forest Service (USFS) under the authority of the Cooperative Forestry Assistance Act of 1978 (P.L. 95–313) and the Forest Stewardship Act of 1990 (P.L. 101–624). These acts recognize the need for public and private cooperation in combating forest insects and disease and the need for federal leadership and financial assistance on all forest lands. Since 1993, Blackwater NWR, has been plagued with repeated infestations of Gypsy moths. As soon as infestations were detected, the refuge requested assistance from the USFS North East Area State and Private Forestry. USFS personnel have since provided technical and hands-on assistance by performing annual egg mass surveys and population estimates, making treatment recommendations, assisting with funding requests and contract preparation, providing oversight on treatment projects, conducting follow-up aerial defoliation surveys and developing detailed reports of the initial findings and treatment efficacy.

However, the most valuable assistance provided by the USFS is the actual funding for the detection and control of forest insects and diseases. Blackwater NWR has applied for and received forest pest management funding every year since the initial outbreaks in 1993, with the exception of 1999, when no treatment was required. Without their support over the years, it is highly likely that the refuge may have lost a significant portion of its DFS habitat. Over the past

8 years, with the help of the USFS, 12,744 acres have been treated to suppress growing populations of gypsy moth larvae (see figures, below). Since many of those acres received double applications, the actual area treated equals 19,655 acres. The most common and effective method of controlling Gypsy moth populations is aerial application of the biological insecticide *Bacillus thuringiensis* (B.t.). Gypcheck, a synthetic insecticide that mimics a naturally occurring virus, has also been used on the refuge, with somewhat unsubstantiated results.

Table 32. Gypsy moth control (Blackwater NWR) 1993–2001

Year	Control Agent	Treatment Area (ac)	No. of Applications	Acres Treated	Cost
1993	Gypcheck	150	2	300	$6,000 ?
1994	B.t.	1,843	1	1,843	$25,376
1995	B.t.	1,837	2	4,520	$46,000
		846	1		
1996	B.t.	896	2	1,792	$19,900
1997	Gypcheck	1,329	2	2,658	$51,000
1998	Gypcheck	2,087	2	4,174	$75,000
1999	N.A.				
2000	B.t.	608	2	1,216	$24,000
2001	B.t.	2,878	2	3,152	$87,460
		270	1		
Total		**12,744**		**19,655**	**$334,736**

Throughout the history of Blackwater NWR, the lack of forest management, coupled with other endemic processes, has had significant impacts on forest health. Their increased stress and decreased vigor leave our forests susceptible to infestations of gypsy moths and other forest insect pests and diseases. Using sound forest management, we can significantly improve forest health and vigor, while providing quality habitat for Federal trust species and other wildlife. Over time, as forests improve on the refuge, their susceptibility to the variety of stress-related killing agents will decrease, thus, reducing our reliance on insecticides to control forest pests. However, the use of insecticides will never be eliminated completely, due to its lower cost and greater effectiveness.

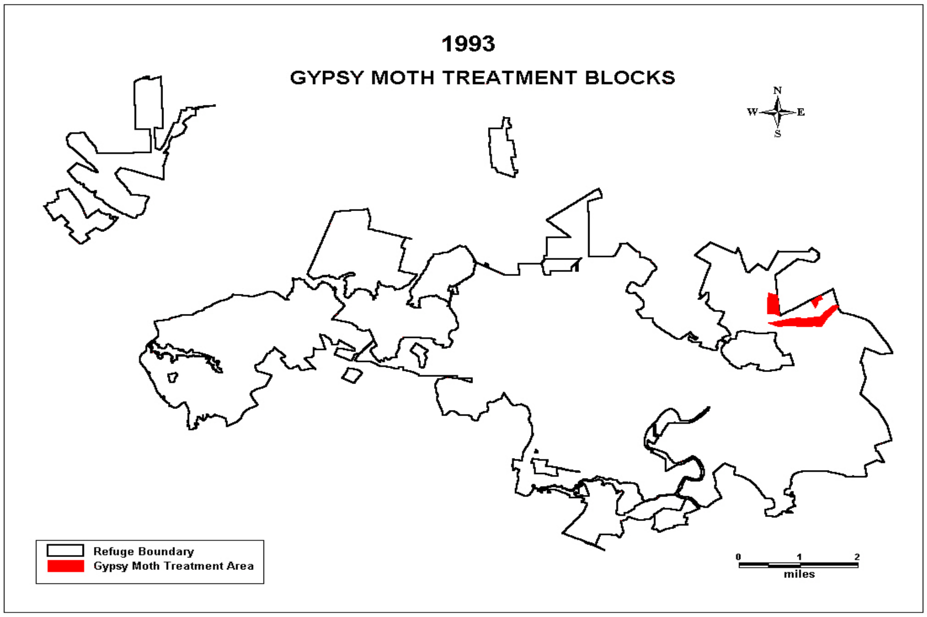


Figure 81. Gypsy moth treatments 1993 (color plate)

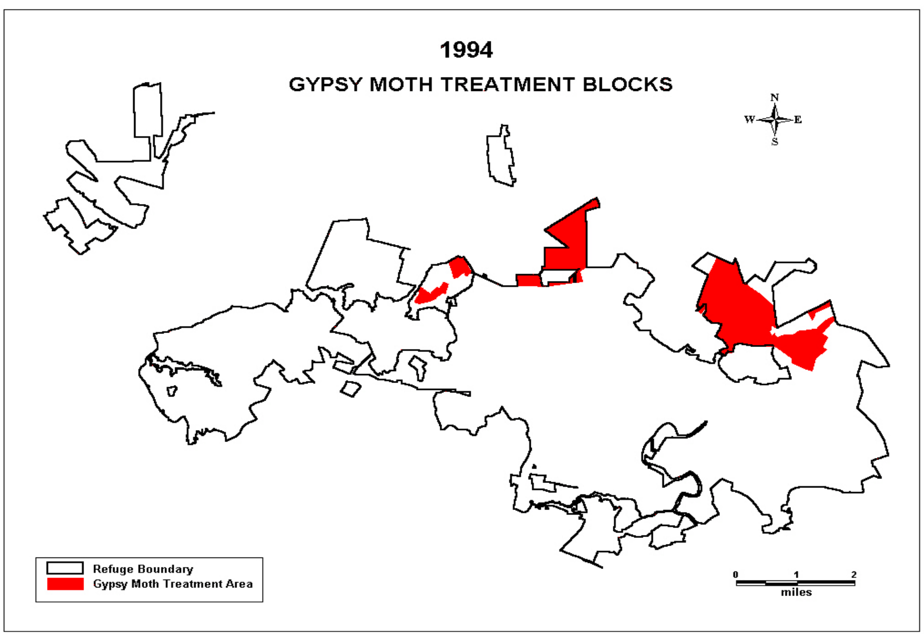


Figure 82. Gypsy moth treatments 1994 (color plate)

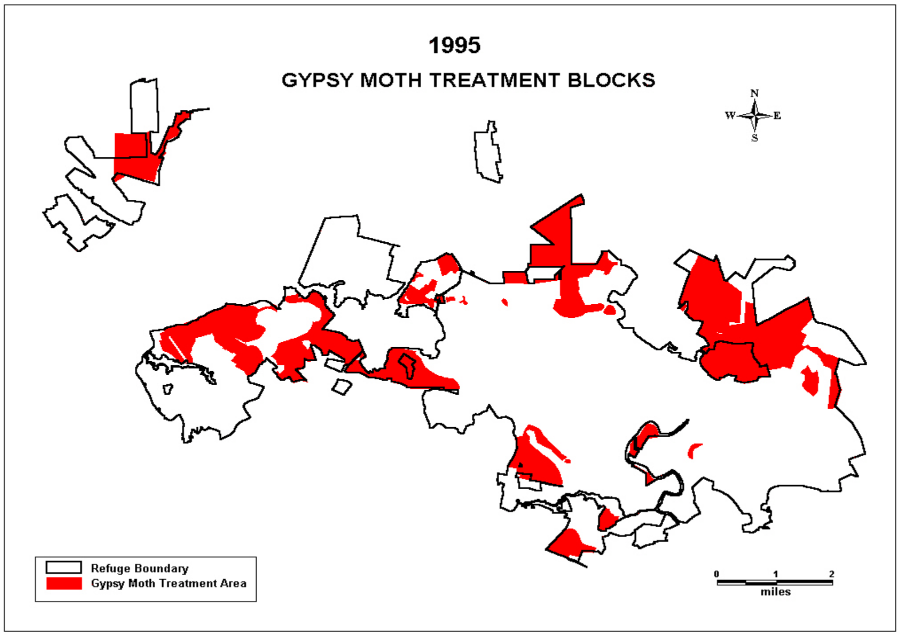


Figure 83. Gypsy moth treatments 1995 (color plate)

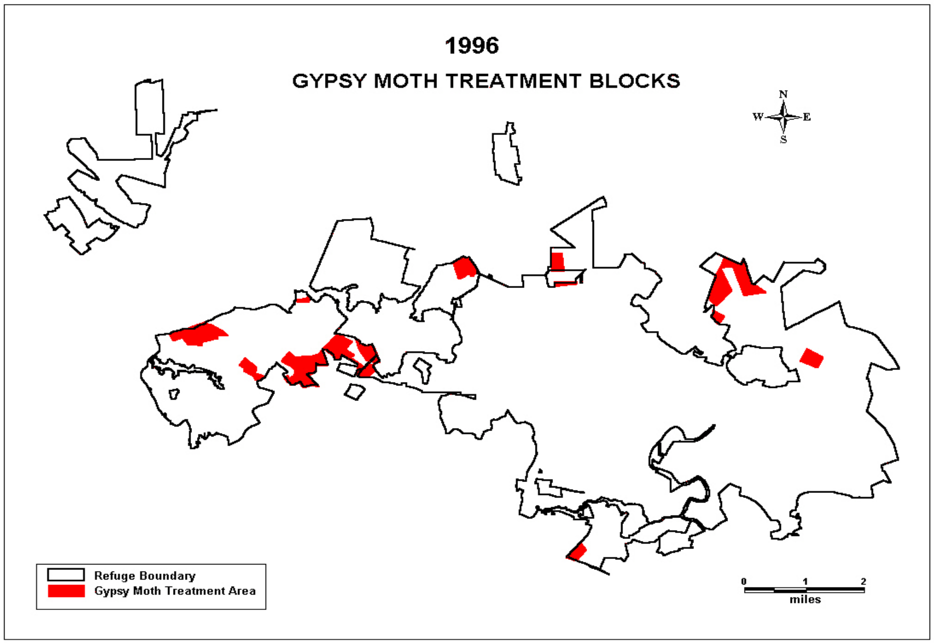


Figure 84. Gypsy moth treatments 1996 (color plate)

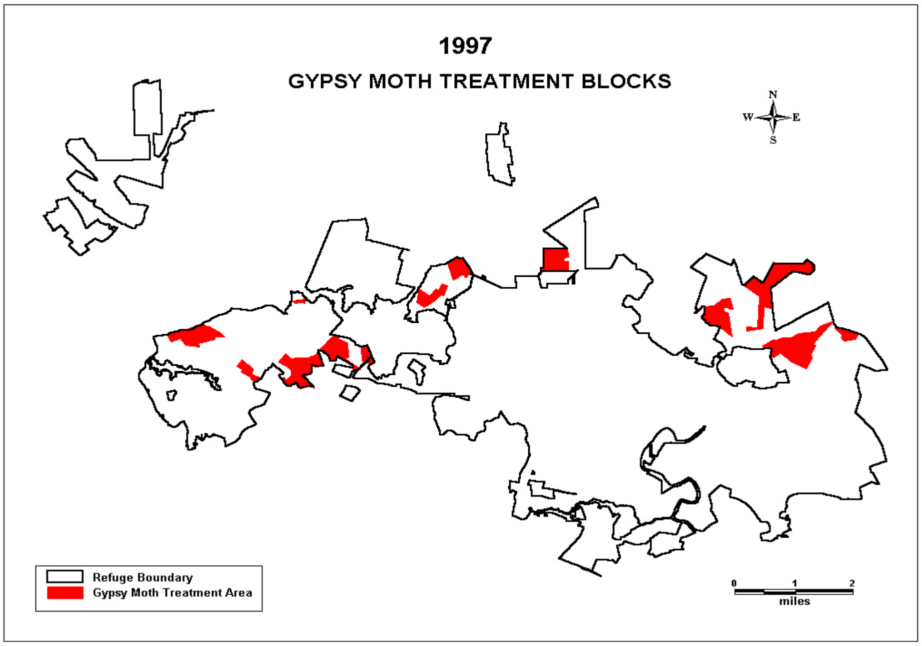


Figure 85. Gypsy moth treatments 1997 (color plate)

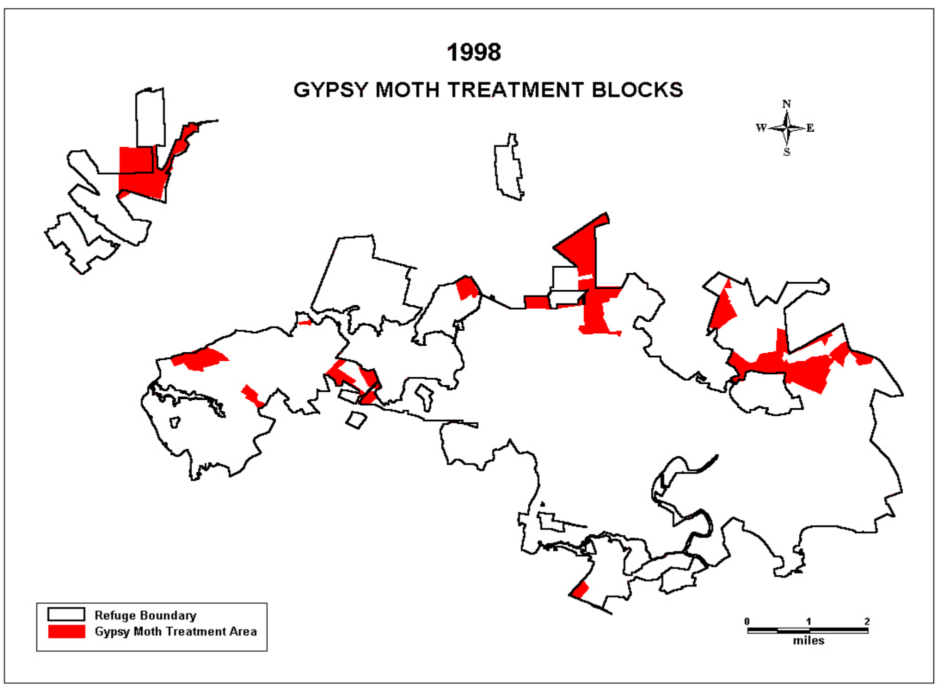


Figure 86. Gypsy moth treatments 1998 (color plate)

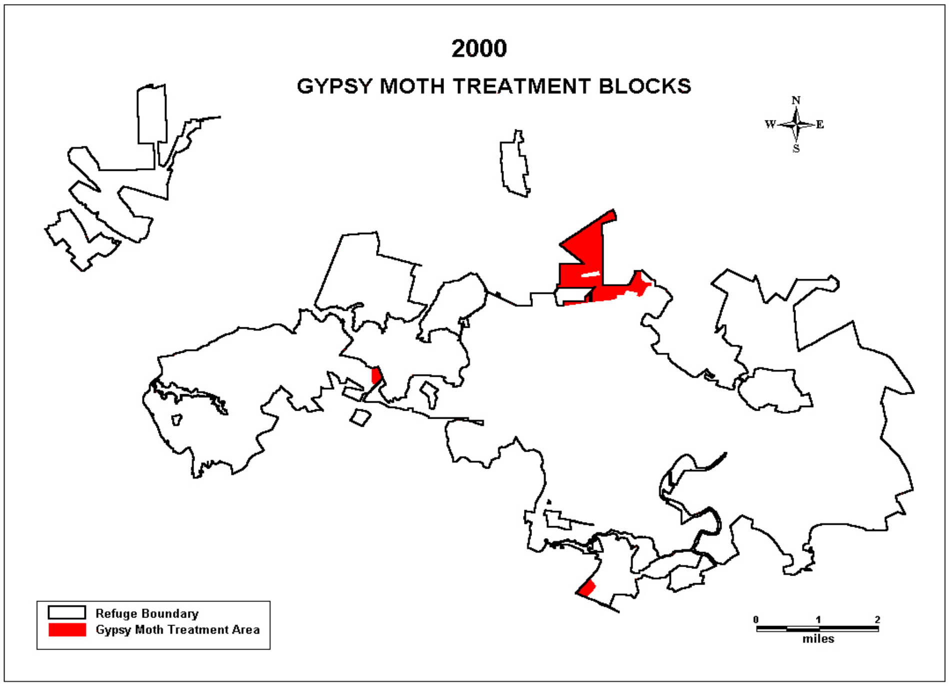


Figure 87. Gypsy moth treatments 2000 (color plate)

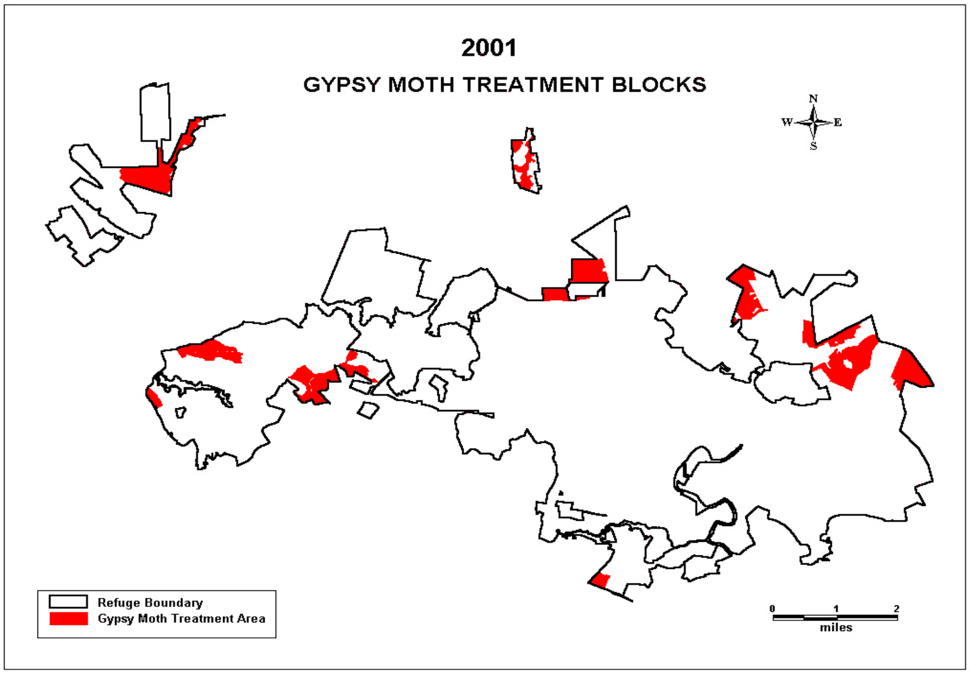


Figure 88. Gypsy moth treatments 2001 (color plate)

Resident Species

Resident Canada geese.—The phrase “resident Canada geese” refers primarily to local breeding Canada geese that nest and raise their young in Maryland. Resident Canada geese do not migrate to northern Canada, but remain year-round in southern Dorchester County. All Canada geese, regardless of their migratory status, are technically classified as migratory birds, and are managed under the Migratory Bird Treaty Act (MBTA). The distinction between resident geese and migratory geese often is confusing to the public. The nearest comparison is between the domesticated park mallard, or marina mallard, and the wild migratory mallard; both are generally the same in appearance, yet behaviorally quite different. The MBTA recognizes those distinct behavioral differences among mallards, and efforts are ongoing to amend the MBTA to recognize similar differences between resident and migratory Canada geese.

At Blackwater NWR, banding programs conducted by refuge staff and Maryland DNR staff have been underway for the past 10 years to determine whether geese are resident or migratory. Both neck collars and leg bands have been used, and investigations have verified that the birds at the refuge are locally raised geese that subsequently stay year-round and raise their young, which become breeders and raise even more young. The resident Canada geese are now adversely affecting the purpose(s) for which the refuge was established.

Present-day populations originated from birds that were released or escaped from private waterfowl collections or hunting clubs between 40 and 50 years ago, and from birds that were moved to the refuge from other areas. These non-migratory stocks of geese probably include a mix of several different subspecies, including the giant (*Branta canadensis maxima)*, western (*B.c. moffitti),* North Atlantic (*B.c. canadensis),* and interior (*B.c. interior)* races. The refuge’s resident goose population grew from only about 350 birds in 1989 to more than 5,000 in 1998, and increased by almost 70 percent in just the last breeding season. That increase may be the result of the exploitation of man-made food resources, e.g., clover, corn, winter wheat, buckwheat, and other agricultural crops planted on the refuge resulting in improved nutritional health and thus, better reproductive success and gosling survival; few predators; and almost complete protection from harvest by hunting except when birds fly to private lands.

The resident Canada geese's feeding and breeding behavior, habitat preference, and adaptability to man-made environments create situations in which Canada geese and humans conflict. Resident Canada geese feed on clover, grasses, and cereal grains, exactly the types of crops that migratory Canada geese need to survive the winter. Resident Canada geese also favor short, manicured grass, particularly near a water source, for loafing and feeding. Refuge dikes, important for managing water levels for migratory waterfowl, shorebirds, and other marsh and water birds, provide just such feeding and loafing areas which resident birds quickly denuded of vegetation causing erosion and dike failure.

Another indicator of the increasing problems with resident Canada geese is the number of complaints received by USDA Wildlife Services Offices. In 1993, their Annapolis office received no complaints from Dorchester County residents. In 1994, 1995, 1996, 1997, and 1998, complaints increased to 3, 5, 4, 4, and 6, respectively. While the number of complaints is relatively low, it is interesting to note that, while only $300 in economic damage was noted from

1993 through 1997, $34,000 in damages to private agricultural crops was noted in 1998. Damages sustained by the refuge during these years were not included in these statistics.

Resident Canada geese nest from March through June. Eggs take approximately 30 days to hatch. Parent geese are very protective and aggressive in defense of young and nest. This aggressive behavior can potentially lead to attacks on human visitors, particularly visitors along the Wildlife Drive, where geese sometimes nest. The refuge is not open to the special Maryland September hunting season for resident Canada geese, since waterfowl hunting would interfere with other management objectives and refuge purposes.

However, even if the refuge were open to public waterfowl hunting, control of resident Canada geese would be extremely minimal based on the reports of harvest statistics obtained from Edwin B. Forsythe NWR in New Jersey and Tudor Farms, Inc., a 6,000-acre private hunting preserve adjoining the refuge. At Edwin B. Forsythe NWR, 762 hunters, hunting 3,866 hours during three consecutive state seasons, took only 413 geese from the refuge impoundment system. Despite considerable hunting pressure at Tudor Farms, Inc., very few geese were taken during the 10-day State season, and the landowner was forced to eventually acquire a depredation permit from the FWS.

Statewide, the resident Canada goose population has increased from 25,000 in 1989 to 90,000 in 1998. (Maryland's population objective for resident Canada geese is 30,000). The direct and indirect results of this population explosion are adversely affecting the primary purpose for which the refuge was established. Exclosures built by refuge staff in the spring of 1999 clearly demonstrate that resident geese are seriously impacting the refuge's natural marsh vegetation, which is already stressed by sea-level rise, salt water intrusion, and overgrazing by nutria, and are contributing to the loss of wetlands important to the Chesapeake Bay ecosystem.

Studies and investigations by researchers Haramis and Kearns in the Patuxent Marshes, Maryland; May and Kangas in Kenilworth Marsh, Washington, D.C., and Nichols on the Maurice River, New Jersey, substantiate similar destruction of natural marsh vegetation by resident Canada geese. A study at Bombay Hook NWR also statistically validated that resident geese are significantly affecting natural vegetation in moist soil impoundments. While not statistically validated at Blackwater NWR, observations by refuge staff during scheduled vegetation transects also documented impacts on moist soil vegetation in impoundment systems important for producing food resources for migratory waterfowl. Likewise, resident Canada geese are causing significant damage to agricultural crops planted to provide critical forage for migrating and wintering waterfowl.

Increasing damage has been documented by refuge staff during the past 10 years throughout the refuge, but particularly on the 240 acres of crops within the Key Wallace corridor, the area from the Little Blackwater River to State Highway 335. In 1999, for example, refuge staff documented the total destruction of 47 acres, almost half, of the refuge's annual corn crop, and 126 acres of ladino clover. Also, observations by refuge biologists validate that resident Canada geese concentrate around the remaining water during summer impoundment drawdowns. The resulting concentrations of fecal droppings in these stagnant pools, when the temperatures are high, create excellent mediums for degraded water quality, and increase the potential for human and avian diseases transmitted by fecal material.

For example, during a 1998 survey conducted by the National Wildlife Health Research Center (NWHRC), 16 percent of 37 resident Canada geese studied from Blackwater NWR were DVE (duck virus enteritis or duck plague) positive. There is also increased concern regarding transmission of diseases such as cryptosporidiosis, giardiasis, and chlamydiosis. Because of this potential problem, Region 5 funded investigations by NWHRC and New Jersey Division of Fish, Game and Wildlife in 1999 to evaluate threats to human health posed by resident Canada geese in Rhode Island, New Jersey, and Virginia.

Resident gosling production on the refuge exceeded 2,000 in 1998, and resulting damage to refuge habitats was significant despite the expenditure of at least one full staff-year of effort and thousands of dollars for harassment or scare devices. When these habitats are destroyed or their productivity is significantly reduced, the refuge lacks enough wintering habitat to support its migrating and wintering waterfowl; thus, the refuge cannot achieve the purpose for which it was established. The refuge population of resident geese is also expanding to private lands, and it is not uncommon to see flocks of nonbreeding geese flying almost anywhere south of Route 50 during the spring and early fall. These nonbreeders join with breeders and their fledgling young in the early fall cause extensive damage by overgrazing and polluting private agricultural fields, alfalfa and hay meadows, lawns, golf courses, and other areas.

Other species.—Bobwhite quail and the eastern wild turkey are common on Blackwater NWR and in the Nanticoke protection area, but are not found on any of the Island Refuges.

Purple loosestrife.—Purple loosestrife, a beautiful but aggressive invader, arrived in eastern North America in the early 1800's. Plants were brought into the United States by settlers for their flower gardens, and since has spread to much of the nation. Purple loosestrife was first observed on the Refuge Complex at Blackwater NWR in 1996. Thirty-five plants were pulled and incinerated. Treatment has been continued by manually pulling up and incinerating the few plants that are observed or by spraying glyphosate (as Rodeo, the formulation approved by the U.S. Environmental Protection Agency for use in wetlands) at the prescribed rate.

The best time to control purple loosestrife is in late June, July, and early August, when it is in flower and plants are easily recognized, and before it goes to seed. Once flower petals start to drop, the plant begins to produce seed, and care will be taken to avoid seed dispersal. It should be noted that biological control using *Galerucella, Hylobius,* and *Nanophyes* beetles is not currently being used primarily because of the lack of plant density. Biological control is preferred in areas of high plant densities and severe infestations on relatively large acreage where manual and chemical control are ineffective and may contribute to the problem.

Other noxious weeds.—The State of Maryland mandates control of Canadian thistle and Johnson grass. Efforts to control these noxious weeds have been ongoing at Blackwater NWR for many years. However, each year some spot treatment with Roundup on between 10 and 15 acres is required to maintain control.

Cultural and Historical Environment

Paleoenvironment

Millis, et. al (2000) described the paleoenvironment as follows. The more than 11,000 years of human occupation of the Atlantic Slope is divided into two broad climatic periods. The earlier period spans from 13,000 to 10,000 B.P. and is the ice age, or Latest Pleistocene. The later period began at 10,000 B.P. and is referred to as the Holocene. Although the Chesapeake Bay region was never covered by the Canadian Laurentide continental glacier, early inhabitants assuredly felt its effects. At times the glacial front was as close as northern Pennsylvania, and glacial outwash flowed down the Susquehanna River (Schuldenrein 1994).

During the Pleistocene, the Delmarva Peninsula weather could have been cold because of proximity to the glaciers. Air supercooled by its passage over the glaciers (katabatic winds) would have settled into the region at times, bringing extremely rigorous weather. The Maryland Eastern Shore region lies between the zone of active Pleistocene glaciation, which is approximately 160 miles (257.50 km) to the north, and the zone of minimal glacial effects, which begins approximately 230 miles (370.15 km) to the south (Keel 1976). Custer (1989) places the Delmarva Peninsula region south of periglacial activity, which he defines as restricted to the area above the fall line in Maryland. The study area thus experienced some of the marginal effects of glaciation, such as permafrost and lowered sea level, without undergoing the scraping away of soils and vegetation, as in fully glaciated landscapes.

Recent studies of late Pleistocene climate around the north Atlantic basin have shown it to be somewhat different from that of the world at large. Pleistocene conditions ended in most areas of the world around 13,000 B.P. (Delcourt and Delcourt 1983, 1985; Watts 1979, 1980). However, due to the wasting of the Laurentide ice sheet, near ice-age conditions reappeared once in northeast North America (Broecker and Denton 1990; Fitting 1974). This cold episode followed 11,000 B.P., when runoff from the melting glacier suddenly shifted from the Mississippi River to the St. Lawrence River (Broecker and Denton 1988). The rush of cold fresh water from the St. Lawrence River disrupted the Gulf Stream’s warm northward current, returning the North Atlantic basin to near ice-age conditions for about 700 years. It was registered as a somewhat cooler period in most of the world, but was quite cold in northeast North America. It should be thought of as resembling the Little Ice Ages of the last 2,000 years (Denton and Karlen 1973), rather than a reappearance of full glacial conditions. During the Holocene, the glacier retreated and finally disappeared.

Over 23,000-year periods, wobbling of the Earth’s axis of rotation around the north pole appears to have been the greatest influence on the changing climate. The effects were the most dramatic in the Northern Hemisphere. During the ice ages, the North Pole tilted away from the Sun in the fall (Kukla 1975; Kukla and Gavin 1992). The tilting reduced the supply of energy from the Sun reaching the Northern Hemisphere by 7 percent, resulting in dark falls that allowed the glaciers to grow each year and eventually expand to immense proportions (Davis and Seller 1994; Kutzbach and Guetter 1986).

Also during the ice ages, seasonal diversity diminished, producing an equitable climate of permanent poleward winter and permanent equatorial summer, although the summers were cool like a modern spring. The equitable seasons of the Pleistocene produced a mosaic vegetation, a species-diverse, patchy arrangement of plant and animal communities. During the Early to Middle Holocene interglacial, the tilt of the Earth shifted toward the Sun in summer and away in winter (Davis and Sellers 1994; Bryson 1994). This resulted in bright, hot summers and dark, cold, dry winters.

A major sea level transgression that eventually formed the modern Chesapeake Bay began about 18,000 years ago. The impacts of this transgression began to be felt at Blackwater NWR about 4,000 years ago, at which time tidal marshes began to form in Blackwater River. Prior to the formation of marshes, most of Blackwater NWR was a freshwater ecosystem with large tracts of nontidal freshwater swamps formed by low-drainage soils. After marshes formed, much of the area evolved from tidal freshwater marsh to brackish marsh, and now even to salt marsh. Presently Blackwater NWR marshes stand out among all other Chesapeake Bay marshes in that they are converting to open water. This change is most likely a result of an array of natural and man-made disturbances.

Historical Overview

Early settlement of Maryland by Euro-Americans began in 1634, when two shiploads of British immigrants established Saint Mary's City at the mouth of the Potomac River. The settlement was on land granted on the north side of the Potomac to the first Lord Baltimore, George Calvert. Calvert's son Cecil oversaw the settlement of the colony. Generous land grants were made to all settlers who paid their way across the Atlantic, while those who could not pay worked as indentured servants for a set number of years, after which they could purchase land (Kellock 1962:6). George Calvert had converted to Catholicism and it was his dream that his colony promote religious tolerance. His children carried out his dream, and the colony of Maryland attracted a diverse population from England, Wales, Scotland, Ireland, and France.

At the time of European contact, Algonquin-speaking tribes inhabited the peninsula (Davidson et al. 1985). European conquest brought an end to the Late Woodland lifestyle, although many relics of the material trappings, belief systems, and social structure of classic Late Woodland society lingered into the eighteenth century in parts of the East. Four Native American groups on the Eastern Shore were recognized by the Maryland colonial government: the Choptank, Nanticoke, Pocomoke, and Assateague. Treaties were signed by the government in the mid-seventeenth century to provide specific lands for the exclusive use of these groups and establish procedures for resolving conflicts (Davidson 1982). John Smith and John White, two early seventeenth century explorers of this region, reported numerous villages west of Blackwater NWR along the Patuxent River and east of Blackwater NWR on the Nanticoke and Pocomoke Rivers (Feest 1978:241). No exploration of the Blackwater River is documented for this period, and little is known of the groups that inhabited southern and interior Dorchester County at that time.

Early seventeenth century maps of the region are fairly inaccurate in depicting the lower Eastern Shore, showing a very general coastline, and only the mouths of most drainages (Hawley and Lewger 1635). A 1635 map depicts mountains on the interior of the Delmarva Peninsula, which suggests that little exploration of this area had been accomplished by that time. Comparing a 1651 map (not shown due to poor quality) with the 1635 map suggests that extensive exploration of the Choptank, Nanticoke, and Pocomoke rivers occurred in the mid-seventeenth century (Farrer 1651). These are also the three major drainages in this area associated with significant Contact period Native American settlements.

No Native American villages are known to have existed near Blackwater NWR during the period 1620–1837 (Feest 1978:241), but reservations for the Choptank and Nanticoke were established near present-day Cambridge in the late seventeenth century (Jones 1966:183–184). Four Indian towns are documented on tributaries of the Choptank River (Davidson 1982:6), north of the project area. In 1669, the 16,000-acre Choptank Indian Reservation was established that consolidated these towns, centered around Cambridge on the Choptank River.

The Choptank Reservation was large enough that it incorporated the towns as well as the traditional hunting territory up to the headwaters of the Little Blackwater and Transquaking rivers (Rountree and Davidson 1997). The reservation was within 3 miles of the northern border of Blackwater NWR, and it is possible that hunting forays extended onto refuge property. Rountree and Davidson (1997:128) estimate that the early seventeenth century population on this reservation was at least 130 people.

Piece by piece, the large Choptank reservation was sold to Euro-American settlers, some with knowledge and consent of the Native Americans, but much without (Rountree and Davidson 1997:147). In 1721, a new survey of the reservation was made and new terms for use established. From that point on, the Native Americans were permitted to use the land not sold up to that point, but they no longer held ownership. In 1792, when William Vans Murray was commissioned by Thomas Jefferson to record the Nanticoke language, he reported that most of the Native Americans had left to join the Iroquois (Mowbray and Rimpo 1987:5). The Choptank reservation was dissolved in 1799.

Local Native Americans have recently incorporated as the Nause–Waiwash Band, and are working on legal recognition and a history (Fitzhugh 1991). One local Native American recollected that their family’s seasonal patterns included living in Blackwater and the marshes in the winter, and migrating to Goose Creek and the Chesapeake Bay in the summer and fall (Chase 1992). It is unclear if this is a historical reference regarding contact period use of the refuge or evidence of later seasonal use of the refuge for hunting.

Settlers acquired land on the Eastern Shore rapidly. As early as 1665, only 6 years after the area was officially opened, almost 80,000 acres of land had been surveyed to be issued as grants. In 1666, Somerset County was created, and included what are now Somerset, Wicomico, and Worcester Counties. Dorchester County was established in 1668 and was primarily settled by people from the Western Shore of Maryland, unlike the Somerset County settlers, who primarily came from Virginia. Dorchester County was named for the Earl of Dorset, a family friend of the Calverts.

By the time Maryland was settled, Virginia colonists had shown that soil and climate conditions in the mid-Atlantic coastal plain were highly productive for the growth of tobacco, and that this crop could be very profitable. Tobacco farming required large plots of land, because it quickly depleted the soil of nutrients and crop rotation did not completely restore fertility (Carr 1987:6). Land in the Chesapeake region was relatively cheap and available during the seventeenth and early eighteenth century and most plantations were 200- to 250-acre tracts (Carr 1987:7).

Dorchester County historians Calvin Mowbray and Maurice Rimpo describe the early settlement of the county as beginning along the Choptank River, with at least eight tracts surveyed in 1659, then in the next few years land was acquired on James Island, Taylors Island, Little Choptank River, and Honga River (Mowbray and Rimpo 1987:6). Land was next surveyed along Blackwater and Transquaking rivers, and then the Nanticoke. Lastly, the interior of the county was surveyed. During the years from 1659 to 1668, approximately 170 tracts were patented in Dorchester County, many for residents of Calvert County, approximately 50 percent of whom did not develop the land, but sold it over the next 10 years (Mowbray and Rimpo 1987:6). Richard Preston was an early landowner on Barren Island who apparently used his 700-acre property for pasture (Mowbray and Rimpo 1987:92). He was a Dorchester County delegate to the Maryland assembly who lived on the property he owned near Cambridge.

A study by TRC Garrow Associates, Inc., encountered no direct evidence of any seventeenth-century through early eighteenth-century plantations on Blackwater NWR. A survey of rural cemeteries in the county by the Dorchester County Historical Society found only three in the county with pre-1700 dates, although a number of unmarked graves were found that could date to this period (Marshall n.d.). One early landowner on Blackwater NWR was Raymond Staplefort, the grandson of Raymond Staplefort, also spelled variously Stapleforte, Staplefoot, and Staplefoote in county records, the first Sheriff of Dorchester County. According to the USFWS site form for BLK–001H, either Raymond Staplefort (II) patented “Blackwater Farm” in 1750, or his father George did in 1726.

Numerous patents to Stapleforts are recorded in this area in the mid to late eighteenth century (Hester 1994:8). Deed records between 1780–1852 were lost in a courthouse fire and the deed string for BLK–001H has not been fully researched. Genealogy of the Staplefort family has been researched by several refuge staff members (Julie Barker and Jeanette Haas), however. Kammeyer (1980) reports that property known as Blackwater Farm was patented by Raymond (II), then passed to George, then to Thomas S., then to Thomas, then to William T., then to John C., and then to Zebulon Mitchell in 1866. This does not explain the presence of the earliest two graves in the Staplefort family cemetery (BLK–002G) though, which are those of Abraham Meekins (d, 1813) and Mary King (d, 1814). Hester also mentions that Dorothy Staplefort left farm land on the west side of Little Blackwater River to her granddaughter Dorothy that she received from William Woolford. Both Dorothys are buried in the cemetery near the house.

The Staplefort estate house was used by Blackwater NWR managers until 1992, when it became unsafe and was demolished (USFWS site form). The family cemetery (BLK–002G) located near the house is still fairly intact, and although the plantation house was reportedly constructed in 1752, interment dates range from 1813–1857 with most falling after 1829 (Marshall n.d.:6; Wilson and Kanaski 1990). The locations of other outbuildings that existed or were constructed during the twentieth century are recorded on the USFWS site form and on 1932 and 1934 maps on file at Region 5 in Hadley, Massachusetts. Twentieth-century construction in the area has impacted subsurface features in some areas, but archaeological features and deposits likely remain intact.

Evidence for one other eighteenth-century occupation (BLK–068H/18DO160) on the refuge exists from a site recorded and collected on a limited scale by Thomas Davidson, at that time the Lower Delmarva regional archaeologist for the MHT. He reported eighteenth century ceramics in the vicinity of a Late Woodland shell midden on Barren Island (BLK–047P). The artifact scatter is located on the east side of Barren Island on Tar Bay and is not associated with any above-ground features (USFWS site form). No structures are depicted in this location on the later 1877 map.

Probably the most famous Dorchester County native from the Civil War period is Harriet Tubman. Born on the Bordess plantation in Bucktown, she was originally called Armitta Ross, and was the daughter of one free and one slave parent. She began escorting slaves along the "underground railroad" in 1850 and returned to Dorchester County at least 11 and possibly as many as 30 times to accompany slaves (primarily friends and family) on their way north to freedom (Pierce 1995). Some of Tubman's methods for evading capture included varying routes, following drainages, avoiding roads, traveling at night, and sleeping in swamps during the day (Pierce 1995). She also preferred to leave on Saturday evening because newspapers were not published on Sundays and runaway notices could not be posted until Monday (Pierce 1995). By that time she and her group could be well into Delaware.

North of Camden, Delaware, the route she used has been well established and several safe houses are known (Bentley 1993). The route from Bucktown to Camden is not known, but it is thought that she followed the Choptank River, and she may have followed the Transquaking River to reach the Choptank River (Bentley 1993). Harriet Tubman's destination on these trips was Philadelphia, Pennsylvania but the original departure locations are not recorded. She specifically used a tactic to allow her a head start, however, and would have tried to get as far as possible before stopping to rest. It is unlikely that, even if the starting point were somewhere within Blackwater NWR, her party would have stopped the night within the boundaries of the refuge.

William Alvin Linthicum constructed a house from 1910–1915 west of the former Captain Linthicum residence on what is currently referred to as Hog Range. The Captain Linthicum tenant house and barns were demolished in the 1950's by W. A. Linthicum's nephew, Herb Asplen, who was farming the land at that time (USFWS site form). The William Alvin Linthicum house (BLK–026S) is still standing. Service archaeologists conducted limited surface reconnaissance in 1993 for several proposed projects in the vicinity of site BLK–026S. The locations of the former tenant house and two barns were identified and shown on a sketch map attached to the BLK–026S site form. The W. A. Linthicum House is a two-and-a-half-story farmhouse sitting on brick piers and oriented toward the road (Route 335). Bartons Creek that forms the western boundary of this property is now called Buttons Creek. On the 1932 map it is labeled as Hudson Creek.

One school and several residences were located along Key Wallace Drive in 1877, within property now part of the refuge. School No. 4 (BLK–009H) was located on the north side of Key Wallace Drive in 1874, but was apparently used as a single family home in the early twentieth century (USFWS site form).

Several residences, some that were probably tenant farms, were located on the south side of Key Wallace Drive in 1877, including the J. Coulson (BLK–008H), E. W. LeCompte (BLK–007H), C. Reditt (BLK–005H and BLK–063H), and Z. Mitchell (BLK–001H) houses. The Zebulon Mitchell house was previously owned by the Staplefort family and the USFWS site form records this site as Blackwater Farm. This site was described above as the initial occupation began in the eighteenth century. Zebulon Mitchell acquired the Staplefort farm from John C. Staplefort in 1866 (Kammeyer 1980). The Staplefort family cemetery (BLK–002G) is located north of the original residence location and dates primarily to the mid-nineteenth century. The cemetery was the focus of a study conducted in 1990 by Service archaeologists, who confirmed the locations of 19 graves, including two unmarked (Wilson and Kanaski 1990).

The J. Coulson Farmstead (BLK–008H) recorded on the 1932 map (McQueen 1932), included an L-shaped house and two outbuildings to the southwest. Two L-shaped structures with two outbuildings between them are depicted on a 1934 (Cassel 1934) map. This farmstead was impacted sometime shortly after this for the construction of the Civilian Conservation Corps complex. Three structures are shown on the 1942 (USGS 1942b) topographic map and probably include the J. Coulson main house. Refuge staff may have been using this house until 1942 (USFWS site form). This is also the location of the present-day Visitors Center and the entire area has been highly disturbed. The locations of the structures have not been determined by an archaeological investigation.

The LeCompte Farmstead (BLK–007H) is depicted on the 1932 map, (McQueen 1932) which shows the main house, one outbuilding and two wells. The 1934 (Cassel 1934) map shows the main house, six outbuildings, and three wells. The 1934 map is not tied to a known reference point, and the precise locations of structures have not been determined. No structures are depicted in this area on the 1942 (USGS 1942b) topographic map. The easternmost Reditt tenant house (BLK–063H) was removed by 1932. The westernmost Reditt tenant house (BLK–005H) was recorded on the 1932 survey map (McQueen 1932), which shows the house, a well, and an outbuilding.

Both Reditt tenant farms have associated cemeteries. The Wright Cemetery (BLK–006G) is located southwest of the westernmost Reditt house (BLK–005H) and contains the burials of Mary L. Wright and her daughter Mary E. Wright who both died in 1825 (Marshall n.d.:6). Field visits in 1992 and 1993 by Service archaeologists found no surface evidence of markers or an enclosure, but did find a scatter of bricks (USFWS site form). Refuge maintenance workers reported that a burial vault collapsed and was filled in. The Bell Cemetery (BLK–069G) is located south of the easternmost Reditt tenant house (BLK–063H) and contains the grave of Lawamanda Bell, who reportedly died on February 30, 1851. The location of this grave was verified during a field visit by Service archaeologists. The exact location(s) of Wright Cemetery interments have not been confirmed in the field, although the cemetery boundary is marked on a 1938 survey map (Taylor 1938).

East of Little Blackwater River is the Bucktown District. Four residences and a business shown on the Bucktown District map of 1877 are now within the refuge. The homes of D. Clash (BLK–024H), W.J. Elsey (BLK–034H), and George E. Austin (BLK–022H) are shown north of Blackwater River, on the southern edge of Green Brier Swamp, or possibly on an island in the marsh. A structure is depicted on the 1932 map (McQueen 1932) in the approximate location of the George Austin house and is labeled as a cabin on Waterbush Island. According to the BLK–022H site form it was known as Waterbush Island Camp. It is not known whether this site represents the correct location of the 1877 residence.

According to the Bucktown 1877 map, the W. J. Elsey Farmstead was situated northwest, and the D. Clash Farmstead was located north, of the George Austin place. The Service has assigned possible locations for these sites based on compass readings using the 1877 map. Neither has been confirmed by an archaeological or deed investigation. A 1941 appraisal attached to the site form for BLK–023H, a twentieth-century trappers shack on the same property as BLK–024H, describes a two-story frame house in poor condition. This house may also be the subject of several photographs taken before and during the construction of the Kuehnle Dike, which are included in the May–August 1953 Annual Narrative Report on file at the Visitor Center.

The house is shown at the end of the eastern, or left, fork of a farm road that extends southwest off of Bestpitch Road from Longfield. This location is a more likely candidate for the D. Clash Farmstead. According to the survey noted above, the correct location of BLK–023H (hunting camp) is on a point of marsh on Bear Garden Creek (now called Back Garden) opposite Pear Tree Island. The Dr. Phelps residence (BLK–027H) in Green Brier Swamp also is shown on the 1877 Bucktown District map. Two structures are shown on the 1942 topographic map in this location, but are not shown on the 1982 (USGS 1942b, 1982a) topographic map.

Two structures associated with Carter & Co. (BLK–035H) are shown on the 1877 map at a sharp curve in Maple Dam Road on the east side of Green Brier Swamp. Neither of these structures appears to be depicted on the 1942 topographic map (USGS 1942b), and it is unclear whether these locations are within the present refuge boundary. Hester (1994:15) reports that “there was a country store at Seward, just across the Little Blackwater from the present refuge headquarters, owned by Charles ‘Hallie’ Seward.” The residence of C. H. Seward is shown at the crossroads of Key Wallace and Maple Dam Road, in the area that is now called Seward. No other structures are shown nearby, and it is possible that Carter & Co. was their country store, but this has not been confirmed. The refuge boundaries around Green Brier Swamp include the location of one other 1877 structure, the residence of J. McGrath. The refuge also abuts several structures, including Colored School No. 2 and the residences of Thomas M. Meredith, B. Holt, J. Willey, and William Shorter.

The Hooper’s Island District map shows that Barren Island was moderately settled with 13 houses and one school in 1877. All of the residences are located near the shoreline; the only structure on the interior of the island is Schoolhouse No. 5 (BLK–046H). Most of the residences are situated on the east side of the island (BLK–036H/Mary Adams, BLK–038H/J. T. Creighton, BLK–039H/J. Dean, BLK–040H/G. Flowers, BLK–041H/C. Pritchett, BLK–044H/J. T. Creighton, BLK–048H/J. Aaron, BLK–050H/W. Aaron, BLK–051/W. Adams, BLK–052H/Mary Adams, BLK–054H/F. Flowers), and only two are located on the west side (BLK–037H/D. Johnson Farmstead and BLK–045H/J. Dean Farmstead).

None of these sites has been verified by field investigation, but archaeological investigation in the vicinity of BLK–044H, the J. T. Creighton Farmstead southern location led to the recording of site 18DO169. Gardner and Stewart (1977) found a scatter of historic ceramics, including gray stoneware, red earthenware, ironstone, and porcelain along the shoreline. Limited shovel testing failed to produce indications of any structures or artifact concentrations, and the researchers concluded that the J. T. Creighton Farmstead had eroded into Tar Bay. This is true for many of the locations of former structures on Barren Island. According to Service records, a cemetery (BLK–070G) was located west of the schoolhouse, but this is unconfirmed. No structure is depicted in the vicinity of site 18DO160, a prehistoric shell mound (BLK–047P) that also produced some eighteenth century ceramics (BLK–068H). Barren Island was abandoned by the 1920's, except for a gunning club (BLK–042S) on the northwest end of the island, now a ruin (Mowbray 1981:91).

Two residences are depicted on Spring Island on the 1877 Strait district map. These are the G. T. Walters (BLK–061H) and the S. Jones (BLK–062H) residences. This island was owned by Bishops Head Hunting Lodge, Inc. from 1967–1992 (USFWS site form). Neither of these sites has been verified through field investigation.

Three 1877 residences are depicted within the boundaries of the refuge in the Bishops Head area, none of which have been verified in the field. These are the G. Mills (BLK–057H), T. Mills (BLK–058H), and Captain A. Jones (BLK–059H) residences. Several other houses were located nearby and a school (No. 3) was located in what is now the Conservation Fund's demonstration forest. Most of the development at this point in time has occurred north of the refuge near the Bishops Head post office. The Bishops Head post office was in operation from 1860–1947 (Mowbray and Rimpo 1987). All three of the residences within the refuge are situated on the water, but most of the rest of the houses on Bishops Head are oriented along the roads. Settlement on the islands between Bishops Head and Spring Island and east of Barren Island was water-oriented.

In 1927, Delmarva (also spelled "D-e-l-m-a-r-v-i-a" in some references) Fur Farm, Inc., a Delaware firm, purchased a large tract of land in the Blackwater River area to lease sections to farmers and trappers. Land was purchased from Charles and Margaret Seward, Ernest H. Burns, Chester C. Housh, and Wilbert Rawley (Kammeyer 1980). This 8241-acre tract became the original part of the newly created Blackwater River Migratory Bird Refuge when it was conveyed to the Government in 1933 by means of condemnation. Delmarva Fur Farm, Inc. retained timber, farming, and trapping rights on the refuge for the remainder of the decade (Hester 1994:24). No information regarding this company was found during the research for this project. According to the Delmarva Fur Farm, Inc. president, C. Albert Kuehnle, when the 8241-acre tract was conveyed it included seven farm residences with associated outbuildings (four unoccupied and all but one in poor condition) and four trapper cabins (Kammeyer 1980). Fur trapping continued on the refuge, and in 1975 it was reported that nutria make up one-half of Maryland's annual 500,000-fur catch (Anonymous 1975).

The mounds of oyster shells generated by local packing plants proved to be an excellent surface for roads, but road construction proceeded slowly, and in the early twentieth century, most of Dorchester County was still characterized as rural with scattered, isolated farmsteads. Water travel by small craft was still an efficient means of local transportation within the refuge area. Settlement density declined along Blackwater River after the establishment of the refuge.

One other twentieth century site is recorded on the refuge, BLK–003S, or Quarters 2. It is described on the site form as a typical house and garage of the second quarter of the twentieth century. This site is located north of the cemetery (BLK–002G) associated with the Staplefort House (BLK–001S). The date of construction is not known, but it is not shown on the 1932 survey map (McQueen 1932) or the 1933 sketch map of Site BLK–002G and BLK–001H.

The “Blackwater Migratory Wildlife Refuge” was created in 1933, and the initial improvements were performed by Civil Conservation Corps (CCC) workers under the supervision of Army officers (Hester 1994:26). The CCC established a headquarters (near the present-day Visitors Center) and built roads, dug ditches, and excavated a dike. The headquarters was constructed on the former J. Coulson Farmstead (BLK–008H), impacting that site, also impacted later by the construction of the Visitors Center.

Agricultural lands on Blackwater NWR were leased to local farmers until 1989, when the refuge staff took over farming activities in an effort to attract waterfowl. Improved water control systems have been constructed, including miles of dikes and freshwater impoundments. Other improvements were directed at the human visitors to the refuge, and include a Visitor Center and Education Building, Headquarters Office, foot trails, Wildlife Drive, and parking areas.

Cultural Resources

Several Federal laws required Federal agencies to locate and protect historic resources (archaeological sites and historic structures eligible for or listed in the National Register of Historic Places) on their land or on land affected by their activities. In Region 5, the Regional Historic Preservation Officer oversees compliance with these laws and consults with the Maryland Historical Trust when necessary. This legislation keys site preservation to National Register of Historic Places eligibility, a measure of the site or structure’s quality. Federal agencies are also charged with locating, evaluating and nominating sites on their land to the National Register.

Blackwater NWR and the Barren Island, Bishops Head and Spring Island Divisions of the Chesapeake Island Refuges.—Information about archaeological sites and historic structures at Blackwater NWR comes from two sources.

Our Region 5 Archaeological Site Inventory and cultural resource project files provide the location of prehistoric and historic archaeological sites discovered during limited archaeological surveys of proposed project locations on the refuge. In addition, the site inventory contains locations of nineteenth century structures based on an 1877 map of the area. Most of these locations have not been confirmed in the field. Because the refuge predates historic preservation laws, the Region 5 Real Property Inventory also provides information about, and photographs of, refuge structures that have been removed and demolished.

The second source of information about Blackwater's cultural resources is a set of sensitivity maps showing the probability of cultural resources being located on various Blackwater land forms. These maps were developed to assist in long term planning for the refuge, and incorporate information about landscape changes through time. In 1997, TRC Garrow Associates, Inc. conducted a cultural resource reconnaissance study of the Blackwater NWR to provide information about archaeological sites and landscape formation on the refuge. The reconnaissance survey consisted of a literature review and limited field survey for archaeological sites and palaeoenvironmental information. Their report, "Archaeological and Geomorphological Reconnaissance at the Blackwater National Wildlife Refuge, Dorchester County, Maryland" was submitted in final in May 2000. This document includes the sensitivity maps mentioned above and specific site locations of historical and archaeological sites on Blackwater NWR, Barren Island, Bishops Head, and Spring Island.

Blackwater NWR

Blackwater NWR contains nine known prehistoric archaeological sites, and 60 historical archaeological sites. Because no comprehensive subsurface archaeological survey has been conducted, these known sites are likely to represent only a small subset of all preserved sites on the refuge. Seven of these prehistoric archaeological sites have been reported by collectors or identified during inspections of the ground surface by archaeologists. Two additional prehistoric sites were located during subsurface testing as part of the Garrow study.

There is little information about the quality or character of the seven original prehistoric sites, and not enough information to evaluate the National Register eligibility of the sites. Six of these seven original sites are on Barren Island. Changes in the shore line of Barren Island mean that at least four of these Barren Island sites are likely to have been inundated or damaged since they were reported in 1985. The condition of these six sites has not been checked since they were reported 15 years ago. The seventh original prehistoric site is in an 85-acre field which extends deep into Green Briar Swamp. This site is known only through finding an undated projectile point on the surface. Surface inspection of the site as part of the TRC Garrow study yielded no new artifacts, and showed no signs of disturbance.

One of the two newly discovered prehistoric sites, 18DO399, which has Late Woodland Period (A.D. 900–1600), nineteenth, and twentieth century components, is likely to be eligible for the National Register, based on work done there by TRC Garrow Associates as part of their reconnaissance study. This means the site is likely to contain important information about prehistory. The site is at least 60 X 165 meters in extent, and a radio carbon date on charcoal from a basin shaped feature has been calibrated to a range of A.D. 1275–1425. The site is contained in deposits likely to have formed through river and estuary deposition activity.

Almost half of the known prehistoric archaeological sites in the vicinity of the refuge date to the Woodland Period, characterized by more sedentary village life and maize agriculture (Millis et al.,1998:78). Until about A.D. 1250, the climate was unusually warm and sea level was similar to today. Between A.D. 1250 and 1900, global climate was cyclically colder than today. This affected the Atlantic Slope and thus, Blackwater NWR. Sea level during the period of this Late Woodland site's occupation was lower than today by 2 or 3 feet. Thus, the time when the site was occupied was a period when the refuge was more suitable for human habitation than today. At the time of occupation, the site was along side fresh water, and remains contain no evidence of shellfish harvesting.

The second newly discovered prehistoric site at Blackwater, 18DO400, seems to contain few artifacts. A flake of quartzite produced during tool making and a worn sherd of Middle to Late Woodland Period pottery are the only artifacts. These artifacts had been disturbed by plowing, but limited testing at the site was not enough to evaluate the site's eligibility for the National Register.

Most of the 60 historical archaeological sites in the Archaeological Site Inventory are believed to exist based on an 1877 map. Most locations have never been confirmed in the field. In addition to these inventoried potential nineteenth century sites, there may be unlocated seventeenth and eighteenth century historical archaeological sites at Blackwater, as well.

The Eastern Shore was open to patenting in 1659, but period maps indicate that most settlement was along the Bay shore and the lower reaches of major drainages until the eighteenth century (Millis et al., 1998:83–84). Maryland's Eastern Shore was settled by Anglo-Americans from the Western Shore, driven by the need for fertile well drained tobacco farming land. The land along the Blackwater and Transquaking Rivers was surveyed for sale a few years after1659. Barren Island was used for pasture by an owner living in Cambridge. By 1673, plantations along Parson's Creek and Slaughter Creek may have extended into the refuge (Millis et al., 1998:84). Because early transportation was by water, sites related to these plantations would have been oriented to the rivers and creeks, rather than nineteenth and twentieth century roads. No historical archaeological sites or structures sites on the refuge are known to date to this period.

Blackwater contains two confirmed eighteenth century archaeological sites. By the eighteenth century, perhaps as early as 1726, the Stapleforts were farming on the refuge, on the bank of the Little Blackwater River. Twenty seven other eighteenth century patents included refuge land. The Staplefort "Blackwater Farm" site is BLK–001H. The site is likely to contain intact archaeological deposits, even though there has been twentieth century disturbance. By the early eighteenth century, Maryland farmers used slaves for labor, and as yet unlocated slave quarters and cemetery may be part of BLK–001H. A 1794 map shows Routes 16, 335, and Key Wallace Drive traversing what is now the refuge. Subsequent change in sea level means that some formerly habitable locations along these roads and elsewhere in the refuge may now be poorly drained or submerged. In addition to the Staplefort site, Blackwater contains an eighteenth century site in the vicinity of a Late Woodland Period prehistoric shell midden (18DO160 or BLK 047P/068H) on Barren Island.

Martin NWR

Before about 8000 years ago, Smith Island was an upland area west of the paleochannel of the Susquehanae River. Archaeological sites from the Paleoindian Period and Early Archaic Period on what is now Smith Island are known only from collections made by non-professionals. No professional archaeological surveys of the island have been completed.

Archaeological site inventory records at the Maryland State Historic Preservation Office contain information about 15 archaeological sites on the refuge. Four of those sites are prehistoric, located along the shore of the island, and contain Archaic and Woodland Period remains. One of the four prehistoric sites also contains the remains of nineteenth-century Historic Period occupation.

Eleven Historic Period archaeological sites are known, nearly all on the west shore of the island. Three of these Historic Period sites are known to date to the 18th century. The remaining sites are so far only known to date to the 19th century. The shoreline locations reflect not only a preference for access to the Bay's resources, but also the visibility of eroding sites on the shore. Work by the Service and a Maryland State Historic Preservation Office intern has not been detailed or systematic enough to evaluate the eligibility of the site for the National Register. The current condition of the other 14 sites is not known.

The changes in the environment of the refuge through time means that prehistoric people used the refuge for different purposes at different periods. Prehistoric hunters may have hunted on the refuge, and campsites at former ridge saddles and stream mouths may still exist in today's marshes and islands in the marshes. These sites will be difficult to locate with standard archaeological survey practices, but may continue to be exposed and destroyed by shoreline erosion.

During the Revolutionary War, many Smith and Tangier Islanders were loyalists. The island was known as a haven for Tories, deserters and escaped prisoners. Tory picaroons and British ships foraged for provisions on Smith Island, and American ships punished islanders for disloyalty. About 1780, the Maryland Council constructed a fleet of shallow draft, 25 man barges capable of carrying oars, sails, and guns. In November, 1782, the British defeated some of these Americans in the Battle of the Barges in Kedges Strait, on the north end of Smith Island.

Solomon Evans watched the battle from a tree on what is now the refuge, at that time his family's farm. As subsidence, sea level rise, and human excavation of channels created more open water, reduced the amount of well drained land, and reduced the size of the island, late eighteenth century house and farm sites in the interior tended to remain occupied. Comparison with maps of the late nineteenth century shows that interior farm sites from that period are recognizable on modern aerial photos as hummocks with trees such as hackberries. It is likely that the interior hummocks on the refuge contain as yet undocumented historic archaeological sites. Many shoreline historic sites have been lost to or damaged by erosion, however. In addition, marsh has overtaken much of the well drained land of the eighteenth and nineteenth century. It is likely that some farm sites and fishing and processing locations are now under water or marsh.

From the early 19th century on, two lighthouses were operated at Fog Point and Solomon's Lump. Both locations are now off shore. One early lighthouse keeper, Lorenzo Dow Evans, participated in documenting bird kills during migration periods, assisting in early migratory bird research. His records are exhibited at Patuxent Research Refuge in the National Wildlife Visitor Center. There are no known remains of the lighthouses, and their sites are not likely to be within the Service's current ownership.

By 1820, New England had so depleted its oyster beds that the Chesapeake Bay became a profitable source to harvest and market oysters in the North (Horton 1996:43). This activity peaked in Maryland in 1886 (Horton 1996:44). The refuge shore may contain evidence of early oyster processing operations from this period.

The refuge owns one structure in the village of Ewell on Smith Island. The 1916 Charles D. Middleton house has been altered, including replacement of its windows. The Regional Historic Preservation Officer feels the house is unlikely to be eligible for the National Register. It is currently used as an education and interpretation center for the refuge.

Susquehanna NWR

Susquehanna NWR has no known archaeological sites. The U.S. Coast Guard owns the National-Register-listed Fishing Battery Lighthouse, located on a portion of Battery Island that the Department of Commerce retained when the refuge originally was established.

Socioeconomic Environment

Regional Overview

On satellite photographs taken at night, an arc extending along the Atlantic coast from Richmond, Virginia to Portland, Maine, shows as an almost unbroken band of lights from developed areas. More than 70 million people live within that band. The Delmarva Peninsula, containing Delaware and the eastern shores of Maryland and Virginia, is the only relatively rural, undeveloped area remaining in that urban band of development. The total population of the Delmarva Peninsula, by the 1990 census; including Wilmington, Delaware, the largest city; was fewer than 850,000 people.

Table 33. Delmarva Peninsula population statistics (1990)

Area (mi.^{2})	by State	Population	Density†
1,978	Delaware*	548,104	277
3,050	Maryland	277,432	91
696	Virginia	43,446	62

* includes population of Wilmington
†people/mi^2

On the Delmarva Peninsula, we will focus on those counties that compose the watersheds of Marshyhope Creek, the Blackwater, Little Blackwater, and Nanticoke rivers, and the island communities of Smith Island; Caroline, Dorchester, Wicomico, and Somerset Counties in Maryland; and Sussex County in Delaware. We will discuss Dorchester and Somerset Counties in greater detail, because they contain the existing Blackwater and Martin NWRs. Harford County in Maryland, Kent County in Delaware, and Watts Island in Virginia contain only very small percentages of the study area, and so are not discussed.

European colonists and their descendants have populated, farmed, logged, and otherwise altered the Eastern Shore for more than 300 years. Before that, Native Americans lived on the Delmarva Peninsula and affected the landscape for thousands of years. With humans providing such a long, varied, and continued impact on the study area, it is important that we understand the past, present, and future human context.

Table 34. Eastern Shore population statistics

County, State	1990	1995	2000	2005	2010	2015
Caroline, MD[1]	27,035	29,050	30,600	31,800	32,900	33,850
Dorchester, MD[2]	30,236	30,000	30,360	30,600	30,800	31,060
Wicomico, MD	74,339	79,400	84,000	88,400	92,600	96,500
Somerset, MD	23,400	24,515	25,630	26,810	28,055	
Sussex, DE[3]	60,525		71,350		81,126	

[1]The numbers for 1995–2015 are projections from June 1995 by the Maryland Office of Planning. The population estimates for all counties from 1995 on are not in line with actual numbers (see following table). The 1995 estimated population for Wicomico County was not actually reached until 1998. Dorchester's current population is lower than its 1990 level.
[2]1995–2015 from the Maryland Office of Planning, Planning Data Services (revised 8/98)
[3]Population projections within the Nanticoke or Blackwater River watersheds based on available Delaware data (1990 population of entire Sussex County is 113,229)

Land development on the lower Eastern Shore is driven by geography, transportation routes, and proximity to metropolitan areas. Major transportation corridors are the key to development growth in the area; counties showing most growth are in the Upper Shore area, including Caroline County in Maryland. Over the past three decades, the Upper Shore area grew at greater rates than the other Eastern Shore counties. They serve as bedroom areas within a 1-hour commute of the employment centers of Baltimore, Washington, or Wilmington. Consequently, the demand for rural and residential land in these areas is increasing.

Table 35. Lower Shore population statistics

County, State	Population 1980	1990	1996	1998	2000	Percent Change	Area (mi.^{2})	Density (2000)*
Caroline, MD	23,143	27,035	29,113	29,489	30,600	23.2%	321	90.7
Dorchester, MD	30,623	30,236	29,933	29,503	30,360	-0.8%	594	50.4
Wicomico, MD	64,540	74,339	79,010	79,367	84,000	30.1%	380	207.9
Somerset, MD	19,050	23,440	24,515		25,630	22.3%	330	76.3
Sussex, DE		60,525			71,350	17.9%	414	172.3

* Density within the Nanticoke watershed based on 2000 population projection and percent change from 1990

Access to and through the peninsula is afforded by the transportation corridors of U.S. Routes 50 and 13, Interstate 95, and Maryland Route 404. These routes link the Baltimore–Washington metropolitan areas on the Western Shore to the Maryland–Delaware seacoast. Because of commuting distance and time, Dorchester County is at the extreme southern limit of daily western shore commuters. For the amenities afforded by waterfront living and recreation, as well as the lower density of population, people have sought locations in the mid-shore and lower shore areas for retirement homes and secondary or recreational homes.

Aesthetic Environment

> "A faire Bay compassed but for the mouth with fruitful and delightsome land. Within is a country that may have the prerogative over the most pleasant places of Europe, Asia, Africa or America, for large and pleasant navigable rivers. Heaven and Earth never agreed better to frame a place for man's habitation."—Captain John Smith

No one has captured better the essence of the Bay and its character than its principal discoverer, Captain John Smith. Each refuge contributes to the spectacular aesthetic qualities of the area: expansive, lush green marshes; fantastic sunsets; long waving skeins of Canada geese honking on a crisp, clear autumn morning; or an American bald eagle perched atop a dead snag, white head glistening. These are a few of the many images and scenic values that invoke strong feelings associated with Blackwater, Susquehanna, and Martin NWRs and the Eastern Shore.

The charm and beauty of the area are magnets for both natives and outsiders. The area is also attractive to writers, film makers, and artists, who are generous in their praise. They recognize these areas for their location in time, space, and culture; their characteristic combinations of land and water; and their old fashion values and modern technology. Writer Tom Horton characterizes the area as "not so much about its abundance of nature; rather, its juxtaposition of the human and the natural; and even more to the point, the fact that it had achieved a balance between them."[14]

Wilstach (1931) describes the area as follows.

> "Open the door and an abundant table is the great tradition. In the social garden, the perennial bloom seems to have been hospitality. Here are not only the gift of field and orchard and garden; but the bay country seems, even from the time that Captain John Smith first sampled the succulent 'oisters,' to have been always a sanctuary of self-replenishing food-life. The depths of the waters have been prolific in a variety of shell and finny fish. Along the tide-soaked banks has lurked the traditional terrapin. Above them fluttered an endless variety of wild winged game. One may smile, but it can not be otherwise than tolerantly, so meaty is the kernel of fact, when one hears it said that here every farm, at its garden gate, has an oyster-bed, a fishing-bar, and a ducking blind. It is a beckoning region. It opens trails of glowing romance in so many directions; sometimes historic, sometimes legendary; nearly all leading along paths of our own first national footsteps."[15]

County Descriptions

Caroline County

Caroline County, Maryland, lies in the upper northwestern portion of the Nanticoke River and Marshyhope Creek watershed. The county is bounded on the north by Queen Anne County; on the west by the Tuckahoe River and Talbot

Table 36. Mean income

County	Family Households	Non-family Households	Poverty Level[1]
Caroline, MD	$30,071	$17,515	12%
Wicomico, MD	$40,860	$20,307	8%
Dorchester, MD	$34,077	$15,526	13%
Somerset, MD	$24,225	$??	??%
Sussex, DE	$36,061	$18,331	12%

[1]All households

[14]Need footnote citation here.

[15]Need footnote citation here.

County; on the east by the State of Delaware; and on the south by the Choptank River and Dorchester County.

Caroline County is primarily a rural agricultural community that focuses on grain and vegetable crop production. However, since Bay Bridge opened, the county also has served as a bedroom community to Baltimore, Washington, D.C. and Wilmington. The linking of Maryland Route 404 to U.S. Route 50 at Wye Mills enabled a boom in county population, connecting it to those major metropolitan areas as well as to the seacoast areas of the peninsula. The population of the county within the Nanticoke watershed is expected to grow at a rate of about 12 percent over the 30-year period from 1990 to 2020.

Table 37. Sources of income

County	Wage and salary	Non-farm self employment	Farm self employment	Interest, dividend,	Social Security	Public assistance income	Retirement income
Caroline	75	14	7	32	34	10	15
Wicomico	78	12	2	33	27	6	15
Dorchester	77	11	5	24	32	7	14
Somerset							
Sussex	75	10	5	28	31	8	18

[1]Percentage of all households with any income from each source

Its total land area (excluding water acreage) is 205,383 acres, with approximately 20 percent, or 40,337 acres, within the Blackwater and Nanticoke rivers watershed. The predominant land use is agriculture (57 percent), then forest (38 percent), and urban or residential (4.5 percent). Some industry is located in Denton and Federalsburg, and manufacturing accounts for about 21 percent of total employment.

On a percentage and acreage basis, change in land use is greatest in Caroline County, of all Maryland counties within the watershed. Development pressure, particularly along Marshyhope Creek, is expanding rapidly; approximately 6.7 percent of the agricultural and forest land has been converted to residential or urban use since 1973.

Dorchester County

Dorchester County, Maryland, is the watershed for the Blackwater and Little Blackwater Rivers, much of Marshyhope Creek, and the lower reaches of the Nanticoke River. Located in the southwestern portion of Maryland's Eastern Shore, it is bounded on the north by the Choptank River and Talbot and Caroline Counties; on the west by the Chesapeake Bay; on the south by Bloodsworth Straits and Tangier Sound; and on the east, by the Nanticoke River, Wicomico County, Maryland and Sussex County, Delaware. The county is virtually surrounded by water, except for the point of “attachment” in its northeast section.

Table 38. Counties employment by industry percent[1]

Industry	Caroline	Wicomico	Dorchester	Somerset	Sussex
Agriculture, Forestry and Fisheries	6	4	9	18	6
Mining (sand and gravel)	0	0	0		0
Manufacturing (durable goods)	8	7	14	5.1	5
Manufacturing (non-durable goods)	19	8	17	5.1	18
Construction	8	8	9	5.1	10
Retail trade	16	18	11	13	16
Wholesale trade	5	5	4	7.2	4
Finance, Insurance, Real Estate	4	5	2	4.1	4
Health Services	6	9	8		8
Educational Services	5	9	5		6
Other Services	11	14	9		13
Other	12	13	12	3.1	9

[1]Percent of employed persons 16 years and older

U.S. Route 50 connects Cambridge, the county seat, to the Baltimore–Washington area and to the Maryland seacoast. The extension of Maryland Route 16 west of Cambridge and the Cambridge–Vienna section of Route 50 separate “North Dorchester” from “South Dorchester”. The division of the county is due to geographic differences that also affect the extent and nature of development and the use of the land. Prime agricultural soils, those most easily converted to residential or industrial development, are found in North Dorchester. Not surprisingly, most new residential development is also in North Dorchester County, in the Cambridge–Hurlock corridor.

The county’s population has been growing very slowly, with a 3-percent increase from 1970–1990. Population decreased slightly from 1980 to 1990. The only portions of the county with significant population gains between 1970 and 1990 were in North Dorchester. With the exception of Hurlock and Secretary, all of the incorporated towns lost population between 1970 and 1990. Most portions of South Dorchester had a more than 10-percent loss of population between 1980 and 1990. Many districts had a more than 30-percent population loss between 1970 and 1990. The 1990 census characterized 92.9 percent of the population as rural in nature, and of that, 5.4 percent were on farms, and 7.1 percent were considered urban. Although the Blackwater and Nanticoke rivers watershed spans 67 percent of the county, it contains only 30 percent of the population.

Compared to other Maryland counties, Dorchester County is relatively poor. Dorchester has a higher proportion of low and moderate income households and a lower effective buying income. In 1990, 14 percent of the population was below the poverty level. The county’s housing stock is older, and housing values are lower compared to other counties. A higher proportion of homes are substandard.

The county’s economic problems include an estimated 1,150 manufacturing and warehouse jobs that have been lost since 1986. Non-manufacturing employment has increased in recent years, but has not made up for that loss. The county’s unemployment rate was 9.8 percent in 1993, up from 7.6 percent in 1990. The Statewide unemployment rate was 6.2 percent in 1993. Dorchester County’s share of regional employment fell from 20 percent in 1971 to 15 percent in 1992. Competing job opportunities, decreasing yields, and increasing operating expenses resulted in the decline of farming, forestry, and fishing occupations. Social problems have been cited as contributing to labor force quality problems and lagging incomes.

Table 39. Dorchester County land use[1]

Land Use	Acres	Percent
Residential	9764	2
Non-residential[2]	2389	1
Agricultural	107,426	30
Forest	143,878	41
Extractive/Barren	342	>1
Wetland	86,507	25
Total	**350,306**	**100**

[1]1990
[2]Commercial/industrial

Dorchester's two industrial parks are located in the incorporated towns of Cambridge and Hurlock. Approximately 1900 acres are zoned industrial in the unincorporated parts of the county.

Agriculture is a key industry for Dorchester County, which ranked 7th in value of products produced in Maryland. According to the 1992 Census of Agriculture, Dorchester's 347 farms (123,762 acres) covered one-third of the county's land, down from the 438 farms (139,416 acres) in 1982. The total value of all agricultural products sold exceeded $64 million, the most valuable products being poultry and poultry products, followed by soybeans, corn, and wheat. Fresh vegetables, aquaculture, and watermelons, and hogs are also important. Approximately 500 farm employees earned more than $3.3 million. In 1992, 3,170 acres were enrolled in agricultural preservation districts, and 1,303 acres were protected from development by perpetual easements. With the advent of the Rural Legacy Program and other incentives, thousands of additional acres have been protected from development in recent years.

Historically, woodland and forest products have been important to Dorchester County's economy. Ninety-eight percent of the forest land is privately owned: 40 percent by farmers; the remainder, by industry and private individuals. Loblolly pine is the principal commercial timber species because it grows rapidly and straight. A local forestry board, appointed by the secretary of the State's Department of Natural Resources, reviews timber harvest plans within the Chesapeake Bay Critical Areas. Outside the Critical Area, forest resources are protected primarily through non-tidal wetlands regulations and the county's forest conservation ordinance. Loss of forest land to crop farming has declined, and the size of the county's forest resources has stabilized.

Table 40. Dorchester County land and water area

Area	Acres	Percent
Water (excluding wetlands)	278,800	44
Land	350,300	56
Total	629,100	100
Chesapeake Bay Critical Area	176,600	50*
Wetland (tidal and non-tidal)	86,500	25*

* percent of land area

Sand and gravel are the county's only mineral resources. Areas of potential sand or sand and gravel are located mostly in North Dorchester, and south of Vienna to Henry's Crossroads. The sand and gravel industry grew from one operator in 1966 to seven in 1992. Most operations are north of Route 50. As of 1994, 220 acres were under permit form mining and 111 acres were actively being worked.

Tourism has significant potential in contributing to Dorchester's economy. Compared to other counties in Maryland, Dorchester ranked 21st out of 24 in terms of expenditures by travelers. The Offices of Tourism and Economic Development estimate that Blackwater NWR generates approximately $15,000,000 annually, or almost 90 percent of the county's tourism revenue. The new Sailwinds Park and Hyatt Conference Center will undoubtedly have a significant effect on the county's tourism industry in years to come.

Table 41. Dorchester County forest statistics

Total forest area[1]	162,000 acres
Commercial forest area (% of county)	141,000 acres (40%)
Predominant tree species (% of forest)	loblolly pine (3%) oak–pine (28%) hardwood (41%)
Value of standing saw timber	$43.9 million
Number of forest landowners	2,200
Number of tree farms[2]	64
Number of forest industry jobs	150

[1]1995
[2]1980

Approximately 60 percent of Dorchester County lies in the 100-year flood plain. Most of that is tidal flood plain. As of 1990, 15 percent of the county's population lived in the flood plain.

At 350,300 acres of land, Dorchester County is Maryland's largest county. Dorchester has large natural resource areas, including substantial coastal areas, wetlands, forests, and agricultural lands. The county is characterized by open, natural, agricultural, and forested areas. Only 3 percent of its land is developed. As shown in the tables above, its developable land area is small, compared to the entire county.

Wicomico County

Wicomico County, Maryland, is bounded on the west by the Nanticoke River and Dorchester County; on the north by the State of Delaware's Sussex County; on the east by the Pocomoke River and Worcester County; and on the south by Somerset County and Tangier Sound. Salisbury, the county seat, is located in the center of the county, at the intersection of U.S. Routes 50 and 13. Due to its location at this major intersection, the city has grown in commerce and industry, and social and cultural development. It is the area's transportation and industrial center. The population of the county is nearly 80,000 persons, while more than 40,000 persons live in the Salisbury metropolitan area.

People in Wicomico County make more money and are less likely to be below the poverty level compared to other counties in the study area. This comparative wealth likely is due to the growth and prosperity of Salisbury.

Somerset County

Somerset County, Maryland, is the southernmost county on Maryland's Eastern Shore. It lies along the Chesapeake Bay side of the peninsula and its county seat, Princess Anne, is 14 miles south of Salisbury, approximately 120 miles southeast of Baltimore, and 100 miles north of Norfolk, Virginia, via the Chesapeake Bay Bridge Tunnel. The county has a land area of some 330 square miles, including several islands in the Chesapeake Bay. The county's northern and southern boundaries are the Wicomico River and Pocomoke River, respectively.

The county is strategically located to take advantage of a number of opportunities for both development and conservation. Crisfield is important as a fishing, shipping, and tourism center, while Princess Anne's significance as the historic country seat lies in its potential to attract businesses and tourism. To the northeast and southwest of Princess Anne, respectively, are the campus of the University of Maryland (Eastern Shore) and the new State Penitentiary. The county's proximity to Salisbury, Pocomoke, and Ocean City is both an advantage in terms of the availability of services, as well as a disadvantage in terms of the net migration of jobs out of the county. The county depends on Routes 13 and 413 as its lifelines. Route 13, in particular, channels thousands of regional vehicle trips a day through the county en route from New York and Philadelphia to Norfolk and the south.

Somerset County has a shoreline of more than 600 miles along the Chesapeake Bay, and its character varies from fishing communities and summer homes, to marshland and wilderness. Several peninsulas, or necks, extend into the bay separated by meandering rivers. From north to south the necks are: Victor Neck, Monie Neck, Revells Neck, Manokin Neck, and Crisfeild Peninsula. The principal rivers are the Wicomico, the Manokin, which has its source in the vicinity of Princess Anne, and the Pocomoke. The interior of the county is generally flat, with good agricultural soils punctuated by areas of poorly drained wetlands. Somerset County also includes South Marsh Island, Smith Island, and Janes Island in the Chesapeake Bay. Only Smith Island is inhabited, with settlements at Ewell, Rhodes Point, and Tylerton.

Somerset County experienced major changes in the 1980's. The traditional water-oriented economy has declined in part due to changes in the ecology of the Chesapeake Bay itself. Development pressures have continued in bayfront communities. Development pressures have also increased in the Routes 13 and 413 highway corridors, bringing major increases in traffic. Throughout the 1970's and early 1980's, however, Somerset County's population declined. During the late 1980's, the population began to increase, and a steady growth rate has continued since.

In 1989, roughly 33 percent of the population was concentrated in the Crisfield area, 22 percent in the Princess Anne area, and the remaining 45 percent distributed throughout the county. Within the incorporated limits of the county's main centers, Princess Anne had 1,590 residents, and Crisfield had 2,830. According the 1980 Census, African Americans constituted 34.5 percent of the population, down slightly from 37.5 percent a decade earlier. Other minorities totaled less than 1 percent.

The median age of county residents in 1980 was a relatively high 32.1 years. Birth rates were lower, and death rates were higher than the State averages, the county's per capita income is roughly two-thirds of the State average. Household size has steadily declined. Many of these statistics reflect the declining rural economy. Future trends may be toward an expanding urban economy based on service industries, tourism, and aquaculture, rather than fishing, agriculture, and food processing.

Tourism represents a major opportunity to create new jobs. The county is rich in waterfront amenities and rural viewscapes, including pristine salt marsh and wildlife management areas. In addition, it boasts historic and cultural traditions dating from the 17th century. More than

400 historic and cultural sites are located in the county, and 60 of these are on the National Register of Historic Places.

Table 42. Counties land use by percent[1]

Land Use (Percent)	Caroline	Dorchester*	Wicomico	Somerset*	Sussex	**Total**
Agricultural	57	30	41	30	53	52
Forested	38	41	55	38.1	44	45
Urban	4	3	3	3.8	3	3
Total	**99**	**74**	**99**	**71.9**	**100**	**100**

[1]Based on actual watershed acreage, *excluding* water and wetlands
*Dorchester and Somerset Counties are 25% and 29.1% wetlands, respectively.

Smith Island.—Perhaps the most unique and charming place in Somerset County is Smith Island. The culture and society of Smith Island, the location of Martin NWR, is deeply rooted in its ancestry. The independent and pioneering spirit that brought the first settlers almost 350 years ago still prevails. Today's Smith Islanders are not completely isolated from modern society, but their way of life is so unique, and their traditions are so strong that they remain a world apart. Smith Island has no formal government. There are no police, and no need for them. There were no street names until recently. The church is the center of life on the island, and much of the social life on the island is organized around the church. The church, through annual tithes from the members and even non-members, handles such civic responsibilities as maintaining public areas. Water supply is handled by several independent companies formed by a few families joining together to dig a well.

Nearly all the permanent residents of Smith Island depend on the seafood industry for their livelihood. Seafood is harvested and either processed locally or packed for shipment. Although crabs dominate, oysters and clams are also harvested and shipped across Tangier Sound to Crisfield. The return trips yield supplies and petroleum. There are an estimated 150 commercially used boats on Smith Island. Fifty come from Tylerton, 30 from Rhodes Point, and 70 from Ewell. Sixty percent of the boats are “tongers” or oyster vessels, and 40 percent are “scarpers” or crab boats. In practice, 80 percent of the boats are used for both oystering and crabbing. While there is no other industry on the island, a museum, restaurant, and gift shop cater to the seasonal tourists disembarking from the tour boats from May to October.

Each town has a distinct character. There is pride within and rivalry among the three towns. Ewell, the most populated with more than 200 residents, and is considered the unofficial capital city and the most metropolitan. Ewel1 is home to the new visitors center, restaurants, a gift shop, and bed and breakfast lodging facilities. Ewel1 is connected to Rhodes Point by road. Along the road between the two towns, there is an incinerator and a waste treatment facility that is shared by both towns. Rhodes Point is built along a single road. It is the second most populated town with approximately 100 people. Rhodes Point is the most endangered of the three towns due to its proximity to the open Bay.

Rhodes Pointers are required to travel to Ewell for many of their amenities; however, the Marine Railway, a boat-building and repair facility is located at the southern end of Rhodes Point. Tylerton is the most isolated, being separated from the other communities and accessible only by boat. It is said that Tylerton may be the most devoutly religious of the towns. Cars are a rarity there, but bicycles, golf carts and cats are not. Mail is delivered by boat to the post offices at Ewell and Tylerton; mail for Rhodes Point is routed through the Ewell post office.

Each of the towns is indeed unique unto each other, and undeniably unique compared to the rest of modern society. The life of an islander is filled with hard work. The men are up at 3 a.m. to get an early start on the water. The women pick crab meat, maintain the households, and help cultivate the soft shell crabs in the shanties. Most of the residents are descendants of the original settlers. In recent years, the population has been shrinking at an accelerated pace.

A major contributor to this trend is the feeling that the island and its towns will be uninhabitable 20 to 50 years from now due to erosion. The younger residents are moving away, and the population is declining thru the attrition of its elders. This irreplaceable culture is threatened with extinction. Like no place else in Maryland, the Smith Islanders live with nature. Life is dictated by the tides and winds, and the abundance of life in the water. Big Thorofare Channel separates Martin NWR from the settled areas of Smith Island, and is the most important water access to Ewell.

Access to Smith Island may be had by three ferry boats which ply between the island and the port of Crisfield. These boats usually leave the Port of Crisfield around noon 6 days a week. The Island Star is a convenient tourist boat and may be had by appointment.

Ewell.—The initial patent for Smith Island dates to 1679, when 1,000 acres surveyed as “Pitchcroft” for Captain Henry Smith, the island's eponym and a prominent figure in early Somerset County history. Henry Smith first appears in county records in 1669 as having relocated from Accomack County, where he was drawn into divorce proceedings by the Virginia court. Despite his marital problem in Accomack, Smith assumed prominent roles in Somerset as justice of the peace, a captain of the militia, and a representative from the county in the Lower House of Maryland General Assembly. Although he owned the large “Pitchcroft” tract, it is thought Smith actually occupied a tract patented as “Smith's Recovery”, located on the south side of Manokin River near the confluence of King's Creek.

Tax records indicate the island was occupied during the eighteenth century, and Dennis Griffith's map of Maryland, first drawn in 1794, indicates what was probably an earthen fort at the north end of the island. The presence of the fort as well as the island's strategic location at the bottom of the bay encouraged British occupation during the Revolution and later during the War of 1812.

The buildings that compose the small village of Ewell include many two-story, two- and three-bay frame dwellings, some of which date from before the Civil War. One of the oldest houses to stand until recent times was the house called Pitchcroft, located at the north end of the island.

Tylerton.—Tylerton is a small watermen's village located on Smith Island in Tangier Sound. Tylerton is geographically separate from Ewell and Rhodes Point by Tyler Creek, which runs between the island's two principal land masses, Merlin Gut runs east of the high ground on which Tylerton was built. During the nineteenth century, a ferry operated between the two land masses, but now access is provided only by private boat travel.

Tylerton retains a more diverse collection of period dwellings than the other Smith Island villages. Two of the houses appear to date from the antebellum period. A group of “telescope” houses with three distinct parts contrasts with the more standard two-story, two- or three-bay houses. A large percentage of the dwellings retains decorative exterior trim such as eaves brackets or intricately sawn barge boards. The largest building in Tylerton is the Gothic Revival Methodist Church in the center of the village. Quiet foot paths and large shade trees contribute to the continuing nineteenth century character of the community.

Rhodes Point.—Rhodes Point is the smallest of the three communities located on Smith Island. Rhodes Point, formerly “Rogues Point,” developed along Shanks Creek at the southwest tip of the island and by 1877 included a score of frame houses and a school. The waterman's village consists of approximately two dozen one- or two-story houses and the Calvary United Methodist Episcopal Church. Built in 1921 the L-shaped frame church has Gothic Revival style doors and windows. The houses largely consist of two basic types: the three-part telescope dwelling and the two-and-a-half-story, cross-gabled frame house with a rear service wing. The largest structure standing in the village is a turn-of-the-century frame house on the north side of the bridge. Distinguished by a pyramidal roof with multiple gables, this squarish building is surrounded by a Tuscan-columned front porch. Located on the west side of the village road is a group of single story watermen's work shanties of board-and-batten construction.

Sussex County

Sussex County, Delaware is predominantly a rural, agricultural county that is experiencing rapid growth along the Atlantic coast and moderate growth in the Seaford area, within the Nanticoke watershed. The western portion of Sussex County includes agricultural areas near the Maryland line. About half the county’s population lives within the Nanticoke watershed. The industry and commerce of Seaford, and its water-based opportunities are made possible by the navigable Nanticoke River.

Community Attitudes and Opinions

Just as important as the factual data above are the opinions and attitudes of local residents. In March 1995, the Maryland Chapter of The Nature Conservancy hired the Cromer Group to conduct a random sample phone survey of 400 adult residents from throughout the Blackwater and Nanticoke rivers watershed. TNC’s Delaware Field Office also was contracted by DNREC Division of Water Resources in 1994 to do a more limited opinion survey of 45 landowners who owned property along the Nanticoke River or its tributaries in Delaware. Some of the more salient findings as presented in TNC’s Nanticoke River Bioreserve Strategic Plan follow.

Maryland Survey

First, people living in the watershed tended to be long-term residents. About 85 percent of all survey respondents had lived in the area for 10 years or longer. Nearly 70 percent of all residents agreed that "the quality of life in this area is truly one of the best I think I could ever find."[16]

People in the watershed also had generally favorable opinions of the groups that are active in their area. Of the groups rated during the survey, the Chesapeake Bay Foundation (CBF) had the highest rating, at 7.2 out of a possible 10, while TNC registered 6.5 on the same question. The Fairness to Landowners Committee ranked last, at 5.2. Similar statistics held true for name recognition: 89 percent had heard of CBF, 72 percent had heard of TNC, while only 60 percent had heard of the Fairness to Landowners Committee, the lowest rating of any group mentioned.

The Fairness to Landowners Committee works primarily to support private property rights. It seems, however, that their central issue has little support in the watershed. When asked to support either a pro-private property rights statement, or an anti-property rights statement, only 12 percent favored the former, while 66 percent favored the latter. Additionally, testing on various statements found that only approximately 6 percent of the respondents were anti-environmentalists.

Respondents seemed to single out development as one of the least desirable activities for the watershed. Although 77 percent rated real estate development as very or somewhat important to the local economy, 67 percent of all residents agreed that, as a whole, development on the Eastern Shore is beginning to destroy our way of life. Also, 83 percent of the farmers surveyed opposed the idea of selling parts of their land for development.

Delaware Survey

Most landowners surveyed stated very clearly that they wanted their land to remain untouched. Forty-four percent of respondents said their long-term intention was to pass their property on to their children, while an additional 22 percent said they intended to maintain the land in its present condition. Only 15 percent planned eventually to sell their property or develop it.

Most landowners surveyed (58 percent) conveyed their disinterest in speaking with any entity regarding conservation of their lands. Of those who did indicate a willingness to discuss land protection, a majority chose The Nature Conservancy as the entity with whom they would be most interested in working.

In assessing landowners' knowledge of wetland functions and values, it was found that, in general, people were most knowledgeable about the role of wetlands in flood control (avg. score 4.07, with 5.00 being the highest possible score). People were also very knowledgeable about the importance of wetlands for wildlife habitat (4.02) and fisheries habitat (3.93). In descending order, survey respondents understood the value of wetlands for surface water quality (3.82), ground water quality (3.77), ground water quantity (3.61), and rare plant habitat (3.57).

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[16] Anonymous responder

While only about 1 in 4 survey respondents had heard about the wealth of state-listed rare species in the area, residents seemed a bit conflicted about whether to welcome them. Eighty-three percent of those surveyed said that endangered species are a bad thing (but the result can be construed either as bad for people, or as bad for nature). However, while 44 percent favored jobs over environmental protection, 88 percent believed there is a moral responsibility to protect all of God's creatures. These somewhat conflicting results suggest that certain messages and wording resonate more than others.

Groundwater is a larger and clearer concern than endangered species. Two-thirds of the residents rely on groundwater, and 63 percent feel that high cancer rates in the region may be due to the (poor) quality of the groundwater. And a vast majority believe that the river is in worse condition than it used to be. Therefore, while we may have limited support for citizen action to protect rare species, we will have more support for actions to clean up groundwater.

Recreation and Tourism

Given the counties' composition of agriculture, forests, wetlands and waters, there is a long history of fishing, shellfishing, trapping, and hunting as the principle forms of recreation as well as income. Fishing and waterfowl hunting continue to be major recreational activities and industries throughout the study area. State and federal waterfowl refuges, including Blackwater NWR and Fishing Bay Waterfowl Management Area, are important for maintaining and protecting the waterfowl resource. State-managed public hunting areas within the study area include Maryland's Taylors Island, Deals Island, South Marsh Island, LeCompte, Linkwood, Fishing Bay, Ellis Bay, Nanticoke, and Idylwild Wildlife Management Areas; and Delaware's Nanticoke Wildlife Area.

In 1985, residents and landowners established a new waterfowl-oriented industry unique to Dorchester County: Regulated Shooting Areas (RSA's), which promote free-flying and flighted mallard release programs, and provide thousands of hours of recreational hunting. According to Resource Management, Inc., more than $22 million have been invested in land purchases for RSAs, and an additional $109 million have been spent on improvements and equipment since 1985. At least 115 jobs developed as a result of the RSA's. The real estate market reflects the importance of conservation and recreational hunting properties to the Dorchester County economy.

Fur trapping is a source of both recreation and supplemental income to some residents, particularly watermen and farmers. Trappers in Maryland have historically earned about a million dollars a year, although that amount has continually been reduced each year as the demand for fur products diminishes.

Other forms of recreation that contribute to the local economy are fishing and crabbing, sailing on the Bay, boating on the Blackwater and Nanticoke rivers and their tributaries, swimming, picnicking, biking, and golfing. A rapidly growing segment of the population, whose contribution to the economy also is substantial, engage in wildlife observation and photography.

Recreation opportunities on Smith Island are shaped by its history, its location in the Bay, and its environmental resources. The island's unique culture and relative isolation continue to be strong influences on the recreation activities of its residents. When not actually crabbing, oystering, or fishing, watermen and their families spend considerable time maintaining and preparing their boats and equipment. These tasks, such as making crab pots, require time and care that might otherwise be invested in more recreational crafts, such as wood working and carving wooden decoys.

Group recreational activities focus around family, community, church, and school. Each of the three Smith Island communities has a small complement of recreation facilities. Church buildings in each town provide space for club meetings, dinners, and similar organized indoor recreation activities. The Community Center in Ewell serves as a focus of other recreational functions and a new tourist center is also available for group activities. Both Ewell and Tylerton have ball fields and school playgrounds, and the Community Meeting Hall in Rhodes Point is used as a Senior Citizen Center, serving communal meals and sponsoring other activities. Several business locations also serve as regular informal gathering places. Watermen, teenagers, housewives, and retirees relax and talk, shoot pool, and conduct business at the two grocery markets in Ewell (Charlie's Store) and Tylerton (Drum Point Market), and at Ruke' s Store and Restaurant, near the county dock at Ewell.

In more solitary recreational pursuits, island residents watch television, phone friends, monitor their home weather stations, paint, and write poems, stories and historical sketches. Bicycle riding is a popular form of recreation as well as a practical way to get around on the island's narrow lanes. Island residents report that gardening and raising the rose bushes common in earlier times has been more difficult as the land has become wetter.

The necessity of boats to island life makes boating an easily accessible recreation activity. Seasonal residents, day-tripping tourists, and transient boaters may be more likely to enjoy recreational boating, touring, bird-watching, and sport fishing in the island waters. However, both islanders and visitors find the marshes and waterways of the island a magnet for hunting, fishing, observing nature, and the kind of poking around that the locals call “proging.”

Tourists arrive on the island by private boats or on the ferries that cross from the Eastern shore at Crisfield or Point Lookout State Park, Maryland, or from Radville, Virginia, on the west shore of the Bay. There are limited transient docking facilities on the island, but lodging is available at two commercial bed and breakfasts (at Ewell and Tylerton) and at several private homes. Several restaurants, generally catering to group tours arriving on the ferries, are located near the harbor at Ewell. Most facilities for visitors, such as the bed and breakfasts and the tourist center at Ewell, are open during the summer tourist season or by prior arrangement. Ferry access to the island during the winter is limited by fewer scheduled trips and by weather conditions. In spite of the logistical constraints, approximately 40,000 tourists visit Smith Island each year (based on conversations with residents), drawn by its natural beauty and quiet charm.

The planning and tourism offices of Somerset County have plans to promote eco- and heritage tourism in the county, including Smith Island. The Crisfield and Smith Island Cultural Alliance was instrumental in the construction of the Smith Island Tourist Center at Ewell and has plans for additional development at the center.

Recreational Opportunities on the Refuge Complex

The following principles have guided our management of public use on the Refuge Complex.

1. Promote the station message, thereby enabling the visitor to have a more enjoyable experience and perhaps helping to reduce the impacts on other wildlife areas.

2. Provide environmental education and training for teachers and students, incorporating the station message.

3. Increase self-service opportunities to better educate the public and promote the station message (especially, print an adequate quantity of brochures).

4. Provide compatible opportunities for wildlife observation, photography, hunting, and fishing.

5. Provide professionally produced interpretive information at appropriate locations.

6. Improve the training of staff and volunteers to enable them to provide quality interpretive experiences for the public that convey the station message.

7. Maintain and improve visitor facilities to ensure that high quality experiences of different levels and abilities that are safe, enjoyable, and educational are available to the public.

8. Conduct effective outreach and work with State and local organizations to provide recreational facilities that enable the visitor to enjoy the refuge without adversely affecting either wildlife or wildlife habitat.

Blackwater NWR

In order to protect sensitive island ecosystems and wildlife in the Island Refuges, public use generally is confined to Blackwater NWR. The Island Refuges are closed to public use, except for limited interpretive tours conducted by refuge staff and self-guided interpretation at the Martin NWR visitor contact station in Ewell on Smith Island.

In 2000, Blackwater NWR provided more than 505,000 visitors the opportunity to learn about and view waterfowl, endangered species, and migratory birds. Approximately 70,000 of these visitors annually receive information from the Visitor Center; up to 100,000 observe and photograph wildlife from the Wildlife Drive; and 25,000 use the nature trails.

Wildlife observation and photography.—The interest in wildlife viewing and education is evident at Blackwater NWR. According to the Dorchester County Department of Tourism, Blackwater NWR visitors spend an estimated $15 million in the Dorchester County economy annually, having a tremendous impact on local restaurants, hotels, retail merchants, and other attractions. This is based on an average annual visitation number of 100,000 to Blackwater NWR, excluding donations and gift shop totals, and the Eastern Shore's average visitor spending of $150.00 a day on hotels, meals, and retail items.

Environmental education and interpretive programs.—Blackwater NWR provides structured environmental education programs for 1,700 students and scouts a year. With funding and assistance from the Friends of Blackwater, an environmental education manual is being developed to meet the requirements of the school systems. A Visitor Center with exhibits, films, and information desk and gift shop provide education and interpretation materials about wildlife recreational activities to the visitors. Current Blackwater leaflets, consisting of a general brochure, bird list, reptile and amphibians list, mammals list, Wildlife Drive guide, endangered species guide, interpretive leaflet for the Marsh Edge Trail, Friends of Blackwater brochure, handout on entrance fees, deer hunt information and maps, and a brochure on the management of Canada geese, are routinely distributed to the public.

The Friends of Blackwater issue a quarterly newsletter. Audio visual programs are offered to the public at the visitor center. The only leaflet available for the Island Refuges is the general brochure for Martin NWR. An active volunteer program of 100 volunteers contributes more than 11,000 hours annually, mostly to help staff the Visitor Center.

A self-guided, paved, 6½–mile interpretive tour on the Wildlife Drive is available for wildlife observation and photography. This auto tour route is interpreted, with numbered stops and accompanying leaflet or an audio tape. A self-guided interpretive tour of the Marsh Edge Trail is also available. This ⅓–mile accessible paved trail is interpreted, with numbered stops and accompanying leaflet. Four interpretive kiosks with a variety of interpretive panels to orient visitors and describe management programs are located around the Wildlife Drive. The Woods Trail is a ½–mile trail that offers opportunities for wildlife and wildlands observation.

Hunting opportunities.—Big game hunting for white-tailed and sika deer is permitted for 42 days each year on Blackwater NWR (35 days of archery, a 1-day special youth-only shotgun hunt, 2 days of muzzle-loading rifle or shotgun hunting, and 4 days of shotgun hunting) to help reduce neighboring crop depredation by refuge deer and to provide public recreation. No other hunting presently is available for the public on the Refuge Complex.

Blackwater NWR provided hunting opportunities for more than 3,000 deer hunters in 2000. The $25,000 collected annually in the hunt program are used to hire a hunt coordinator and maintain parking areas and signs. Sportsmen also contribute substantially to the economy of an area through local purchases of gas, food, lodging, and supplies. Trapping is conducted on the refuge in an effort to control nutria and muskrat populations. Trapping income from the refuge is estimated to contribute approximately $30,000 to the local economy annually.

Fishing opportunities.—Limited commercial fishing on Blackwater NWR was authorized under special use permits until 1989, when the program was stopped to minimize disturbance to wintering waterfowl. The navigable waters of Martin NWR are not under the control of the

Service, and remain open to commercial fishermen, who are dependent on the rich marine resources of the Bay.

Recreational fishing is permitted on Blackwater NWR during the summer months, and annual visits average approximately 1,700. The refuge closes to boating October 1–March 31 for waterfowl protection, limiting fishing opportunities during other periods of the year to two bridges on public roadways where there are no parking facilities.

Chesapeake Island Refuges

Because of the limited size of most of the islands, difficulty of access, and the high degree of sensitivity of most of their wildlife species to human disturbance, public use is severely limited. The Middleton House at Ewell serves as a contact station for the refuges, and provides an opportunity to inform 40,000 visitors annually about objectives and management.

The Karen Noonan Environmental Education Center on the Bishops Head Division is operated and maintained by the Chesapeake Bay Foundation. Approximately 1,000 students and teachers annually utilize the Bishops Head Division, Watts Island, Martin NWR, and Barren Island Division for environmental education subject to the conditions of an existing Memorandum of Understanding.

Susquehanna NWR is not open to the public. Access to Battery Island is difficult, and its 1-acre area offers little opportunity for public use. Except for special environmental education activities mentioned above, the islands are closed to the general public due to their environmental sensitivity and difficult access.

Other Refuge Complex Uses

The Refuge Complex now conducts or cooperates with research on DFS, mute swans, tundra swans, trumpeter swans, Canada geese, snow geese, effects of released mallard programs, marsh loss, water quality, nutria damage and control, land subsidence, fire management, phragmites, wetland restoration, sea level rise, salt water intrusion, and many other management issues. Monitoring and surveys conducted by refuge staff, cooperators, and volunteers include waterfowl, reptiles and amphibians, DFS, eagle, breeding bird, shorebird, muskrat, deer, owl, and moist-soil vegetation surveys; DFS and nutria mark and recapture; blue bird and wood duck nest box use and production; water quality monitoring; waterfowl, osprey, colonial bird, and barn owl banding; and, gypsy moth and pine beetle egg mass and defoliation surveys.

Administrative Staff and Facilities

Headquarters for the Refuge Complex is at Blackwater NWR, in Dorchester County, approximately 12 miles south of Cambridge, Maryland. Only Blackwater NWR and Martin

Table 43. FY 1999–2002 budget allocations (BLK)

Activity	Fiscal Year ($1,000's)			
	2002	2001	2000	1999
Wildlife Resources	1,355	2,263	1,389	1,059
FTEs[1]	12.25	12.52	13.40	13.80

[1] Number of funded staff positions

NWR are staffed and funded. Our conceptual organization charts display the organization and staffing that would support our preferred alternative B with our funding history and lists of facilities and equipment. They summarize total combined staffing and individually identified funding for the past 10 fiscal years for both refuges.

Equipment and Facilities

Blackwater NWR

Most of the refuge administrative facilities, including the Visitor Center, were built in the early 1960's, and show their age. We began building a new headquarters in 1997, and occupied it in spring 2001. A renovation and updated exhibits would benefit the Visitor Center.

Chesapeake Island Refuges

Table 44. FY 1999–2002 budget allocations (MRN)

Activity	**Fiscal Year ($1,000's)**			
	2002	2001	2000	1999
Wildlife Resources	178.00	233.60	118.80	121.60
FTEs	2.34	2.46	1.50	2.00

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