

Chapter 3. Summary Refuge and Resource Description

Physical Environment

Climate

Forsythe National Wildlife Refuge (Forsythe Refuge) is within the New Jersey coastal weather station zone (Sandy Hook, Long Branch, Atlantic City, and Cape May weather stations). The ocean moderates the State's continental climate within the coastal weather zone. The average monthly temperature is 35°F in January, the coldest month of the year, and 75°F in July, the hottest month of the year. The growing season for the Refuge is 245 days. The growing season is the period of the year in which the average temperature is 43°F or more. The average annual precipitation in the coastal zone is 42.6 inches. Precipitation is distributed fairly evenly through the year, with slightly more in July and August, and less in February.

Air Quality

New Jersey is the most densely populated State in the country. The State also has the highest densities of roads and traffic. These factors impact air quality. The greatest adverse impact seems to be elevated levels of low-altitude ozone in the State. The ozone levels exceed Environmental Protection Agency (EPA) thresholds set for the State. Investigations at the Brigantine Division of Forsythe Refuge indicate that the low-altitude ozone levels at that site are high, with resultant damage to vegetation (Davis, 1995).

In 1978, Congress designated the Brigantine Wilderness Area (Wilderness Area) as a Class I air quality area, giving it special protection under the Clean Air Act. Congress charged the Service with the responsibility of protecting the air quality and air quality related values (AQRVs) of the area from manmade pollution. AQRVs include vegetation, wildlife, soils, water quality, visibility, odors, and cultural and archaeological resources.

Despite this protection, air pollution is impacting the Wilderness Area. The area lies in a highly industrialized airshed, with air pollution coming from many sources, including industry, automobiles, and power plants. Surveys conducted from 1993 to 1996 indicated that certain plant species exhibited typical symptoms of ozone injury (e.g., stippling and chlorosis).

In addition to these documented effects, there is concern that other effects may be occurring. Rainfall throughout the area is acidic; rainfall pH at sampling locations in New Jersey is often less than 5.0. As is the case in most of the eastern US, visibility in the Wilderness Area is affected by pollution-caused haze. Also, inshore waters of the Wilderness Area may be at risk from atmospheric nitrogen pollution. Research along the Atlantic Coast has demonstrated that atmospheric nitrogen (primarily from power plant and automobile emissions) has contributed to nutrient level increases of inshore waters, with subsequent algae blooms, loss of seagrass beds, and deterioration of fish and wildlife habitat.

The New Jersey Department of Environmental Protection (NJDEP) operates continuous sulfur dioxide and ozone monitors at the Nacote Creek Station at the west side of Forsythe Refuge. The ozone monitor has recorded various violations of the National Air Quality Standards for ozone (the entire State of New Jersey is a "non-attainment area" for ozone).

In addition, the Service monitors air quality at the Wilderness Area through two national programs. The Service monitors atmospheric pollutants in rain as part of the National Atmospheric Deposition Program (NADP; the "acid rain" program). The Service monitors fine particles as part of the Interagency Monitoring of Protected Visual Environments (IMPROVE) Program.

The Service and NJDEP cooperate in the emission permitting process to protect air quality in the Brigantine Wilderness.

Geology, Topography and Soils

The Forsythe Refuge is within the Outer Coastal Plain, which consists of sedimentary deposits dating from the Tertiary period.

Elevations on the Refuge range up to 50 feet above mean sea level. Topography is nearly level to gently sloping. Uplands slope gradually to a wide band of salt marsh to shallow bays. These bays are separated from the ocean by barrier islands or spits.

The major soil series in the Barnegat Division are: Sulfaquents-Sulfihemists association and Manahawkin-Atsion-Berryland association. Major soil series in the Brigantine Division are Tidal Marsh-Coastal Beach association and Downer-Hammonton-Sassafras association.

Hydrology

The major aquifer underlying the Refuge is the Kirkwood-Cohansey system, which dates from the Miocene and Pliocene Epochs. The Kirkwood Formation is chiefly sand, silt, and clay. The Cohansey Sand is chiefly unconsolidated quartz sand with some gravel and many clay beds. This system provides most of the potable water to the area.

Pleistocene and Recent Age deposits overlie the Kirkwood-Cohansey formations and contain sand, gravel, silt, peat, and organic muck. Some shallow wells from these formations may be tapped locally for domestic use. Several aquifers underlie the Kirkwood-Cohansey system and are tapped to a lesser extent for public and domestic supply.

The Refuge has both tidal and non-tidal surface waters. Non-tidal waters include marshes, bogs, ponds, creeks, artificial impoundments, and seasonally flooded forests. Tidal waters include ponds, salt and fresh marshes, creeks and old ditches, coves, bays, river channels, and inlets. Most of the salt marsh is tidally flooded daily, with the greatest inundation occurring at new and full moons.

The Barnegat Division is drained by Reedy Creek, Sloop Creek, Clamming Creek, Maple Creek, Stouts Creek, Bridge Creek, Forked River, Oyster Creek, Double Creek, Gunning River, Cedar Creek, Mill Creek, Cedar Run, Dinner Point Creek, Westecunk Creek, Parker Run, Jesse Run and Salp Creek.

The Brigantine Division is drained by the Mullica River, Roundabout Creek, Ballenger's Creek, Bass River, Nacote Creek, Motts Creek, Oyster Creek, Landing Creek, Rubes Creek, and Doughty Creek.

Contaminants

The Service collected sediments, mummichogs, and fiddler crabs in and adjacent to Forsythe Refuge in 1996 to determine baseline contamination. Sediments were collected at 25 locations; mummichogs and fiddler crabs from 10 of the 25 locations. The samples were analyzed for trace metals, organochlorine pesticides, polychlorinated biphenyls (PCB's), and butyltin compounds (USFWS, 1998).

The Service analyzed the samples for 19 trace metals: aluminum, arsenic, barium, beryllium, boron, cadmium, chromium, copper, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, selenium, strontium, vanadium, and zinc. All of these trace metals were detected in the sediment samples. None of

the sediment samples contained metal concentrations that exceeded severe toxic effects guidelines for sediment.

Many sediment trace metal concentrations exceeded lower toxic effects guidelines, but these concentrations were not notably greater than background levels within New Jersey. Fiddler crabs contained higher mean metal concentrations than mummichogs for all detected metals except zinc.

There was no strong relationship between the sediment concentrations of metals and those in crabs. Inorganic contaminant concentrations in Refuge biota were not notably greater than reference levels and were less than levels measured in areas known to be polluted. The whole body concentrations of inorganic contaminants in both fish and crabs were not sufficient to cause acute or sublethal effects to piscivorous birds and predatory fish.

Several organic contaminants, dichlorodiphenyl-dichloroethane (DDD), dichlorodiphenyl-dichloroethylene (DDE), total PCB's, and PCB 77, were detected in measurable quantities in all sediment samples. Levels of several organic contaminants, particularly the metabolites of DDT (DDD and DDE) were greater than available reference concentrations from other areas within southern New Jersey. Some of the highest sediment concentrations of these organic contaminants were detected at sampling stations located just downstream of inactive cranberry bogs. One bog yielded a DDD concentration of significant ecotoxicological concern. A few other sampling stations also contained levels of DDE and total chlordane that exceeded severe toxic effect sediment guidelines.

Detectable levels of p,p¹-DDD, p,p¹-DDE, dieldrin, heptachlor epoxide, oxychlordane, and total PCB's were found in all crab and fish samples analyzed. Unlike the inorganic contaminant result, crabs did not have higher organic contaminant levels than fish. Organic contaminant concentrations in Refuge biota were not notably greater than reference levels and were less than levels measured in areas known to be polluted. Body burdens of organic contaminants in mummichogs did not indicate that these fish should be suffering physiological impairment. The whole body concentrations of organic contaminants in both fish and crabs were not sufficient to cause acute or sublethal effects to piscivorous birds and predatory fish.

Overall, the contaminant levels in sediment and biota from the Forsythe Refuge, with some exceptions, were found to be low and of little concern with regard to the potential for adverse effects on resident biota or their predators. Exceptions were limited to seven sampling stations where the concentrations of DDD, DDE, or total chlordane exceeded severe toxic effects sediment guidelines. Two of these stations were located at the surface water outfalls of inactive cranberry bogs. Unfortunately, biota were not collected from these two stations. It is reasonable to suspect even greater concentrations of organic contaminants exist inside the cranberry bogs themselves. These inactive cranberry bogs may be a serious threat to Federal trust resources foraging there. In addition, these cranberry bogs may be a risk to Refuge visitors, if the areas were open to the public.

Biological Environment

Forsythe Refuge plant and animal communities are described in "Significant Habitats and Habitat Complexes of the New York Bight Watershed" (USFWS, 1997). The key biological value of the Refuge is the coastal estuaries and associated watershed. The Refuge hosts a number of rare species and communities. Many birds depend upon the habitat during migration and commercial fish species depend on the waters for a portion of their life cycle.

Threatened, Endangered, Recovered and Rare Species

In and around Forsythe Refuge, there are 14 animal species Federally-listed as endangered, threatened, recovered, or species of concern, formerly called candidate species (Appendix E). We actively manage for the piping plover (*Charadrius melodus*), peregrine falcon (*Falco peregrinus*), and bald eagle (*Haliaeetus leucocephalus*).

Piping plovers nest on the protected Wilderness Areas of the Holgate Unit and on Little Beach Island. Generally 19-37 pairs nest at the two areas. These breeding pairs represent about 29 percent of New Jersey breeding population.

Peregrine falcons use the Forsythe Refuge throughout the year. Two nesting pairs use artificial nesting structures on the Refuge. The peregrine falcon has successfully nested on the Refuge since 1980. The Refuge is also important for wintering peregrines.

Bald eagles regularly use the Refuge wetlands to forage while migrating through or wintering in the area. During the nesting season, most use is along the Mullica River, but occasionally eagles forage over Refuge impoundments and adjacent salt marsh. During the winter eagles regularly forage in the impoundments and salt marshes of the Brigantine Division.

Vegetation and Habitat Types

About 82% of the Refuge land is wetland, and 18% is upland. Salt marsh makes up about 78% of the Refuge land. This is the largest single land use/habitat type within the Refuge. The dominant salt marsh species are salt marsh cordgrass (*Spartina alterniflora*) and salt-meadow grass (*Spartina patens*). Most of the salt marsh was grid-ditched during the first part of this century for mosquito control. Approximately 6,000 acres of salt marsh is unditched, and was designated as wilderness under the Wilderness Act. The salt marsh is interlaced with small tidal streams, mudflats, and ponds or pannes.

Forested wetlands make up about 4% of the Refuge land. The dominant overstory trees in this habitat are red maple (*Acer rubrum*), oaks (*Quercus* spp.), black gum (*Nyssa sylvatica*), sweetgum (*Liquidambar styraciflua*), and occasional stands of Atlantic white cedar (*Chamaecyparis thyoides*). Bogs and brush-dominated wetlands are interspersed through the forested wetlands. The cedar swamps and bogs are classified as sensitive ecological communities, with several rare plant species (e.g., bog asphodel - *Narthecium americanum* and swamp pink - *Helonias bullata*).

Forested uplands make up about 13% of the Refuge land. Upland forests range from deciduous to coniferous dominated overstory composition, with tree species including: pitch pine (*Pinus rigida*), oaks (e.g., white oak - *Quercus alba*, chestnut oak - *Q. prinus*, black oak - *Q. velutina*, scarlet oak - *Q. coccinea*), black cherry (*Prunus serotina*), and sweet gum (*Liquidambar styraciflua*). Fire played a prominent role in defining the composition and structure of upland plant communities, both historically and prehistorically (Little, 1998). There are still some nearby State lands in the Pine Barrens that receive regular fire treatment (both prescribed and wild), but fire on Refuge lands has been suppressed for decades.

Grassland uplands make up about 3% of the Refuge land. These grasslands contain forbs and grasses interspersed with sassafras (*Sassafras albidum*), eastern red cedar (*Juniperus virginiana*), and winged sumac (*Rhus copalina*). Current grasslands are comprised of both native and exotic species.

Beaches and vegetated dunes make up about 2% of the Refuge land. These habitats are critical for species unique to those communities. Most of the Refuge's shrub/scrub habitat is located on islands. Additional shrub/scrub habitats (upland brush) are found on the mainland, and represent early successional stages of

upland forest. The Holgate Unit and Little Beach Island, which are part of the Brigantine Wilderness Area, represent these community types.

Open water habitat types of the Refuge include bays, streams, rivers and small ponds or reservoirs. These shallow waters are critical elements of the coastal ecosystem. However, only the small ponds and reservoirs are owned by the Refuge. All navigable waterways and inter-tidal areas (between mean high and low tide) fall within the jurisdiction of the State of New Jersey. Ownership notwithstanding, open waterways found throughout the lands owned by the Refuge have a major influence on the ecological functions of those communities.

Three large, managed impoundments are an important feature of the Brigantine Division. The Northwest Pool and the Southwest Pool, about 500 and 300 acres respectively, are fed by Doughty Creek and springs. These two pools are managed as a freshwater impoundment and moist-soil unit. The East Pool (536 acres), receives water from the two west pools and tide gates. This pool is managed as a brackish impoundment.

Other freshwater bodies in the Brigantine Division include: the spring-fed Experimental Pool, Lily Lake (a 22-acre reservoir upstream from the impoundments on Doughty Creek), and two ponds that were former borrow pits. Several freshwater impoundments and one brackish impoundment (totaling about 350 acres) are located in the Barnegat Division.

Wildlife Resources

Migratory Birds: Migratory birds use the Refuge in three different ways. First, many thousands of birds of all kinds use the Refuge as stopover habitat during the spring and fall migrations. Second, a wide variety and, in some cases, very large portions of populations depend upon the Refuge for wintering habitat. Finally, a rich variety and number of birds breed on the Refuge.

The coastal wetlands of New Jersey are of international importance to wintering waterfowl. In 1991, 39% of the Atlantic Flyway American black duck (*Anas rubripes*) population, 67 % of the Atlantic brant (*Branta bernicla*) population, and 34% of the greater snow goose (*Chen caerulescens*) population were recorded in New Jersey during the Service's mid-winter inventory.

The wetlands of the Forsythe Refuge are classified as Wetlands of International Importance under the Ramsar Convention, one of only seventeen sites so designated in the United States. During a December 6, 1991, aerial survey of the Refuge, 85,570 waterfowl were observed. The highest waterfowl concentrations at the Refuge do not occur until late December. Weekly waterfowl counts conducted at the Brigantine Division Impoundments indicate waterfowl populations nearly double from early in the month, so it is possible nearly 180,000 birds use the Refuge during the peak period.

Many marsh and water birds use the Refuge. The most common include great blue heron (*Ardea herodias*), great egret (*Casmerodius albus*), snowy egret (*Egretta thula*), black-crowned night heron (*Nycticorax nycticorax*), glossy ibis (*Plegadis falcinellus*) and cattle egret (*Bubulcus ibis*). Herons and egrets nest on or near the Refuge, frequently foraging in the salt marshes, streams, ponds, and impoundments. Until recently, least terns and black skimmers nested in substantial numbers on Holgate and other barrier/bay islands.

Shorebird use of the Refuge peaks during the spring migration. The most common species are: sanderling (*Calidris alba*), semi-palmated sandpiper (*Calidris pusilla*), dunlin (*Calidris alpina*), semi-palmated plovers (*Charadrius semipalmatus*), short-billed dowitcher (*Limnodromus griseus*), willet (*Catoptrophorus semipalmatus*), greater yellowlegs (*Tringa melanoleuca*), lesser yellowlegs (*Tringa flavipes*), black-bellied plover (*Pluvialis squatarola*), least sandpiper (*Caladris minutilla*), ruddy turnstone (*Arenaria interpres*),

red knot (*Calidris canutus*), whimbrel (*Numenius phaeopus*), spotted sandpiper (*Actitis macularia*) and pectoral sandpiper (*Calidris melanotos*).

Many raptors breed on the Forsythe Refuge, including: red-tailed hawks (*Buteo jamaicensis*), turkey vulture (*Cathartes aura*), sharp-shinned hawks (*Accipiter striatus*), broad-winged hawks (*Buteo platypterus*), red-shouldered hawks (*Buteo lineatus*), northern harriers (*Circus cyaneus*), great horned owls (*Bubo virginianus*), common barn owls (*Tyto alba*), barred owls (*Strix varia*), and short-eared owls (*Asio flammeus*). Many other raptors may be seen during migration; some of them winter at the Refuge.

Many songbirds species use the Refuge for nesting and to rest or feed during migration. The most important nesting species are those dependent upon the marshes and coastal island habitats, for example, seaside sparrow (*Ammodramus maritimus*), marsh wren (*Cistothorus palustris*), and sedge wren (*Cistothorus platensis*). A large number of birds nesting on or migrating through the Refuge are Neotropical migrants (wintering in Central and South America). As a group, Neotropical migrants have shown recent population declines due to habitat loss and deterioration in wintering areas and along migration corridors.

Mammals: Over 30 species of mammals occur on the Refuge, in assemblages characteristic of the Mid-Atlantic coastal communities. Forest species include red fox (*Vulpes vulpes*), grey fox (*Urocyon cinereoargenteus*), coyote (*Canis latrans*), raccoon (*Procyon lotor*), long-tailed weasel (*Mustela frenata*), short-tailed weasel (*Mustela erminea*), striped skunk (*Mephitis mephitis*), opossum (*Didelphis virginiana*), white-tailed deer (*Odocoileus virginianus*), grey squirrel (*Sciurus carolinensis*), red squirrel (*Tamiasciurus hudsonicus*), chipmunk (*Tamias striatus*), white-footed mouse (*Peromyscus leucopus*), red-backed vole (*Clethrionomys gapperi*), pine vole (*Microtus pinetorum*), masked shrew (*Sorex cinereus*), short-tailed shrew (*Blarina brevicauda*), eastern mole (*Scalopus aquaticus*), and a variety of bat species. Shrubland and grassland species of mammals include the meadow vole (*Microtis pennsylvanicus*), meadow jumping mouse (*Zapus hudsonius*), woodchuck (*Marmota monax*), eastern cottontail (*Sylvilagus floridanus*), and several of the forest and wetland species. Mammals associated with wetlands include mink (*Mustela vison*), river otter (*Lutra canadensis*), muskrat (*Ondatra zibethicus*), meadow vole, southern bog lemming (*Synaptomys cooperi*), and least shrew (*Cryptotis parva*).

Several species of bats occur in forested habitat types during the summer breeding season. Forest openings are common foraging areas for this group. A number of other migrating bat species probably pass through southern New Jersey during migration, while others would use caves for hibernacula (not found locally). Very little research has been done on bats in the vicinity.

Several mammals have substantial impacts on the habitat and populations managed on the Refuge. High densities of white-tailed deer have negatively affected the structure and composition of plant communities. High densities of muskrats, have compromised the integrity of dikes needed to retain and manipulate water in impoundment.

Many species of nesting, migrating, or wintering raptors dependent on the availability of small mammal populations in all cover types.

Reptiles and Amphibians: Nineteen species of reptiles and amphibians occur on the Refuge. These species fall into two major groups -- Pine Barrens and coastal estuarine environment. Important species from the Pine Barrens group include wood turtles (*C. insculpta*), Cope's gray and pine barrens treefrog (*Hyla chrysoscelis* and *H. andersonii*), ambystomid salamanders (*Ambystoma* spp.). The most important estuarine environment species is the northern diamondback terrapin (*Malaclemys t. terrapin*).

Fish: The salt marshes, streams, ponds, bays, and rivers that comprise the estuaries of the Refuge are critical to a rich variety of fish, shell fish, and crabs. These species are the foundation for sport and commercial fisheries, as well as food base for many birds and mammals. Most of the species are found in navigable waterways, areas the Service does not own.

Invertebrates: A wide variety and number of invertebrates, both terrestrial and aquatic, are of biological importance. Invertebrates are not well documented from this area, unless they are economically important. Tiger beetles and lepidopterans, some rare, are frequently observed. There is a long history of aggressive mosquito control, which has impacted other species.

Archaeological and Historical Environment

Prehistoric Period

Human occupation of the New Jersey coast began with the arrival of Native American hunter-gatherer bands, approximately 10,000 B.C. Only a few archaeological sites earlier than about 5000 B.C. have been found in the area, probably partly due to a major rise in sea level due to Pleistocene glacial melting. The coastline of that time is now lies submerged in the Atlantic Ocean, and former freshwater river valleys are now salt marsh. An artifact collection from the area of Cape May Refuge is one of the few signs of settlement in this period.

Human population on the coast seems to have increased somewhat after 5000 B.C., as the climate became notably warmer. The locations and contents of archaeological sites reflect a more diverse mix of hunting and gathering of upland, wetland, and aquatic resources that varied with the seasons. Sea level change became much more gradual by about 2000 B.C., and the extensive coastal wetlands that developed provided rich hunting, shellfishing, and plant gathering environments. This greater resource reliability supported a larger and more stable human population. Small scale hoe agriculture, pottery, and the bow and arrow are notable developments found at sites dating after about 1000 B.C.

Except for a handful of studies prior to Refuge construction projects, Forsythe Refuge lands have never been surveyed for archaeological sites. Prehistoric site potential is high, but site discovery is complicated by major changes in sea level over the last 12,000 years. Much of the Refuge is tidal marsh, and archaeological sites in this setting are especially difficult to locate and study. In exposed areas, they have often been lost to erosion. The upland portions of the Refuge have generally high potential for prehistoric sites, as much of this land adjoins wetland resources used by their inhabitants.

Historic Period

Permanent settlement of the Forsythe Refuge area by Euro-Americans began in the second quarter of the 18th century. This was preceded by a long period of contact with Native American Lenape through offshore fishing and the fur trade. By the middle of the century, the Lenape were severely diminished by European diseases and had lost nearly all of their former lands. Many emigrated to northwest New Jersey and the Ohio Valley during this period.

Colonial towns on the New Jersey shore were generally established at estuaries with suitable harbors for fishing and trade, such as the Mullica River. The New York Road linked these communities along the shore. Ore from bogs and charcoal from the pine barrens provided raw materials for an ironworks at Batsto that produced munitions for the American Revolution. A British raid in 1778 burnt the community of Chestnut Neck and all the vessels in the harbor, including some privateers, but did not achieve its secondary goal of destroying the ironworks. Limited by shallow and small harbors, these shore communities experienced slow

economic and population growth during the 19th century. Fishing, shellfishing, and agriculture remained the primary economic activities for most families. The later development of Atlantic City, Cape May, and other resorts had little effect on the surrounding areas without beachfront. This factor has done much to preserve the rural character of the Refuge vicinity.

Upland areas on Forsythe Refuge generally consist of former farmland associated with historic period settlement. Much of the Brigantine Division, for example, was part of a large early 19th century farm based on Brigantine Island. Therefore, historic period archaeological resources are unlikely except in a few settings, such as present or former landing areas. Some remains of wharves for these landings, and possibly sunken small craft, may exist in the marshes. A lifesaving station site near Brigantine City is one of the few documented historic archaeological sites at the Refuge.

There are currently no standing historic structures on the Refuge, but the Forked River Game Farm, proposed for acquisition from the New Jersey Division of Fish and Wildlife, has several structures that will require review of their eligibility for inclusion in the National Register of Historic Places.

Socioeconomic Environment

The Forsythe Refuge receives over 300,000 visitors per year. The predominant public uses of the Refuge are hunting, fishing, clamming, crabbing, wildlife observation, environmental education, and boating. The dikes surrounding the impoundments at the Brigantine Division serve as an 8-mile auto tour for the public. The Brigantine impoundment area accounts for about one-half of the Refuge visitors. The impoundment area is renowned as one of the premier birding sites in North America. A recent study shows that birders alone, who make up about 75% of the auto tour visitors, annually add about \$4.01 million to the local economy (Kerlinger, 1995).

Wildlife-dependent public use at the Refuge is consistent with the primary industry for the region—tourism. The New Jersey shore has long been a major tourist destination. Boating, fishing, hunting, shellfishing, and beach-related pursuits are typical for tourists. Most of the tourists come from major nearby metropolitan centers: Philadelphia, Newark, and New York City.

Over the last 20 years, the development of casinos and related industries has created a large influx of people. This has spurred the rapid construction of housing and support infrastructure (e.g., roads, malls, plazas, utility towers and corridors). The increase in human density and associated uses have caused considerable strains on the ecosystem from the following factors:

1. Habitat loss - direct conversion of natural habitat types to developed types.
2. Habitat fragmentation - conversion of large contiguous tracts of natural habitat types to a mosaic of discontinuous, smaller habitat type relicts; or erecting barriers that cause direct lethal impacts to fish, wildlife and plants (e.g., roads, towers, dams).
3. Habitat degradation - partial deterioration of habitat due to pollution (siltation, nutrients, pesticides, metals), exotic and pest species (phragmites, house cats), incompatible uses (all-terrain vehicles, personal watercraft).
4. Water consumption - reducing subsurface and surface waters due to irrigation, home consumption, and industrial applications.

There is a substantial commercial fishing industry in southern New Jersey. Important species include: finned fish, clams, mussels, and crabs. There is an increase in shellfish aquaculture, especially oysters. Bait fish, eel, and horseshoe crabs are also a major component of the industry.

In addition to the above more apparent environmental economic connections, there are others. A study conducted in Minnesota determined that there is a statistically significant positive relationship between the amount of wetland acres in an area and residential property values (Lupi, et al., 1991). The authors were not able to identify which values were captured (i.e., open space, view, habitat, etc). A study conducted in Maine outlines the economic benefits of open space to local communities (American Farmland Trust, 1992).

Beyond the economic factors in land use planning there are ethical considerations. Is the land a commodity that belongs to us? Or is land a community to which we belong? Are we the masters of the land or are we stewards of the land?

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