Historical Analysis and Map of Vegetation Communities, Land Covers, and Habitats of Fort Delaware State Park New Castle County, Delaware

Lower Delaware River Watershed

Submitted to:

Delaware State Parks
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CHAPTER 1: INTRODUCTION AND METHODS

Setting of Fort Delaware State Park

Fort Delaware State Park is located in east central New Castle County, Delaware (Figure 1.1). No formal tracts exist for the park, but for discussion purposes the park was divided into two sections, Delaware City (3 acres) and Pea Patch Island (257 acres). The Delaware City Section includes those parts of the park on the mainland adjacent to the boat landing. The Pea Patch Island Section includes all of the park land on Pea Patch Island.

Pea Patch Island is the location of the largest heronry on the Atlantic Coast and in 1993 was the home of 12,000 nesting pairs of birds[1]. By 2003, the number of nests had shrank to 3,285.[2]

[1] DNREC-Coastal Management Program. 1998. The Pea Patch Island Heronry Region: Special Management Plan. Delaware Department of Natural Resources and Environmental Control.
[2] http://delawarecity.info/nature.htm

Figure 1.1. Fort Delaware State Park Location

History and Formation of Fort Delaware State Park

Early History of the Land [3]

Pea Patch Island was formed in late 1700's as a mud bank in the Delaware River. Later a ship laden with peas grounded on the mud bank and gave the island its name. During the War of 1812 an effort was made to fortify the mud bank now turned island, but the major effort was not accomplished until 1813 when the state of Delaware seized the island from a Dr. Gale. Construction on the first fort was begun in 1817. The present fort was constructed between 1848 and 1859 and was used to house Confederate prisoners of war during the War between the states.

Formation of Fort Delaware State Park[4]

The state of Delaware acquired the island in 1947 as a federal surplus site.

Soils and Geology of Fort Delaware State Park [5]

Underlying Geology

The Scotts Corners Formation underlies the uplands on Pea Patch Island and on the mainland. It is described as a "heterogeneous unit of light-gray to brown to light yellowish-brown, coarse to fine sand, gravelly sand and pebble gravel with rare discontinuous beds or organic-rich clayey silt, and pebble gravel."

Soils

Broadkill Mucky Peat (147 acres) is the primary soil on Pea Patch Island. Other minor soils include Othello Silt Loam (44 acres), Endoaquepts and Sulfaquepts (28 acres), and Urban Land-Othello Complex (24 acres). Elevations of the park range from sea level to

[3] Fort Delaware. http://en.wikipedia.org/wiki/Ft._Delaware. Wikipedia
[4] Fort Delaware. http://en.wikipedia.org/wiki/Ft._Delaware. Wikipedia
5 Ramsey, Kelvin W. 2005. Geological Map of New Castle County. Delaware Geological Survey, Geologic Map Series No.13.

Delaware City Section Soils

Hambrook-Urban Land Complex (3 acres) is the only soil type present in the Delaware City Section.

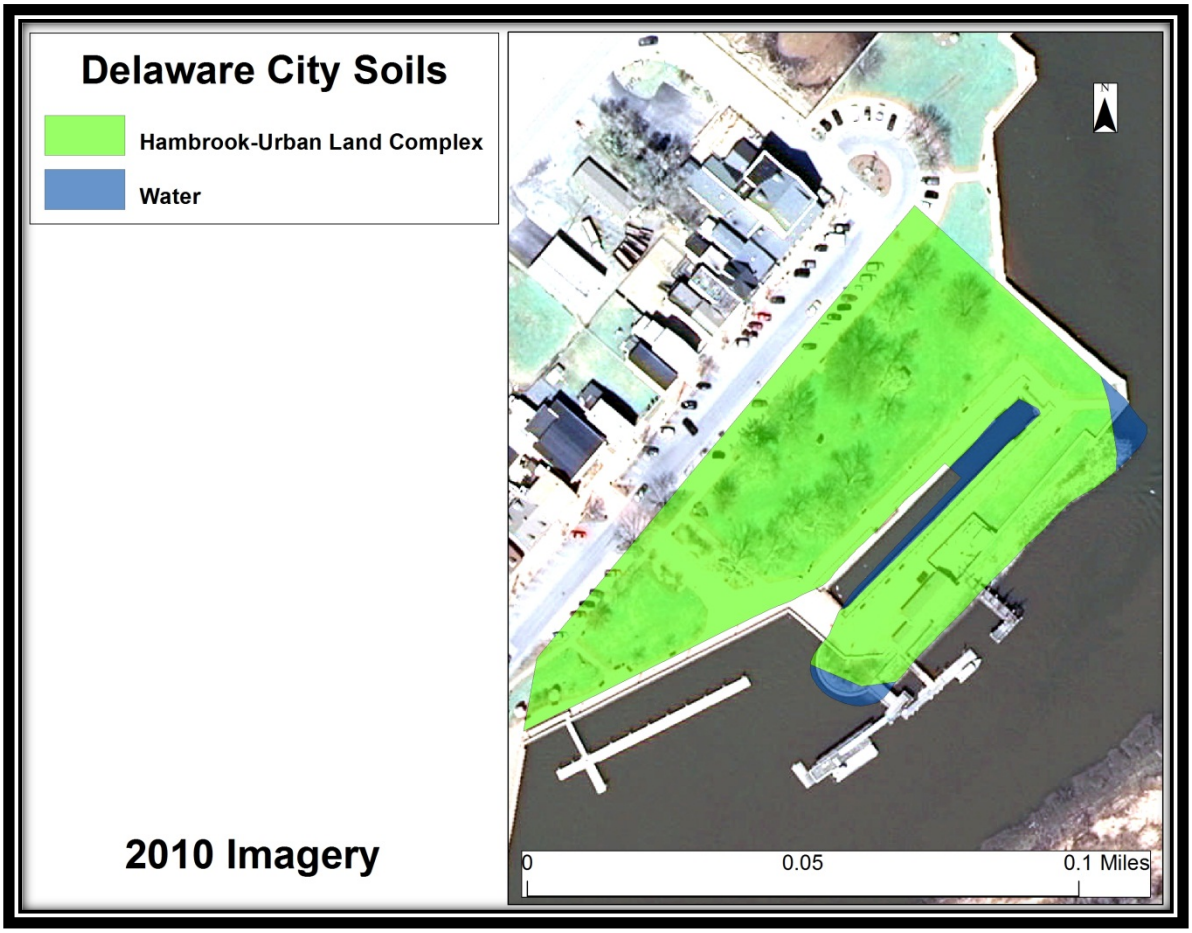

Figure 1.2. Delaware City Section Soil Map

Pea Patch Island Section Soils

Broadkill Mucky Peat (147 acres) is the primary soil on Pea Patch Island. Other minor soils include Othello Silt Loam (44 acres), Endoaquepts and Sulfaquepts (28 acres), and Urban Land-Othello Complex (24 acres).

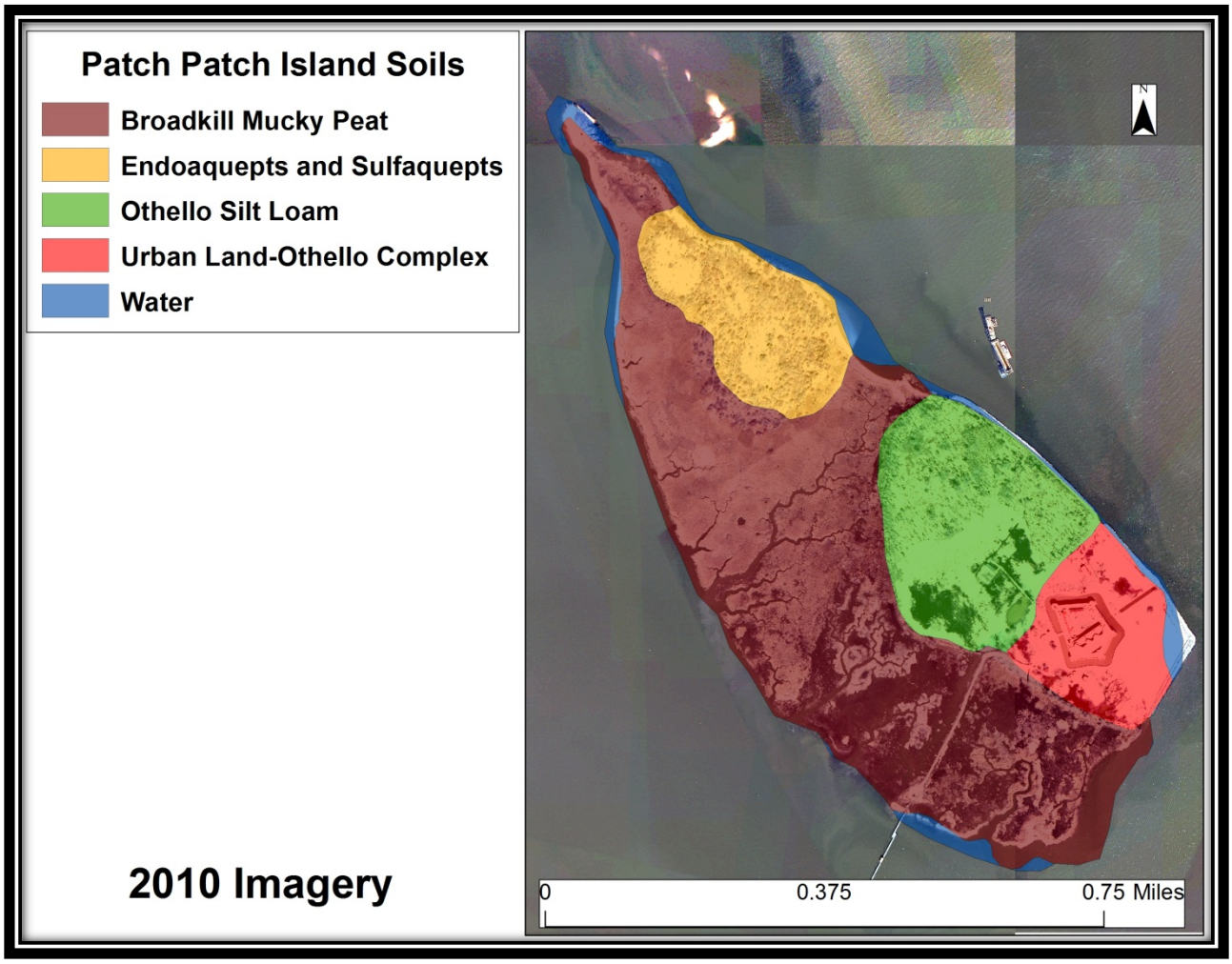

Figure 1.3. Pea Patch Island Section Soil Map

Discussion of vegetation communities in general and why they are important in management

While Natural Communities provide the optimal habitats and structure that are needed for animals to exist, vegetation communities provide an approximation of natural communities. The differences in the vegetation communities are governed by non-biotic factors and biotic factors. Non-biotic factors include things such as geology (soil type, availability of moisture, and exposure), climate, and fire regime. Biotic factors include: number and amount of predators and prey, biodiversity of the community and presence and absence of contributors to ecosystem health such as ants, fungi and bacteria and size of forest blocks. Historically these factors have not changed much other than changes brought about by larger climate shifts. Since the time of modern European settlement of Eastern North America (i.e. from about 1600 A.D.), physical factors such as fire regime and moisture availability have changed and nearly all of the biotic factors have changed resulted in a markedly different landscape today than what the original settlers saw. Today, instead of having Natural Communities, we have Vegetation Communities, which only approximate Natural Communities and are essentially artificial shells of what they could be.

Discussion of Sea-Level Rise and why it may affect the vegetation communities at Fort Delaware State Park

To understand the effects of sea-level rise on vegetation communities near the coast one can look at what has happened historically. From the late Pleistocene period to 5,000 years ago, sea-level rise in Delaware was about 3 cm/decade (30 cm/100 years). From 3,000 years to the recent past it has been rising 1 cm/decade (10 cm/100 years).[6] More recent data from the Indian River Inlet (1972-1983) shows the rate of rise to be 3.73 mm/year and at Lewes (1919-2009), 3.24 mm/year[7]. More recent historical ground data from the National Aeronautics and Space Administration (NASA) from 1870 to 2000 has shown a sea level rise of 1.7 mm/year or 1.7 cm/decade. Even more recent data from the Jason satellites (1993-present) has shown an increase in the rise to 3.28 mm/year or 3.3 cm/decade.[8] This is above the fast rate of rise seen from the Late Pleistocene to 5,000 years ago. Jay Custer in his book Prehistoric cultures of the Delmarva Peninsula states that "Rising sea-level had three major effects on the environments of the Delmarva Peninsula: changes in the availability and distribution of coastal resources, changes in interior water tables, and potential changes in local air mass distributions and weather patterns. Changing availability of coastal resources with sea-level is related both to the rate of sea-level rise and changing shoreline topography. Before 3,000 years ago the rate of sea-level rise was so great that stable estuarine environments did not have time to develop". The slower sea-level rise after this time has allowed estuaries and marshes to increase in size, by lateral erosion.[9] Sea-level rise can also cause water tables to rise, water logging swamps away from the coast, a fact that has been stated in elsewhere in the Mid-Atlantic [10,11,12]. The rising rate of rise may factor into the difference

6 Belknap, D.F. and J.C. Kraft. 1977. Holocene relative sea-level changes and coastal stratigraphic units on the northwest flank of the Baltimore Canyon geosyncline. Journal of Sedimentary Petrology 47(2): 610-629 in Custer (1989).
7 Data from Permanent Service for Mean Sea Level website (www.psmsl.org)
8 NASA Global Climate Change Website (http://climate.nasa.gov/keyindicators) December 12, 2010 update.
9 Custer, Jay F. 1989. Prehistoric cultures of the Delmarva Peninsula: archaeological study. (Cranbury, NJ: Associated University Presses, Inc.), 447 pp.
10 Rappleye, L. and W.M. Gardner. 1979. A cultural resources reconnaissance and impact assessment of the Great Dismal Swamp National Wildlife Refuge, City of Suffolk, Chesapeake, and Nansemond Counties, Virginia. Manuscript on file. Department of Anthropology, Catholic University, Washington, DC in Custer (1989).

between the Indian River Inlet and Lewes tidal stations. The Lewes station has been operating longer and has a more complete data set than the Indian River Inlet station.

Other sources have stated the rise on the Mid-Atlantic Coast to be 3-4 mm/year, while the global average is 1.8 mm/year[13], the difference of which is caused by geological subsidence from the glaciers of the last ice age. The rate sea-level rise now is equal to the time historically when estuaries and marshes did not have time to develop. Marshes have been accreting about 3 mm/year for the past 100 years [14], but the current rate of sea level rise is above the accretion rate resulting in losses. It is projected to go much higher with rates of 10 cm/decade (1 m/100 years) as a median[15]. Kraft and Khalequzzaman project that most of the fringing salt marshes in Delaware will be eliminated in 200-300 years and by extinct in 1,500 to 1,700 years.[16] Other investigators have pointed out that there is a lack of temporal scale to a lot of the studies and that there may be a significant time lag between sea level rise and anthropogenic inputs of carbon dioxide. [17] These changes would also impact the fisheries and economy related to it in the area.

Components of Sea Level Rise

There are many factors that all come together to produce the observed rise above. These include Eustatic (rise due to increased water volume), stearic (rise due to increased temperature and salinity), and isostatic (rise due to geological subsidence).

Eustatic Rise

Most people think of this factor when they talk about sea level rise. This is the contribution of increased water volume coming from the melting of glaciers, snowpack, and groundwater extraction. Using the figure for Indian River Inlet above this accounts for about 1.2 mm/year of the rise when subtracted from the other factors[18]. Added to this is newer research that shows groundwater depletion is adding 0.8 mm/year to sea level rise[19]. From this you have to subtract the amount of water that has been impounded on land. Chao, et al. states that about 10,800 cubic kilometers has been impounded in

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11 Whitehead, D.R. 1972. Developmental and environmental history of the Dismal Swamp. Ecological Monographs 42:301-15 in Custer (1989).
12 Gardner, W.M. 1978. Comparison of Ridge and Valley, Blue Ridge, Piedmont, and Coastal Plain Archaic Period Site Distribution: An idealized transect (preliminary model). Paper presented at the 1978 Middle Atlantic Archeological Conference, Rehoboth Beach, Delaware in Custer (1989).
13 Johnson, Zoe Pfahl. 2000. A Sea Level Rise Response Strategy for the State of Maryland. Maryland Department of Natural Resources.
14 Nikitina, Daria L., James E. Pizzuto, Reed A. Schwimmer, and Kelvin W. Ramsey. 2000. An updated Holocene sea-level curve for the Delaware Coast. Marine Geology 171 (1-4): 7-20.
15 Barth, M.C. and J.G. Titus. 1984. Greenhouse Effect and Sea Level Rise: A Challenge for this Generation. (New York: Van Nostrand Reinhold Co., Inc.) 238 pp.
16 Kraft, John C. and Md. Khalequzzaman. 1992. Geologic and human factors in the decline of the tidal salt marsh lithesome: the Delaware Estuary and Atlantic coastal zone. Sedimentary Geology 80 (3-4): 233-246.
17 Larsen, C.E. and I. Clark. 2006. A search for scale in sea-level studies. Journal of Coastal Research 22(4): 788-800.
18 Davis, George H. 1987. Land Subsidence and Sea Level Rise on the Atlantic Coastal Plain of the United States. Environmental Geology 10 (2): 67-80.
19 Wada, Y., L.P.H. van Beek, C.M. van Kempen. J.W.T. Reckman, S. Vasak, and M.F.P. Bierkens. 2010. Global depletion of groundwater resources. Geophysical Research Letters 37

the last half century which subtracts about 0.55 mm/year from the rise[20]. When added together, eustatic factors account for 1.45 mm/year of the rise.

Stearic Rise

This factor comes from thermal expansion of ocean water and salinity currents. This factor contributes about 0.9 mm/year of the observed rise[21]. Yin et al states that this factor could account for more than the global mean in the future through a weakening of the meridional overturning circulation in the Atlantic[22], accounting for much more rise than in earlier studies. They go further to say that these contributions in New York City could result in a rise of 15 cm, 20 cm, or 21 cm, under low, medium, and high rates of emissions, respectively[23]. Other studies have pointed out that variations in rise in the Mid-Atlantic can be 20 cm and persist for years due to the North Atlantic Subtropical Gyre[24].

Isostatic Rise

Geological land subsidence adds the most to the rise currently accounting for about 1.6 mm/year[25] in the Mid-Atlantic region. Another study has given an amount ranging from 1.02 to 1.53 mm/year[26]. Liu, et al gives a similar for New York City stating a sea level rise of 2-4 mm/year to which glacio-isostatic factors account for about 40%[27].

All of these factors added together

If we add all of these factors together using the data above we get a range of 3.15 mm to 3.95 mm/year.

E= Eustatic (1.45 mm/yr.)
S= Stearic (0.9 mm/yr.)
I= Isostatic (1.6 mm/yr.-Davis, 1.02-1.53 mm/yr.-Engelhart, et al., 0.8 mm-1.6 mm/yr.-Liu)

20 Chao, B.F., Y.H. Wu, and Y.S. Li. 2008. Impact of Artificial Reservoir Water Impoundment on Global Sea Level. Science 320(5873): 212-214.
21 Ditto
22 Yin, Jianjun., S.M. Griffies, M. Schlesinger, R.J. Stouffer. 2010. Regional Sea Level Rise Projections on the Northeast Coast of the United States. American Geophysical Union, Fall 2010 meeting.
23 Yin, Jianjun, M.E. Schlesinger, R.J. Stouffer. 2009. Model Projections of Rapid Sea Level Rise on the Northeast Coast of the United States. Nature Geoscience 2(4): 262-266.
24 Hong, Byung-Gi. 1998. Decadal variability in the North Atlantic Subtropical Gyre: Can it explain variability in sea level along the East Coast of the United States. Ph.D. Thesis, The Florida State University, 77 pp.
25 Davis, George H. 1987. Land Subsidence and Sea Level Rise on the Atlantic Coastal Plain of the United States. Environmental Geology 10(2): 67-80.
26 Englehart, S.E., B.P. Horton, B.C. Douglas, W.R. Peltier, T.E. Tornqvist. 2008. Spatial variability in the 20th century record of sea level rise along the US Atlantic Coast. American Gophysical Union, Fall 2008 Meeting.
27 Liu, J., R. Horton. 2007. Impacts of combined sea level rise and coastal subsidence, New York City Metropolitian Area. American Geophysical Union. Fall 2007 Meeting.

Using vegetation communities to map sea level rise and changes in the landscape

One of the first studies in Delaware to use vegetation communities to map human induced changes in the landscape was done by a Victor Klemas at the University of Delaware in the early 1970s[28]. Victor compared aerial imagery from 1954 and 1968 on a qualitative basis and looked at changes in the marshes and other man-made features. He incorporated some multispectral analysis to determine some of the vegetation types. Though he did not refer to specific vegetation communities as we know them now, he did look at vegetation assemblages (Low marsh, high marsh, and salt shrub) that are very similar to the groupings now. No figures were given in his paper regarding the overall changes. He did note, however, that the shoreline at Cape Henlopen had receded 4 to 21 feet per year from 1843 to 1939[29]. Other papers have also used historical aerial imagery to map vegetation change[30,31] and salinity factors can impact on those changes[32].

More recent studies looking at both changes in tidal marshes[33] and coastal forests[34] have shown that both can suffer effects of a rising sea level. Matthew Kirwan states that a tidal marsh can keep up with sea level rise through accretion if the amount of sediment is adequate, but that reforestation and dam building has restricted the sediment inflows[35]. Shirley and Battaglia come roughly to the same conclusion on the Gulf of Mexico coast, stating that they do not believe the marshes are keeping pace with the aquatic to terrestrial transition, but it is hard to map in the Coastal Plain because of major land use changes[36]. Kimberlyn Williams states that some of the factors leading to forest decline in coastal areas result from; soil flooding—resulting in low oxygen availability and reducing conditions, elevated soil and groundwater salinity, and saltwater intrusion.

One study in the Delaware River Estuary stipulated that freshwater tidal marshes are needed to help the development of brackish and salt marshes[37] in areas where the coast was submerging. The freshwater marshes help produce the environmental conditions later needed by the more saline marshes.

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28 Klemas, Vytautas. 1972. Use of remote sensing to determine natural and man-made changes in the coastal zone. Transactions of the Delaware Academy of Science. 2: 13-34.
29 Vytautas, Klemas. 1972. Use of remote sensing and to determine natural and man-made changes in the coastal zone. Transactions of the Delaware Academy of Science 2:13-34.
30 Kadmon, R. and R. Harari-Kremer. 1999. Studying the long term vegetation dynamics using digital processing of historical aerial photographs. Remote Sensing of the Environment 68:164-176.
31 Smith, Carrie, Merryl Alber, and Alice Chalmers. 2001. Linking shifts in historic estuarine vegetation to salinity changes using a GIS. Proceedings of the 2001 Georgia Water Resources Conference.
32 Earle, J.C. and K.A. Kershaw. 1988. Vegetation patterns in James Bay coastal marshes. III. Salinity and elevation as factors influencing plant zonations. Canadian Journal of Botany 67: 2967-2974.
33 Kirwan, Matthew L. and A. Brad Murray. 2007. A coupled geomorphic and ecological model of tidal marsh evolution. Proceedings of the National Academy of Science 104(15):6118-6122.
34 Williams, Kimberlyn, et al. 1999. Sea-level rise and coastal forest retreat on the west coast of Florida, USA Ecology
35 Kirwan, Matthew L. and A. Brad Murray. 2007. A coupled geomorphic and ecological model of tidal marsh evolution. Proceedings of the National Academy of Science 104(15):6118-6122.
36 Shirley, Laura and Lorretta L. Battaglia. 2006. Assessing vegetation change in coastal landscapes of the northern Gulf of Mexico. Wetlands 26(4): 1057-1070.
37 Orson, Richard A., Robert L. Simpson, and Ralph E. Good. 1992. The Paleoecological development of a late Holocene, Tidal Freshwater Marsh of the Upper Delaware River Estuary. Estuaries and Coasts 15(2): 130-146.

Purpose of the Study

This study was conducted with the following goals in mind:

1. Classify and map vegetation communities, land covers, and assess habitat conditions for Species of Greatest Conservation Need (SGCN)[as defined in the Delaware Wildlife Action Plan (DEWAP)] for Fort Delaware State Park based on 1954, 2002, and 2007 aerial imagery and field observations.
2. Use the maps above to determine changes in the vegetation communities and the effects of sea level rise and to determine the relative rate of sea level rise in the state park.
3. Determine the forest blocks located within or partially within the state park.
4. Produce Ecological Integrity Assessments (EIAs) for vegetation communities that ranked S2 or higher.

Surveys were conducted during 2010 and 2011 by Robert Coxe, an Environmental Scientist with the Delaware Natural Heritage and Endangered Species Program (DNHESP) within the Delaware Division of Fish and Wildlife, Department of Natural Resources and Environmental Control (DNREC).

Vegetation Community and Land Cover Surveys

Vegetation communities and land covers were determined by qualitative analysis using observations made in the field and aerial photo-interpretation using 1954, 2002, 2007, and 2010 aerial imagery. Vegetation communities are named according to the *Guide to Delaware Vegetation Communities* [38]which follows the National Vegetation Classification System (NVCS). The NVCS classifies vegetation on a national scale for the United States and is linked to international vegetation classification. The NVCS helps provide a uniform name and description of vegetation communities found throughout the country and helps determine relative rarity. Descriptions of the communities are provided. A crosswalk to the Delaware Wildlife Action Plan (DEWAP) and the Northeast Habitat Classification (NHC) is given at the top of each individual description.

Analysis of Historical Imagery

Historical imagery of Fort Delaware State Park from 1954 and 2002 and current imagery from 2007 were examined. A vegetation community map was produced for each year in order to compare vegetation and land cover change over a 5, 48, and 53 year time frame. Changes in the respective vegetation communities and land covers are discussed in the descriptions while broader changes are discussed in the state park as a whole discussion. There is more imagery available (1937, 1961, 1968, 1992, and 1997) but these sets were not used due to geo-registration problems in the image tiles.

Sea Level Rise Analysis

An analysis was performed for the wildlife area as whole using the DNREC Sea Level Rise Scenarios to project the amount of acres lost under each scenario for the sections, the vegetation communities, and the land covers.

38 Coxe, Robert. 2010. Guide to Delaware Vegetation Communities-Fall 2012 Edition. Unpublished report.

Natural Capital Analysis

The natural capital of each vegetation community was determined using a table in Costanza, et al.[39] The values from the table were calculated per acre of the vegetation community and then adjusted using an inflation calculator (DollarTimes.com) from 1994 values to 2012 values. Using these methods the following values were obtained:

Estuaries (water): $9,247/acre/year

Temperate Forest (Upland forests): $122/acre/year

Wetlands

-General (not as below): $5,988/acre/year

-Tidal Marsh: $4,046/acre/year

-Swamps/floodplains: $7,930/acre/year

Lakes (Impoundments): $3,442/acre/year

Cropland: $37/acre/year

Grassland/fields: $94/acre/year

Open Ocean: $102/acre/year

Values were rounded off to the nearest whole dollar.

39 Costanza, Robert, et al. 1997. The value of the world's ecosystem services and natural capital. Nature 387:253-260.

CHAPTER 2: RESULTS OF EIAS, FOREST BLOCKS, AND GENERAL OBSERVATIONS

Summary of Findings from this study

1. **Vegetation Communities:** Six vegetation communities and seven land covers were found at Fort Delaware State Park. Northeastern Modified Successional Forest (43 acres) is the largest vegetation community, followed by Cultivated Lawn with 42 acres. Water (28 acres) is the largest land cover, followed by Impervious Surface with 4 acres.

2. **Rare Plants:** One rare plant is known to exist in Fort Delaware State Park (Table 2.1).

Scientific Name	Common Name	Rank	Last Observed
Scutellaria galericulata	Hooded Skullcap	S1	1988

Table 2.1 Rare Plants at Fort Delaware State Park

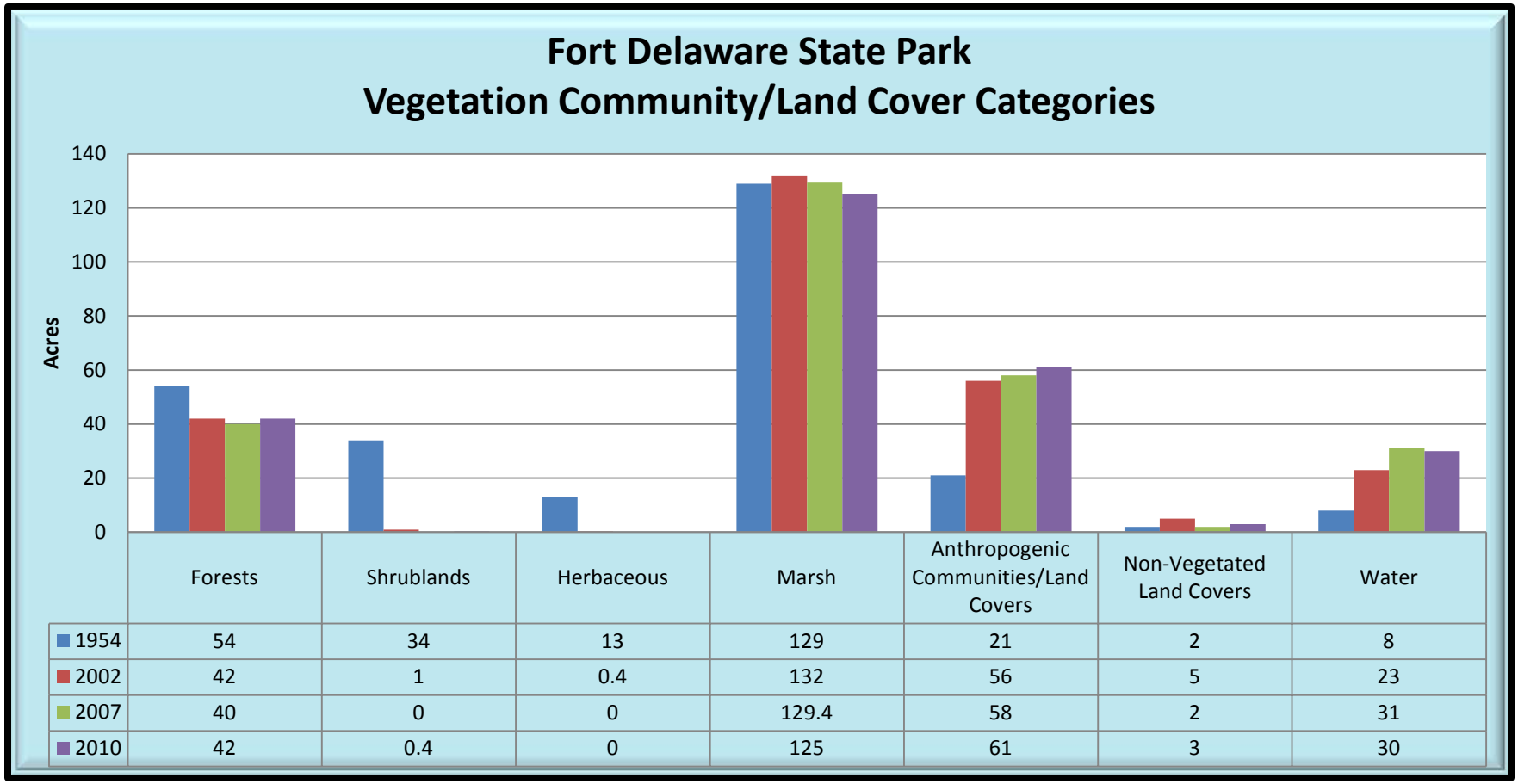
3. **Rare Animals:** Nine rare animals are known to exist in Fort Delaware State Park (Table 2.2).

Scientific Name	Common Name	Rank	Last Observed
Ardea alba	Great Egret	S1B	???
Ardea herodias	Great Blue Heron	S2B	2011
Bubulcus ibis	Cattle Egret	S1B	1995
Egretta caerulea	Little Blue Heron	S1B	1995
Egretta thula	Snowy Egret	S1B	1995
Egretta tricolor	Tricolored Heron	S1B	1995
Nyctanassa violacea	Yellow-crowned Night-heron	S1B	1995
Nycticorax nycticorax	Black-crowned Night-heron	S1B	1995
Libellula deplanata	Glossy Ibis	S1B	1995

Table 2.2 Rare Animals at Fort Delaware State Park

The Natural Progression of vegetation communities on the shores of the Delaware Bay

Vegetation communities located adjacent to the shore of Delaware Bay or the Inland Bays go through a natural progression of retreating backwards as sea level rises. For centuries this has meant that as sea level rises, the forested communities will progress into shrubland, the shrubland will progress into marsh, and then the marsh will convert to open water, perhaps with a brief period as a mudflat. Further gradations can be noticed via different forests, shrublands, and marshes (high and low), and can be used to map out the effects of sea level rise and increasing salinity in the area. In the recent past (70 years) this natural progression appears to be eroding because of sea levels which are rising too fast for the natural progression to continue. In addition some communities reach a hardened shoreline, rip-rap or some other artificial barrier which prevents the progression.



	Forests	Shrublands	Herbaceous	Marsh	Anthropogenic Communities/Land Covers	Non-Vegetated Land Covers	Water
1954	54	34	13	129	21	2	8
2002	42	1	0.4	132	56	5	23
2007	40	0	0	129.4	58	2	31
2010	42	0.4	0	125	61	3	30

Figure 3.1. Fort Delaware State Park Vegetation Categories/Land Covers (1954, 2002, 2007, and 2010)

Fort Delaware State Park Broad Trends (Figure 3.1): Most of Fort Delaware State Park is covered in marshland followed by anthropogenic communities/land covers. Forestland on Pea Patch Island is a close third.

Natural Capital (Table 3.1)

Capital of Fort Delaware State Park has increased since 1954, with a recent decrease due a loss of marshland and water.

Table 3.1. Natural Capital of Fort Delaware State Park	
Year	**Natural Capital (in 2012 dollars)**
1954	$988,677/year
2002	$1,178,489/year
2007	$1,274,592/year
2010	$1,239,373/year

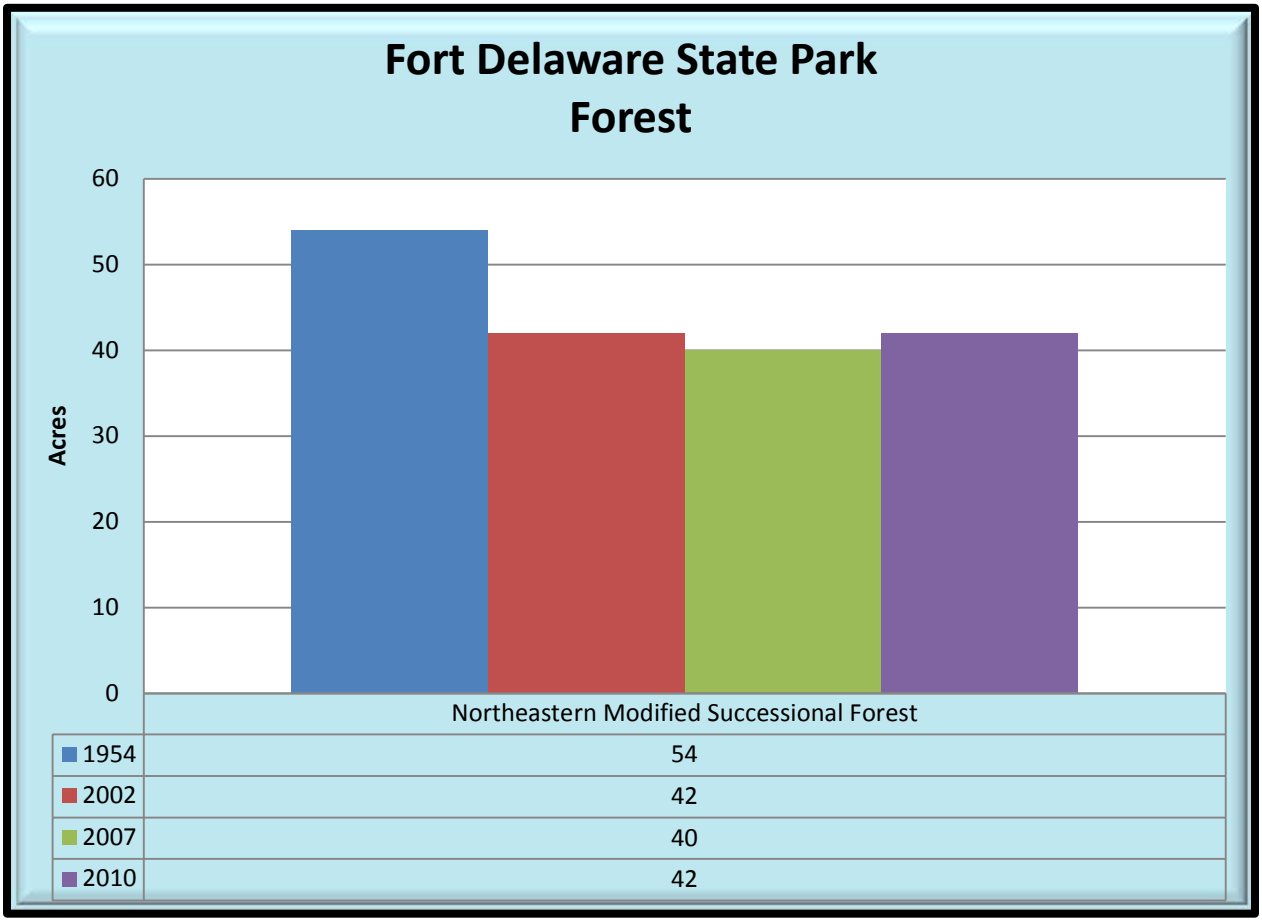


Figure 3.2. Forest at Fort Delaware State Park (1954, 2002, 2007, and 2010)

Fort Delaware State Park Forest (Figure 3.2): Northeastern Modified Successional Forest is the only forest community in Fort Delaware State Park.

Natural Capital (Table 3.2)

Capital of forest has shown a gradual downward trend as forests are converted to anthropogenic communities/land covers.

Table 3.2. Natural Capital of Fort Delaware State Park Forest	
Year	**Natural Capital (in 2012 dollars)**
1954	$10,211/year
2002	$7,942/year
2007	$7,564/year
2010	$7,942/year

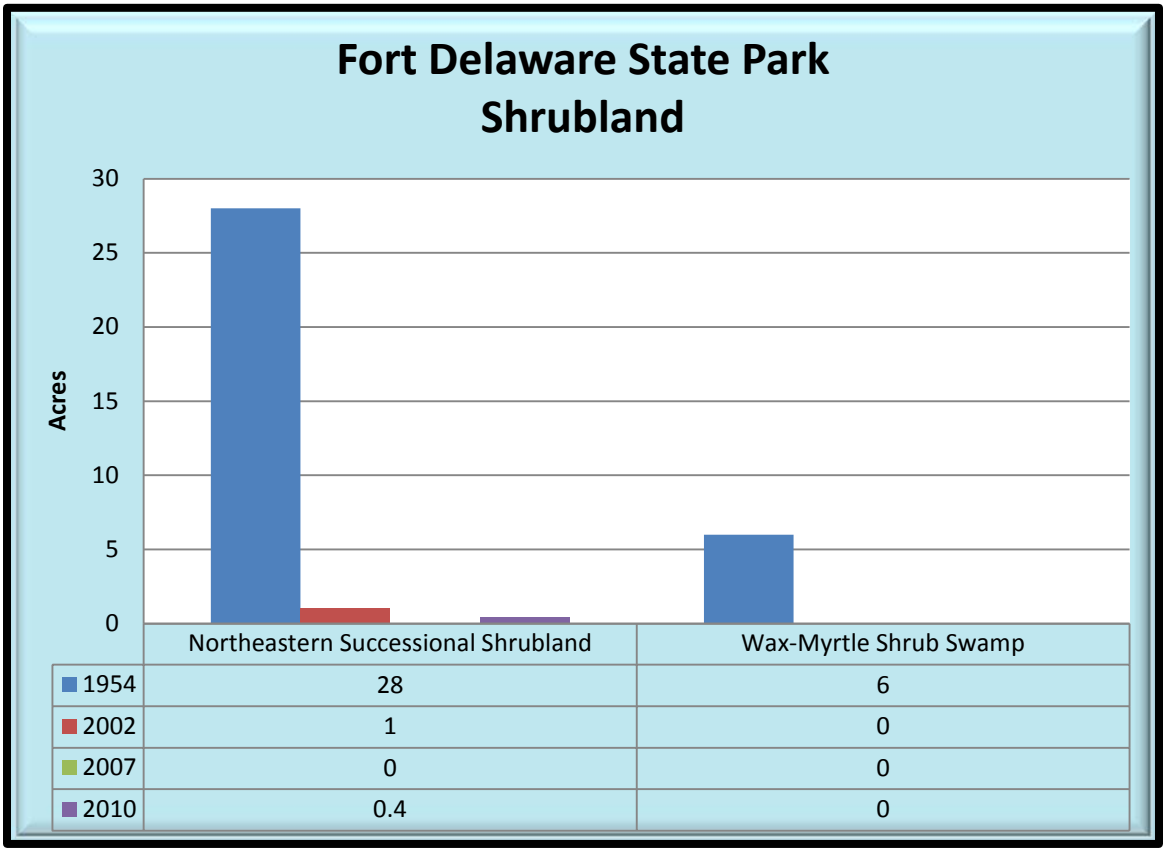


Figure 3.3. Shrubland at Fort Delaware State Park (1954, 2002, 2007, and 2010)

Fort Delaware State Park Shrubland (Figure 3.3): Northeastern Successional is the only shrubland currently present in Fort Delaware State Park.

Natural Capital (Table 3.3)

Capital of shrubland has gradually been declining with maturation of Northeastern Successional Shrubland.

Table 3.3. Natural Capital of Fort Delaware State Park Shrubland	
Year	**Natural Capital (in 2012 dollars)**
1954	$41,707/year
2002	$146/year
2007	$0/year (not present)
2010	$58/year

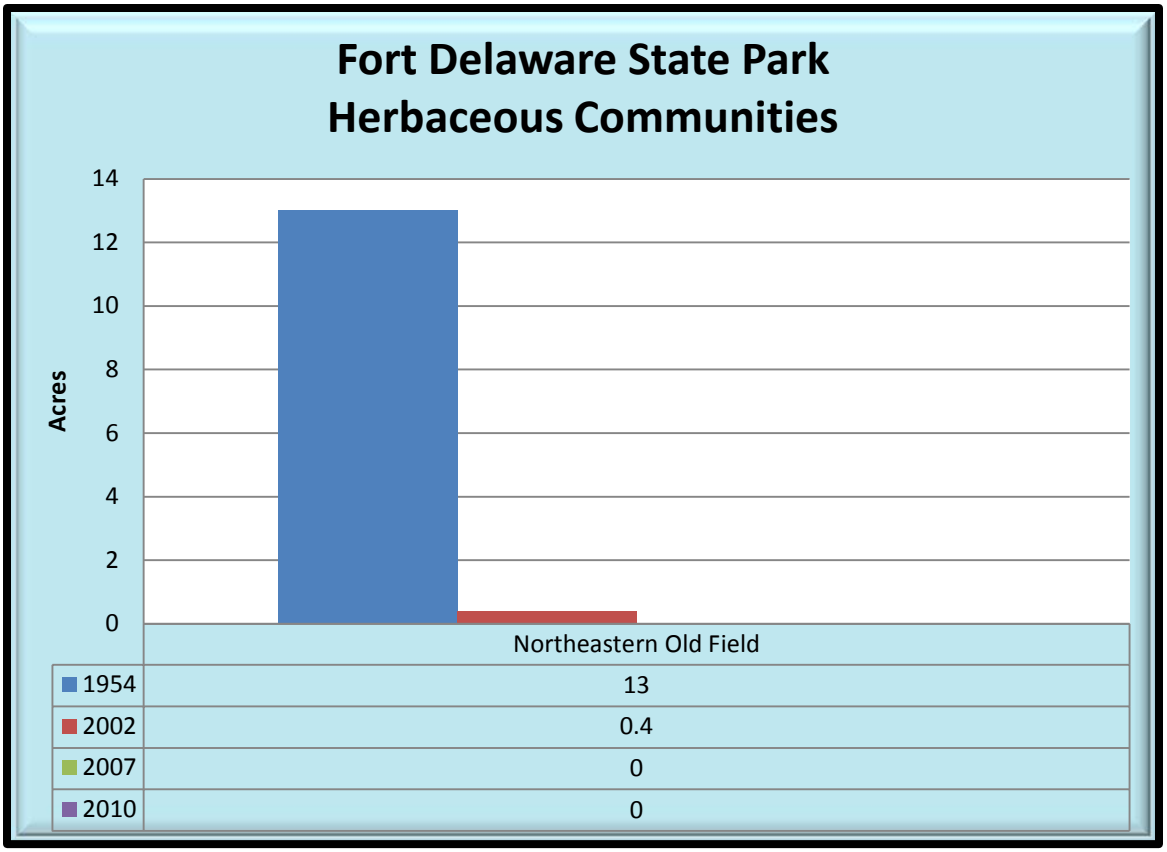


Figure 3.4. Herbaceous Communities at Fort Delaware State Park (1954, 2002, 2007, and 2010)

Fort Delaware State Park Herbaceous Communities (Figure 3.4): Northeastern Old Field is the only herbaceous community located in Fort Delaware State Park.

Natural Capital (Table 3.4)

Herbaceous community capital has been transferred to more mature communities during the study period.

Table 3.4. Natural Capital of Fort Delaware State Park Herbaceous Communities	
Year	**Natural Capital (in 2012 dollars)**
1954	$1,894/year
2002	$58/year
2007	$0/year (not present)
2010	$0/year (not present)

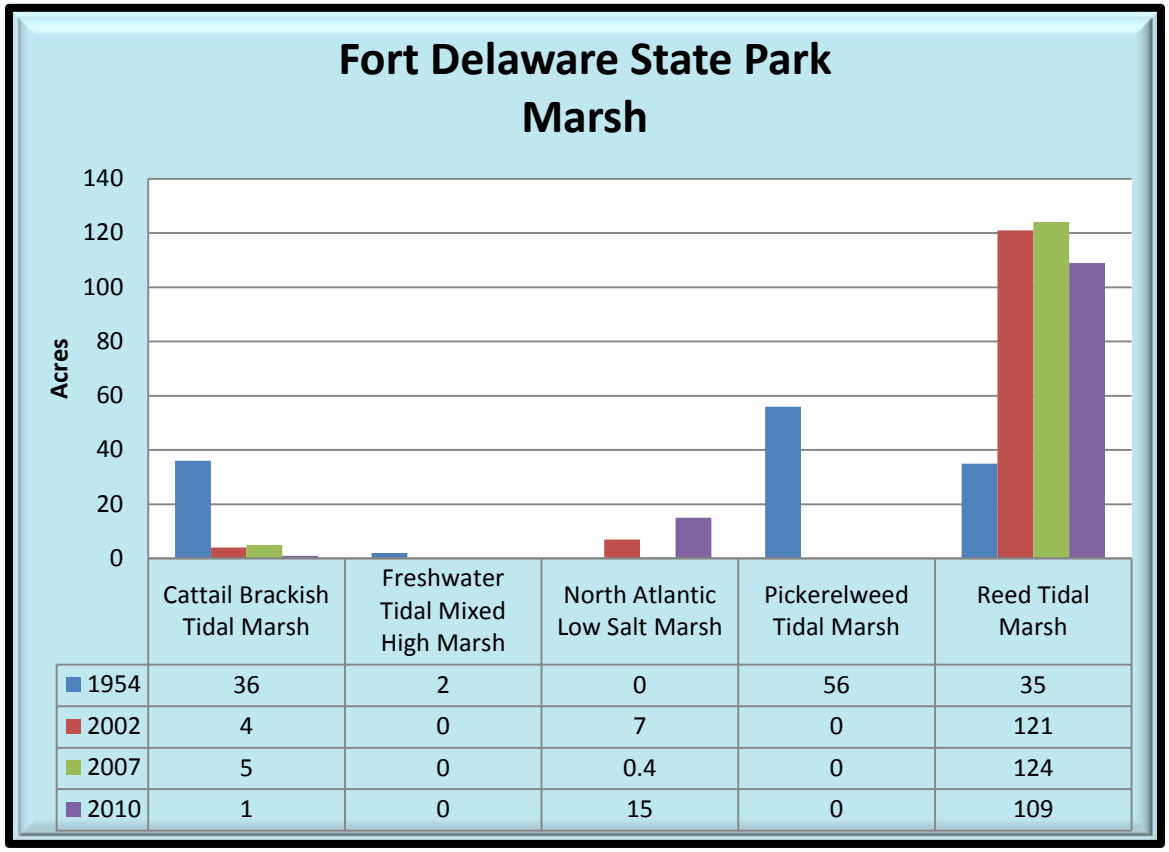


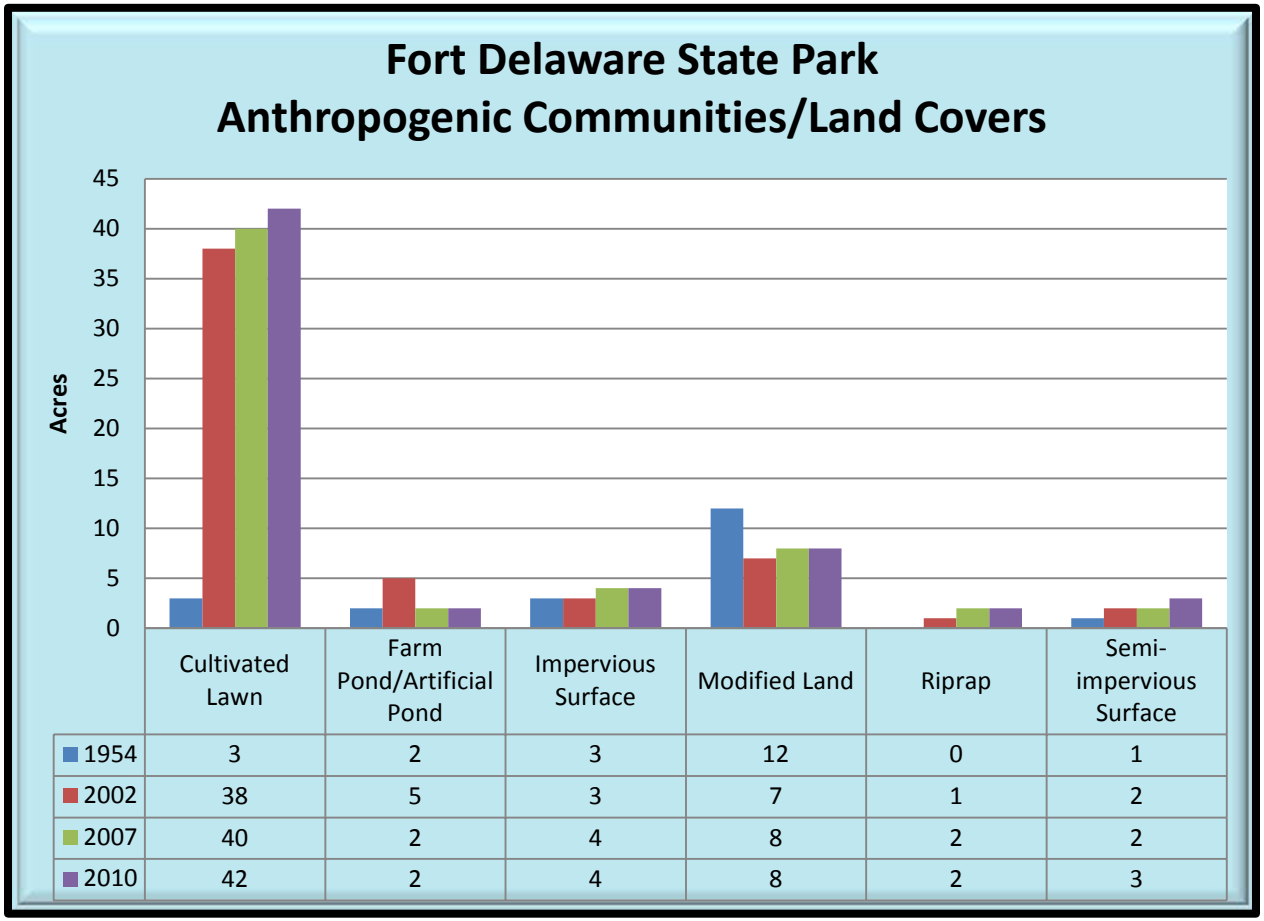
Figure 3.5. Marsh at Fort Delaware State Park (1954, 2002, 2007, and 2010)

Fort Delaware State Park Marsh (Figure 3.5): Reed Tidal Marsh is currently the largest marsh in Fort Delaware State Park, taking the title from Pickerelweed Tidal Marsh in 2002.

Natural Capital (Table 3.5)

Marsh capital has remained at roughly the same amount, with some oscillation during the study period.

Table 3.5. Natural Capital of Fort Delaware State Park Marsh	
Year	**Natural Capital (in 2012 dollars)**
1954	$808,998/year
2002	$827,812/year
2007	$811,506/year
2010	$783,913/year



	Cultivated Lawn	Farm Pond/Artificial Pond	Impervious Surface	Modified Land	Riprap	Semi-impervious Surface
1954	3	2	3	12	0	1
2002	38	5	3	7	1	2
2007	40	2	4	8	2	2
2010	42	2	4	8	2	3

Figure 3.6. Anthropogenic Communities/Land Covers at Fort Delaware State Park (1954, 2002, 2007, and 2010)

Fort Delaware State Park Anthropogenic Communities/Land Covers (Figure 3.6): Cultivated lawn is the largest Anthropogenic Community/land cover in Fort Delaware State Park.

Natural Capital (Table 3.6)

Farm Pond/Artificial Pond is only anthropogenic community/land cover with any capital value. Its amount has been roughly stable with a spike upward in 2002.

Table 3.6. Natural Capital of Fort Delaware State Park Anthropogenic Communities/Land Covers	
Year	**Natural Capital (in 2012 dollars)**
1954	$10,670/year
2002	$26,676/year
2007	$10,670/year
2010	$10,670/year

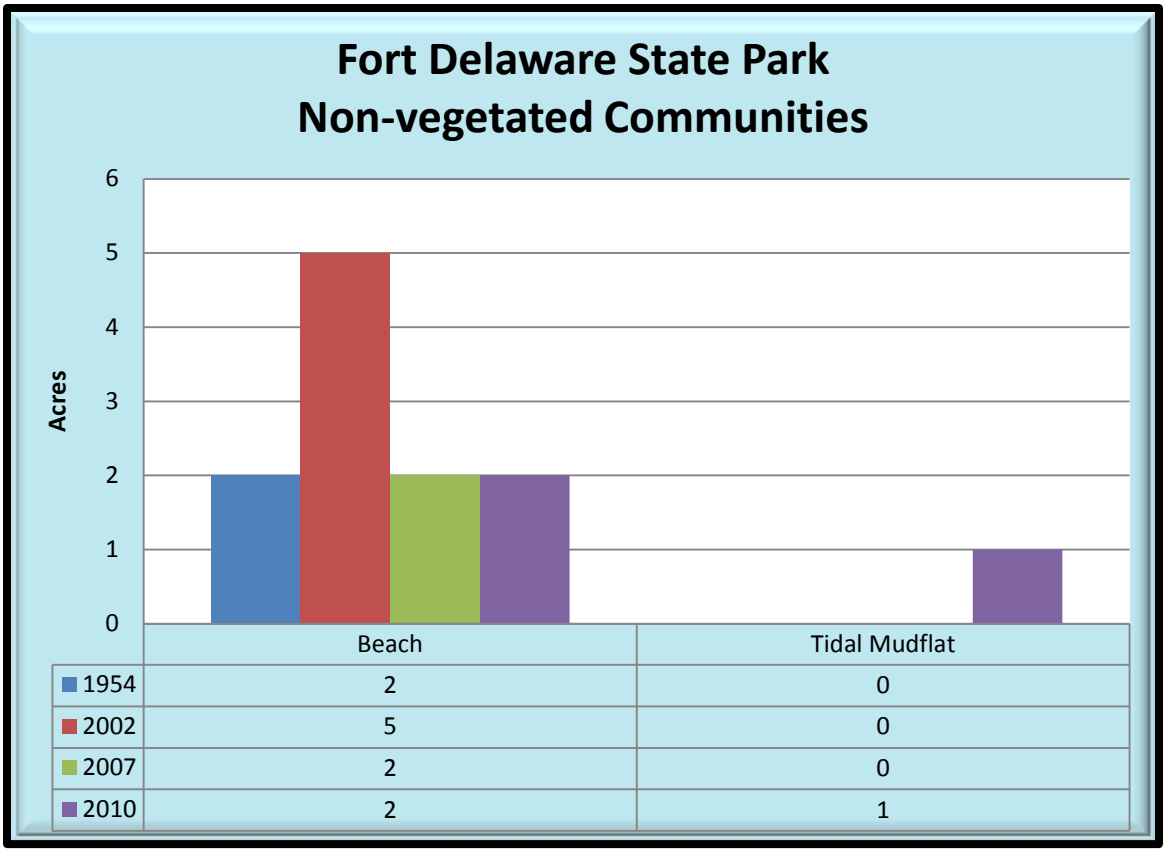


Figure 3.7. Non-vegetated Land Covers at Fort Delaware State Park (1954, 2002, 2007, and 2010)

Fort Delaware State Park Non-vegetated Land Covers (Figure 3.7): Beach is the largest non-vegetated land in Fort Delaware State Park.

Natural Capital (Table 3.7)

Tidal mudflat is the only non-vegetated land cover with capital value. It has recently appeared in 2007 with $6,271 in capital value.

Table 3.7. Natural Capital of Fort Delaware State Park Non-vegetated Land Covers	
Year	**Natural Capital (in 2012 dollars)**
1954	$0/year (not present)
2002	$0/year (not present)
2007	$0/year (not present)
2010	$6,271/year

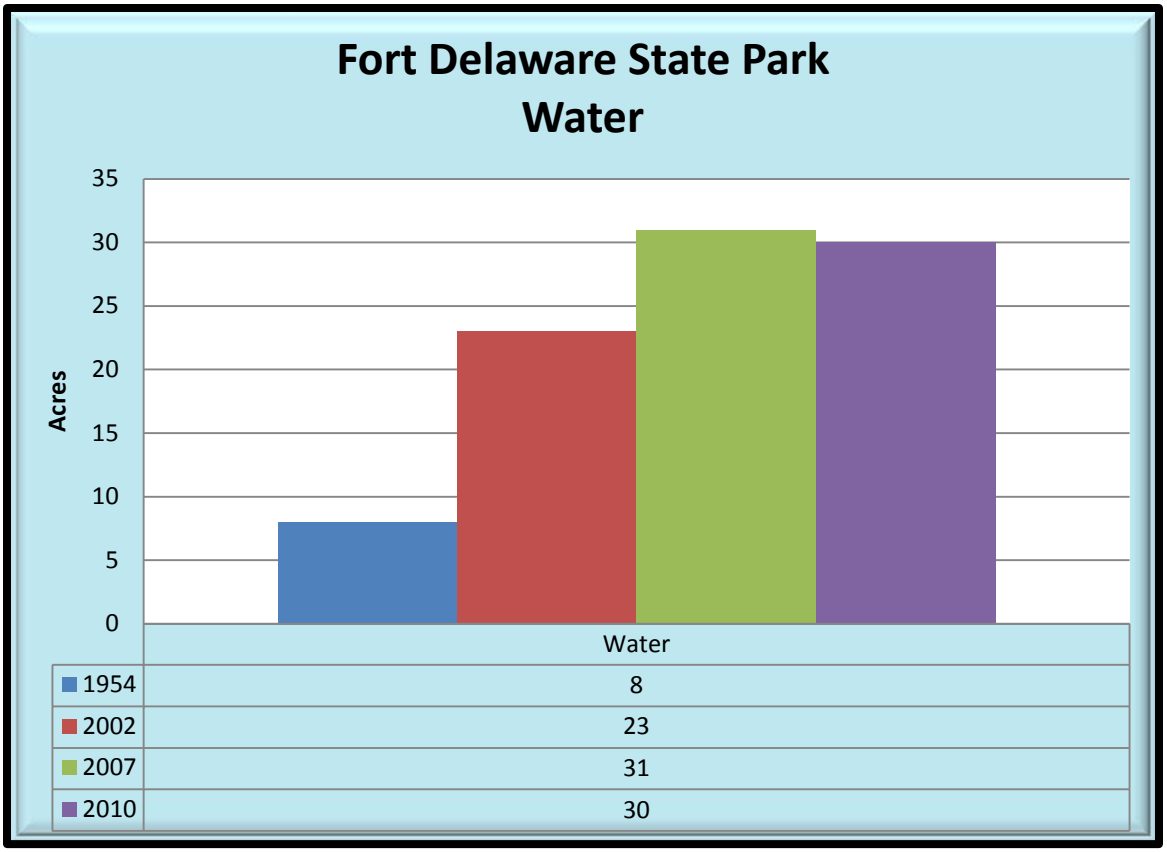


Figure 3.8. Water coverage (non-impoundment) at Fort Delaware State Park (1954, 2002, 2007, and 2010)

Fort Delaware State Park Water (Figure 3.8): Water has been increasing overall in Fort Delaware State Park with some fluctuation due filling and riprapping of the shores of Pea Patch Island.

Natural Capital (Table 3.8)

Capital of water has increased overall with slight decrease in the 2002-2007 period.

Table 3.8. Natural Capital of Fort Delaware State Park Water	
Year	**Natural Capital (in 2012 dollars)**
1954	$114,663/year
2002	$329,656/year
2007	$444,318/year
2010	$429,986/year

CHAPTER 4: VEGETATION COMMUNITIES BY SECTION

1. Delaware City Section

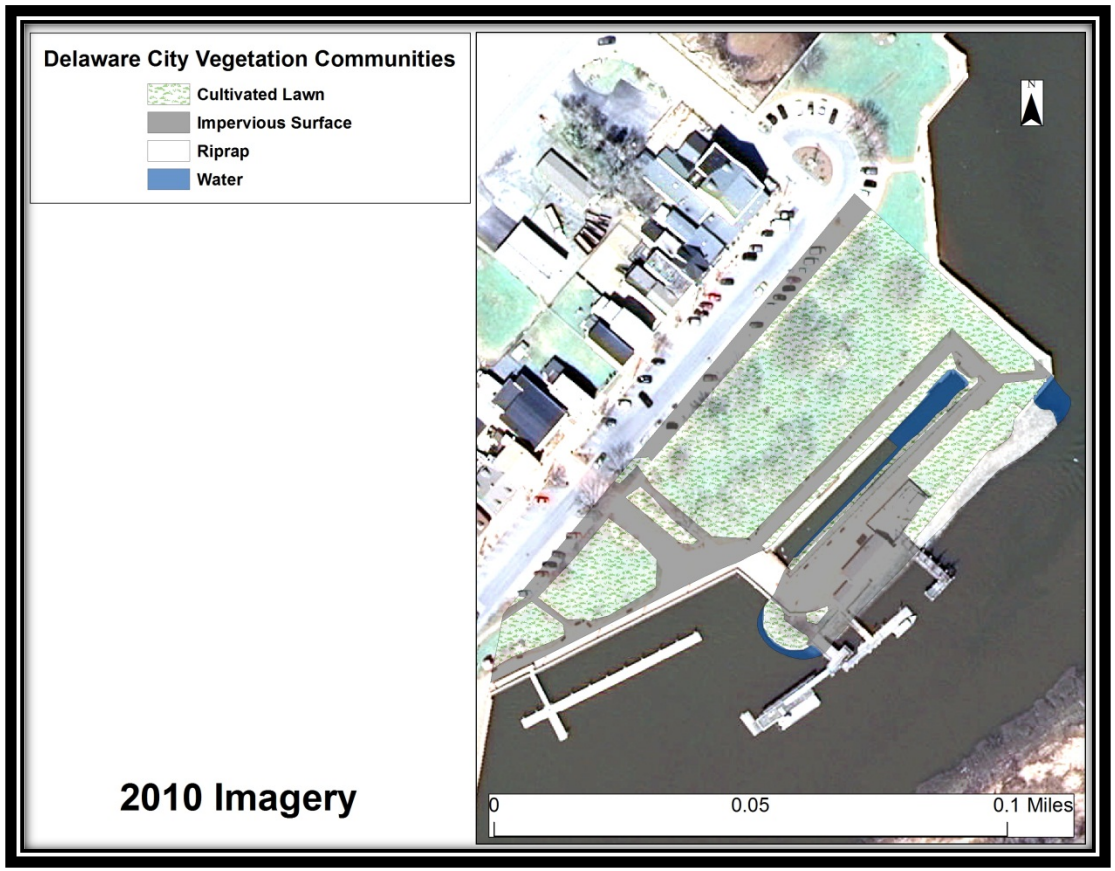


Figure 4-1.1. 2010 Vegetation Community Map of the Delaware City Section

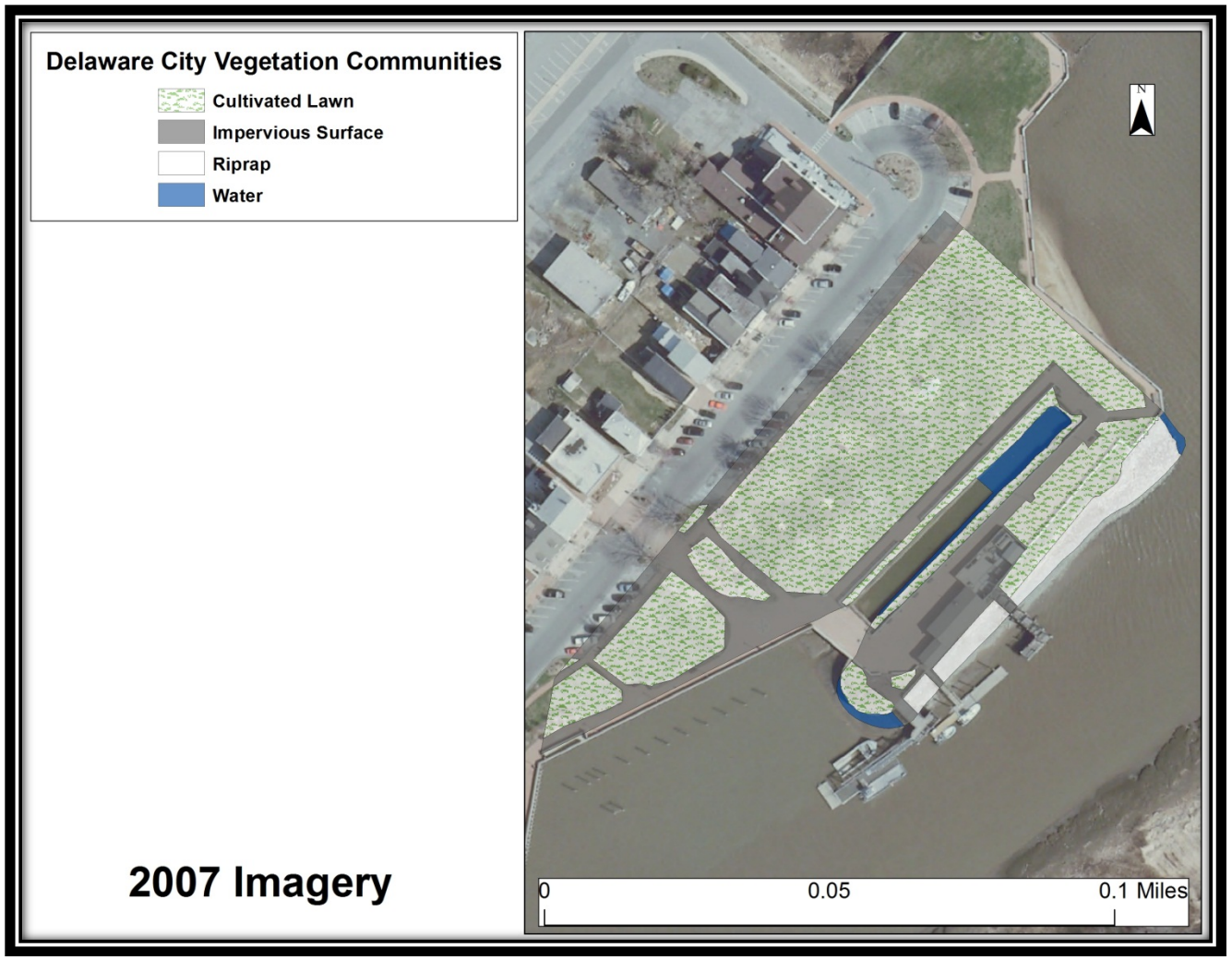


Figure 4-1.2. 2007 Vegetation Community Map of the Delaware City Section

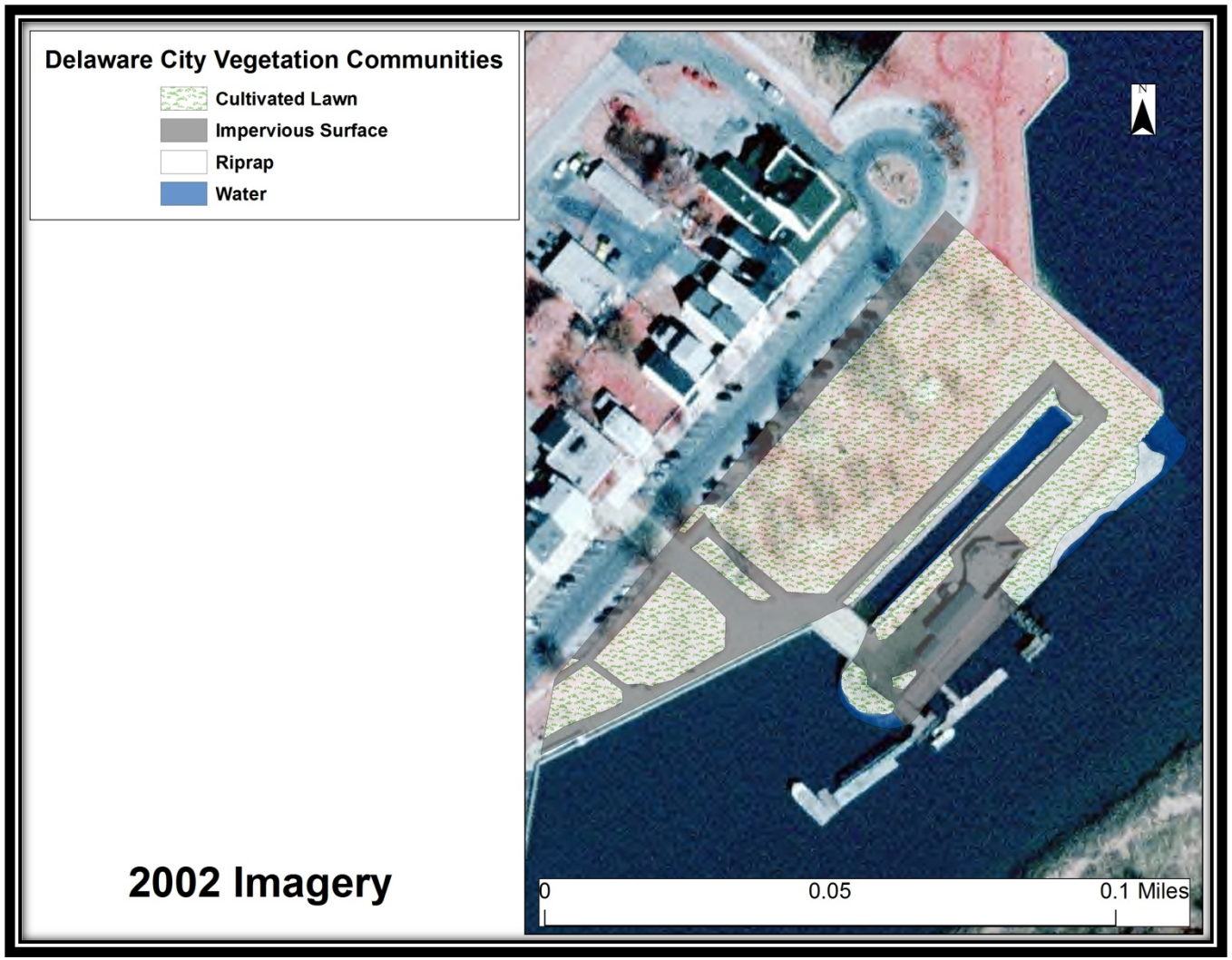


Figure 4-1.3. 2002 Vegetation Community of the Delaware City Section

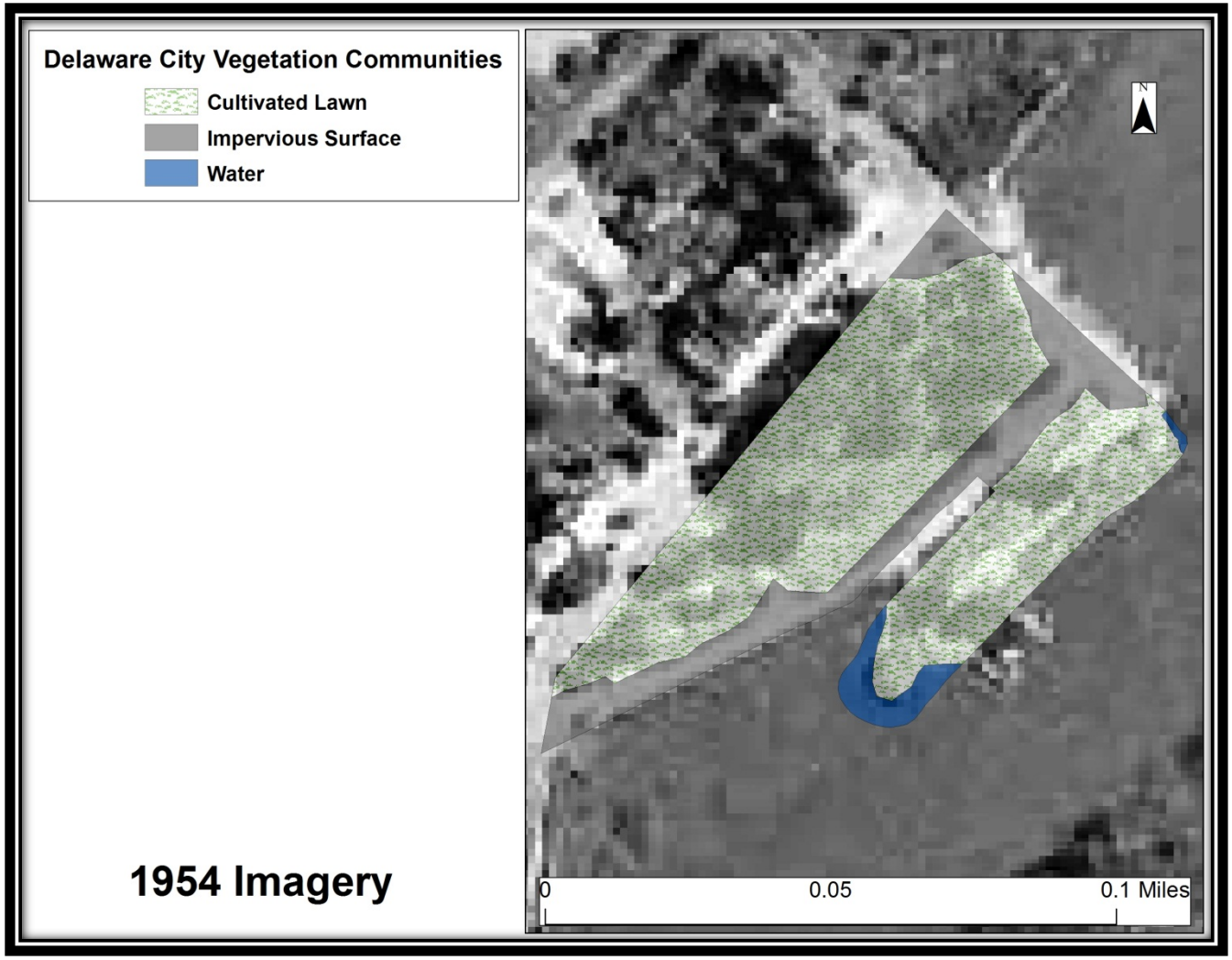


Figure 4.1-4. 1954 Vegetation Community Map of the Delaware City Section

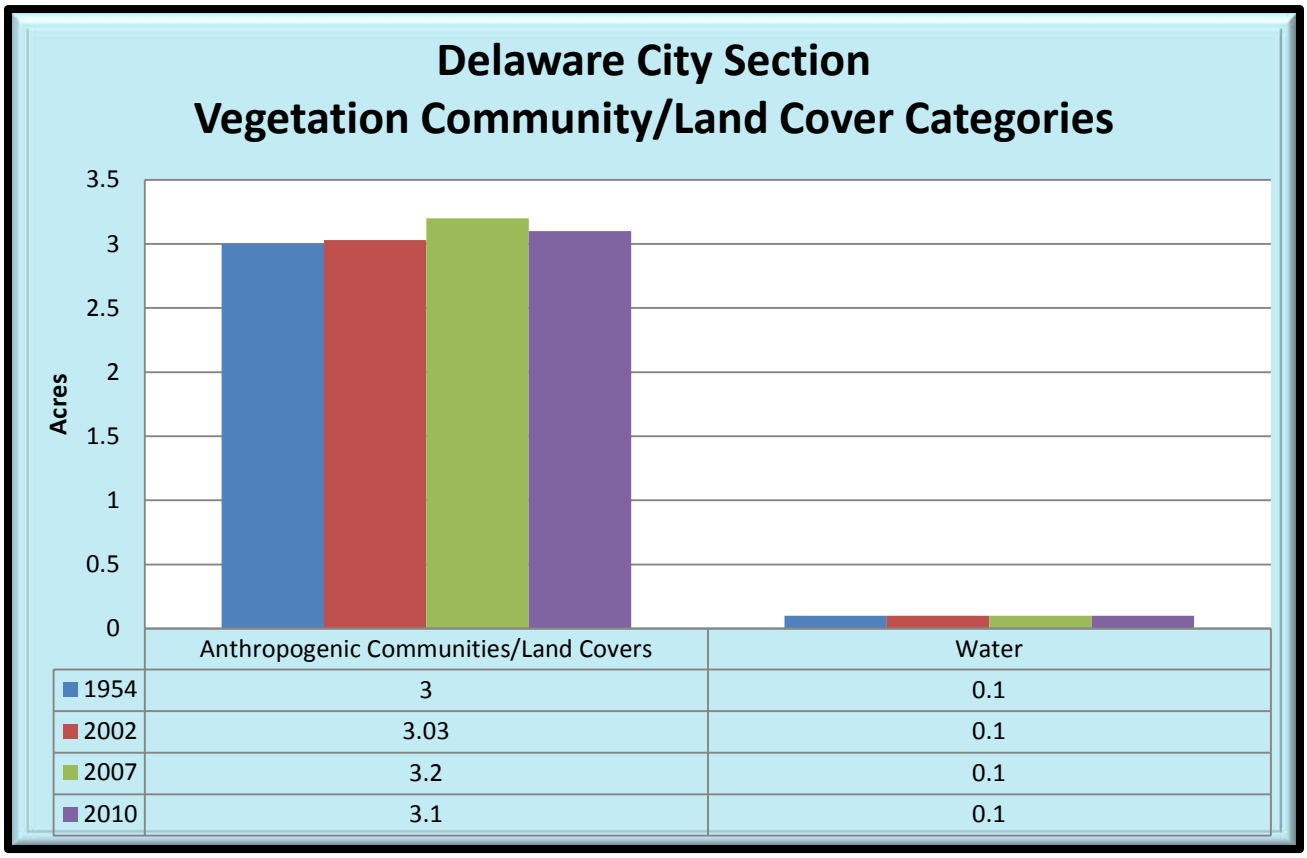


Figure 4-1.5. Delaware City Section Vegetation Categories/Land Covers (1954, 2002, 2007, and 2010)

Delaware City Section Broad Trends (Figure 4-1.5): Anthropogenic communities/land covers are the largest vegetation community/land cover category in the Delaware City Section. An increase in riprap area has resulted in a very slight increase in amount.

DNREC Sea Level Rise Analysis (Table 4-1.1)

Most of the Delaware City Section will inundated with 1 m of sea level rise and all will be flooded with 1.5 m of rise. About 0.4 acres will be inundated with 0.5 m of rise.

Table 4-1.1. Projected acres of the Delaware City Section Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	0.4 acres
1 m	3 acres
1.5 m	3 acres

Natural Capital (Table 4-1.2)

Water is the only vegetation community/land cover with any capital value in the Delaware City Section. It has remained constant in value during the study period.

Table 4-1.2. Natural Capital of the Delaware City Section	
Year	**Natural Capital (in 2012 dollars)**
1954	$534/year
2002	$534/year
2007	$534/year
2010	$534/year

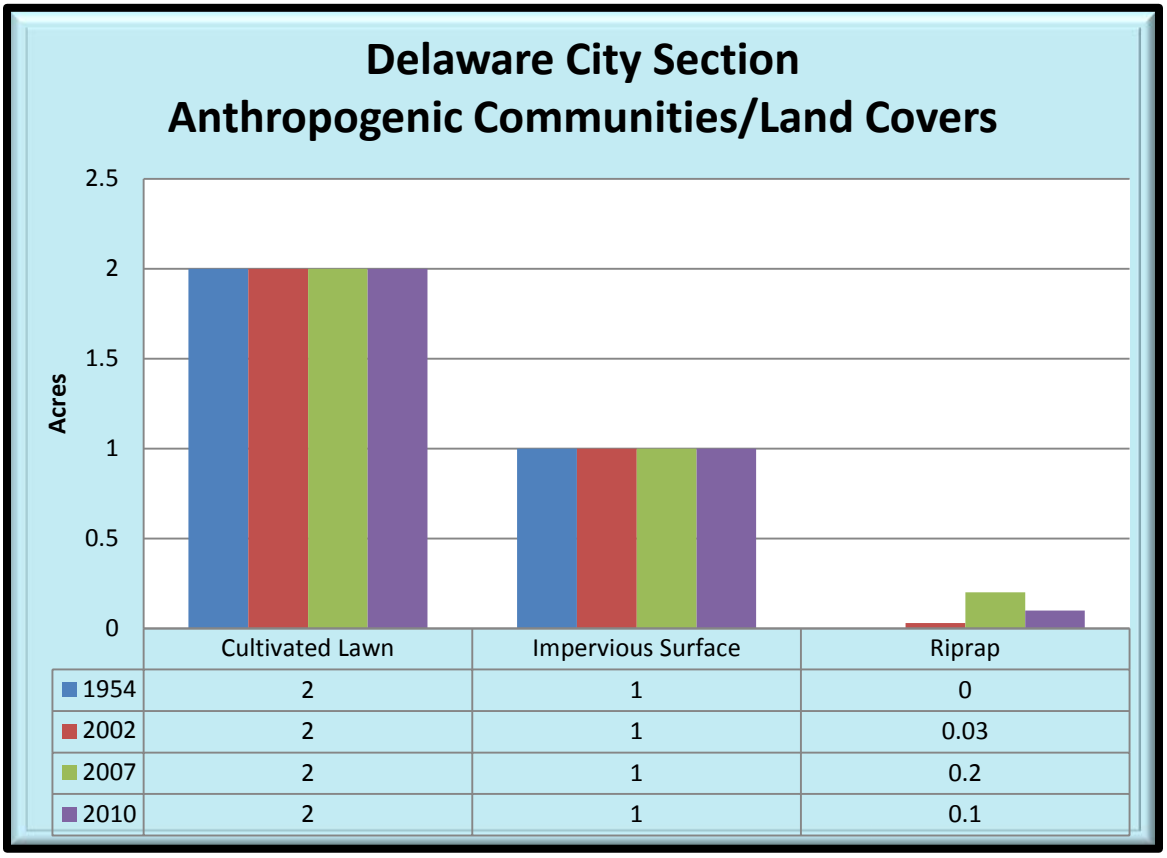


Figure 4-1.6. Delaware City Section Anthropogenic Communities/Land Covers (1954, 2002, 2007, and 2010)

Delaware City Section Anthropogenic Communities/Land Covers (Figure 4-1.6): Cultivated lawn is the largest anthropogenic community/land cover in the Delaware City section followed by impervious surface. Both have remained at the same amount throughout the study period.

DNREC Sea Level Rise Analysis (Table 4-1.3)

A little less than half of the current acreage of herbaceous communities will be inundated with 1.5 m of sea level rise. Most of these communities are grasslands that are located at the tops of dunes and away from the immediate effects.

Table 4-1.3. Projected acres of Delaware City Section Anthropogenic Communities/Land Covers Inundated by Sea Level Rise

Rise	Acres
0.5 m	0.4 acres
1 m	2 acres
1.5 m	3 acres

Natural Capital

None of the Anthropogenic Communities/land covers in the Delaware City Section have any natural capital value.

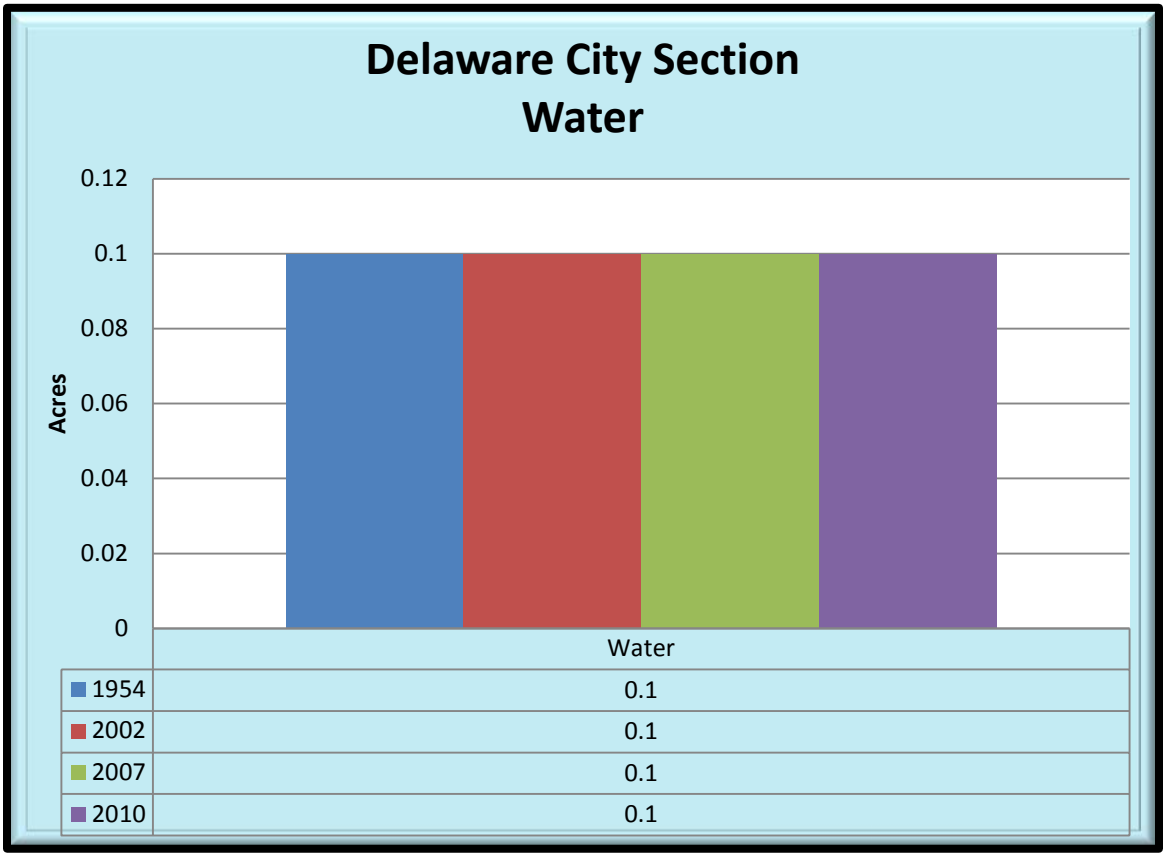


Figure 4-1.7. Delaware City Section water coverage (1954, 2002, 2007, and 2010)

Delaware City Section water coverage (Figure 4-1.7): Water coverage in the Delaware City Section has remained the same throughout the study period.

2. Pea Patch Island Section

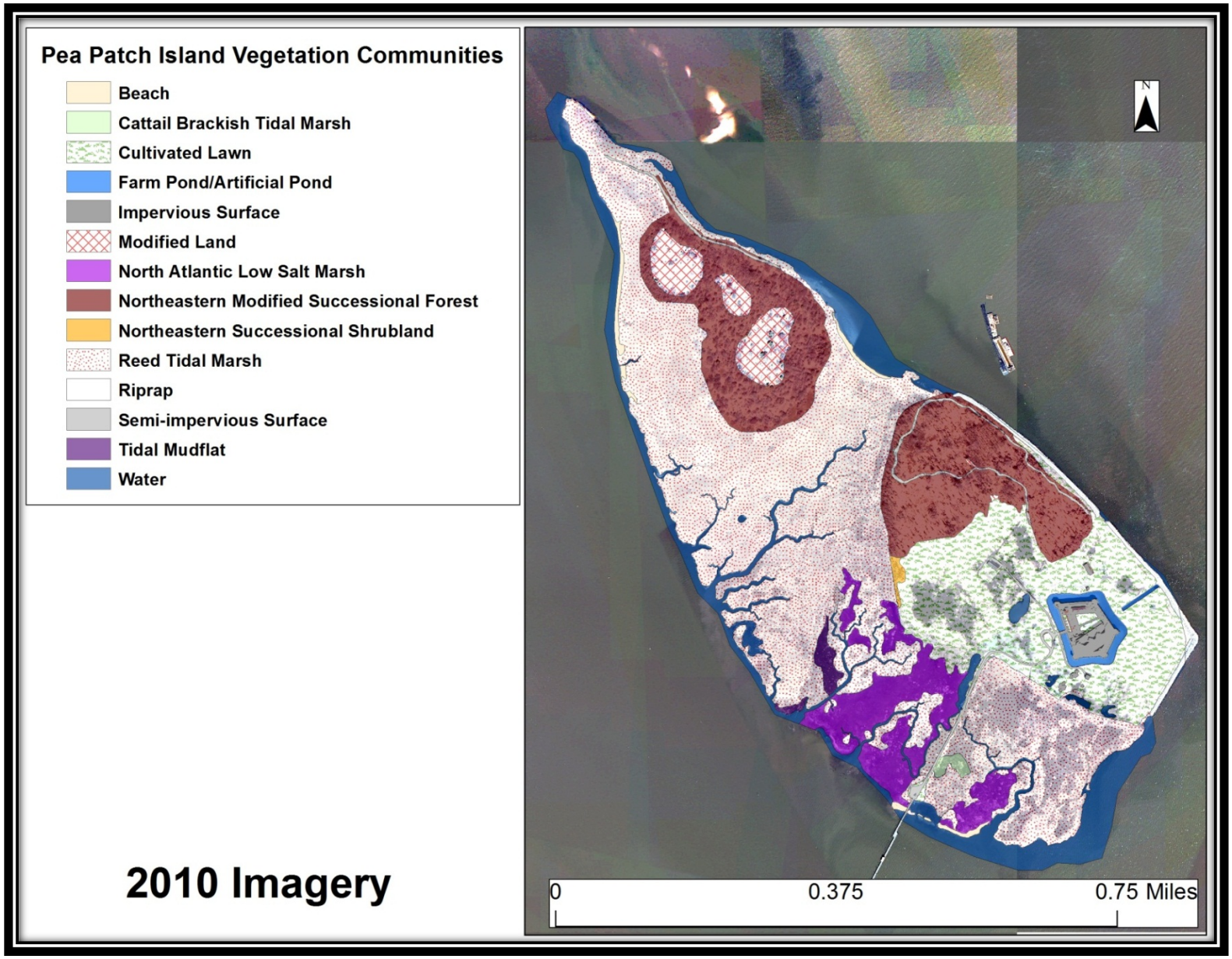


Figure 4-2.1. 2010 Vegetation Community Map of the Pea Patch Island Section

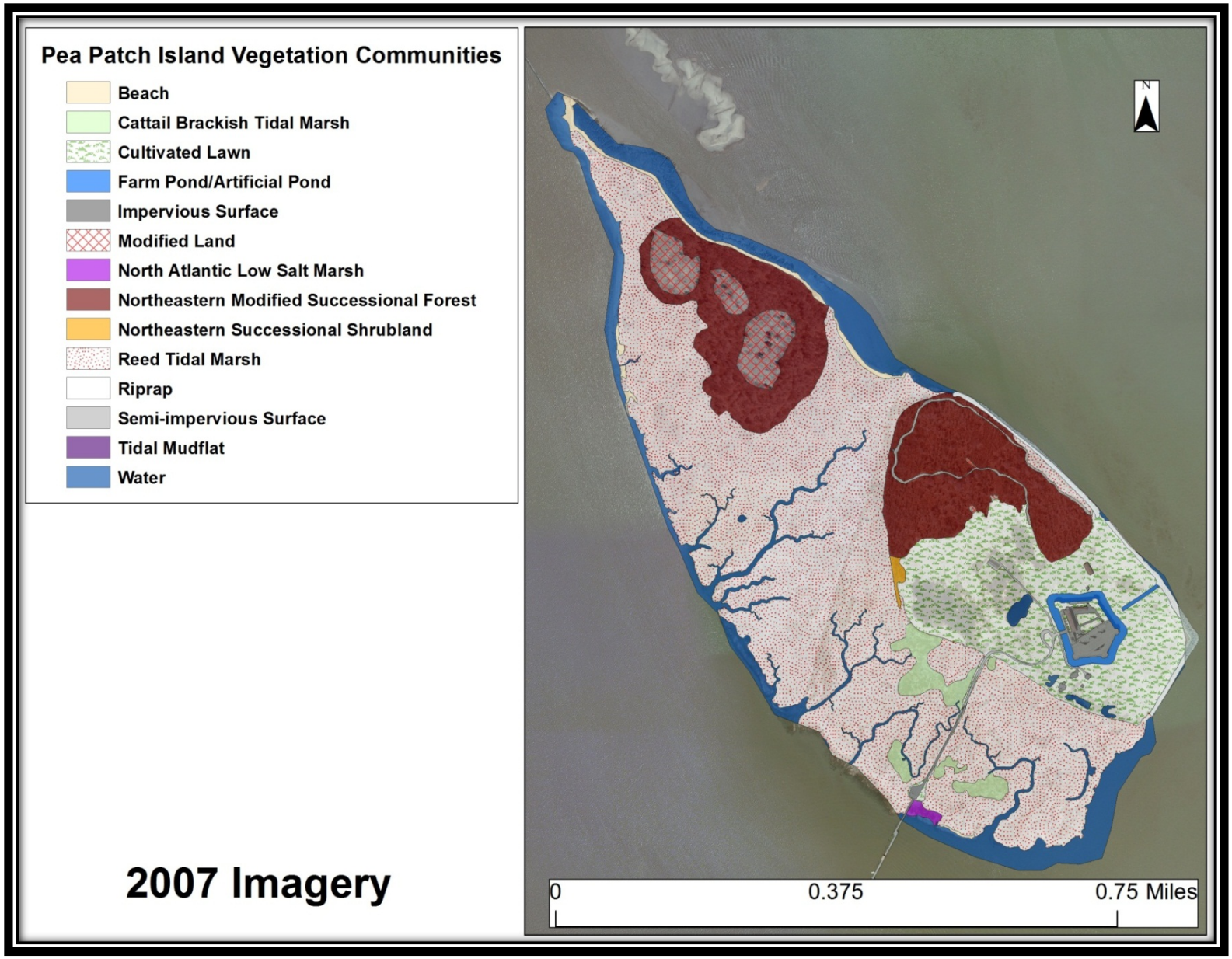


Figure 4-2.2. 2007 Vegetation Community Map of the Pea Patch Island Section

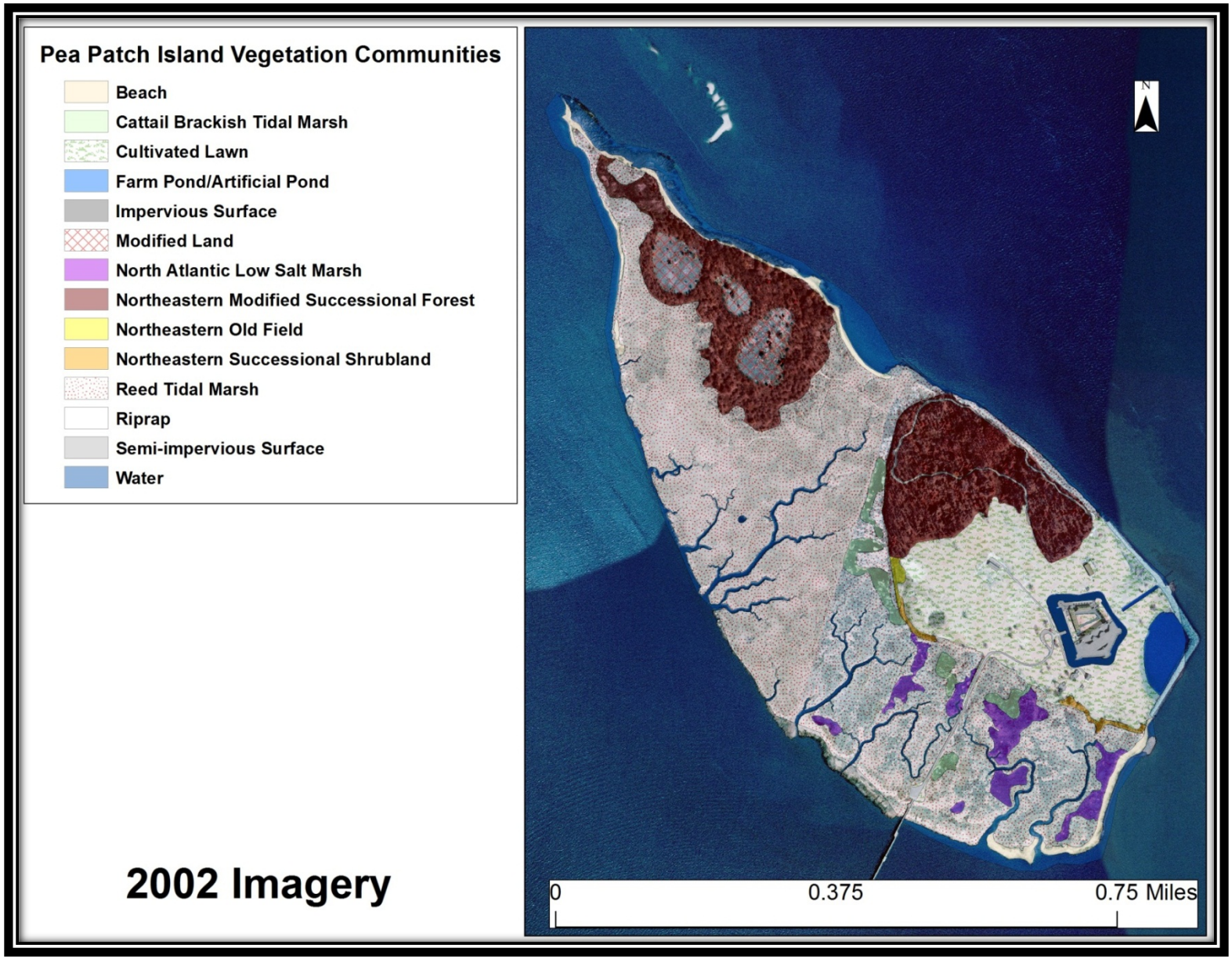


Figure 4-2.3. 2002 Vegetation Community Map of the Pea Patch Island Section

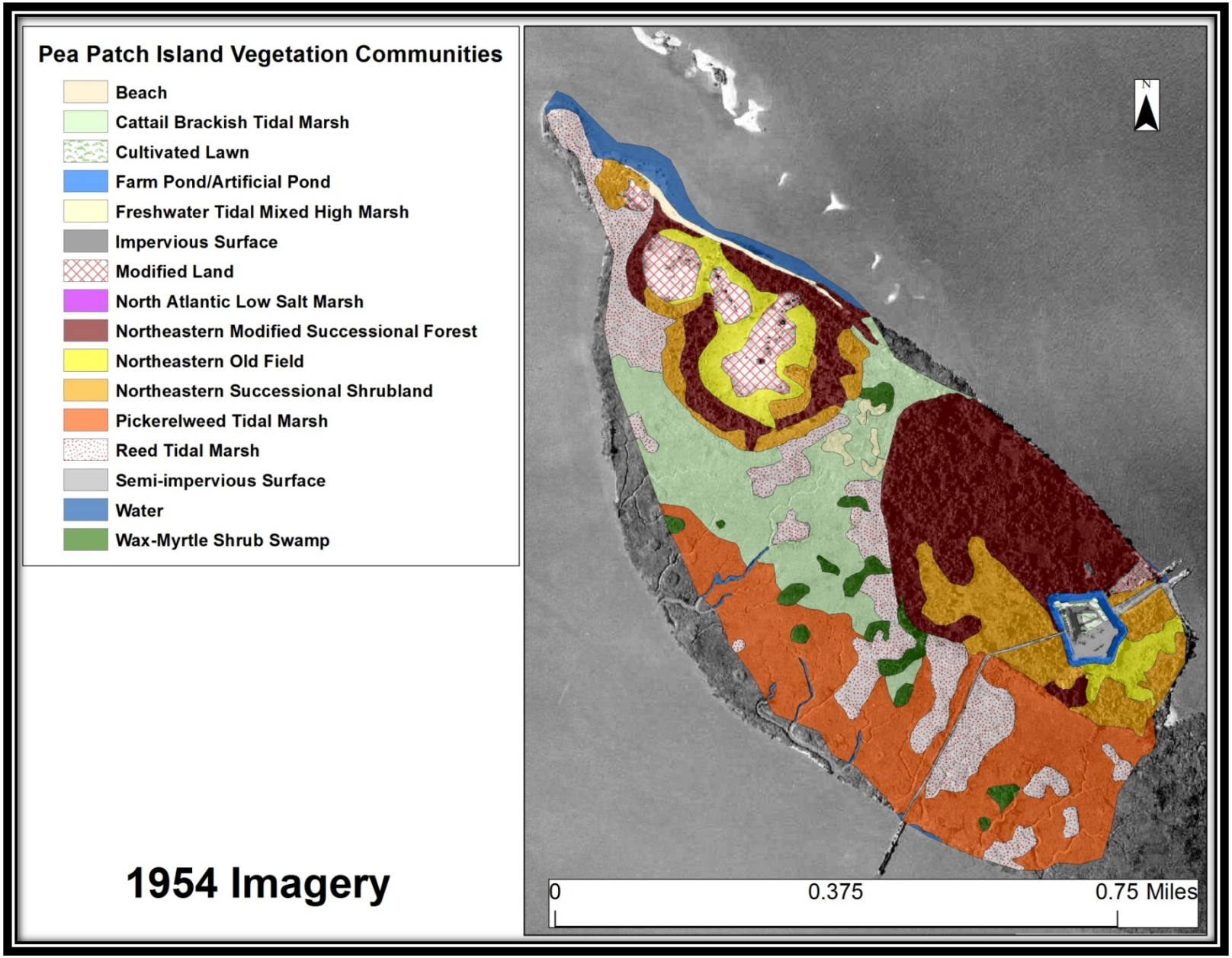
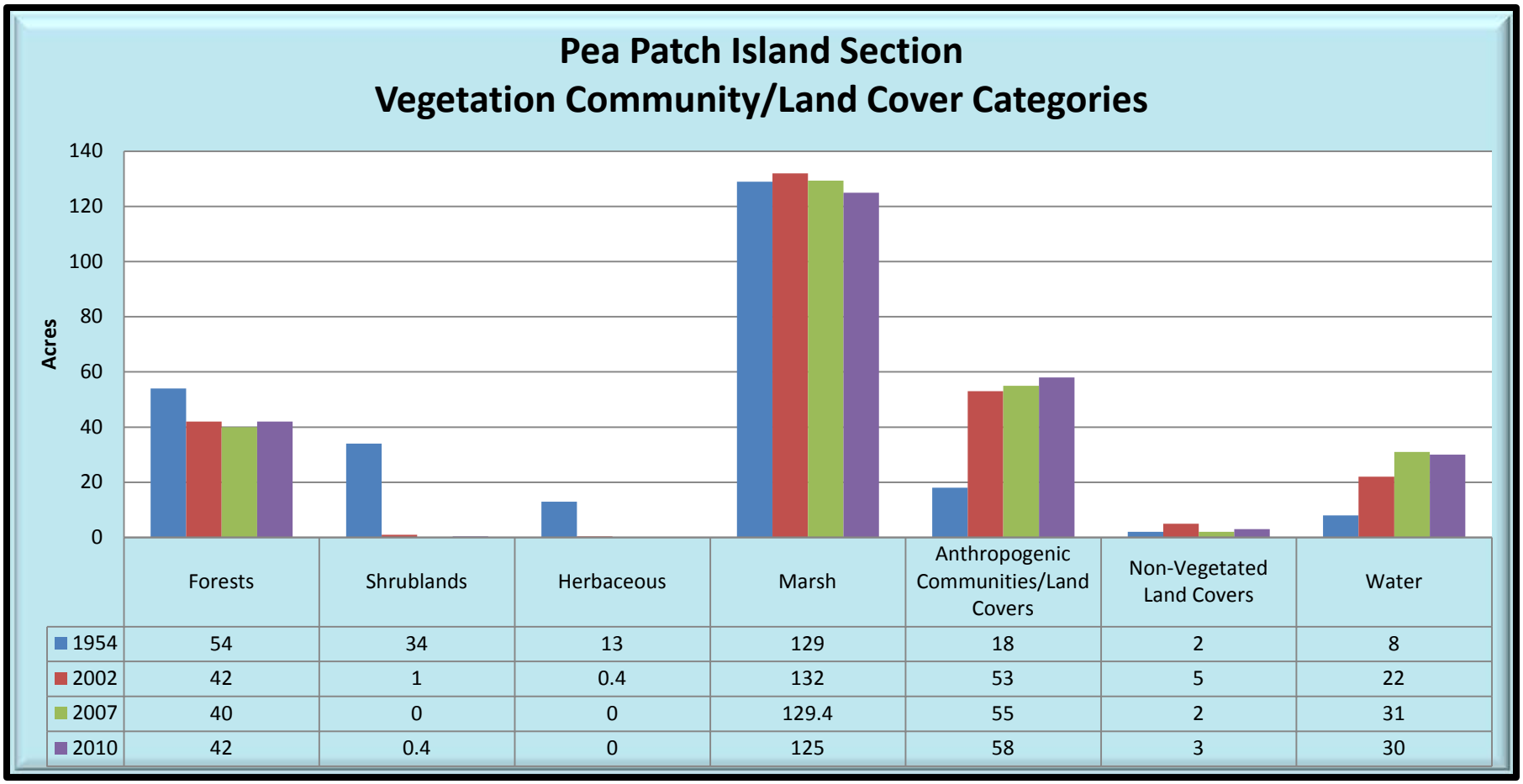


Figure 4-2.4. 1954 Vegetation Community Map of the Pea Patch Island Section



	Forests	Shrublands	Herbaceous	Marsh	Anthropogenic Communities/Land Covers	Non-Vegetated Land Covers	Water
1954	54	34	13	129	18	2	8
2002	42	1	0.4	132	53	5	22
2007	40	0	0	129.4	55	2	31
2010	42	0.4	0	125	58	3	30

Figure 4-2.5. Pea Patch Island Section Vegetation Community/Land Cover Categories (1954, 2002, 2007, and 2010)

Pea Patch Island Section Broad Trends (Figure 4-2.5): Marshland is the largest vegetation community in the Pea Patch Island Section, followed by forest.

DNREC Sea Level Rise Analysis (Table 4-2.1)

A little more than half of Pea Patch Island will be flooded with 0.5 m of sea level rise and most will be inundated with 1.5 m of rise.

Table 4-2.1. Projected acres of the Pea Patch Island Section Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	151 acres
1 m	224 acres
1.5 m	253 acres

Natural Capital (Table 4-2.2)

Capital of the Pea Patch Island Section has increased overall since 1954. A recent decrease was observed during the 2007 to 2010 period due a loss in marshland.

Table 4-2.2. Natural Capital of the Pea Patch Island Section	
Year	**Natural Capital (in 2012 dollars)**
1954	$988,144/year
2002	$1,177,956/year
2007	$1,274,059/year
2010	$1,238,840/year

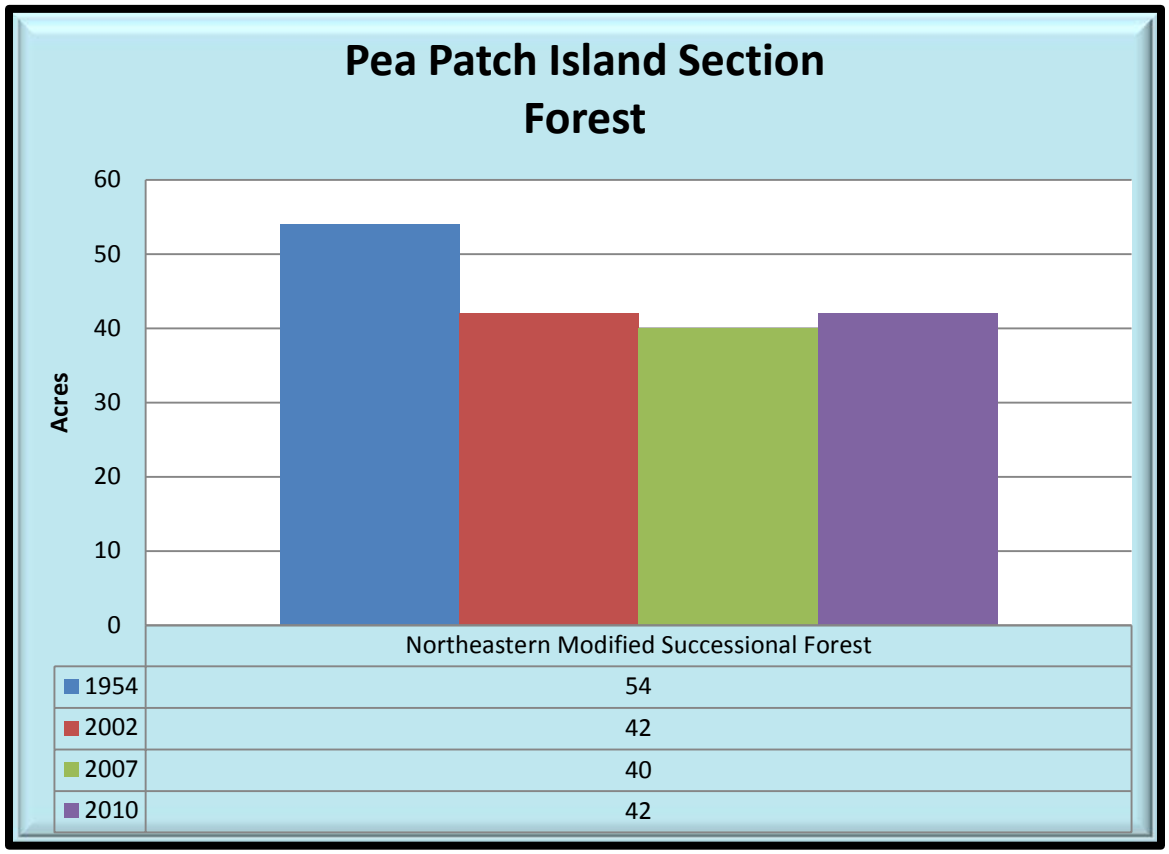


Figure 4-2.6. Pea Patch Island Section Forest (1954, 2002, 2007, and 2010)

Pea Patch Island Section Forest (Figure 4-2.6): Northeastern Modified Successional Forest is the only forest community present on Pea Patch Island. Its amount has declined since 1954 with clearing.

DNREC Sea Level Rise Analysis (Table 4-2.3)

About ¼ of the forestland on Pea Patch Island will be inundated with 0.5 m of sea level rise. Most of the remaining forest will be flooded with 1.5 m of rise.

Table 4-2.3. Projected acres of Pea Patch Island Section Forest Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	10 acres
1 m	29 acres
1.5 m	39 acres

Natural Capital (Table 4-2.4)

Capital of forest has decreased since 1954 as more area is developed into cultivated lawn.

Table 4-2.4. Natural Capital of Pea Patch Island Section Forest	
Year	**Natural Capital (in 2012 dollars)**
1954	$10,211/year
2002	$7,942/year
2007	$7,564/year
2010	$7,942/year

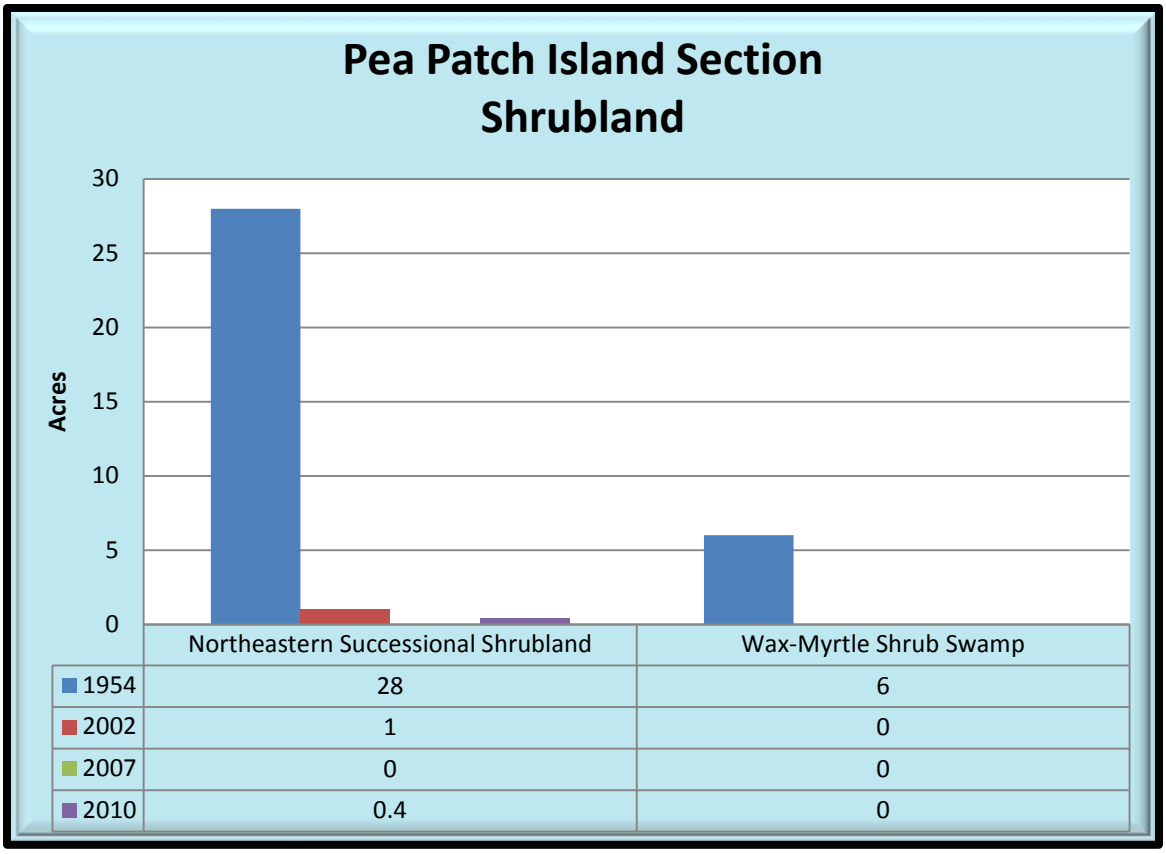


Figure 4-2.7. Pea Patch Island Section Shrubland Communities (1954, 2002, 2007, and 2010)

Pea Patch Island Section Shrubland Communities (Figure 4-2.7): In 1954, two shrublands were present on the island, with Northeastern Successional Shrubland being the largest. At the current time only one shrubland is still present, Northeastern Successional Shrubland.

DNREC Sea Level Rise Analysis (Table 4-2.5)

Shrubland in its current extent will be barely touched with 0.5 m of sea level rise, while it will all be flooded with 1.5 m of rise.

Table 4-2.5. Projected acres of Pea Patch Island Section Shrubland Inundated by Sea Level Rise

Rise	Acres
0.5 m	<0.1 acres
1 m	0.1 acres
1.5 m	0.4 acres

Natural Capital (Table 4-2.6)

Capital of shrubland is down greatly due to conversion to lawn and increased water and salinity in the marsh from sea level rise.

Table 4-2.6. Natural Capital of Pea Patch Island Section Shrubland	
Year	**Natural Capital (in 2012 dollars)**
1954	$41,707/year
2002	$146/year
2007	$0/year (not present)
2010	$58/year

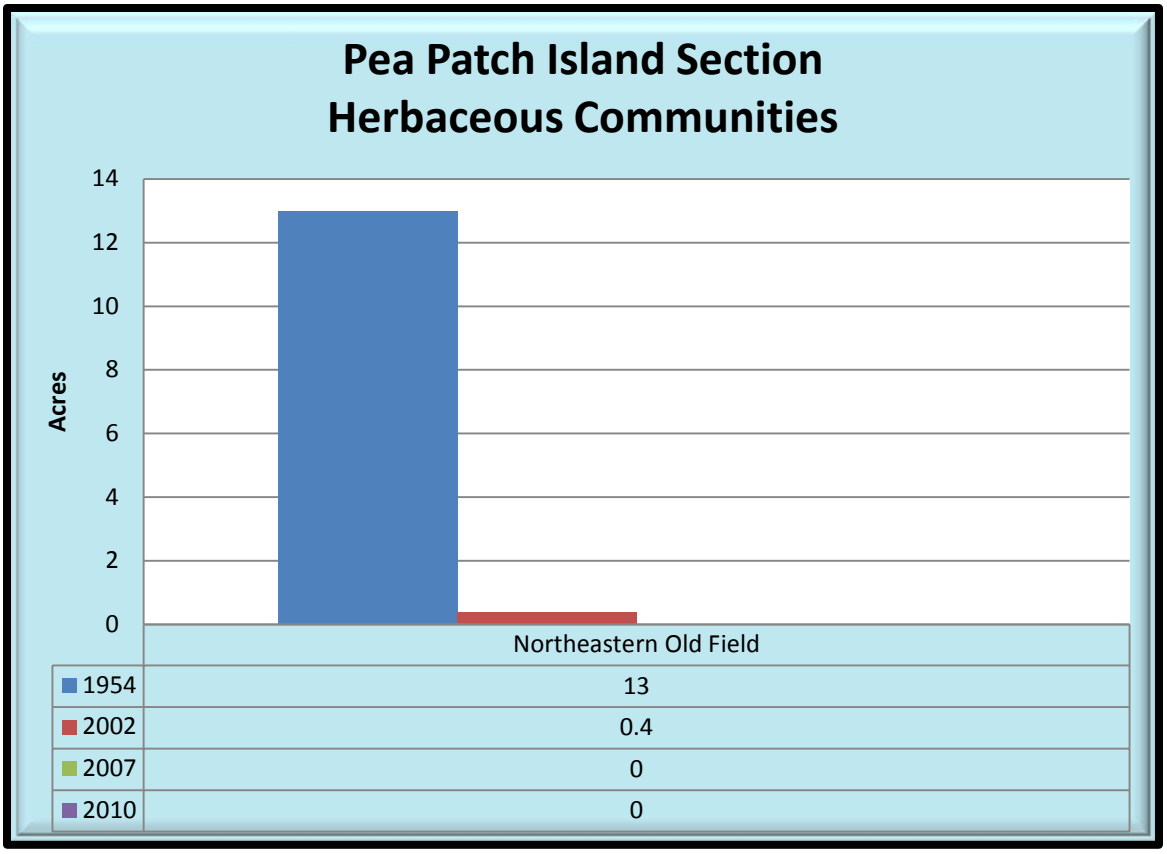


Figure 4-2.8. Pea Patch Island Section Herbaceous Communities (1954, 2002, 2007, and 2010)

Pea Patch Island Section Herbaceous Communities (Figure 4-2.8): Northeastern Old Field was the only herbaceous community present on Pea Patch Island until about 2002. Most of what was this community has become forest or is now lawn. Since this community is no longer present a sea level rise analysis was not conducted.

Natural Capital (Table 4-2.4)

Herbaceous communities do not account for any natural capital currently due to conversion to cultivated lawn.

Table 4-2.4. Natural Capital of Pea Patch Island Section Herbaceous Communities	
Year	**Natural Capital (in 2012 dollars)**
1954	$1,894/year
2002	$58/year
2007	$0/year (not present)
2010	$0/year (not present)

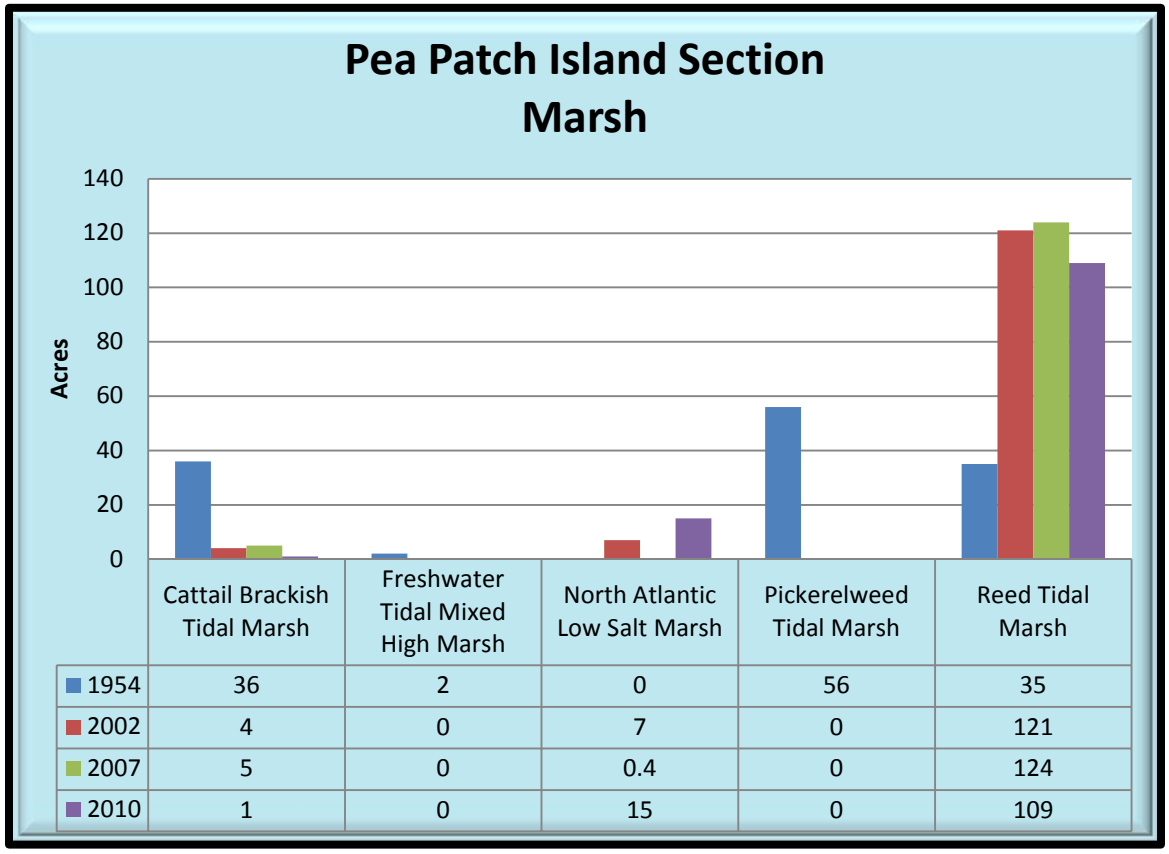


Figure 4-2.9. Pea Patch Island Section Marsh Communities (1954, 2002, 2007, and 2010)

Pea Patch Island Section Marsh (Figure 4-2.9): In 1954, Pickerelweed Tidal Marsh was the largest marsh on the island followed by Cattail Brackish Tidal Marsh. Today there are only three marsh types on the island, with Reed Tidal Marsh being the largest by far.

DNREC Sea Level Rise Analysis (Table 4-2.5)

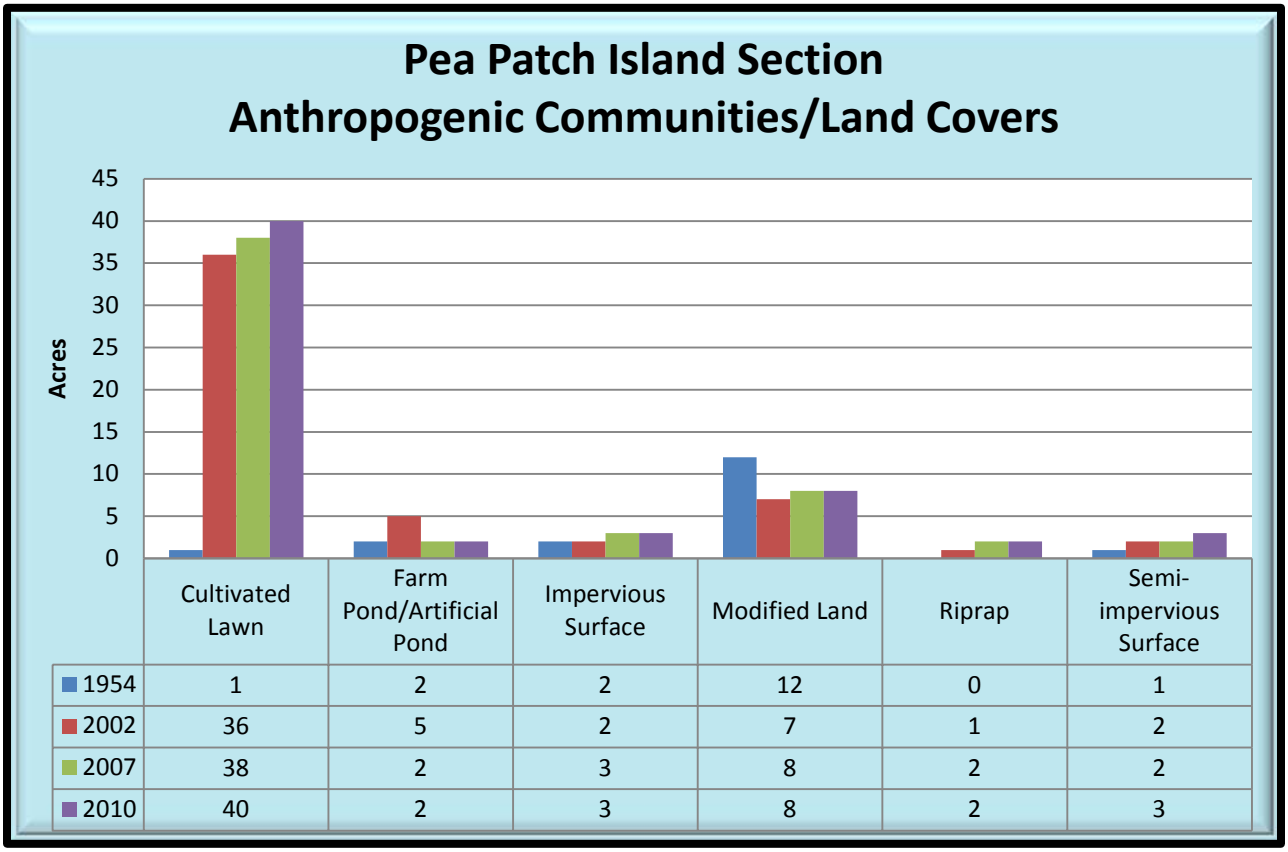
A little less than ¾ of the current marshland will be inundated with 0.5 m of sea level rise. All of the current marsh will be flooded with 1.5 m of sea level rise.

Table 4-2.5. Projected acres of Pea Patch Island Section Marsh Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	90 acres
1 m	118 acres
1.5 m	125 acres

Natural Capital (Table 4-2.6)

Capital of marshland has decreased overall due to losses to water and riprap.

Table 4-2.6. Natural Capital of Pea Patch Island Section Marsh	
Year	**Natural Capital (in 2012 dollars)**
1954	$808,998/year
2002	$827,812/year
2007	$811,506/year
2010	$783,913/year



	Cultivated Lawn	Farm Pond/Artificial Pond	Impervious Surface	Modified Land	Riprap	Semi-impervious Surface
1954	1	2	2	12	0	1
2002	36	5	2	7	1	2
2007	38	2	3	8	2	2
2010	40	2	3	8	2	3

Figure 4-2.10. Pea Patch Island Section Anthropogenic Communities/Land Covers (1954, 2002, 2007, and 2010)

Pea Patch Island Section Anthropogenic Communities/Land Covers (Figure 4-2.10): Cultivated lawn is the largest Anthropogenic Community/land cover on Pea Patch Island, followed distantly by modified land. In the winter of 2005 to 2006 the US Army Corps of Engineers placed a 3,500 foot long riprap sea wall on the island to protect it from erosion[40]

[40] Fort Delaware. http://en.wikipedia.org/wiki/Ft. Delaware Wikipedia

DNREC Sea Level Rise Analysis (Table 4-2.7)

Most of the anthropogenic communities/land covers currently on the island will be flooded with 1.5 m of sea level rise.

Table 4-2.7. Projected acres of Pea Patch Island Section Anthropogenic Communities/Land Covers Inundated by Sea Level Rise

Rise	Acres
0.5 m	19 acres
1 m	44 acres
1.5 m	56 acres

Natural Capital (Table 4-2.6)

Farm Pond/Artificial pond is the only anthropogenic community/land cover with any natural capital value in the Pea Patch Island section. The amount has been relatively stable with an upswing in 2002 from an impoundment present in what is now lawn south of the fort.

Table 4-2.6. Natural Capital of Pea Patch Island Anthropogenic Communities/Land Covers

Year	Natural Capital (in 2012 dollars)
1954	$10,670/year
2002	$26,676/year
2007	$10,670/year
2010	$10,670/year

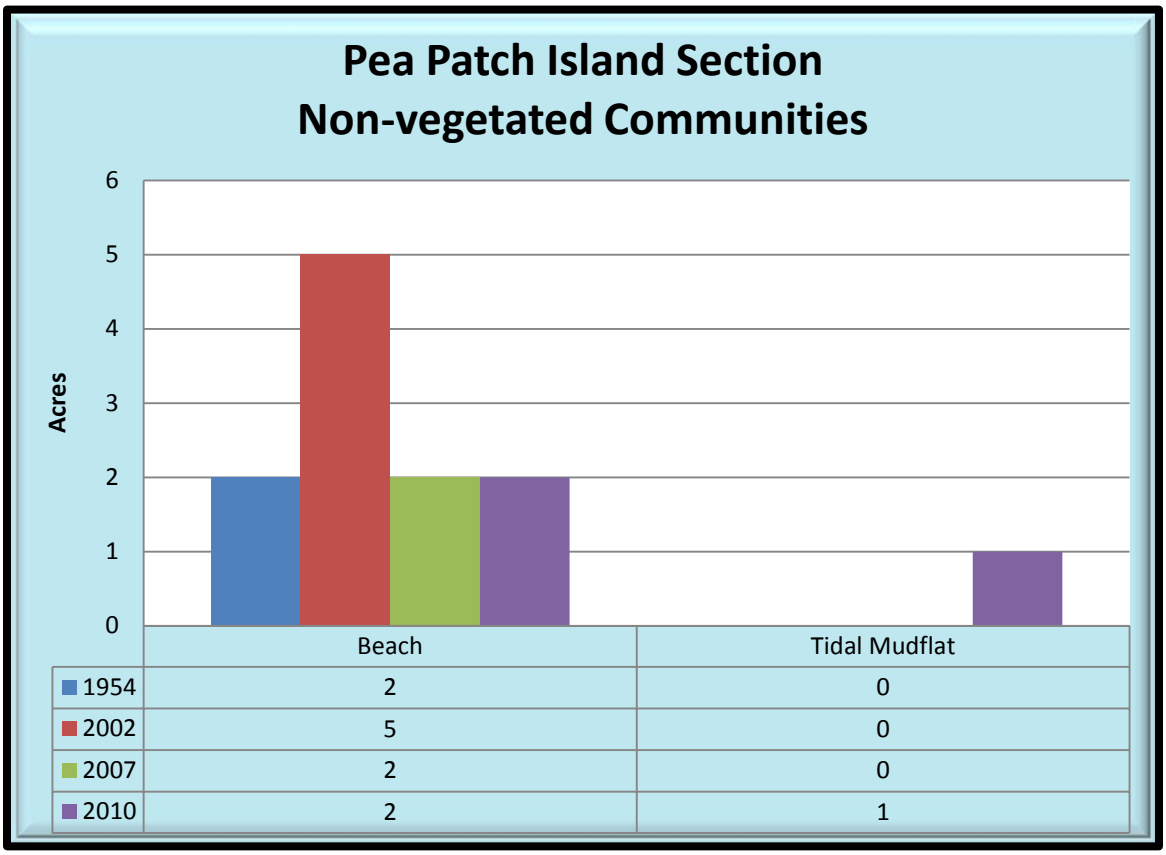


Figure 4-2.11. Pea Patch Island Section Non-vegetated Communities (1954, 2002, 2007, and 2010)

Pea Patch Island Section Non-vegetated Communities (Figure 4-2.11): Beach is the largest non-vegetated community on Pea Patch Island.

DNREC Sea Level Rise Analysis (Table 4-2.7)

All of the current non-vegetated communities will be flooded with 0.5 m of sea level rise.

Table 4-2.7. Projected acres of Pea Patch Island Section Non-vegetated Communities Inundated by Sea Level Rise

Rise	Acres
0.5 m	3 acres
1 m	3 acres
1.5 m	3 acres

Natural Capital (Table 4-2.8)

Tidal mudflat is the only non-vegetated community with any natural capital value. It has only recently come about on the island in 2010.

Table 4-2.8. Natural Capital of Pea Patch Island Section Non-vegetated Communities	
Year	**Natural Capital (in 2012 dollars)**
1954	$0/year (not present)
2002	$0/year (not present)
2007	$0/year (not present)
2010	$6,271/year

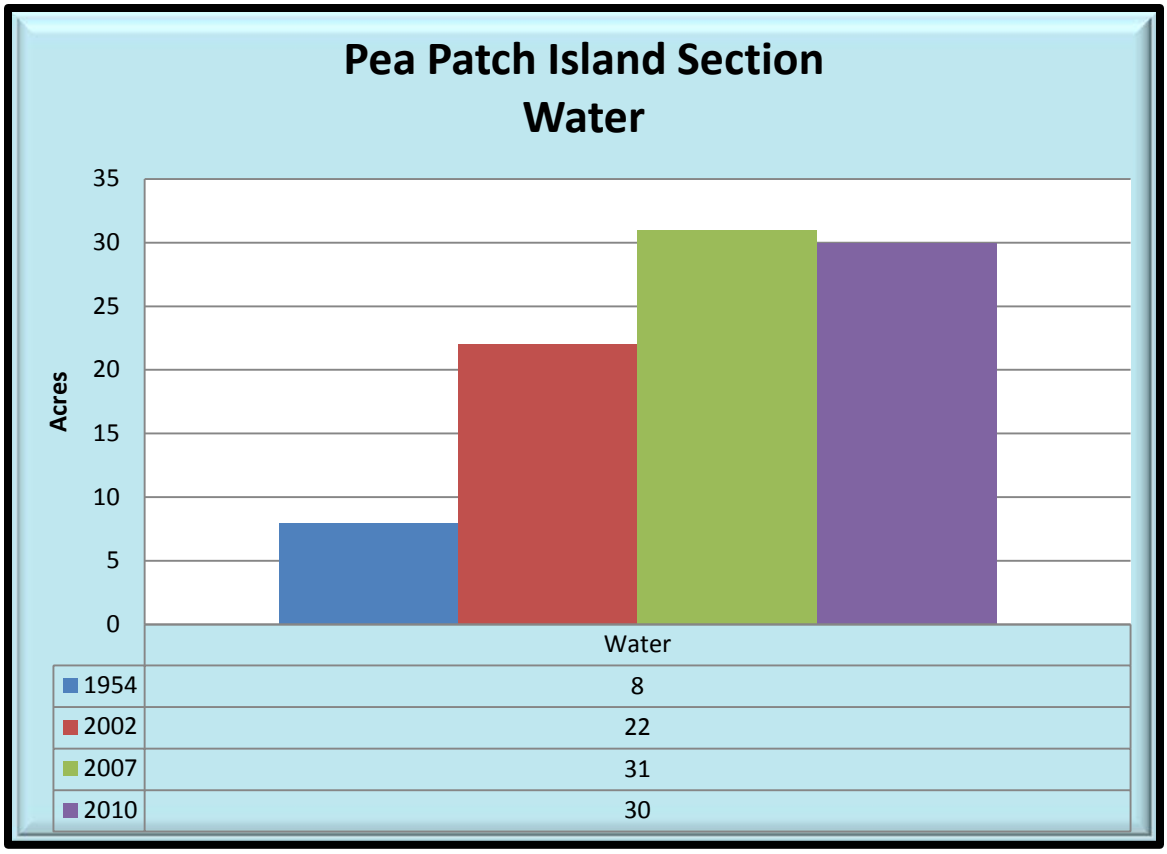


Figure 4-2.12. Pea Patch Island Section Water (1954, 2002, 2007, and 2010)

Pea Patch Island Section Water (Figure 4-2.12): The amount of water coverage overall has been increasing on the island as erosion eats into the island and sea level rise inundates the shore.

Natural Capital (Table 4-2.9)

Capital of water has been roughly increasing as more land surface is flooded by sea level rise.

Table 4-2.9. Natural Capital of Pea Patch Island Section Water	
Year	**Natural Capital (in 2012 dollars)**
1954	$114,663/year
2002	$315,322/year
2007	$444,318/year
2010	$429,986/year

CHAPTER 5: DESCRIPTIONS AND ANALYSIS OF THE VEGETATION COMMUNITIES

Six vegetation communities and two land covers were noted in the survey (Figures 3-1.1-1.4 and 3-2.1-2.4). Below are the descriptions of the vegetation communities. The National Vegetation Classification (NVC) Association number is given with the vegetation community and their approximate acreage in the project area. Names of communities correspond with the common names as given in the NVC and the Guide to Delaware Vegetation Communities.

The vegetation communities include:

1. Cattail Brackish Tidal Marsh (CEGL004201)—1 acre
2. Cultivated Lawn (CEGL008462)—42 acres
3. Eastern Reed Marsh (CEGL004141)—8 acres
4. North Atlantic Low Salt Marsh (CEGL004192)—15 acres
5. Northeastern Modified Successional Forest (CEGL006599)—43 acres
6. Reed Tidal Marsh (CEGL004187)—131 acres

Historical Vegetation Communities

1. Freshwater Tidal Mixed High Marsh (CEGL006325)—2 acres (1954)
2. Northeastern Old Field (CEGL006107)—13 acres (1954), 0.4 (2002)

Cattail Brackish Tidal Marsh **[1 acre (Figure 5.1, Tables 5.1-5.4)] G4G5 S3**

DEWAP: Tidal Low Marshes
NHC: Northern Atlantic Coastal Plain Brackish Tidal Marsh

Description

This marsh community is dominated by wide-leaved cattail (*Typha latifolia*) and narrow-leaf cattail (*Typha angustifolia*) and associated by big salt marsh cordgrass (*Spartina cynosuroides*), marsh-mallow (*Hibiscus moscheutos*), reed grass (*Phragmites australis*), and salt shrub (*Baccharis halimifolia*).

Figure 5.1. Cattail Brackish Tidal Marsh

Analysis of Condition at Fort Delaware State Park

None of the Cattail Brackish Tidal Marsh from 1954 still existed in 2010. It had all become 30 acres of Reed Tidal Marsh, 4 acres of water, 1 acre of North Atlantic Low Salt Marsh, 0.3 acres of Beach, and 0.1 acres of Northeastern Modified Successional Forest (Table 5.1). Since 1954, this marsh has decreased in acreage but has still migrated into 1 acre of Reed Tidal Marsh (Table 5.2).

Table 5.1. What was once Cattail Brackish Tidal Marsh in 1954 has become X in 2010	
X	**Acreage**
Reed Tidal Marsh	30 acres
Water	4 acres
North Atlantic Low Salt Marsh	1 acre
Beach	0.3 acres
Northeastern Modified Successional Forest	0.1 acres

Table 5.2. Cattail Brackish Tidal Marsh has migrated into X since 1954	
X	**Acreage**
Reed Tidal Marsh	1 acre

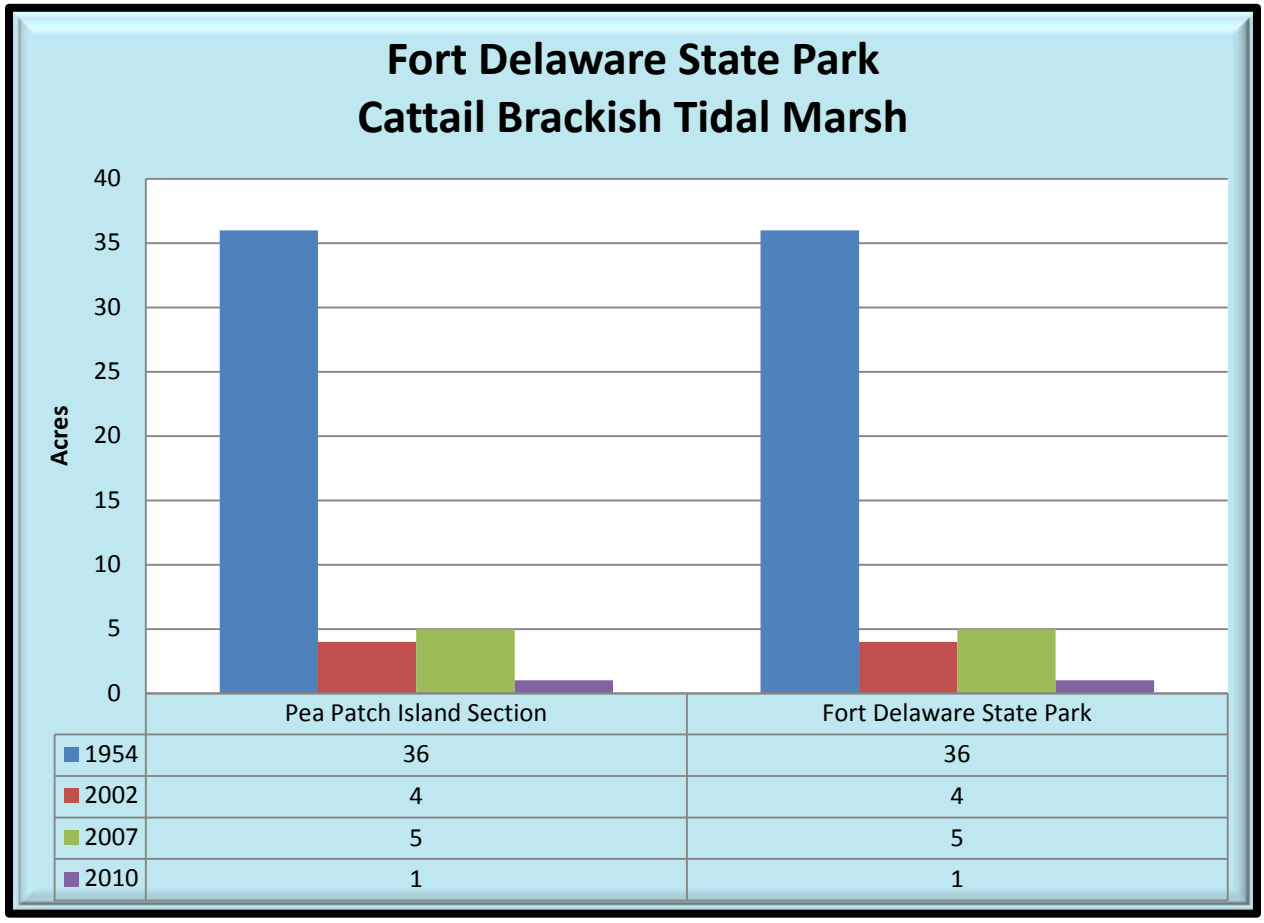


Figure 5.1. Cattail Brackish Tidal Marsh at Fort Delaware State Park (1954, 2002, 2007, and 2010)

DNREC Sea Level Rise Analysis (Table 5.3)

All of the current extent of Cattail Brackish Tidal Marsh will be inundated with 0.5 m of sea level rise.

Table 5.3. Projected acres of Cattail Brackish Tidal Marsh Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	1 acre
1 m	1 acre
1.5 m	1 acre

Natural Capital (Table 5.4)

Capital of Cattail Brackish Tidal Marsh has been declined from its 1954 high as it is taken over by reed grass (*Phragmites australis*) and the salinity of the marsh increases.

Table 5.4. Natural Capital of Cattail Brackish Tidal Marsh	
Year	**Natural Capital (in 2012 dollars)**
1954	$225,767/year
2002	$25,085/year
2007	$31,357/year
2010	$6,271/year

Cultivated Lawn **[42 acres (Figures 5.3-5.4, Tables 5.5-5.6)] GNA SNA**

DEWAP: No Equivalent Classification
NHC: Semi-natural/Altered Vegetation and Conifer Plantations

Description

Figure 5.3. Cultivated Lawn

This anthropogenic community is located the main office in the Delaware City Section and around Fort Delaware in the Pea Patch Island Section. It is composed of ornamental grasses and shrubs that are mowed more than once per year.

Analysis of Condition at Fort Delaware State Park

About two acres of the three acres of cultivated lawn from 1954 was still present in 2010. The remaining acres had become 1 acre of impervious surface, 0.1 acres of riprap, and 0.1 acres of water (Table 5.5). Since 1954, cultivated lawn has greatly increased in acreage and has been developed in 17 acres of Northeastern Successional Shrubland, 15 acres of Northeastern Modified Successional Forest, 4 acres of Northeastern Old Field, and 1 acre of Reed Tidal Marsh (Table 5.6.).

Table 5.5. What was once Cultivated Lawn in 1954 has become X in 2010	
X	**Acreage**
Cultivated Lawn	2 acres
Impervious Surface	1 acre
Riprap	0.1 acres
Water	0.1 acres

Table 5.6. Cultivated Lawn has migrated into X since 1954	
X	**Acreage**
Northeastern Successional Shrubland	17 acres
Northeastern Modified Successional Forest	15 acres
Northeastern Old Field	4 acres
Cultivated Lawn	2 acres
Reed Tidal Marsh	1 acre
Other communities/land covers	3 acres

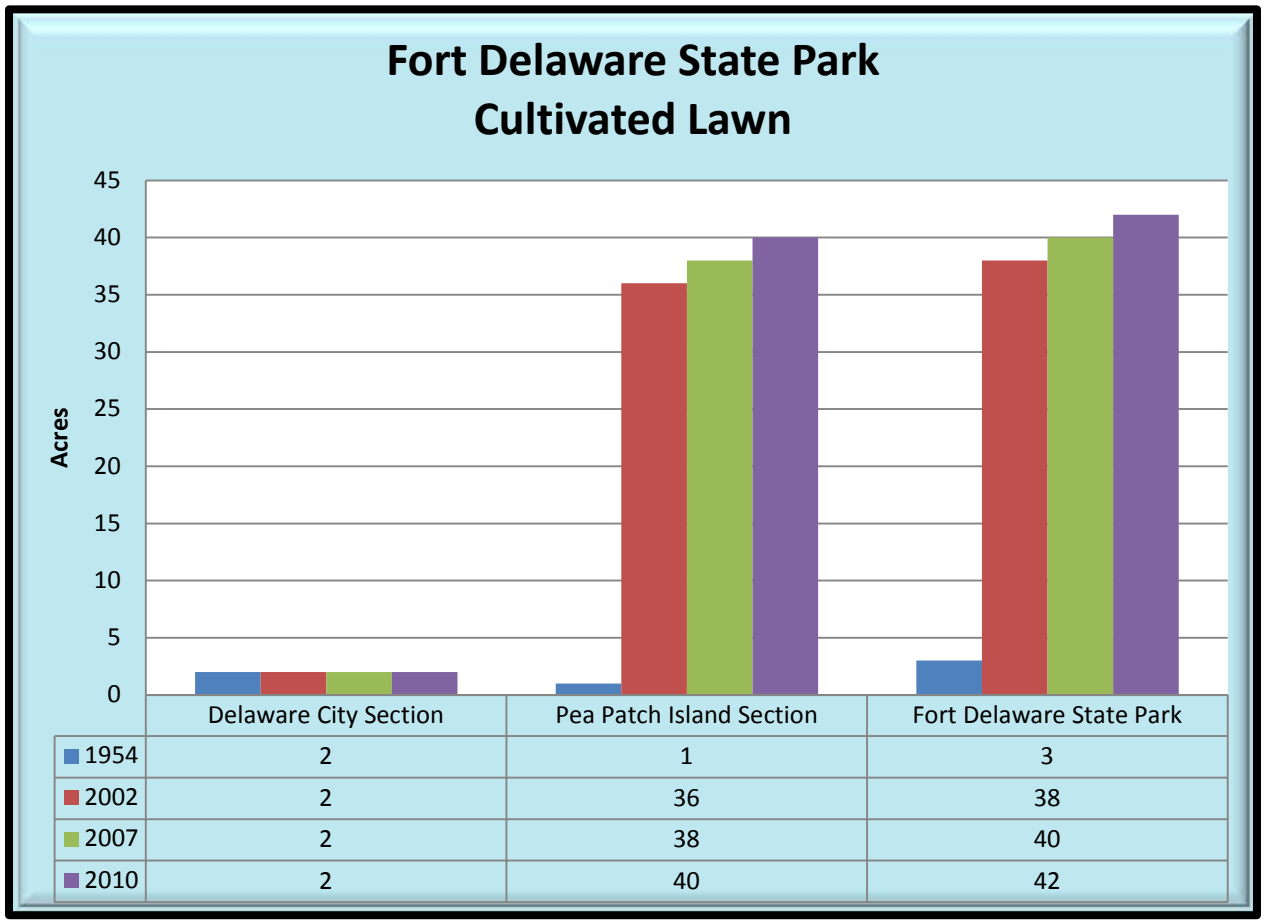


Figure 5.4. Cultivated Lawn at Fort Delaware State Park (1954, 2002, and 2007)

DNREC Sea Level Rise Analysis (Table 5.7)

Most of the current extent of cultivated lawn will be flooded with 1.5 m of sea level rise.

Table 5.7. Projected acres of Cultivated Lawn Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	12 acres
1 m	31 acres
1.5 m	39 acres

Natural Capital

Cultivated lawn does not have any natural capital value.

Freshwater Tidal Mixed High Marsh **[0 acres (Figure 5.5, Tables 5.8-5.9)] GNR S1**

DEWAP: Freshwater Tidal Marshes
NHC: Northern Atlantic Coastal Plain Fresh and Oligohaline Tidal Marsh

Description

This marsh community is no longer present in the park and was the victim of invasion by reed grass (*Phragmites australis*) and likely some more brackish water. Since this marsh is no longer present in the park and exact species of what was here cannot be given, however a typical marsh of this type includes arrow-arum (*Peltandra virginica*), orange-spotted jewelweed (*Impatiens capensis*), broad-leaf arrow (*Sagittaria latifolia*), narrow-leaf cattail (*Typha angustifolia*), halbeard-leaf tearthumb (*Polygonum arifolium*), arrow-leaved tearthumb (*Polygonum sagittatum*), and mild water pepper (*Polygonum hydropiperoides*).

Analysis of Condition at Fort Delaware State Park

Freshwater Tidal Mixed High Marsh from 1954 has become Reed Tidal Marsh in 2010 (Table 5.8).

Table 5.8. What was once Freshwater Tidal Mixed High Marsh in 1954 has become X in 2010	
X	**Acreage**
Reed Tidal Marsh	2 acres

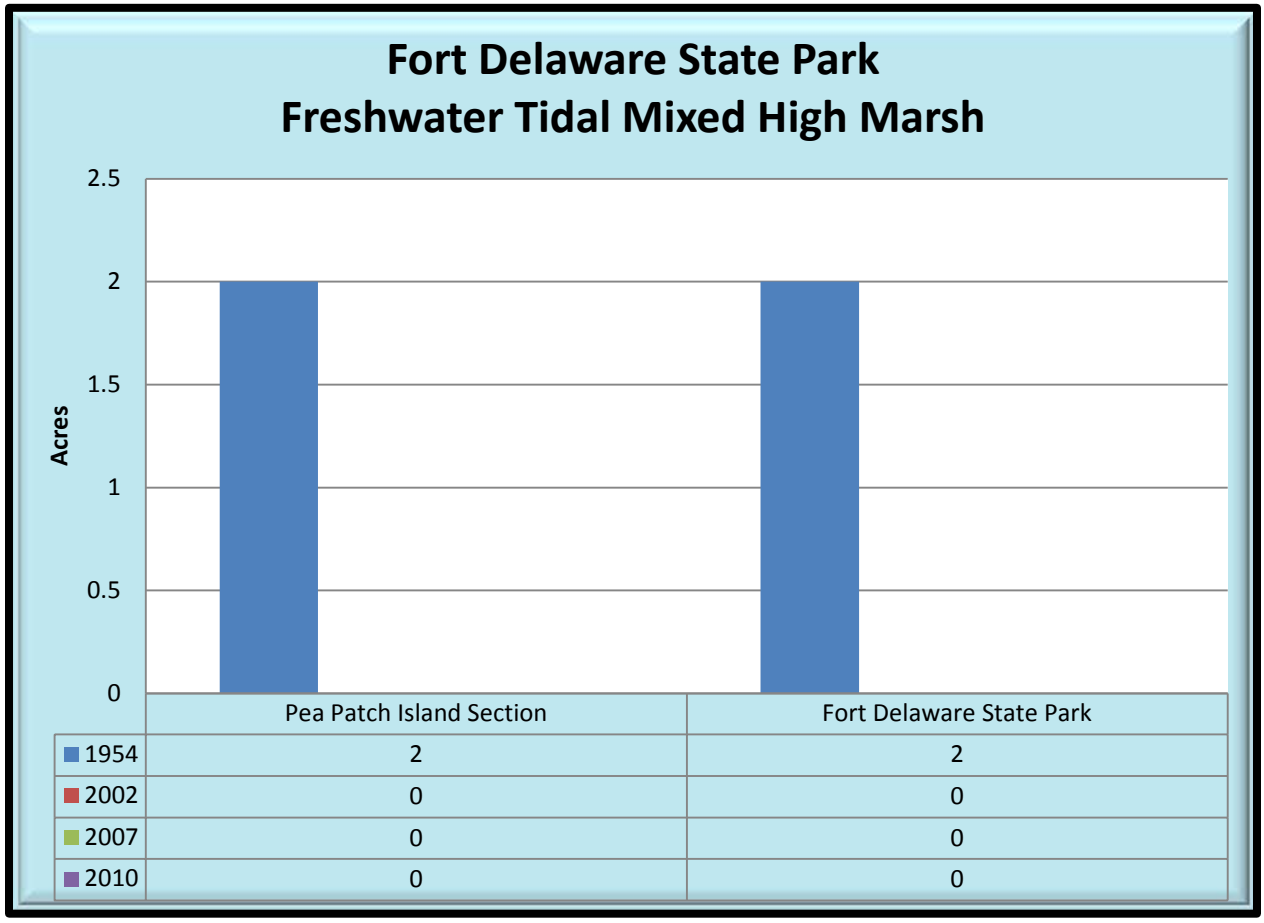


Figure 5.5. Freshwater Tidal Mixed High Marsh at Fort Delaware State Park (1954, 2002, 2007, and 2010)

Natural Capital (Table 5.9)

Freshwater Tidal Mixed High Marsh has transferred its capital to Reed Tidal Marsh since 1954.

Table 5.9. Natural Capital of Freshwater Tidal Mixed High Marsh	
Year	**Natural Capital (in 2012 dollars)**
1954	$12,543/year
2002	$0/year (not present)
2007	$0/year (not present)
2010	$0/year (not present)

North Atlantic Low Salt Marsh **[15 acres (Figures 5.6-5.7, Tables 5.10-5.12)] G5 S5**

DEWAP: Tidal Low Marshes
NHC: Northern Atlantic Coastal Plain Tidal Salt Marsh

Description

Figure 5.6. North Atlantic Low Salt Marsh

North Atlantic Low Salt Marsh is located in some parts of the tidal marsh and has recently experienced re-growth with reed grass (*Phragmites australis*) control efforts. This marsh is dominated by salt meadow cordgrass (*Spartina alternifolia*) and associated by salt meadow hay (*Spartina patens*), salt marsh fleabane (*Pluchea odorata*), and sea lavender (*Limonium carolinianum*).

Analysis of Condition at Fort Delaware State Park

North Atlantic Low Salt Marsh was not present in 1954 and has since populated 10 acres of Pickerelweed Tidal Marsh, 4 acres of Reed Tidal Marsh, 1 acre of Wax-Myrtle Shrub Swamp, and 1 acre of Cattail Brackish Tidal Marsh (Table 5.10). This is likely caused by increasing salinities in the marshes of Pea Patch Island.

Table 5.10. North Atlantic Low Salt Marsh has migrated into X since 1954	
X	**Acreage**
Pickerelweed Tidal Marsh	10 acres
Reed Tidal Marsh	4 acres
Wax-Myrtle Shrub Swamp	1 acre
Cattail Brackish Tidal Marsh	1 acre

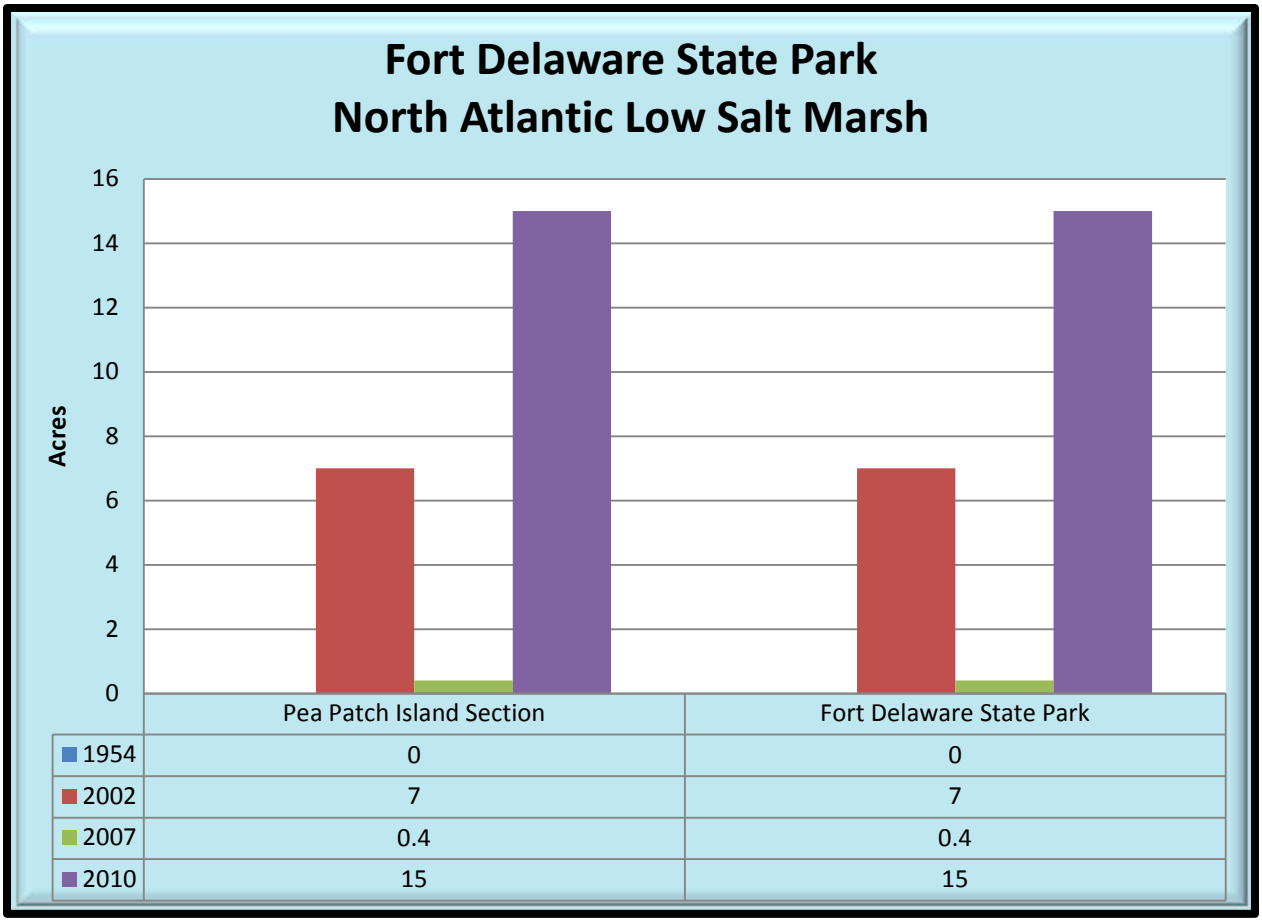


Figure 5.7. North Atlantic Low Salt Marsh at Fort Delaware State Park (1954, 2002, 2007, and 2010)

DNREC Sea Level Rise Analysis (Table 5.11)

All of the current extent of North Atlantic Low Salt Marsh will be inundated with 0.5 m of sea level rise.

Table 5.11. Projected acres of Cattail Brackish Tidal Marsh Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	15 acres
1 m	15 acres
1.5 m	15 acres

Natural Capital (Table 5.12)

North Atlantic Low Salt Marsh has increased its capital since 2002 with reed grass control efforts on the island.

Table 5.12. Natural Capital of North Atlantic Low Salt Marsh	
Year	**Natural Capital (in 2012 dollars)**
1954	$0/year (not present)
2002	$43,899/year
2007	$2,509/year
2010	$94,070/year

Northeastern Modified Successional Forest **[43 acres (Figures 5.8-5.9, Tables 5.13-5.16)]** **GNA SNA**

DEWAP: Coastal Plain Upland Forest
NHC: Semi-natural/Altered Vegetation and Conifer Plantations

Description

This is the only forest community on Pea Patch Island. Canopy species in this community include red maple (*Acer rubrum*), wild black cherry (*Prunus serotina*), tree-of-heaven (*Ailanthus altissima*), sweetgum (*Liquidambar styraciflua*), sassafras (*Sassafras albidum*), pin oak (*Quercus palustris*), and quaking aspen (*Populus tremuloides*). Some areas of the island in the heron nesting areas have a large amount of wild black cherry that is suggestive of a Chesapeake Bay Tall Maritime Forest, but I believe that this situation is artificial due to the heron disturbance and given the location it is likely better put in this community. The understory is composed of the smaller members of the canopy plus persimmon (*Diospyros virginiana*), eastern red cedar (*Juniperus virginiana*), and white oak (*Quercus alba*). The shrub and vine layer is composed of buttonbush (*Cephalanthus occidentalis*), Japanese honeysuckle (*Lonicera japonica*), blackberry (*Rubus* sp.), Oriental bittersweet (*Celastrus orbiculatus*), poison ivy (*Toxicodendron radicans*), highbush blueberry (*Vaccinium corymbosum*), winterberry (*Ilex verticillata*), multiflora rose (*Rosa multiflora*), and autumn olive (*Elaeagnus umbellata*). Common herbs include Japanese stiltgrass (*Microstegium vimineum*), rugosa goldenrod (*Solidago rugosa*), mile-a-minute (*Polygonum perfoliata*), broom-sedge (*Andropogon virginicus*), switchgrass (*Panicum virgatum*), and horseweed (*Conyza canadensis*).

Figure 5.8. Northeastern Modified Successional Forest

This forest community is in a late successional state and will likely remain this way until the exotic invasive plants are removed and the natural ecology is restored.

Analysis of Condition at Fort Delaware State Park

About 28 acres of the 54 acres of Northeastern Modified Successional Forest from 1954 still existed in 2010. The rest had become 15 acres of cultivated lawn, 7 acres of Reed Tidal Marsh, 1 acre of water, and 1 acre of semi-impervious surface (Table 5.13). Since 1954, this forest community has decreased its acreage with development on the island. It has, however, managed to grow into 8 acres of Northeastern Old Field, 3 acres of modified land, 2 acres of Northeastern Successional Shrubland, and 0.5 acres of beach (Table 5.14).

Table 5.13. What was once Northeastern Modified Successional Forest in 1954 has become X in 2010	
X	**Acreage**
Northeastern Modified Successional Forest	28 acres
Cultivated Lawn	15 acres
Reed Tidal Marsh	7 acres
Water	1 acre
Semi-impervious Surface	1 acre
Other communities/land covers	2 acres

Table 5.14. Northeastern Modified Successional Forest has migrated into X since 1954	
X	**Acreage**
Northeastern Modified Successional Forest	28 acres
Northeastern Old Field	8 acres
Modified Land	3 acres
Northeastern Successional Shrubland	2 acres
Beach	0.5 acres
Other communities/land covers	0.2 acres

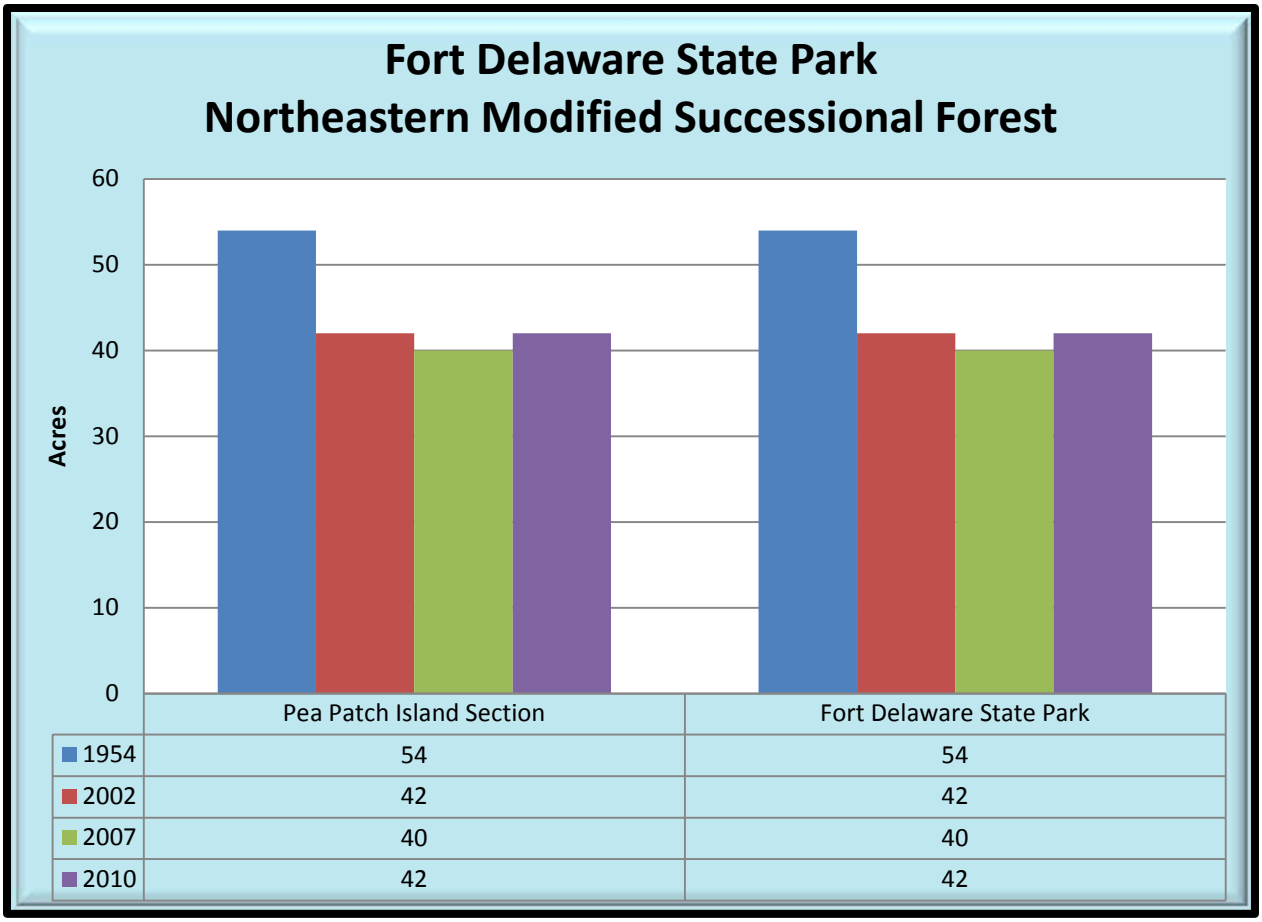


Figure 5.9. Northeastern Modified Successional Forest at Fort Delaware State Park (1954, 2002, 2007, and 2010)

DNREC Sea Level Rise Analysis (Table 5.15)

Most of the current extent of Northeastern Modified Successional Forest will be inundated with 1.5 m of sea level rise.

Table 5.15. Projected acres of Northeastern Modified Successional Forest Inundated by Sea Level Rise

Rise	Acres
0.5 m	10 acres
1 m	29 acres
1.5 m	39 acres

Natural Capital (Table 5.16)

Capital in Northeastern Modified Successional Forest has decreased since 1954 due to development of cultivated lawn in the island. This has resulted in a reduction of natural capital for the island.

Table 5.16. Natural Capital of Northeastern Modified Successional Forest	
Year	**Natural Capital (in 2012 dollars)**
1954	$10,211/year (not present)
2002	$7,942/year
2007	$7,564/year
2010	$7,942/year

Northeastern Old Field **[0 acres (Figure 5.10, Tables 5.17-5.18)] GNA SNA**

DEWAP: Herbaceous Early Successional Upland Habitats
NHC: Semi-natural/Altered Vegetation and Conifer Plantations

Description

Since this community is no longer present in the park an exact species cannot be given. However these fields are often composed of red fescue (*Festuca rubra*), red clover (*Trifolium pratense*), Queen Anne's lace (*Daucus carota*), sweet vernal grass (*Anthoxanthum odoratum*), orchard grass (*Dactylis glomerata*), rough bluegrass (*Poa trivialis*), and common velvet grass (*Holcus lanatus*).

Analysis of Condition at Fort Delaware State Park

This community is no longer present in the park and has become 8 acres of Northeastern Modified Successional Forest, 4 acres of cultivated lawn, and 1 acre of modified land (Table 5.17).

Table 5.17. What was once Northeastern Old Field in 1954 has become X in 2010

X	**Acreage**
Northeastern Modified Successional Forest	8 acres
Cultivated Lawn	4 acres
Modified Land	1 acre

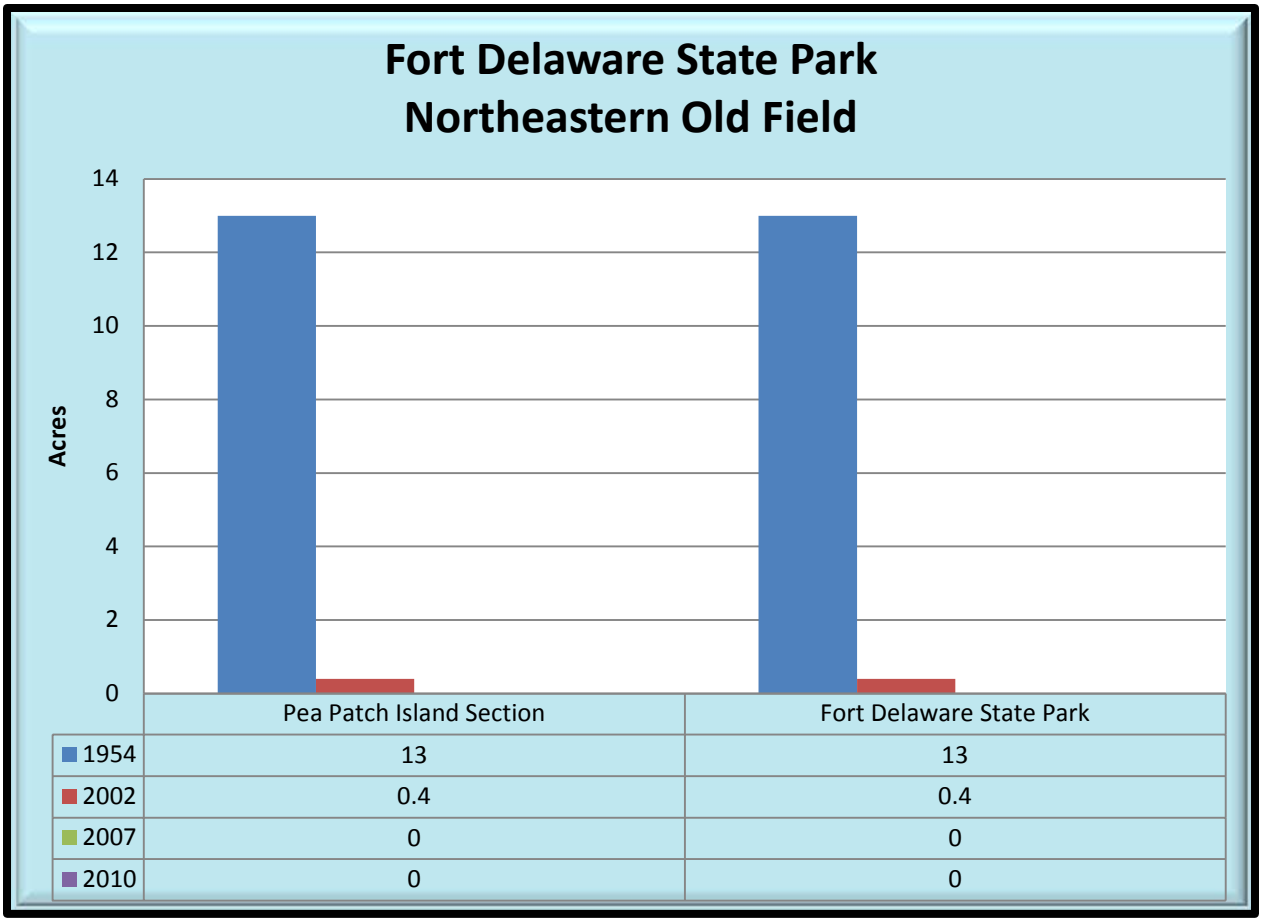


Figure 5.9. Northeastern Old Field at Fort Delaware State Park (1954, 2002, 2007, and 2010)

Natural Capital (Table 5.18)

Capital in Northeastern Old Field has declined to $0.00 as this community has matured to forest or has been developed.

Table 5.18. Natural Capital of Northeastern Old Field	
Year	**Natural Capital (in 2012 dollars)**
1954	$1,894/year
2002	$58/year
2007	$0/year (not present)
2010	$0/year (not present)

Reed Tidal Marsh **[131 acres (Figures 5.10-5.11, Tables 5.20-5.23)] GNA SNA**

DEWAP: Tidal High Marshes
NHC: Northern Atlantic Coastal Plain Tidal Salt Marsh

Description

This tidal community covers most of the marsh on Pea Patch Island is dominated totally by common reed (*Phragmites australis*). Efforts have been conducted to control it but it seems to reappear soon after.

Figure 5.10. Reed Tidal Marsh

Analysis of Condition at Fort Delaware State Park

About 23 acres of the 35 acres of Reed Tidal Marsh from 1954 was still present in 2010. The rest of the marsh had become 5 acres of water, 4 acres of North Atlantic Low Salt Marsh, and 1 acre each of cultivated lawn and Cattail Brackish Tidal Marsh (Table 5.20). Since 1954, Reed Tidal Marsh has invaded 30 acres of Cattail Brackish Tidal Marsh, 30 acres of Pickerelweed Tidal Marsh, 8 acres of Northeastern Successional Shrubland, 7 acres of Northeastern Modified Successional Forest, and 4 acres of Wax-Myrtle Shrub Swamp (Table 5.21).

Table 5.20. What was once Reed Tidal Marsh in 1954 has become X in 2010	
X	**Acreage**
Reed Tidal Marsh	23 acres
Water	5 acres
North Atlantic Low Salt Marsh	4 acres
Cultivated Lawn	1 acre
Cattail Brackish Tidal Marsh	1 acre
Other communities/land covers	1 acre

Table 5.21. Reed Tidal Marsh has migrated into X since 1954	
X	**Acreage**
Cattail Brackish Tidal Marsh	30 acres
Pickerelweed Tidal Marsh	30 acres
Northeastern Successional Shrubland	8 acres
Northeastern Modified Successional Forest	7 acres
Wax-Myrtle Shrub Swamp	4 acres
Other communities/land covers	7 acres

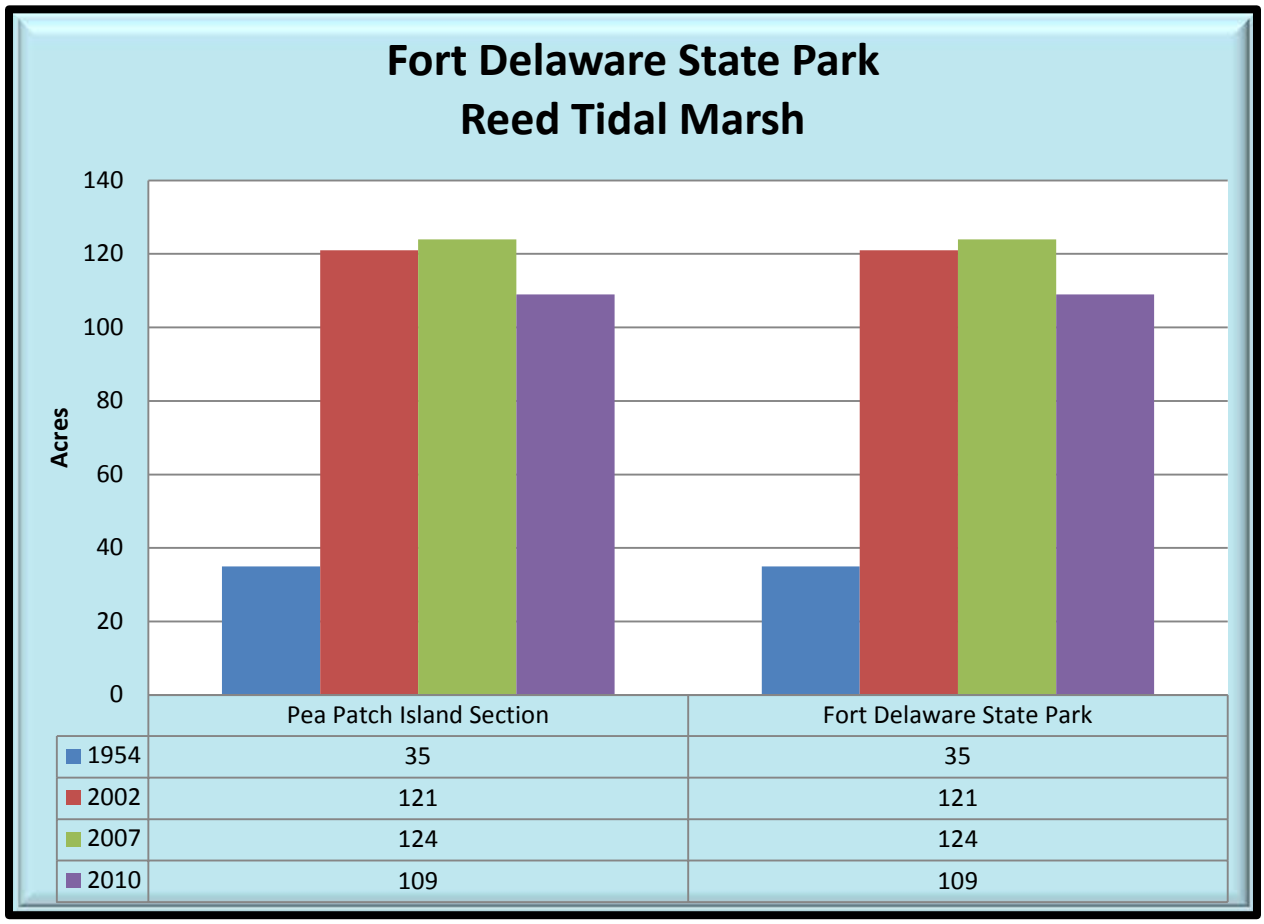


Figure 5.11. Reed Tidal Marsh at Fort Delaware State Park (1954, 2002, and 2007)

DNREC Sea Level Rise Analysis (Table 5.22)

All of the current extent of Reed Tidal Marsh will be inundated with 1.5 m of sea level rise.

Table 5.22. Projected acres of Reed Tidal Marsh Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	74 acres
1 m	102 acres
1.5 m	109 acres

Natural Capital (Table 5.23)

Capital in Reed Tidal Marsh has greatly increased since 1954 and has oscillated in amount in the 2002 to 2010 period.

Table 5.23. Natural Capital of Reed Tidal Marsh	
Year	**Natural Capital (in 2012 dollars)**
1954	$432,915/year (not present)
2002	$1,487,272/year
2007	$1,524,146/year
2010	$1,339,774/year

CHAPTER 6: DESCRIPTIONS AND ANALYSIS OF THE LAND COVERS

Seven land covers were noted during the survey. Land covers are those areas such as agricultural fields or places that do not contain vegetation communities but still cover ground surface. In terms of sea-level rise, water is most important but it effects can also be seen in the impoundments.

The land covers include:

1. Beach—1 acre
2. Farm Pond/Artificial Pond—0.1 acres
3. Impervious Surface—4 acres
4. Riprap—2 acres
5. Semi-impervious Surface—1 acre
6. Tidal Mudflat—1 acre
7. Water—28 acres

Beach **[1 acre, (Figure 6.1 Tables 6.1-6.3)]**

DEWAP: Nearshore Habitats
NHC: No Equivalent Classification

Description

Beach areas are located between the marshlands and the higher drier land. They are often composed of sand, small pebbles, and "beached" debris from the river.

Analysis of Condition at Fort Delaware State Park

None of the beach area from 1954 was still present in 1954. It has all become 1 acre of Reed Tidal Marsh, 0.5 acres of Northeastern Modified Successional Forest, 0.2 acres of Semi-impervious Surface, and 0.2 acres of water (Table 6.1). Since 1954, beach area has covered 1 acre of Reed Tidal Marsh, 0.4 acres of Pickerelweed Tidal Marsh, 0.3 acres of Cattail Brackish Tidal Marsh, 0.2 acres of Northeastern Successional Shrubland, and 0.1 acres of Northeastern Modified Successional Forest (Table 6.2).

Table 6.1. What was once Beach in 1954 has become X in 2010	
X	**Acreage**
Reed Tidal Marsh	1 acre
Northeastern Modified Successional Forest	0.5 acres
Semi-impervious Surface	0.2 acres
Water	0.2 acres

Table 6.2. Beach has migrated into X since 1954	
X	**Acreage**
Reed Tidal Marsh	1 acre
Pickerelweed Tidal Marsh	0.4 acres
Cattail Brackish Tidal Marsh	0.3 acres
Northeastern Successional Shrubland	0.2 acres
Northeastern Modified Successional Forest	0.1 acres

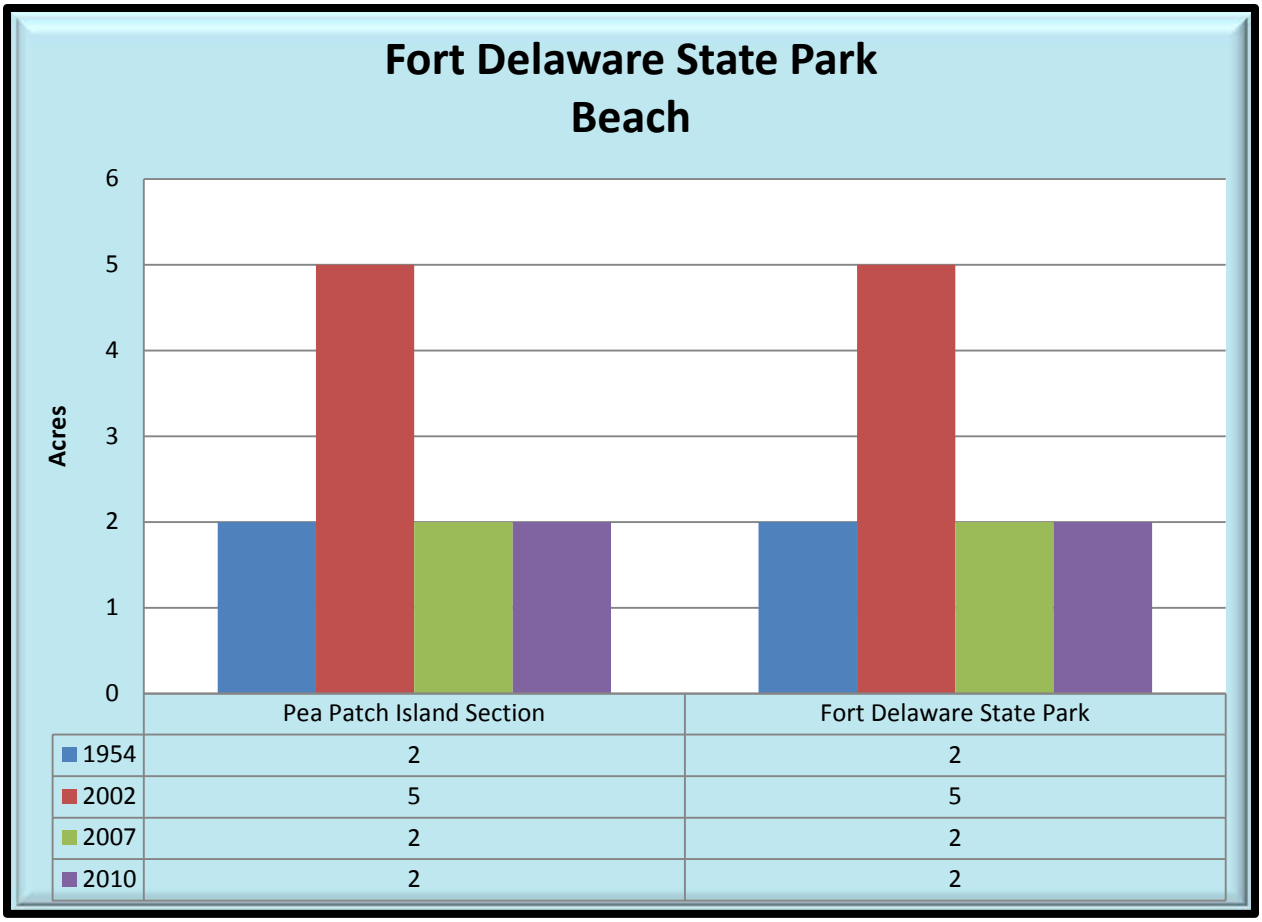


Figure 6.1. Beach at Fort Delaware State Park (1954, 2002, 2007, and 2010)

DNREC Sea Level Rise Analysis (Table 6.3)

All of the current extent of Beach will be inundated with 1.5 m of sea level rise.

Table 6.3. Projected acres of Beach Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	1 acre
1 m	1 acre
1.5 m	2 acres

Natural Capital

Beach does not have any natural capital value.

Farm Pond/Artificial Pond **[0.1 acres, (Figure 6.2, Tables 6.4-6.5)]**

DEWAP: Impoundment
NHC: No Equivalent Classification

Description

This land cover generally includes the moat around the fort and a small pond nearby.

Analysis of Condition at Fort Delaware State Park

All of the Farm Pond/Artificial Pond from 1954 was still present in 2010. Since 1954, about 0.2 acres of Farm Pond/Artificial Pond has been converted to Semi-impervious Surface.

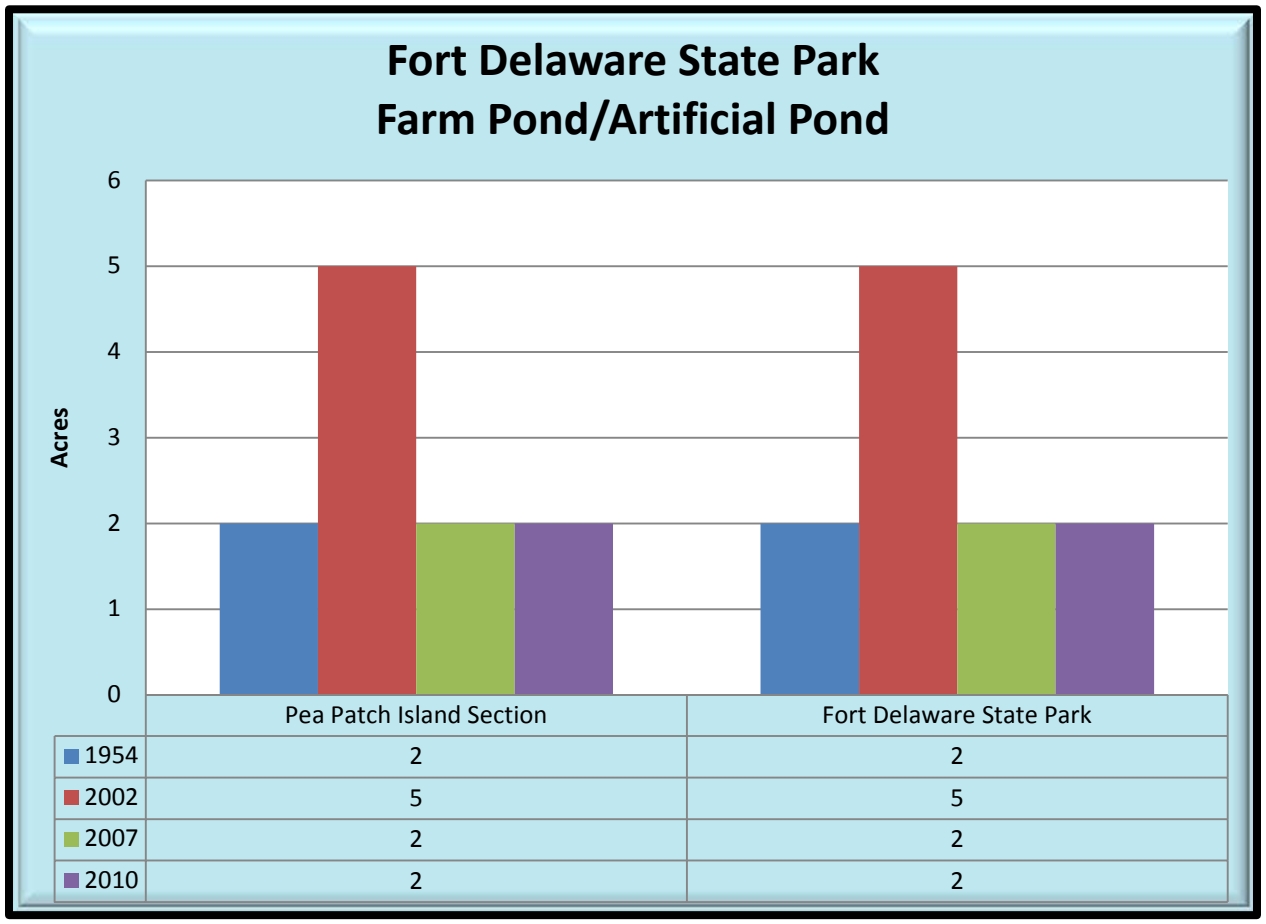


Figure 6.2. Farm Pond/Artificial Pond at Fort Delaware State Park (1954, 2002, 2007, and 2010)

DNREC Sea Level Rise Analysis (Table 6.4)

All of the current extent of Farm Pond/Artificial Pond will be inundated with 0.5 m of sea level rise.

Table 6.4. Projected acres of Farm Pond/Artificial Pond Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	2 acres
1 m	2 acres
1.5 m	2 acres

Natural Capital (Table 6.5)

Capital of Farm Pond/Artificial Pond has stayed the same since 1954 with an upsurge in 2002 to $26,676.

Table 6.5. Natural Capital of Farm Pond/Artificial Pond	
Year	**Natural Capital (in 2012 dollars)**
1954	$10,670/year
2002	$26,676/year
2007	$10,670/year
2010	$10,670/year

Impervious Surface **[4 acres, (Figure 6.3, Tables 6.6-6.8)]**

DEWAP: No Equivalent Classification
NHC: No Equivalent Classification

Description

Impervious surface in Fort Delaware State Park includes buildings, sidewalks, and roads. These areas are impervious to the flow of water.

Analysis of Condition at Fort Delaware State Park

About 2 acres of the 3 acres of impervious surface from 1954 was still present in 2010. The rest of the acreage had been converted to cultivated lawn (Table 6.6). Since 1954, impervious surface has increased by 1 acre into cultivated lawn and 0.1 acres into Northeastern Successional Shrubland (Table 6.7).

Table 6.6. What was once Impervious Surface in 1954 has become X in 2010	
X	**Acreage**
Impervious Surface	2 acres
Cultivated Lawn	0.3 acres

Table 6.7. Impervious Surface has migrated into X since 1954	
X	**Acreage**
Impervious Surface	2 acres
Cultivated Lawn	1 acre
Northeastern Successional Shrubland	0.1 acres

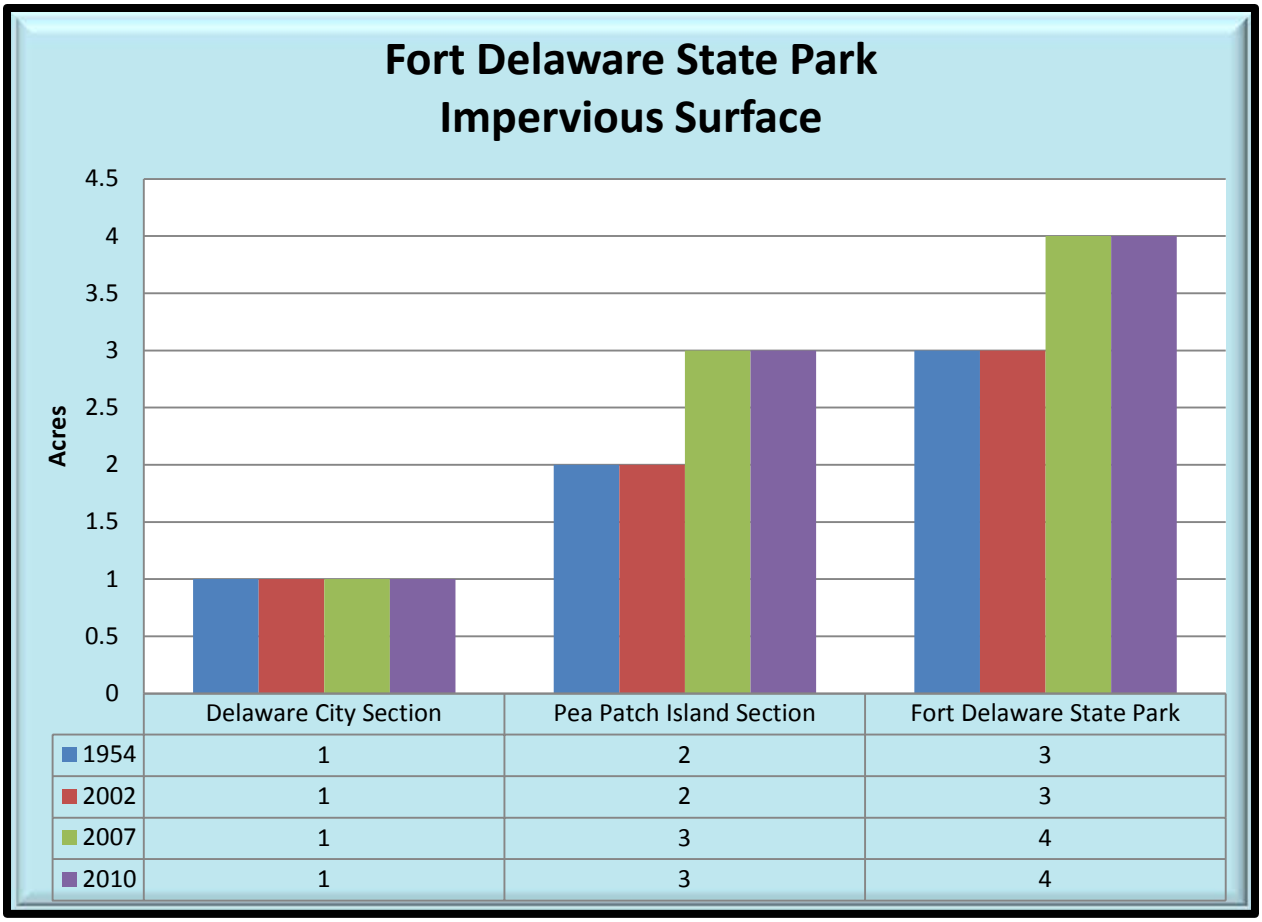


Figure 6.3. Impervious Surface at Fort Delaware State Park (1954, 2002, 2007, 2010)

DNREC Sea Level Rise Analysis (Table 6.8)

About ¾ of the current impervious surface will be inundated with 1.5 m of sea level rise.

Table 6.8. Projected acres of Impervious Surface Inundated by Sea Level Rise

Rise	Acres
0.5 m	2 acres
1 m	2 acres
1.5 m	3 acres

Natural Capital

Impervious surface does not contain any natural capital value.

Modified Land **[8 acres, (Figure 6.4, Tables 6.9-6.11)]**

DEWAP: No Equivalent Classification
NHC: No Equivalent Classification

Description

Modified land includes those areas that have had the vegetation removed. These are often waste areas or preclude development.

Analysis of Condition at Fort Delaware State Park

About 7 acres of modified land from 1954 survived to 2010. The rest had become 3 acres of Northeastern Modified Successional Forest, 1 acre of cultivated lawn, 1 acre of Reed Tidal Marsh, and 0.2 acres of Riprap (Table 6.9). Since 1954, 1 of Northeastern Old Field and 0.1 acres of Northeastern Modified Successional Forest have been developed into modified land (Table 6.10).

Table 6.9. What was once Modified Land in 1954 has become X in 2010	
X	**Acreage**
Modified Land	7 acres
Northeastern Modified Successional Forest	3 acres
Cultivated Lawn	1 acre
Reed Tidal Marsh	1 acre
Riprap	0.2 acres

Table 6.10. Modified Land has migrated into X since 1954	
X	**Acreage**
Modified Land	7 acres
Northeastern Old Field	1 acre
Northeastern Modified Successional Forest	0.1 acres

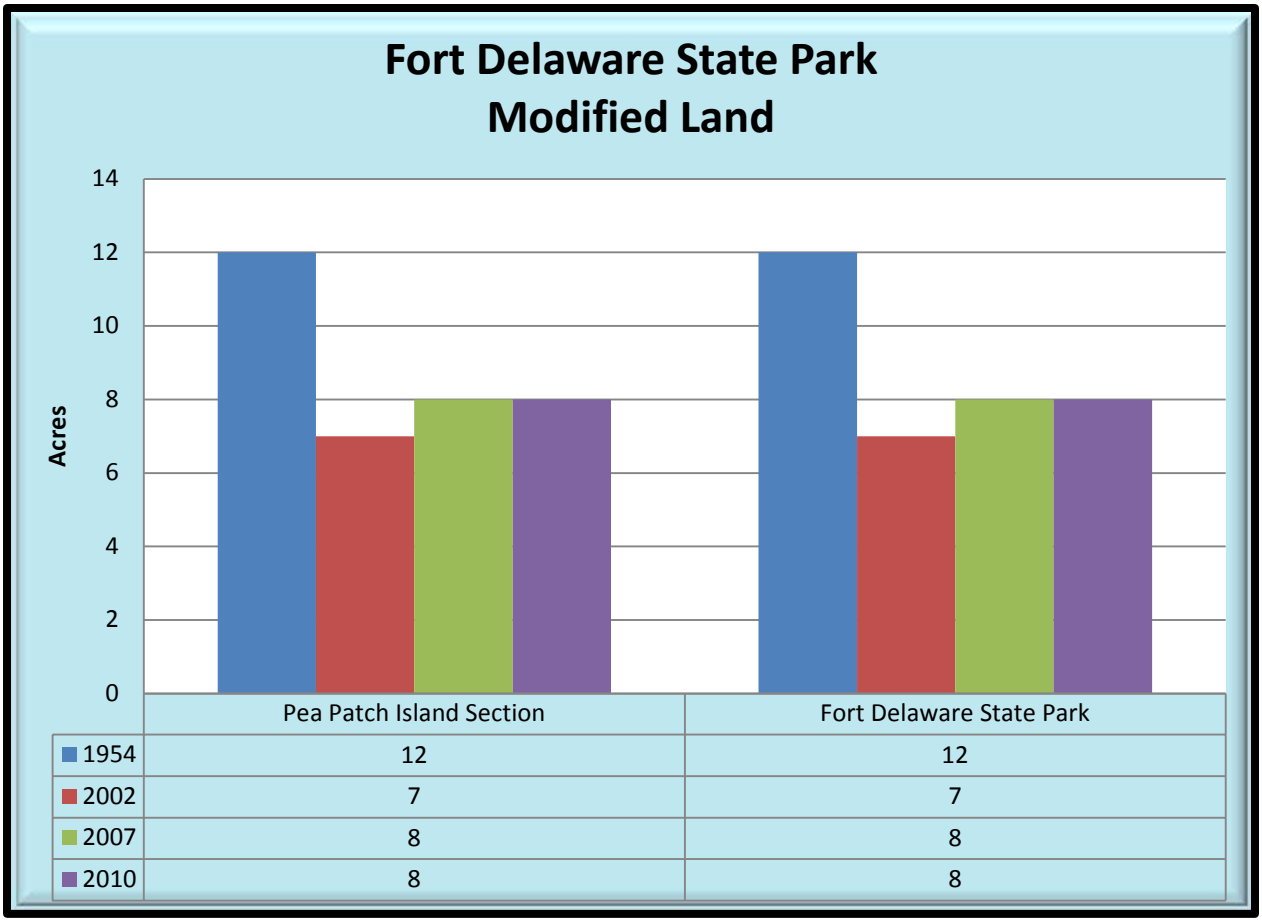


Figure 6.4. Modified Land at Fort Delaware State Park (1954, 2002, 2007, and 2010)

DNREC Sea Level Rise Analysis (Table 6.11)

All of the current extent of Modified Land will be inundated with 1.5 m of sea level rise.

Table 6.11. Projected acres of Modified Land Inundated by Sea Level Rise

Rise	Acres
0.5 m	0.4 acres
1 m	5 acres
1.5 m	8 acres

Natural Capital

Modified land does not have any natural capital value.

***Riprap* [2 acres, (Figure 6.5, Table 6.12-6.13)]**

DEWAP: No Equivalent Classification
NHC: No Equivalent Classification

Description

This land cover includes water bodies that are less than 5 acres in size. One of the ponds present in the Great Dune Section contains cranberry (*Vaccinium macrocarpon*).

Analysis of Condition at Fort Delaware State Park

Riprap did not appear to be present in 1954 and has since been laid in 1 acre of Northeastern Modified Successional Forest, 0.3 acres of Northeastern Successional Shrubland, 0.2 acres of Semi-impervious Surface, 0.2 acres of Modified Land, and 0.1 acres of cultivated lawn (Table 6.12).

Table 6.12. Riprap has been laid into X since 1954

X	Acreage
Northeastern Modified Successional Forest	1 acre
Northeastern Successional Shrubland	0.3 acres
Semi-impervious Surface	0.2 acres
Modified Land	0.2 acres
Cultivated Lawn	0.1 acres

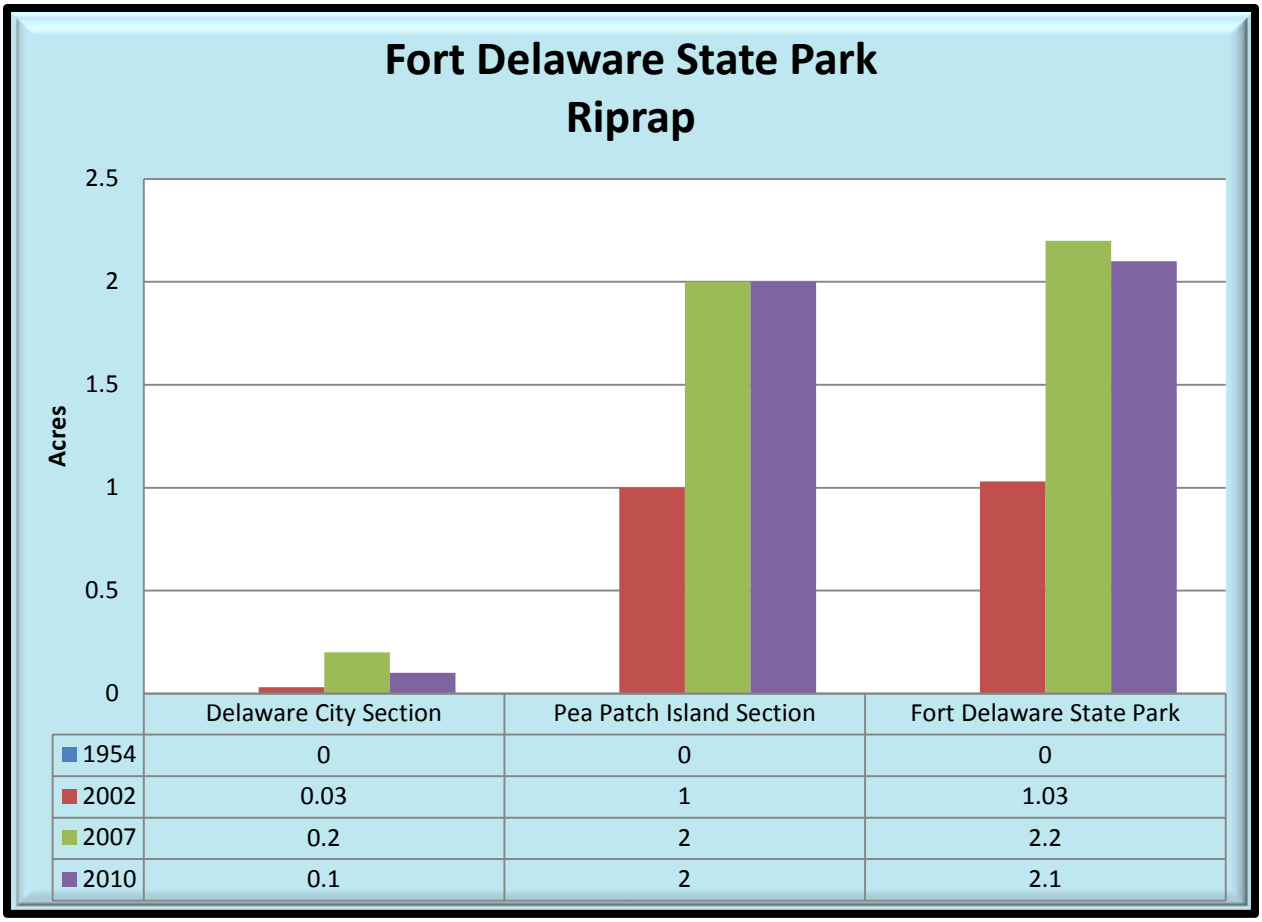


Figure 6.5. Riprap at Fort Delaware State Park (1954, 2002, 2007, and 2010)

DNREC Sea Level Rise Analysis (Table 6.13)

All of the current extent of Riprap will be inundated with 1.5 m of sea level rise.

Table 6.13. Projected acres of Riprap Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	1 acre
1 m	1 acre
1.5 m	2 acres

Natural Capital

Riprap does not have any natural capital value.

Semi-impervious Surface **[1 acre, (Figure 6.6, Tables 6.14-6.16)]**

DEWAP: No Equivalent Classification
NHC: No Equivalent Classification

Description

This land cover includes those areas that are semi-impervious to the flow of water. In Fort Delaware State Park these include dirt roads and some trails.

Analysis of Condition at Fort Delaware State Park

A little less than half (0.4 acres) of the semi-impervious surface from 1954 still existed in 2010. The rest had become 1 acre of cultivated lawn, 0.2 acres of riprap, 0.2 acres of Farm Pond/Artificial Pond, and 0.1 acres of water (Table 6.14). Since 1954, semi-impervious surface has increased in acreage by being developed into 1 acre of Northeastern Modified Successional Forest, 1 acre of Northeastern Successional Shrubland, 0.3 acres of water, and 0.2 acres of beach (Table 6.15).

Table 6.14. What was once Semi-impervious Surface in 1954 has become X in 2010	
X	**Acreage**
Cultivated Lawn	1 acre
Semi-impervious Surface	0.4 acres
Riprap	0.2 acres
Farm Pond/Artificial Pond	0.2 acres
Water	0.1 acres

Table 6.15. Semi-impervious Surface has been developed into X since 1954	
X	**Acreage**
Northeastern Modified Successional Forest	1 acre
Northeastern Successional Shrubland	1 acre
Semi-impervious Surface	0.4 acres
Water	0.3 acres
Beach	0.2 acres
Other communities/land covers	0.4 acres

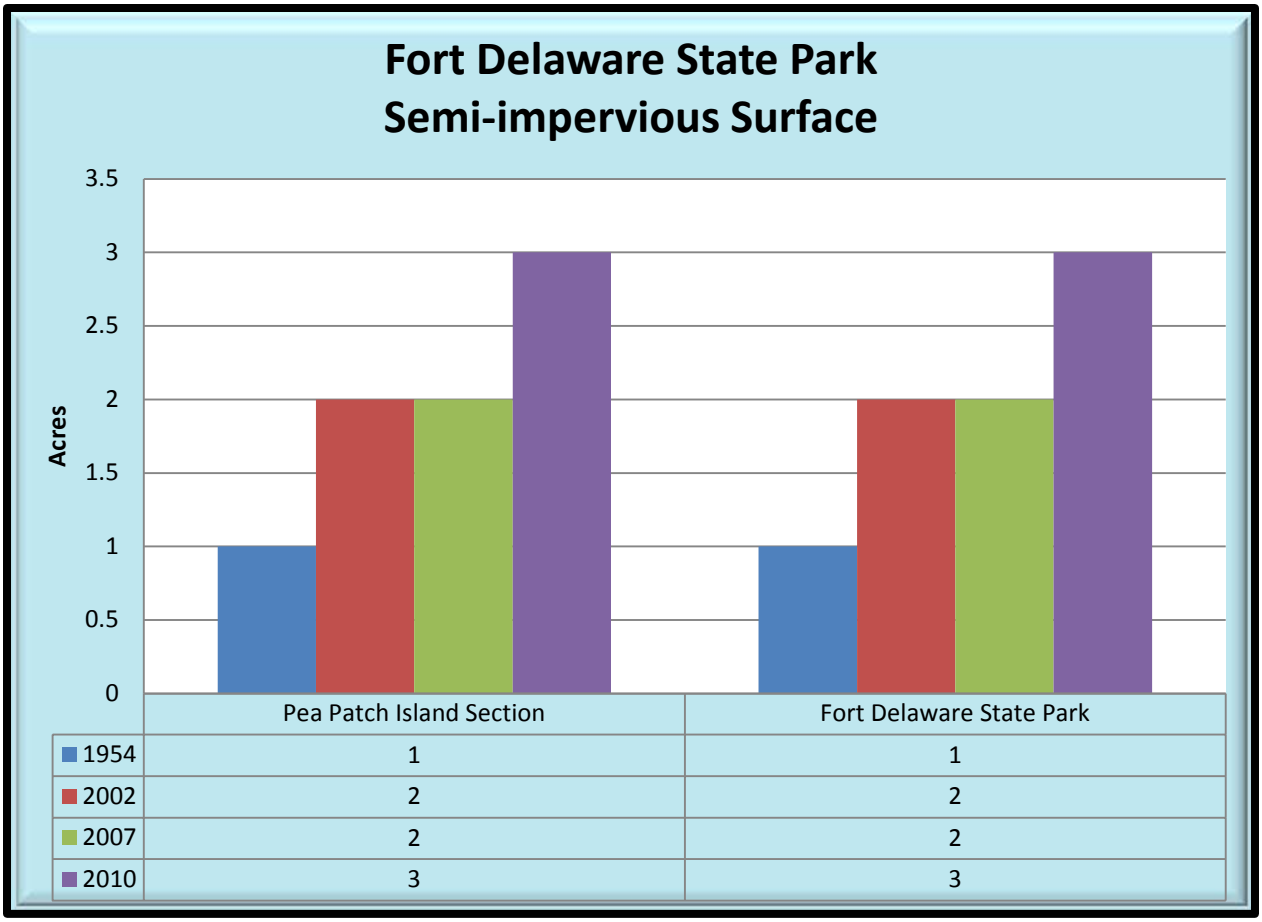


Figure 6.6. Semi-impervious surface at Fort Delaware State Park (1954, 2002, 2007, and 2010)

DNREC Sea Level Rise Analysis (Table 6.16)

All of the current extent of Semi-impervious Surface will be inundated with 1.5 m of sea level rise.

Table 6.16. Projected acres of Semi-impervious Surface Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	1 acre
1 m	2 acres
1.5 m	3 acres

Natural Capital

Semi-impervious surface does not have any natural capital value.

Tidal Mudflat **[1 acre, (Figure 6.7, Tables 6.17-6.18)]**

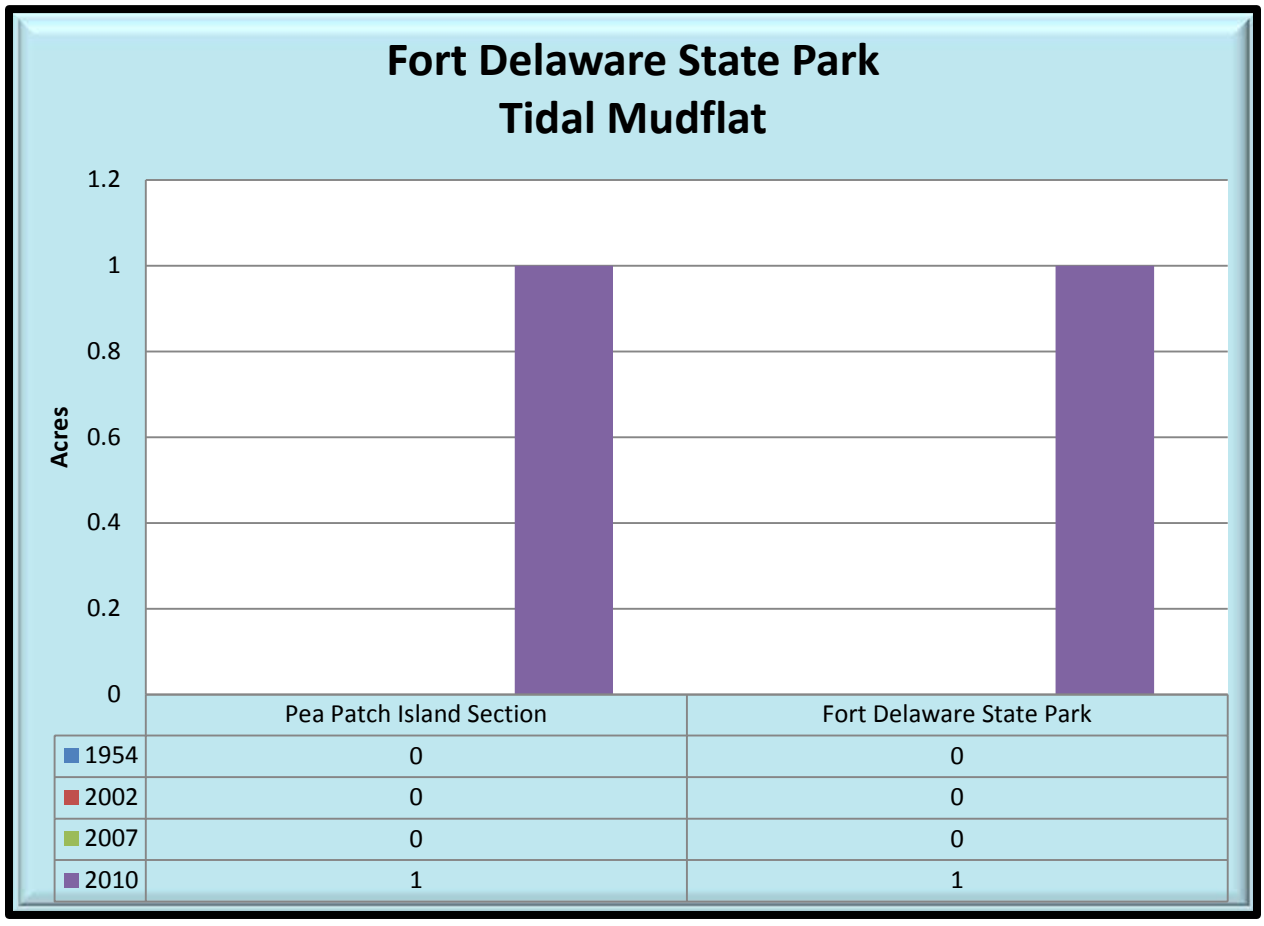
DEWAP: Nearshore Habitats
NHC: No Equivalent Classification

Description

Tidal mudflats are located in tidal marshes and bare of vegetation because of tidal water movement.

Analysis of Condition at Fort Delaware State Park

Tidal mudflat was not present in 1954 and has since covered 1 acre of Pickerelweed Tidal Marsh by 2010.



	Pea Patch Island Section	Fort Delaware State Park
1954	0	0
2002	0	0
2007	0	0
2010	1	1

Figure 6.7. Tidal Mudflat at Fort Delaware State Park (1954, 2002, 2007, and 2010)

DNREC Sea Level Rise Analysis (Table 6.17)

All of the current extent of Tidal Mudflat will be inundated with 0.5 m of sea level rise.

Table 5.3. Projected acres of Tidal Mudflat Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	1 acre
1 m	1 acre
1.5 m	1 acre

Natural Capital (Table 6.18)

Tidal Mudflat acquired $6,271 in natural capital via transfer from another marsh community.

Table 6.18. Natural Capital of Tidal Mudflat	
Year	**Natural Capital (in 2012 dollars)**
1954	$0/year (not present)
2002	$0/year (not present)
2007	$0/year (not present)
2010	$6,271/year

***Water* [28 acres, (Figure 6.8, Tables 6.19-6.21)]**

DEWAP: Nearshore Habitats
NHC: No Equivalent Classification

Description

Water includes primarily the Delaware River and tidal tributaries on the island.

Analysis of Condition at Fort Delaware State Park

Only about half of the water that was present in 1954 was still present in 2010. What was water had become 4 acres of Reed Tidal Marsh, 0.3 acres of Semi-impervious Surface, and 0.1 acres of Northeastern Modified Successional Forest (Table 6.19). Since 1954, water has greatly increased through sea level rise and erosion of the island. About 14 acres of Pickerelweed Tidal Marsh, 5 acres of Reed Tidal Marsh, 4 acres of Cattail Brackish Tidal Marsh, and 1 acre of Northeastern Modified Successional Forest have been inundated by water since 1954 (Table 6.20).

Table 6.19. What was once Water in 1954 has become X in 2010	
X	**Acreage**
Reed Tidal Marsh	4 acres
Water	4 acres
Semi-impervious Surface	0.3 acres
Northeastern Modified Successional Forest	0.1 acres

Table 6.20. Water has migrated into X since 1954	
X	**Acreage**
Pickerelweed Tidal Marsh	14 acres
Reed Tidal Marsh	5 acres
Cattail Brackish Tidal Marsh	4 acres
Water	4 acres
Northeastern Modified Successional Forest	1 acre
Other communities/land covers	2 acres

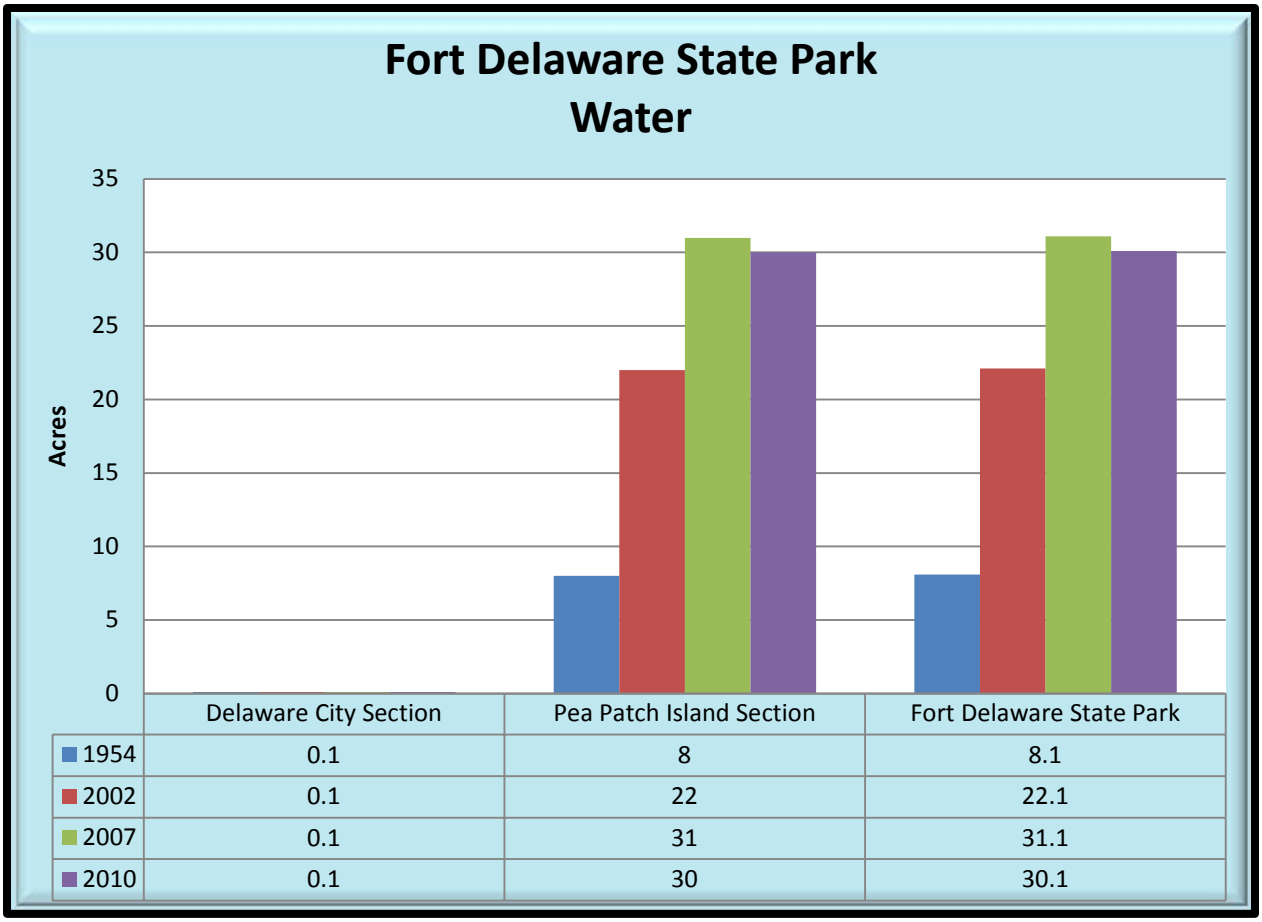


Figure 6.8. Water at Fort Delaware State Park (1954, 2002, 2007, and 2010)

Natural Capital (Table 6.21)

The capital of water has greatly increased since 1954 with its acreage. This trend is expected to continue in the face of sea level rise.

Table 6.21. Natural Capital of Water	
Year	**Natural Capital (in 2012 dollars)**
1954	$116,096/year
2002	$316,756/year
2007	$445,752/year
2010	$431,419/year

APPENDIX I: STATE RARE VEGETATION RANKING CRITERIA

Ranks are based on a system developed by The Nature Conservancy and Natureserve to measure the relative rarity of vegetation communities within a given state. State rarity ranks are used to prioritize conservation and protection efforts so that the rarest of vegetation communities receive immediate attention. The primary criteria for ranking vegetation communities are the total number of documented occurrences with consideration given to the total number of occurrences and total amount of acreage in the state. Ranks for vegetation communities are updated annually and are based on current knowledge and mapping being done for the Guide to Delaware Vegetation Communities.

State Rank

S1 Extremely rare (i.e., typically 5 or fewer occurrences statewide), or may be susceptible to extirpation because of other threats to its existence.

S1.1 Only a single occurrence or population of the species is known to occur. (this rank is only applied to plants.)

S2 Very rare, (i.e., typically 6 to 20 occurrences statewide), or may be susceptible to extirpation because other threats to its existence.

S3 Rare to uncommon, not yet susceptible to extirpation but may be if additional populations are destroyed. Approximately 21 to 100 occurrences statewide.

S4 Common, apparently secure in the state under present conditions.

S5 Very common, secure in the state under present conditions.

SH Historically known, but not verified for an extended period (usually 15+ years); there are expectations that the species may be rediscovered.

SX Extirpated or presumed extirpated from the state. All historical locations and/or potential habitat have been surveyed.

SU Status uncertain within the state. Usually an uncommon species which is believed to be of conservation concern, but there is inadequate data to determine the degree of rarity.

SNR Unranked

SNA Not Applicable

SW Weedy vegetation or vegetation dominated by invasive alien species (this rank is only applied to natural communities).

SM Vegetation resulting from management or modification of natural vegetation. It is readily restorable by management or time and/or the restoration of original ecological processes (this rank is only applied to natural communities).

APPENDIX II: SGCN SPECIES EXPECTED FOR KEY WILDLIFE HABITATS

SGCN Species expected in Coastal Plain Upland Forest			
Species	**Common Name**	**Class**	**Tier**
Cicindela patruela consentanea	Northern barrens tiger beetle	Insect	1
Callophrys irus	frosted elfin	Insect	1
Catocala antinympha	sweetfern underwing	Insect	1
Catocala lacrymosa	tearful underwing	Insect	1
Terrapene carolina	Eastern box turtle	Reptile	1
Eumeces laticeps	broadhead skink	Reptile	1
Cemophora coccinea	scarlet snake	Reptile	1
Elaphe guttata	corn snake	Reptile	1
Lampropeltis triangulum	milk snake	Reptile	1
Haliaeetus leucocephalus	Bald eagle	Bird	1
Accipiter cooperii	Cooper's Hawk	Bird	1
Buteo platypterus	broad-winged hawk	Bird	1
Asio otus	long-eared owl	Bird	1
Melanerpes erythrocephalus	red-headed woodpecker	Bird	1
Certhia americana	brown creeper	Bird	1
Hylocichla mustelina	wood thrush	Bird	1
Wilsonia citrina	hooded warbler	Bird	1
Sciurus niger cinereus	Delmarva fox squirrel	Mammal	1
Discus catskillensis	angular disc	Gastropod	2
Cicindela patruela	Northern barrens tiger beetle	Insect	2
Cicindela unipunctata	one-spotted tiger beetle	Insect	2
Photuris frontalis	a firefly	Insect	2
Erynnis martialis	mottled duskywing	Insect	2
Erynnis baptisiae	wild indigo duskywing	Insect	2
Battus philenor	pipevine swallowtail	Insect	2
Polygonia progone	gray comma	Insect	2
Caripeta aretaria	a geometer moth	Insect	2
Tolype notialis	a lasiocampid moth	Insect	2
Hemileuca maia maia	the buckmoth	Insect	2
Cisthene kentuckiensis	Kentucky lichen moth	Insect	2
Cisthene tenuifascia	a lichen moth	Insect	2
Grammia phyllira	phyllira tiger moth	Insect	2
Zale metata	a noctuid moth	Insect	2
Catocala flebilis	mournful underwing	Insect	2
Catocala residua	residua underwing	Insect	2
Catocala cerogama	Yellow banded underwing	Insect	2
Acronicta exilis	Exiled dagger moth	Insect	2
Acronicta lithospila	Streaked dagger moth	Insect	2
Papaipema araliae	Aralia shoot borer moth	Insect	2
Papaipema baptisiae	Wild indigo borer moth	Insect	2

Lepipolys perscripta	A noctuid moth	Insect	2
Scincella lateralis	Ground skink	Reptile	2
Heterodon platirhinos	Eastern hognose snake	Reptile	2
Lampropeltis getula	Common kingsnake	Reptile	2
Storeria occipitomaculata	Redbelly snake	Reptile	2
Virginia valeriae	Smooth earth snake	Reptile	2
Agkistrodon contortix	Copperhead	Reptile	2
Coragyps atratus	Black vulture	Bird	2
Strix varia	Barred owl	Bird	2
Caprimulgus vociferus	whip-poor-will	Bird	2
Colaptes auratus	Northern flicker	Bird	2
Myiarchus crinitus	Great crested flycatcher	Bird	2
Sitta pusilla	Brown-headed nuthatch	Bird	2
Vireo flavifrons	Yellow-throated vireo	Bird	2
Dendroica dominca	Yellow-throated warbler	Bird	2
Mniotilta varia	Black-and-white warbler	Bird	2
Seiurus motacilla	Louisiana waterthrush	Bird	2
Oporornis formosus	Kentucky warbler	Bird	2
Piranga olivacea	Scarlet tanager	Bird	2
Piplio erythrophthalmus	Eastern towhee	Bird	2
Icterus galbula	Baltimora oriole	Bird	2
Lasionycteris noctivagans	Silver-haired bat	Mammal	2
Lasiurus borealis	Eastern red bat	Mammal	2
Lasiurus cinereus	Hoary bat	Mammal	2
Canis latrans	coyote	Mammal	2

SGCN Species expected in Early Successional Upland Habitats			
Species	**Common Name**	**Class**	**Tier**
Nicrophorus americanus	American burying beetle	Insect	1
Callophrys irus	frosted elfin	Insect	1
Papaipema maritima	maritime sunflower borer moth	Insect	1
Terrapene carolina	Eastern box turtle	Reptile	1
Lampropeltis triangulum	milk snake	Reptile	1
Branta canadensis	Canada goose (migratory)	Bird	1
Circus cyaneus	Northern harrier	Bird	1
Bartramia longicauda	upland sandpiper	Bird	1
Scolopax minor	American woodcock	Bird	1
Asio flammeus	short-eared Owl	Bird	1
Chordeiles minor	common nighthawk	Bird	1
Lanius ludovicianus	loggerhead shrike	Bird	1
Dendroica discolor	prairie warbler	Bird	1
Ammodramus henslowii	Henslow's sparrow	Bird	1
Cincindela scutellaris	festive tiger beetle	Insect	2
Atrytonopsis hianna	dusted skipper	Insect	2

Satyrium liparops	striped hairstreak	Insect	2
Satyrium liparops strigosum	stiped hairstreak	Insect	2
Callophrys gryneus	juniper hairstreak	Insect	2
Speyeria aphrodite	aphrodite fritillary	Insect	2
Speyeria idalia	regal fritillary	Insect	2
Boloria bellona	meadow fritillary	Insect	2
Paratrea plebeja	trumpet vine sphinx	Insect	2
Calyptra canadensis	Canadian owlet	Insect	2
Acronicta rubricoma	a dagger moth	Insect	2
Papaipema rigida	rigid sunflower borer moth	Insect	2
Cirrhophanus triangulifer	a noctuid moth	Insect	2
Schina septentrionalis	a noctuid moth	Insect	2
Plegadis falcinellus	glossy ibis	Bird	2
Cygnus columbianus	tundra swan	Bird	2
Coragyps atratus	black vulture	Bird	2
Colinus virginianus	Northern bobwhite	Bird	2
Pluvialis squatarola	black-bellied plover	Bird	2
Coccyzus erythropthalmus	black-billed cuckoo	Bird	2
Chaetura pelagica	chimney swift	Bird	2
Colaptes auratus	Northern flicker	Bird	2
Empidonax minimus	least flycatcher	Bird	2
Tyrannus tyrannus	Eastern kingbird	Bird	2
Toxostoma rufum	Brown thrasher	Bird	2
Dendroica pensylvanica	Chestnut-sided warbler	Bird	2
Icteria virens	Yellow-breasted chat	Bird	2
Piplio erythrophthalmus	Eastern towhee	Bird	2
Spizella pusilla	field sparrow	Bird	2
Pooecetes gramineus	vesper sparrow	Bird	2
Passerculus sandwichensis	savannah sparrow	Bird	2
Ammodramus savannarum	grasshopper sparrow	Bird	2
Dolichonyx oryzivorus	bobolink	Bird	2
Cryptotis parva	least shrew	Bird	2

SGCN Species expected in Freshwater Tidal Marshes			
Paones massasoit chermockii	Chermock's Mulberry Wine	Insect	1
Nannothemis bella	Elfin Skimmer	Insect	1
Clemmys guttata	Spotted Turtle	Reptile	1
Podilymbus podiceps	Pied-billed grebe	Bird	1
Nycticorax nycticorax	Black-crowned night heron	Bird	1
Nyctanassa violacea	Yellow-crowned night heron	Bird	1
Pandion haliaetus	osprey	Bird	1
Lycaena hyllus	Bronze copper	Insect	2

Papaipema birdii	Umbellifer borer moth	Insect	2
Libellula axilena	Bar-winged skimmer	Insect	2
Argia bipunctulata	Seepage dancer	Insect	2
Nehalennia gracilis	Sphagnum sprite	Insect	2
Botaurus lentiginosus	American bittern	Bird	2
Ixobrychus exilis	Least Bittern	Bird	2
Ardea herodias	Great blue heron	Bird	2
Casmeridius albus	Great egret	Bird	2
Egretta thula	Snowy egret	Bird	2
Egretta caerulea	Little blue heron	Bird	2
Egretta tricolor	Tricolored heron	Bird	2
Bubulcus ibis	Cattle egret	Bird	2
Anas platyrhynchos	mallard	Bird	2
Rallus elegans	King rail	Bird	2
Porzana carolina	sora	Bird	2
Dolichonyx oryzivorus	bobolink	Bird	2

SGCN Species expected in Impoundments			
Species	**Common Name**	**Class**	**Tier**
Podilymbus podiceps	Pied-billed grebe	Bird	1
Branta canadensis	Canada goose (migratory)	Bird	1
Anas rubripes	American black duck	Bird	1
Pandion haliaetus	osprey	Bird	1
Actitus macularia	Spotted sandpiper	Bird	1
Cygnus columbianus	Tundra swan	Bird	2
Anas platyrhynchos	mallard	Bird	2
Anas clypeata	Northern shoveler	Bird	2
Aythya valisneria	canvasback	Bird	2
Aythya marila	Greater scaup	Bird	2
Aythya affinis	Lesser scaup	Bird	2
Bucephala albeola	bufflehead	Bird	2
Lophodytes cucullatus	Hooded merganser	Bird	2
Pluvialis squatarola	Black-bellied plover	Bird	2
Himantopus mexicanus	Black-necked stilt	Bird	2
Catoptrophorus semipalmatus	willet	Bird	2
Calidris pusilla	Semipalmated sandpiper	Bird	2
Calidris alpina	dunlin	Bird	2

SGCN Species expected in Nearshore Habitats			
Species	**Common Name**	**Class**	**Tier**
Callinectes sapidus	Blue crab	Crustaceans	1
Limulus polyphemus	Horseshoe crab	Arachinids	1
Pristis pectinata	Smalltooth sawfish	Fish	1

Acipenser brevirostrum	Shortnose sturgeon	Fish	1
Acipenser oxyrinchus	Atlantic sturgeon	Fish	1
Caretta caretta	Loggerhead sea turtle	Reptile	1
Chelonia mydas	Atlantic green turtle	Reptile	1
Lepidochelys kempii	Kemp's Ridley sea turtle	Reptile	1
Branta canadensis	Canada goose (migratory)	Bird	1
Pandion haliaetus	Osprey	Bird	1
Phocoena phocoena	Harbor porpoise	Mammal	1
Balaenoptera physalus	Fin whale	Mammal	1
Megaptera novaeangliae	Humpback whale	Mammal	1
Balaena glacialis	Northern right whale	Mammal	1
Cetorhinus maximus	Basking shark	Fish	2
Carcharodon carcharias	White shark	Fish	2
Carcharhinus obscurus	Dusky shark	Fish	2
Squatina dumeril	Atlantic angel shark	Fish	2
Alosa mediocris	Hickory shad	Fish	2
Apeltes quadracus	Fourspine stickleback	Fish	2
Eretmochelys imbricata imbricate	Hawksbill	Reptile	2
Pelecanus occidentalis	Brown pelican	Bird	2
Phalacrocorax carbo	great cormorant	Bird	2
Phalacrocorax auritus	Double-crested cormorant	Bird	2
Cygnus columbianus	Tundra swan	Bird	2
Branta bemicla	brant	Bird	2
Aythya valisineria	Canvasback	Bird	2
Aythya americana	Redhead	Bird	2
Aythya marila	Greater scaup	Bird	2
Aythya affinis	Lesser scaup	Bird	2
Clangula hyemalis	Oldsquaw	Bird	2
Melanitta nigra	Black scoter	Bird	2
Melanitta perspicillata	Surf scoter	Bird	2
Melanitta fusca	White-winged scoter	Bird	2
Bucephala albeola	bufflehead	Bird	2

SGCN Species expected in Tidal High Marsh Habitats			
Species	**Common Name**	**Class**	**Tier**
Problema bulenta	rare skipper	Insect	1
Pero zalissaria	a geometer moth	Insect	2
Acontia delecta	a noctuid moth	Insect	2
Papaipema birdi	umbellifer borer moth	Insect	2
Brachymesia gravida	four-spotted pennant	Insect	2
Nycticorax nycticorax	black-crowned night-heron	Bird	1
Nyctanassa violacea	yellow-crowned night-heron	Bird	1
Anas rubripes	American black duck	Bird	1
Circus cyaneus	northern harrier	Bird	1

Laterallus jamaicensis	black rail	Bird	1
Asio flammeus	short-eared owl	Bird	1
Cistothorus platensis	sedge wren	Bird	1
Ammodramus caudacutus	saltmarsh sharp-tailed sparrow	Bird	1
Ammodramus maritimus	seaside sparrow	Bird	1
Botaurus lentiginosus	American bittern	Bird	2
Ixobrychus exilis	least bittern	Bird	2
Ardea herodias	great blue heron	Bird	2
Casmerodius albus	great egret	Bird	2
Egretta thula	snowy egret	Bird	2
Egretta caerulea	little blue heron	Bird	2
Egretta tricolor	tricolored heron	Bird	2
Bubulcus ibis	Cattle egret	Bird	2
Porzana carolina	sora	Bird	2
Fulica americana	American coot	Bird	2
Tyto alba	barn owl	Bird	2
Cistothorus palustris	marsh wren	Bird	2

SGCN Species expected in Tidal Low Marsh Habitats			
Species	**Common Name**	**Class**	**Tier**
Problema bulenta	rare skipper	Insect	1
Malaclemys terrapin terrapin	Northern diamondback terrapin	Reptile	1
Podilymbus podiceps	Pied-billed grebe	Bird	1
Nycticorax nycticorax	Black-crowned night-heron	Bird	1
Branta canadensis	Canada goose (migratory)	Bird	1
Anas rubripes	American black duck	Bird	1
Nyctanassa violacea	yellow-crowned night-heron	Bird	1
Circus cyaneus	northern harrier	Bird	1
Arenaria interpres	Ruddy turnstone	Bird	1
Asio flammeus	short-eared owl	Bird	1
Calidris canutus	Red knot	Bird	1
Sterna hirundo	Common tern	Bird	1
Sterna forsteri	Forster's tern	Bird	1
Rhnchops niger	Black skimmer	Bird	1
Ammodramus caudacutus	Saltmarsh sharp-tailed sparrow	Bird	1
Ammodramus maritimus	Seaside sparrow	Bird	1
Cicindela marginata	Margined tiger beetle	Insect	2
Pero zalissaria	A geometer moth	Insect	2
Acontia delecta	A noctuid moth	Insect	2
Brachymesia gravida	Four-spotted pennant	Insect	2
Pelecanus occidentalis	Brown pelican	Bird	2
Phalacrocorax carbo	Great cormorant	Bird	2

Phalacrocorax auritus	Double-crested cormorant	Bird	2
Ardea herodias	Great blue heron	Bird	2
Casmerodius albus	Great egret	Bird	2
Egretta thula	Snowy egret	Bird	2
Egretta caerulea	Little blue heron	Bird	2
Egretta tricolor	Tricolored heron	Bird	2
Bubulcus ibis	Cattle egret	Bird	2
Plegadis falcinellus	Glossy ibis	Bird	2
Anas platyrhynchos	mallard	Bird	2
Falco peregrinus	Peregrine falcon	Bird	2
Rallus elegans	King rail	Bird	2
Fulica americana	American coot	Bird	2
Pluvialis squatarola	Black-bellied plover	Bird	2
Himantopus mexicanus	Black-necked stilt	Bird	2
Catoptrophorus semipalmatus	Willet	Bird	2
Calidris pusilla	Semipalmated sandpiper	Bird	2
Calidris alpina	dunlin	Bird	2
Sterna nilotica	Gull-billed tern	Bird	2
Tyto alba	Barn owl	Bird	2
Cistothorus palustris	Marsh wren	Bird	2