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

Stony Creek and Upper Delaware River Watersheds

Submitted to:

Delaware State Parks
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CHAPTER 1: INTRODUCTION AND METHODS

Setting of Fox Point State Park

Fox Point State Park is located in northeastern New Castle County, Delaware (Figure 1.1), and is composed of one linear tract totaling 108 acres straddling the Delaware River.

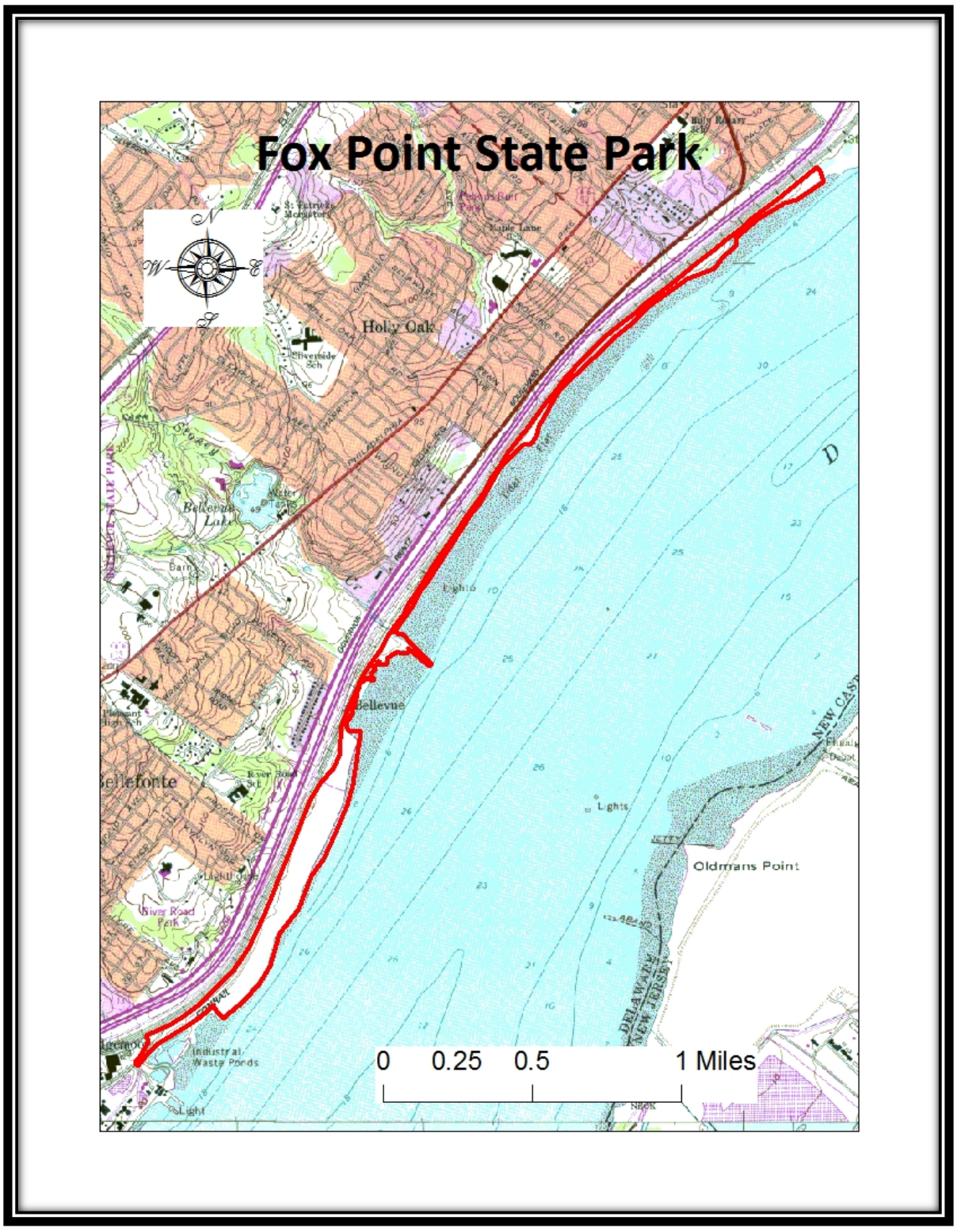

Figure 1.1. Location of Fox Point State Park

History and Formation of Fox Point State Park[1]

Early History of the Land

The land that is now Fox Point State Park was created original as fill for the Pennsylvania Railroad. The efforts of S. Marston Fox resulted in the filling being stopped and the land being turned over to the state.

Formation of Fox Point State Park

The land that is now Fox Point State Park was turned over to the public in the 1970s and to the state in 1990. A lot of remediation has occurred since 1990 to make this area a park.

[1] Delaware State Parks website—Fox Point State Park.

Soils and Geology of Fox Point State Park

Underlying Geology[2]

Fox Point State Park is underlaid by a small amount of Delaware Bay Group (undifferentiated) and mostly by fill. The Delaware Bay Group dates from the Upper Pleistocene and is described as "grayish brown silt overlying a fine to medium silty quartz sand".

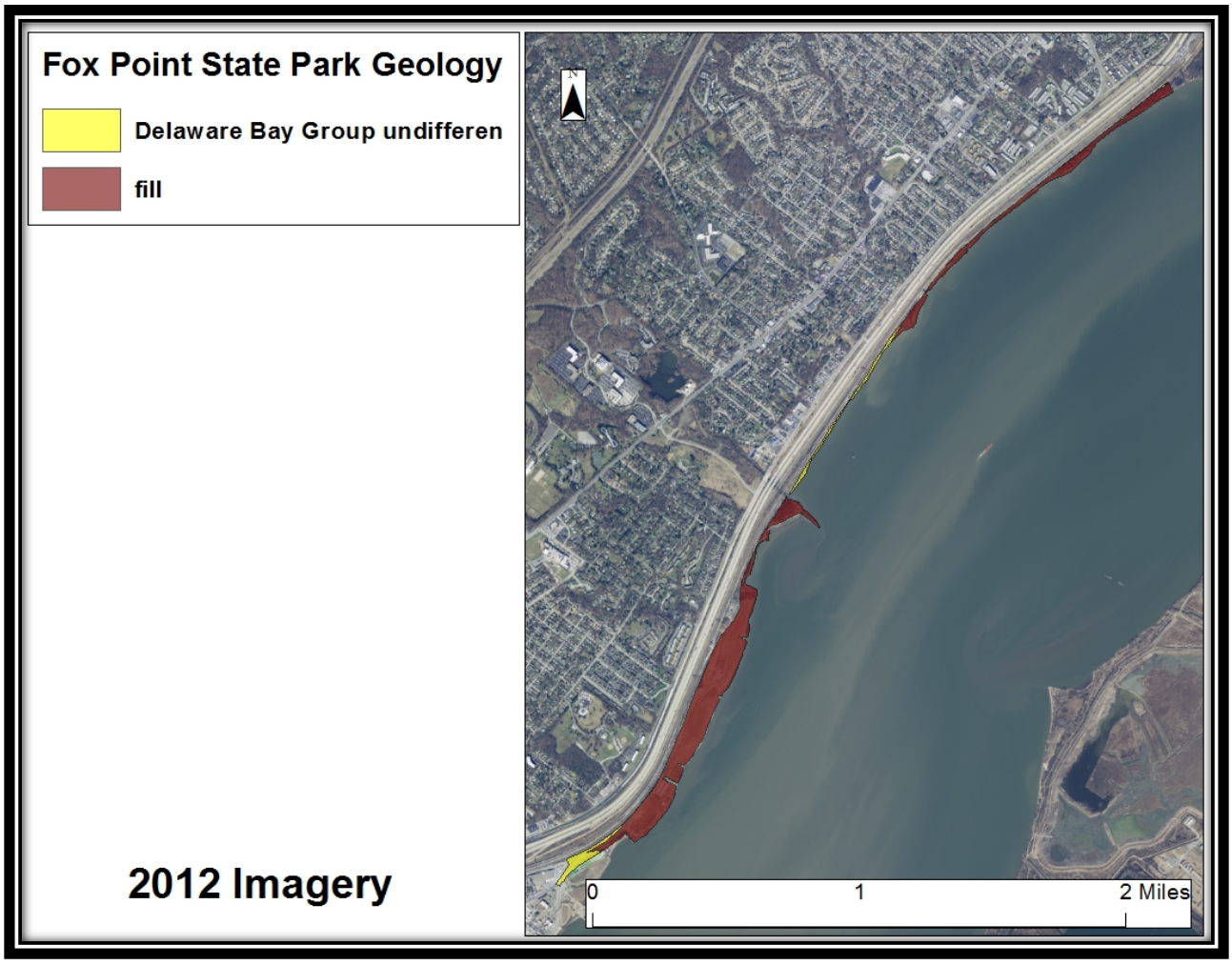

Figure 1.2. Fox Point State Park Geology

[2] Ramsey, Kelvin W. 2005. Geologic Map of New Castle County, Delaware. Delaware Geological Survey, Geologic Map Series No. 13.

Fox Point State Park Soils

Urban land-Othello Complex (72 acres) is the primary soil at Fox Point State Park. The only other soil is Urban Land (21 acres).

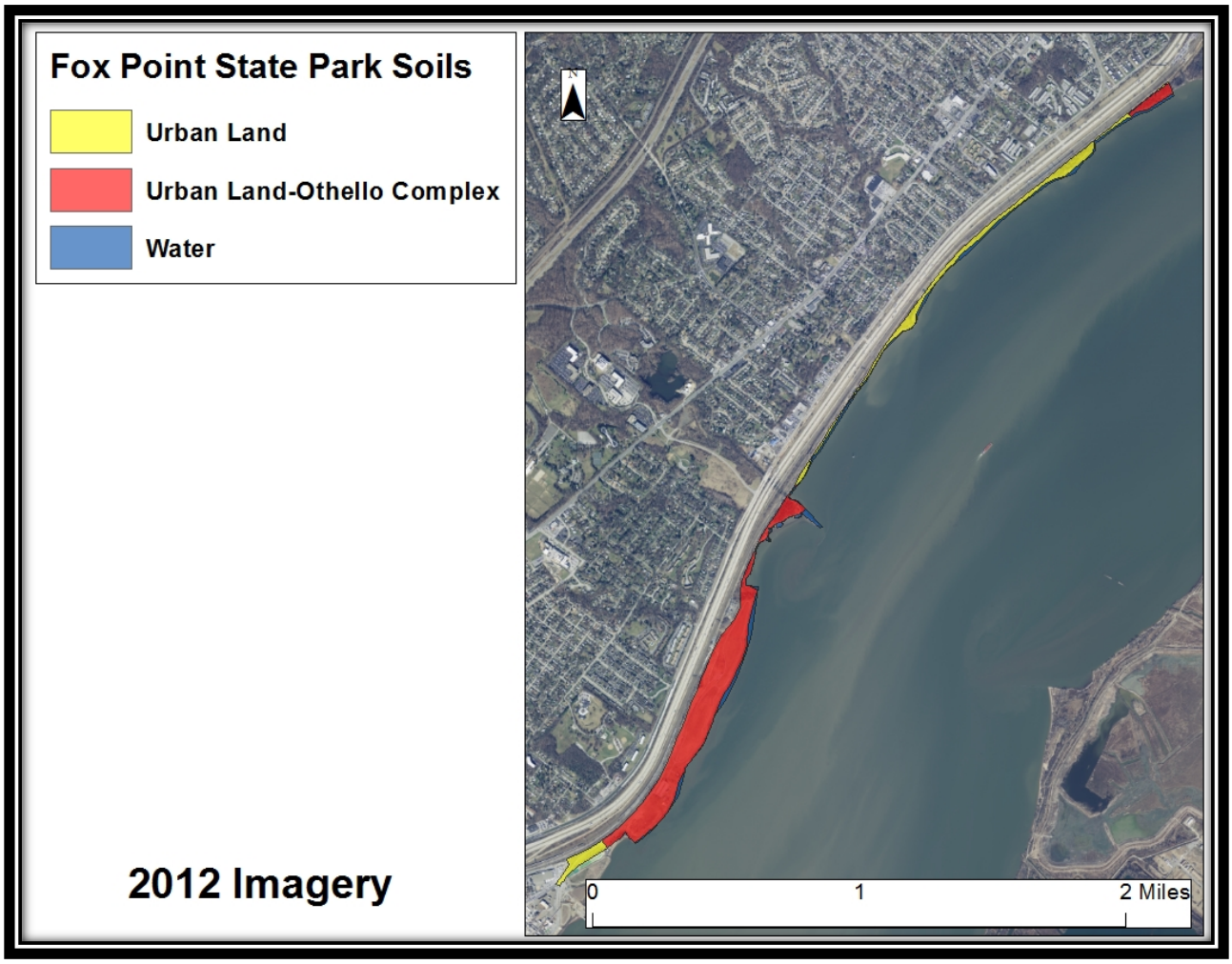

Figure 1.3. Fox Point State Park Soils

Fox Point State Park Elevation

The elevation of Fox Point State Park ranges from sea level on the Delaware River to 20 near the south end.

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 Fox Point 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).[3] 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[4]. 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.[5] 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.[6] 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 [7,8,9]. The rising rate of rise may factor into the difference

3 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).
4 Data from Permanent Service for Mean Sea Level website (www.psmsl.org)
5 NASA Global Climate Change Website (http://climate.nasa.gov/keyindicators) December 12, 2010 update.
6 Custer, Jay F. 1989. Prehistoric cultures of the Delmarva Peninsula: archaeological study. (Cranbury, NJ: Associated University Presses, Inc.), 447 pp.
7 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[10], 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 [11], 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[12]. 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.[13] 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. [14] 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[15]. Added to this is newer research that shows groundwater depletion is adding 0.8 mm/year to sea level rise[16]. 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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8 Whitehead, D.R. 1972. Developmental and environmental history of the Dismal Swamp. Ecological Monographs 42:301-15 in Custer (1989).
9 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).
10 Johnson, Zoe Pfahl. 2000. A Sea Level Rise Response Strategy for the State of Maryland. Maryland Department of Natural Resources.
11 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.
12 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.
13 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.
14 Larsen, C.E. and I. Clark. 2006. A search for scale in sea-level studies. Journal of Coastal Research 22(4): 788-800.
15 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.
16 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[17]. 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[18]. 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[19], 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[20]. 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[21].

Isostatic Rise

Geological land subsidence adds the most to the rise currently accounting for about 1.6 mm/year[22] in the Mid-Atlantic region. Another study has given an amount ranging from 1.02 to 1.53 mm/year[23]. 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%[24].

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)

17 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.
18 Ditto
19 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.
20 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.
21 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.
22 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.
23 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.
24 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[25]. 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[26]. Other papers have also used historical aerial imagery to map vegetation change[27,28] and salinity factors can impact on those changes[29].

More recent studies looking at both changes in tidal marshes[30] and coastal forests[31] 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[32]. 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[33]. 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[34] 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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25 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.
26 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.
27 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.
28 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.
29 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.
30 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.
31 Williams, Kimberlyn, et al. 1999. Sea-level rise and coastal forest retreat on the west coast of Florida, USA Ecology
32 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.
33 Shirley, Laura and Lorretta L. Battaglia. 2006. Assessing vegetation change in coastal landscapes of the northern Gulf of Mexico. Wetlands 26(4): 1057-1070.
34 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 Fox Point State Park based on 1954, 2002, 2007, and 2012 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 2007 and 2013 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 2012 aerial imagery. Vegetation communities are named according to the *Guide to Delaware Vegetation Communities* [35] 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 Fox Point State Park from 1954 and 2002, 2007 and current imagery from 2012 were examined. A vegetation community map was produced for each year in order to compare vegetation and land cover change over a 5, 10, 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.

35 Coxe, Robert. 2013. Guide to Delaware Vegetation Communities-Spring 2013 Edition. Unpublished report.

Natural Capital Analysis

The natural capital of each vegetation community was determined using a table in Costanza, et al.[36] 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.

36 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:** Seven vegetation communities and five land covers were found at Fox Point State Park. Northeastern Old Field (35 acres) is the largest vegetation community, followed by Cultivated Lawn with 19 acres. Oligohaline Tidal Water (21 acres) is the largest land cover, followed by Impervious Surface with 10 acres.

2. **Rare Plants:** Five rare plants are known to exist in Fox Point State Park (Table 2.1).

Scientific Name	Common Name	Rank	Last Observed
Bidens bidentoides	Maryland Bur-marigold	S1	1993
Cyperus engelmannii	Engelmann's Umbrella-sedge	S2	2003
Eleocharis erythropoda	Bald Spikerush	S1	1993
Eriocaulon parkeri	Parker's Pipewort	S2	1988
Najas gracillima	Thread-like Naiad	S1	1990

Table 2.1 Rare Plants at Fox Point State Park

3. **Rare Animals:** No rare animals are known from Fox Point 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.

CHAPTER 3: BROAD TRENDS AT FOX POINT STATE PARK

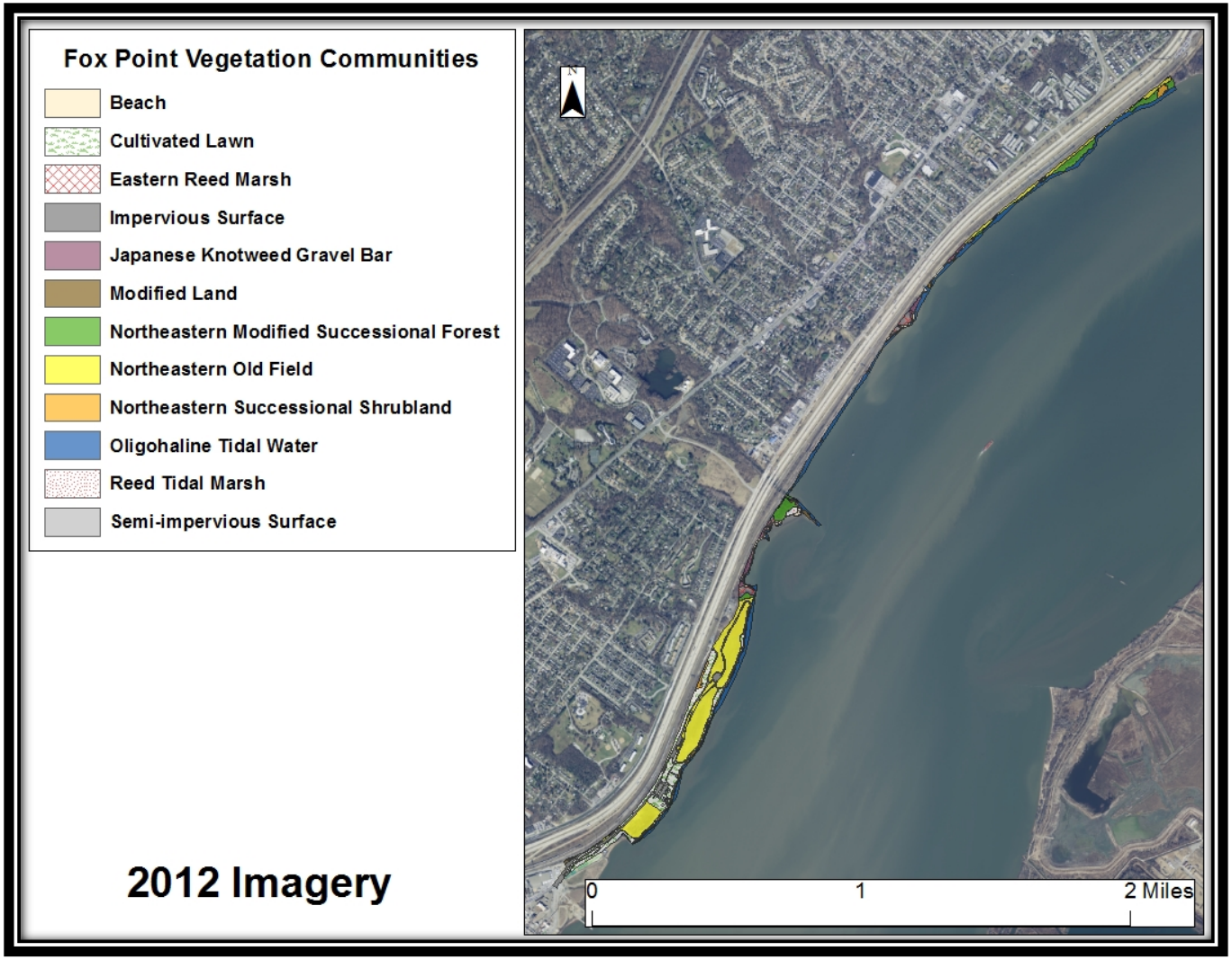


Figure 3.1. 2012 Vegetation Community Map of Fox Point State Park

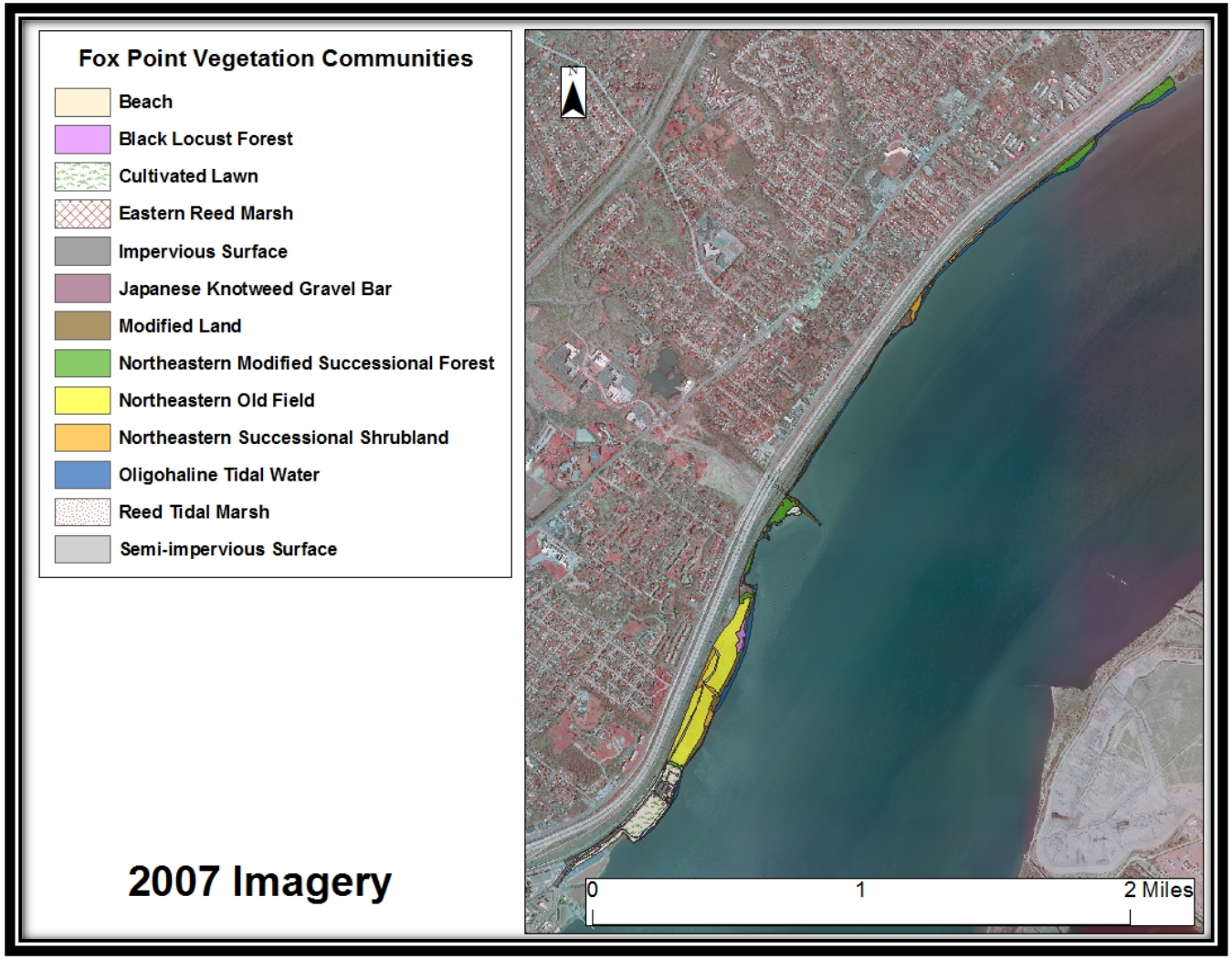


Figure 3.2. 2007 Vegetation Community Map of Fox Point State Park

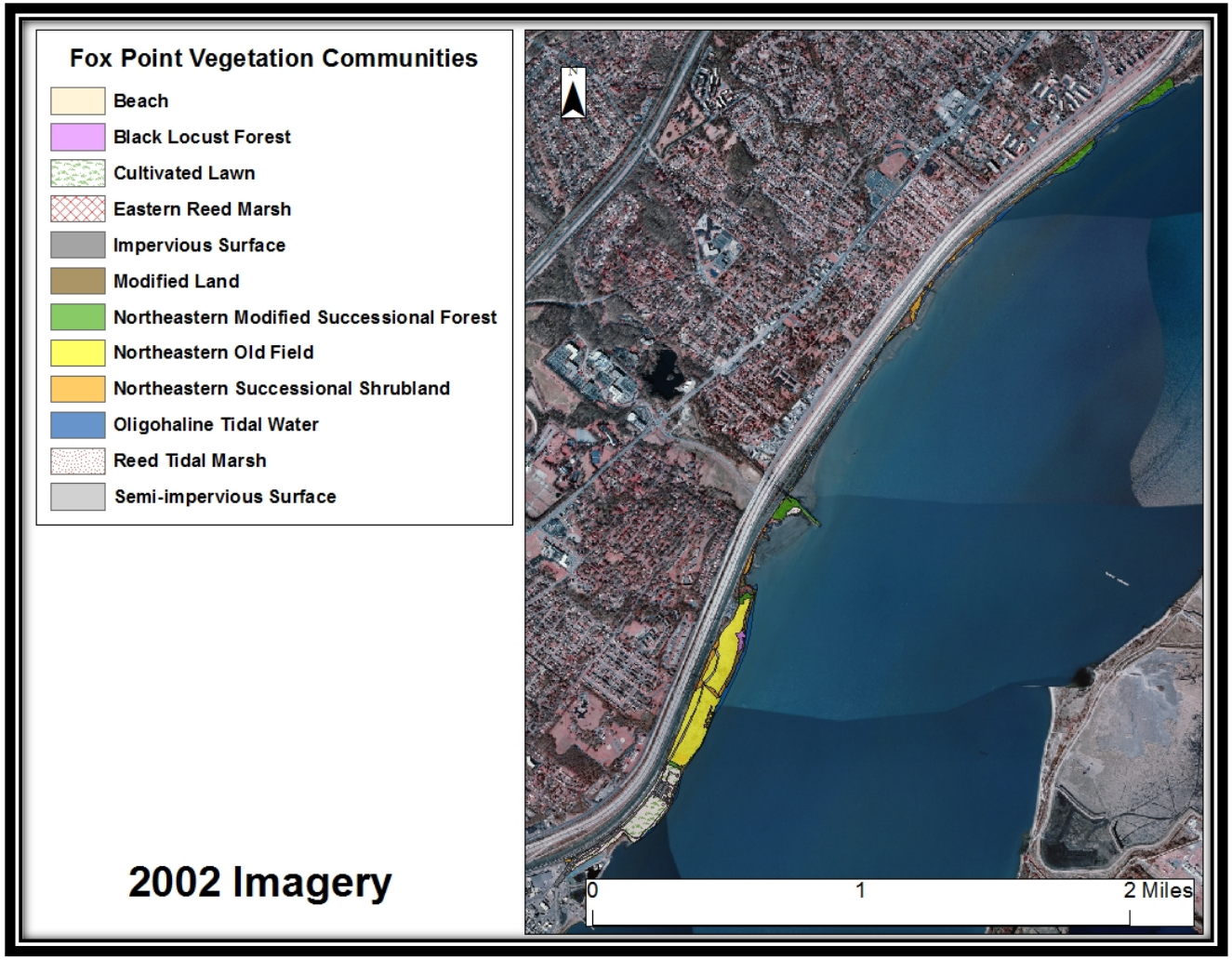


Figure 3.3. 2002 Vegetation Community of Fox Point State Park

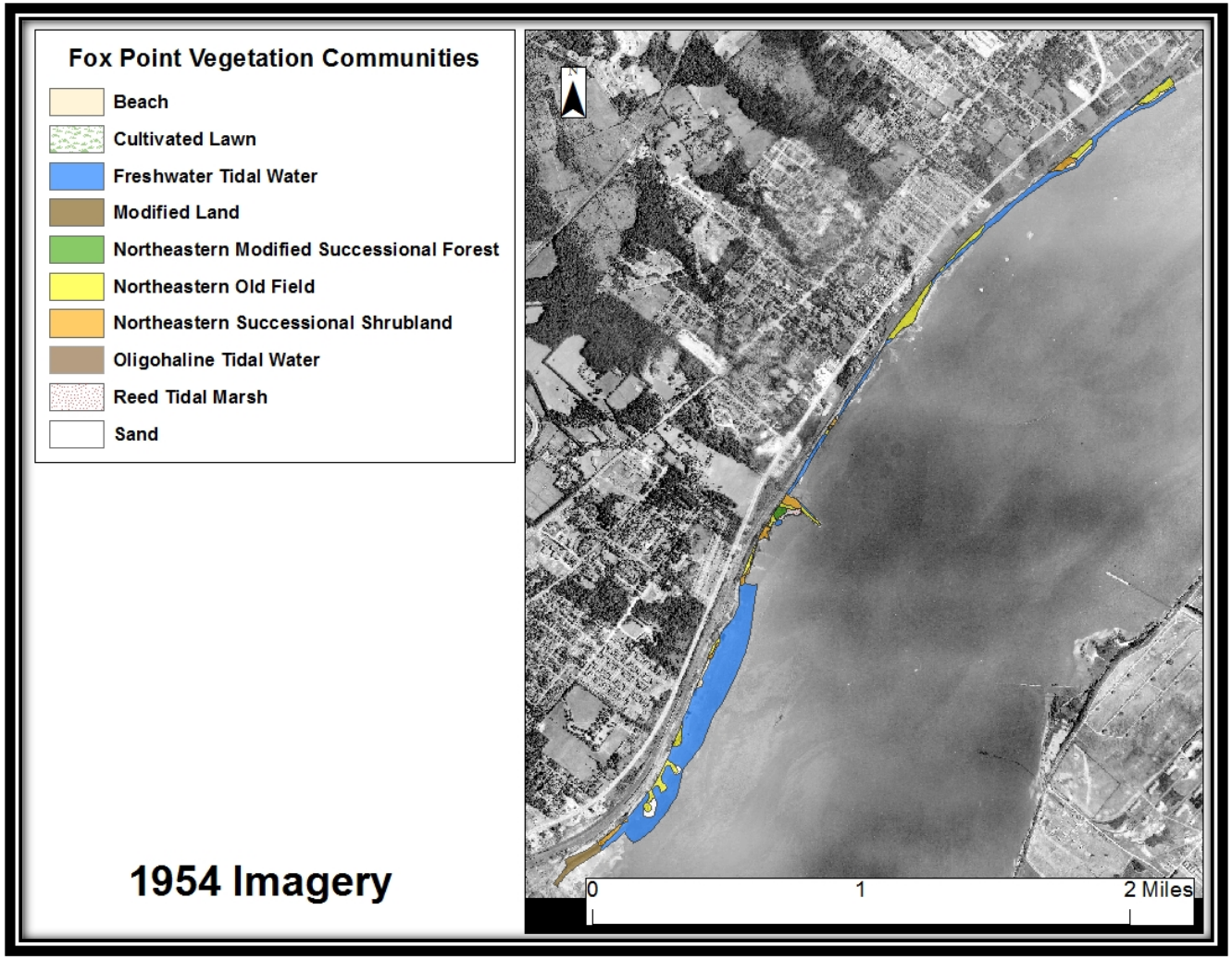
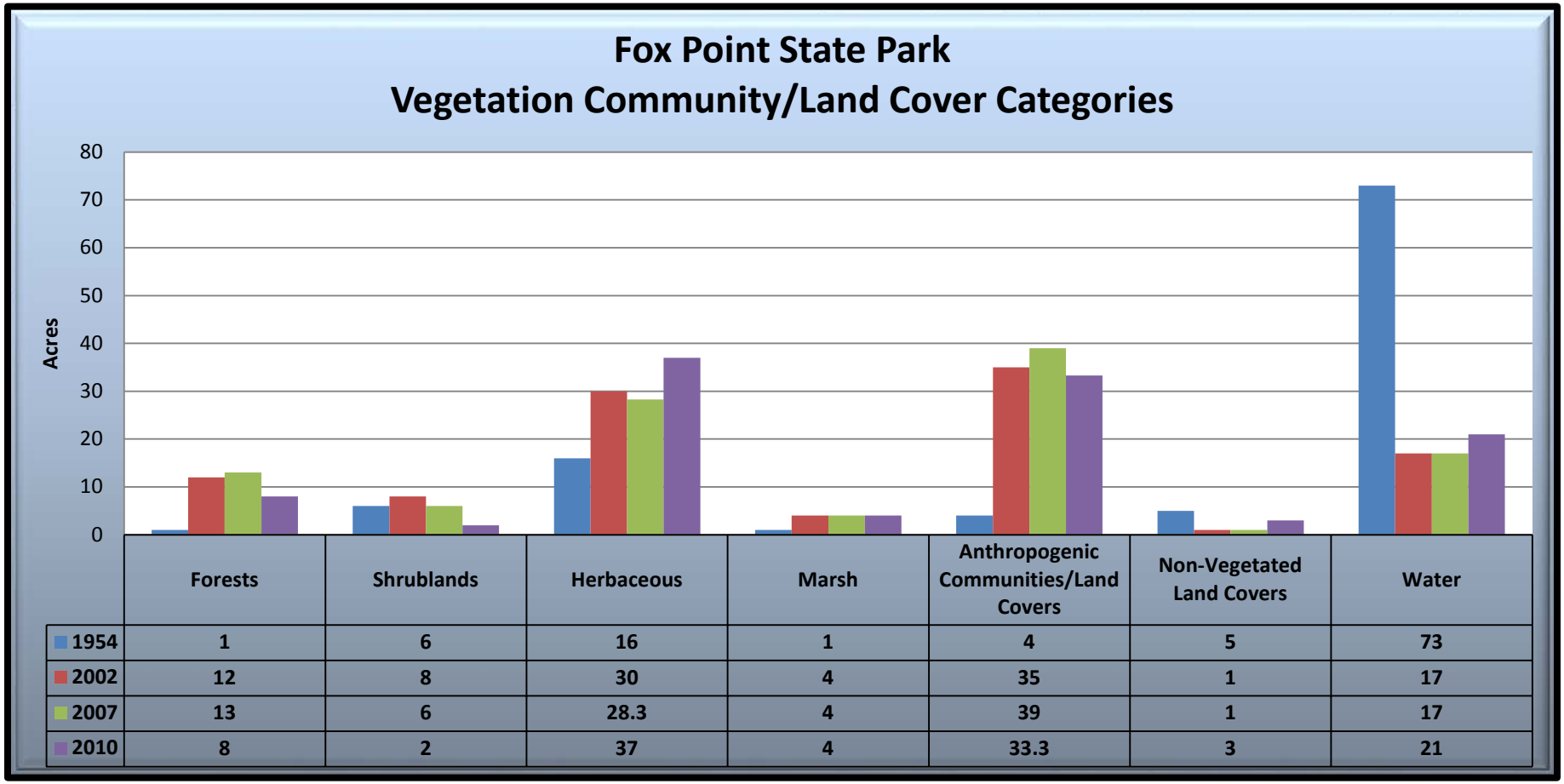


Figure 3.4. 1954 Vegetation Community Map of Fox Point State Park



	Forests	Shrublands	Herbaceous	Marsh	Anthropogenic Communities/Land Covers	Non-Vegetated Land Covers	Water
1954	1	6	16	1	4	5	73
2002	12	8	30	4	35	1	17
2007	13	6	28.3	4	39	1	17
2010	8	2	37	4	33.3	3	21

Figure 3.5. Fox Point State Park Vegetation Categories/Land Covers (1954, 2002, 2007, and 2012)

Fox Point State Park Broad Trends (Figure 3.1): Most of Fox Point State Park is covered in herbaceous communities (Northeastern Old Field) followed by anthropogenic communities/land covers. Forestland on Pea Patch Island is a close third.

DNREC Sea Level Rise Analysis (Table 3.1)

A little less than a third of Fox Point State Park will be inundated with 1.5 m of sea level rise (Table 3.1).

Table 3.1. Projected acres of Fox Point State Park Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	27 acres
1 m	31 acres
1.5 m	35 acres

Natural Capital (Table 3.2)

Natural capital in Fox Point State Park has declined since 1954 due to filling in the river. However, since 2002 the capital has gradually increased (Table 3.1).

Table 3.2. Natural Capital of Fox Point State Park	
Year	**Natural Capital (in 2012 dollars)**
1954	$1,068,066/year
2002	$418,706/year
2007	$421,097/year
2012	$438,828/year

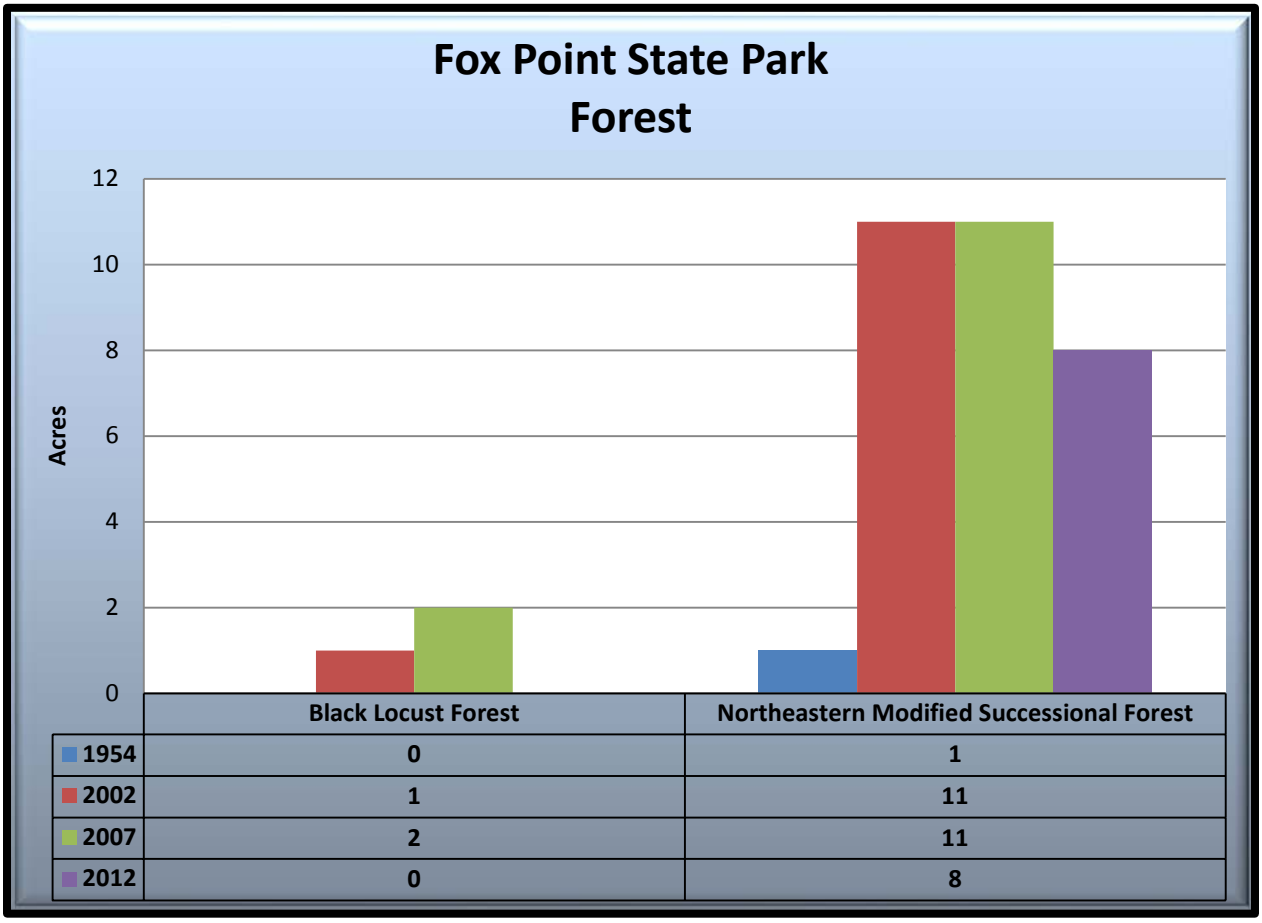


Figure 3.2. Forest at Fox Point State Park (1954, 2002, 2007, and 2012)

Fox Point State Park Forest (Figure 3.2): Northeastern Modified Successional Forest is the only forest community still present in Fox Point State Park. Black Locust Forest was eliminated between 2007 and 2012.

DNREC Sea Level Rise Analysis (Table 3.1)

Less than half of the forestland currently present in Fox Point State Park will be inundated with 1.5 m of sea level rise (Table 3.3).

Table 3.3. Projected acres of Fox Point State Park Forest Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	1 acre
1 m	2 acres
1.5 m	3 acres

Natural Capital (Table 3.4)

Capital of forestland has increased since overall since 1954. Since 2002, though, the capital has decreased due to development in the park (Table 3.4).

Table 3.4. Natural Capital of Fox Point State Park Forest	
Year	**Natural Capital (in 2012 dollars)**
1954	$12,292/year
2002	$135,396/year
2007	$135,585/year
2012	$98,332/year

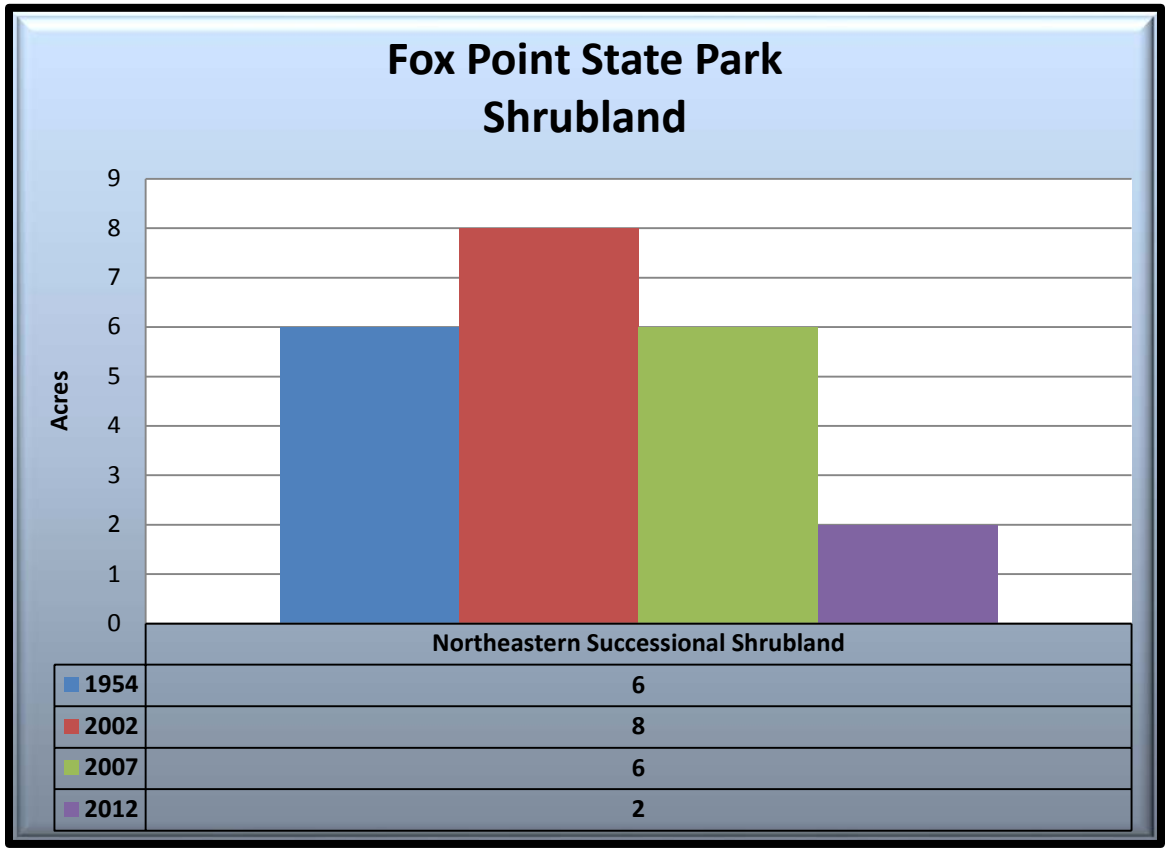


Figure 3.3. Shrubland at Fox Point State Park (1954, 2002, 2007, and 2012)

Fox Point State Park Shrubland (Figure 3.3): Northeastern Successional Shrubland is the only shrubland present in Fox Point State Park.

DNREC Sea Level Rise Analysis (Table 3.5)

About 1/10 of the shrubland in Fox Point State Park will be flooded with 1.5 m of sea level rise.

Table 3.5. Projected acres of Fox Point State Park Shrubland Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	0.1 acres
1 m	0.1 acres
1.5 m	0.2 acres

Natural Capital (Table 3.6)

Capital of shrubland has declined since 1954 and is nearly non-existent (Table 3.3).

Table 3.6. Natural Capital of Fox Point State Park Shrubland	
Year	**Natural Capital (in 2012 dollars)**
1954	$874/year
2002	$1,166/year
2007	$874/year
2012	$291/year

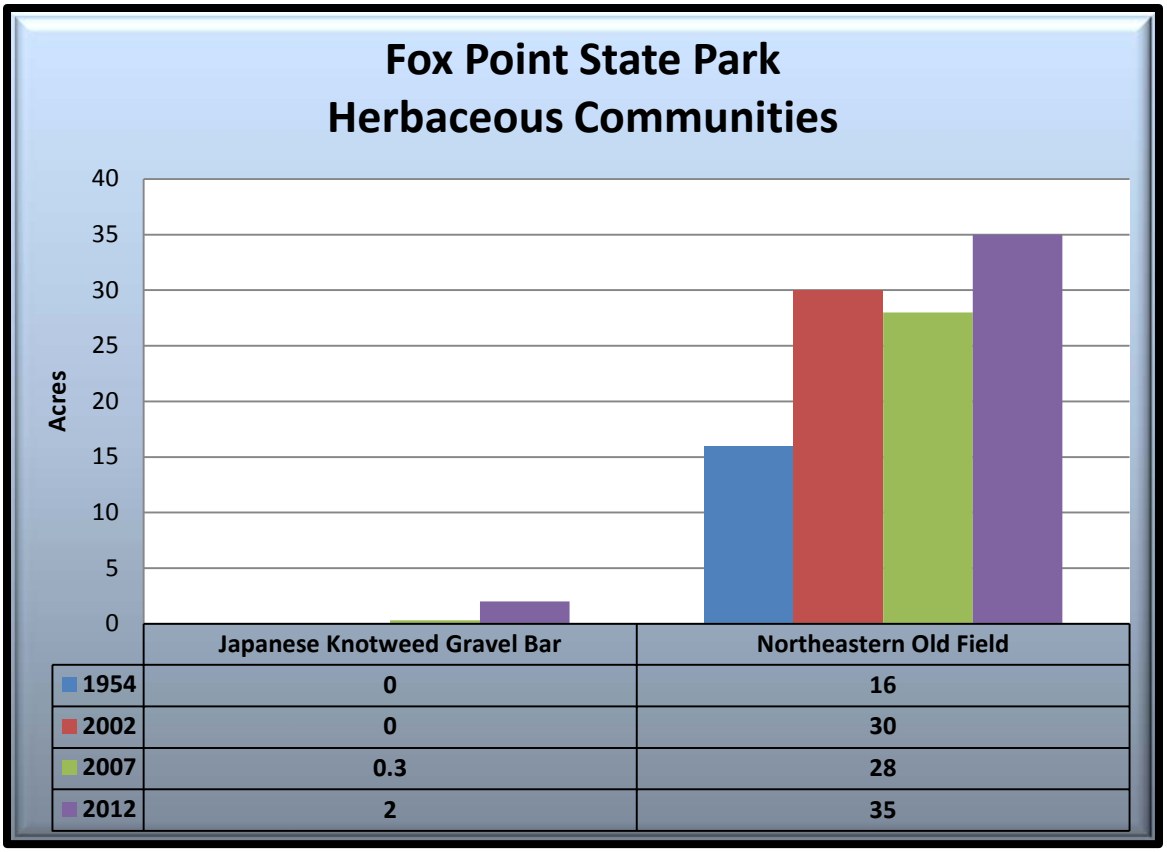


Figure 3.4. Herbaceous Communities at Fox Point State Park (1954, 2002, 2007, and 2012)

Fox Point State Park Herbaceous Communities (Figure 3.4): Northeastern Old Field is the largest herbaceous community at Fox Point State Park. Japanese Knotweed Gravel Bar currently covers a small portion of the park but has been increasing in time.

DNREC Sea Level Rise Analysis (Table 3.7)

Herbaceous communities at Fox Point State Park will be little affected by sea level rise even at the 1.5 m level.

Table 3.7. Projected acres of Fox Point State Park Herbaceous Communities Inundated by Sea Level Rise

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

Natural Capital (Table 3.8)

Capital of herbaceous communities has increased since 1954, but has decreased in the recent period 2007-2012 due to conversion to cultivated lawn (Table 3.4).

Table 3.8. Natural Capital of Fox Point State Park Herbaceous Communities	
Year	**Natural Capital (in 2012 dollars)**
1954	$2,331/year
2002	$4,371/year
2007	$6,864/year
2012	$5,100/year

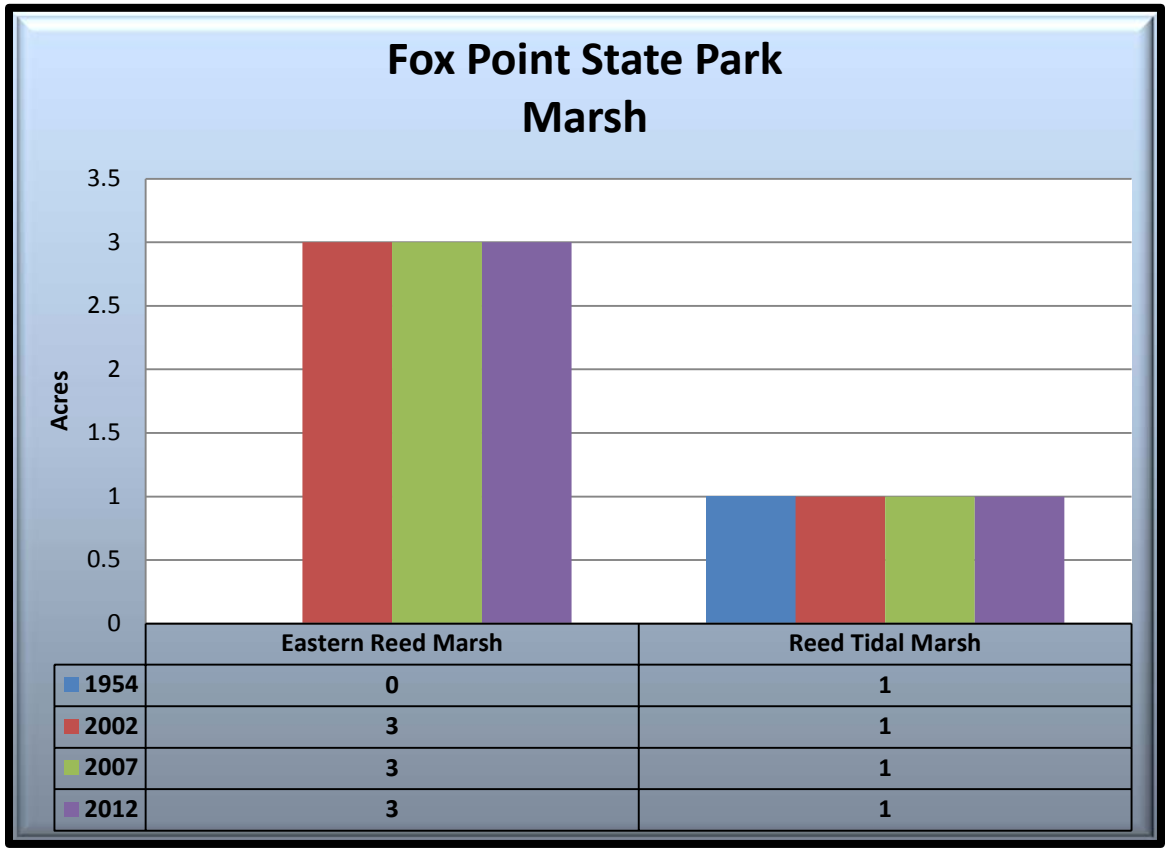


Figure 3.5. Marsh at Fox Point State Park (1954, 2002, 2007, and 2012)

Fox Point State Park Marsh (Figure 3.5): Eastern Reed Marsh is currently the largest marsh type in Fox Point State Park. Reed Tidal Marsh has stayed at about the same amount since 1954.

DNREC Sea Level Rise Analysis (Table 3.9)

Most of the marsh currently present in Fox Point State Park will be eliminated with 1.5 m of sea level rise.

Table 3.9. Projected acres of Fox Point State Park Marsh Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	1 acres
1 m	3 acres
1.5 m	3 acres

Natural Capital (Table 3.10)

Marshland capital has increased greatly since 1954 and remained stable since 2002 (Table 3.5).

Table 3.10. Natural Capital of Fox Point State Park Marsh	
Year	**Natural Capital (in 2012 dollars)**
1954	$6,271/year
2002	$34,116/year
2007	$34,116/year
2012	$34,116/year

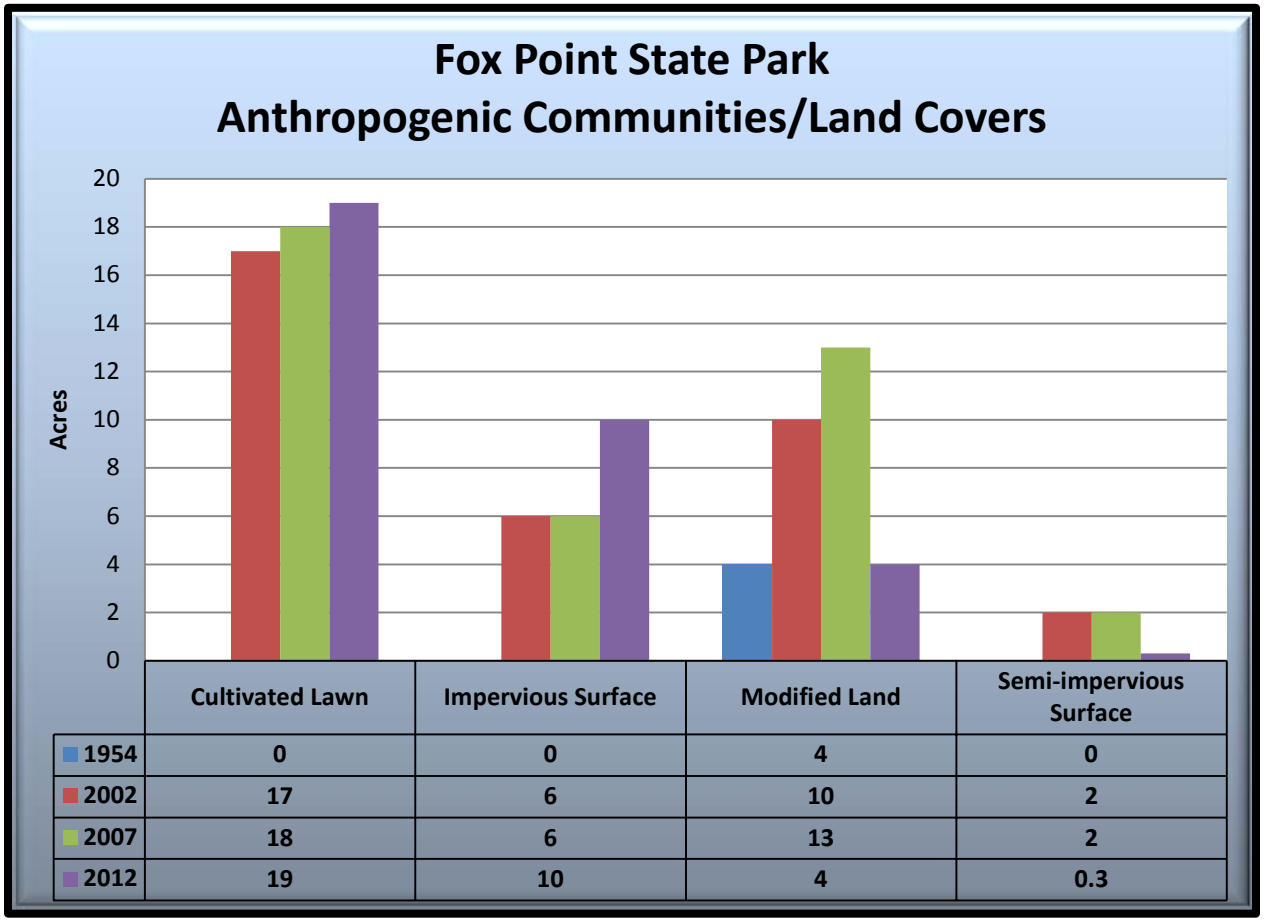


Figure 3.6. Anthropogenic Communities at Fox Point State Park (1954, 2002, 2007, and 2012)

Fox Point State Park Anthropogenic Communities/Land Covers (Figure 3.6): Cultivated lawn is the largest Anthropogenic Community/land cover in Fox Point State Park. Impervious surface has increased markedly in the 2007 to 2012 period due to the development of walking trails in the park.

DNREC Sea Level Rise Analysis (Table 3.11)

Anthropogenic Communities/Land Covers will be little affected with 1.5 m of sea level rise.

Table 3.11. Projected acres of Fox Point State Park Anthropogenic Communities/Land Covers Inundated by Sea Level Rise

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

Natural Capital

None of the anthropogenic communities/land covers in Fox Point State has any natural capital value.

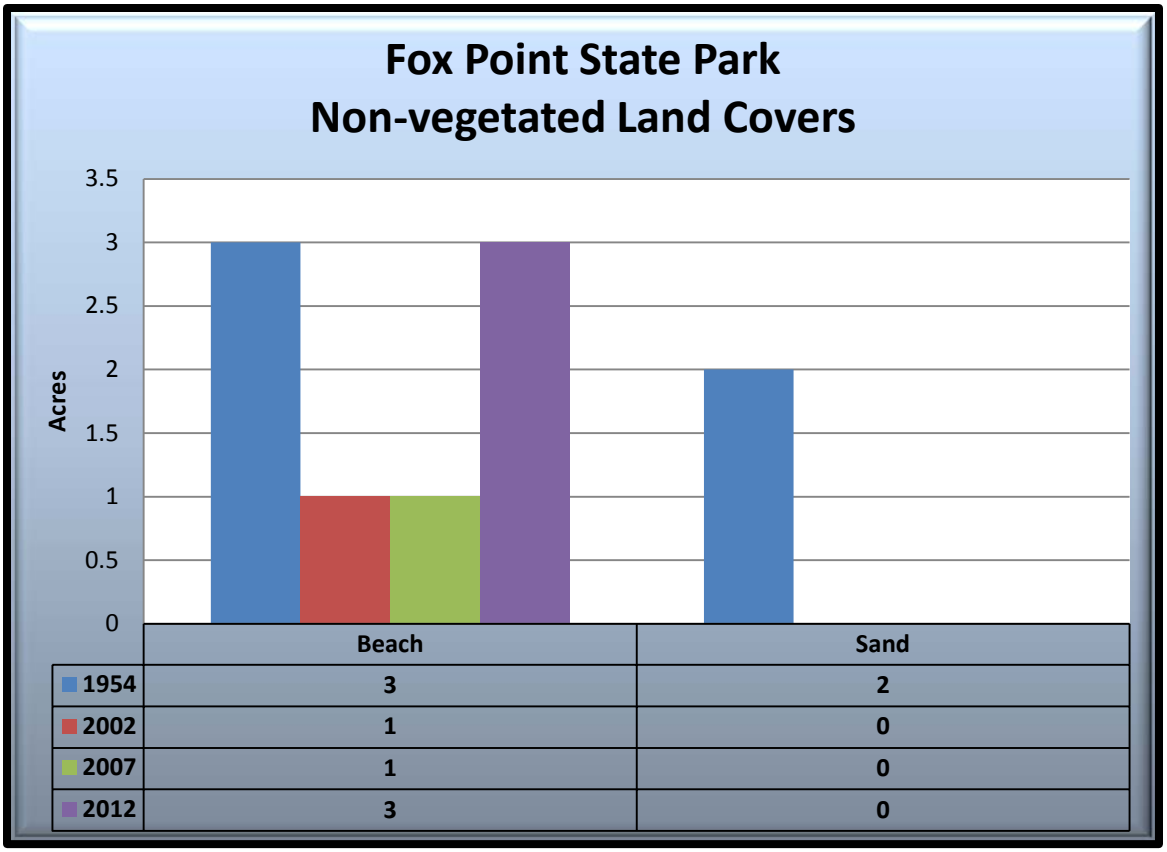


Figure 3.7. Non-vegetated Land Covers at Fox Point State Park (1954, 2002, 2007, and 2012)

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

DNREC Sea Level Rise Analysis (Table 3.12)

Non-vegetated Land Covers (Beach) will be virtually eliminated even with 0.5 m of sea level rise.

Table 3.12. Projected acres of Fox Point State Park Non-vegetated Land Covers Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	2 acres
1 m	2 acres
1.5 m	2 acres

Natural Capital

None of the non-vegetated communities in Fox Point State Park has any natural capital value.

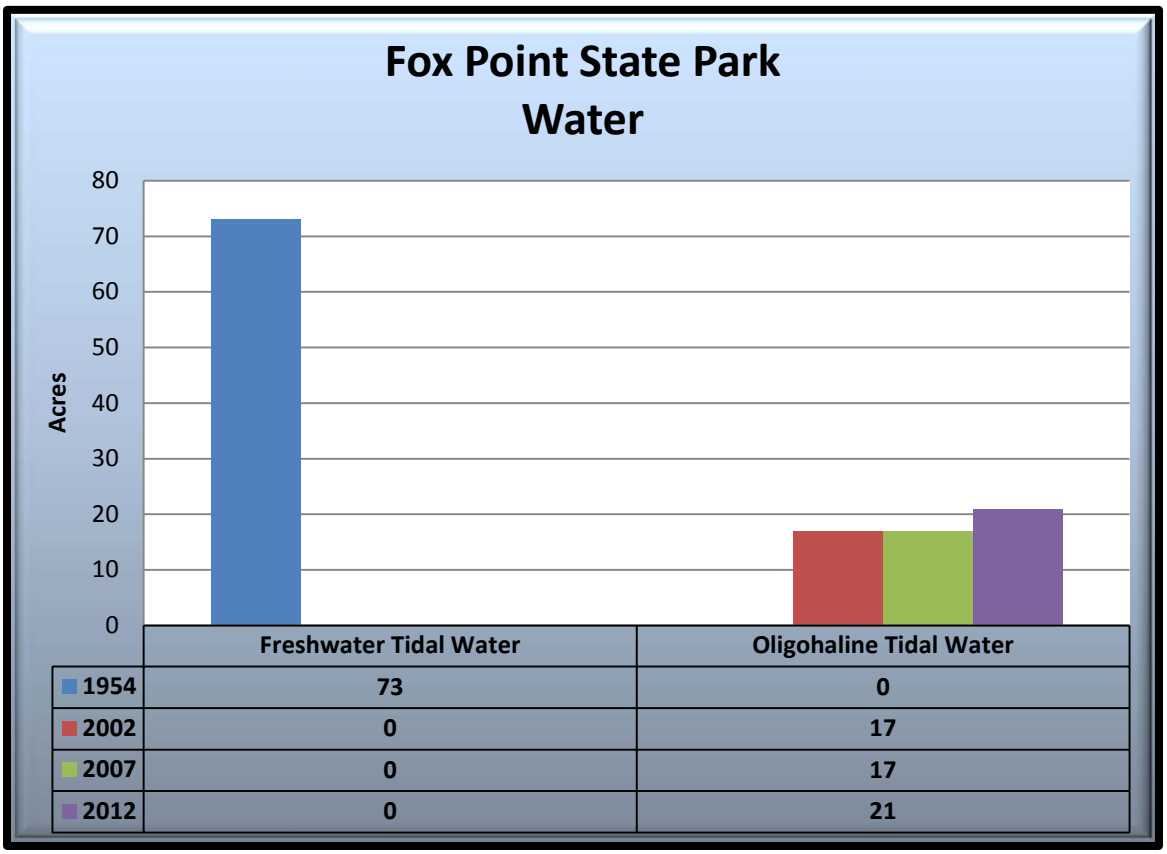


Figure 3.8. Water coverage (non-impoundment) at Fox Point State Park (1954, 2002, 2007, and 2012)

Fox Point State Park Water (Figure 3.8): Freshwater Tidal Water present in 1954 has converted to Oligohaline Tidal Water since 1954. Overall the amount of water within the boundaries of the park has declined greatly due to artificial fill.

Natural Capital (Table 3.13)

Capital of water has decreased since 1954 with the fill. It has, however, increased the 2007-2012 period.

Table 3.13. Natural Capital of Fox Point State Park Water	
Year	**Natural Capital (in 2012 dollars)**
1954	$1,046,298/year
2002	$243,659/year
2007	$243,659/year
2012	$300,990/year

CHAPTER 4: DESCRIPTIONS AND ANALYSIS OF THE VEGETATION COMMUNITIES

Seven vegetation communities and five 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. Cultivated Lawn (CEGL008462)—19 acres
2. Eastern Reed Marsh (CEGL004141)—3 acres
3. Japanese Knotweed Gravel Bar (CEGL008472)—2 acres
4. Northeastern Modified Successional Forest (CEGL006599)—8 acres
5. Northeastern Old Field (CEGL006107)—35 acres
6. Northeastern Successional Shrubland (CEGL006451)—2 acres
7. Reed Tidal Marsh (CEGL004187)—1 acre

Historical Vegetation Communities

1. Successional Black Locust Forest (CEGL007279)—1 acre (2002), 2 acres (2007)

***Cultivated Lawn*[19 acres (Figure 4.1, Tables 4.1-4.2)] GNA SNA**

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

Description

Cultivated lawn is located near the entrance to the park by the bathrooms and the walking trails. Tall fescue (*Festuca arundinacea*), dandelion (*Taraxacum officinale*), crabgrass (*Digitaria* sp.) and other ornamental plants are common species in this area.

Analysis of Condition at Fox Point State Park

Cultivated Lawn was not apparently present in 1954 and has since been planted in the park by converting 13 acres of Freshwater Tidal Water, 3 acres of Northeastern Old Field, 2 acres of Modified Land, 1 acre of Northeastern Successional Shrubland, and 0.5 acres of sand (Table 4.1). This is probably one of the few places in Delaware where you will see water taken by land. Since 2002, amount of lawn has been steadily increasing as the park is developed (Figure 4.1).

Table 4.1. Cultivated Lawn has migrated into X since 1954

X	**Acreage**
Freshwater Tidal Water	13 acres
Northeastern Old Field	3 acres
Modified Land	2 acres
Northeastern Successional Shrubland	1 acre
Sand	0.5 acres
Other vegetation communities/land covers	0.2 acres

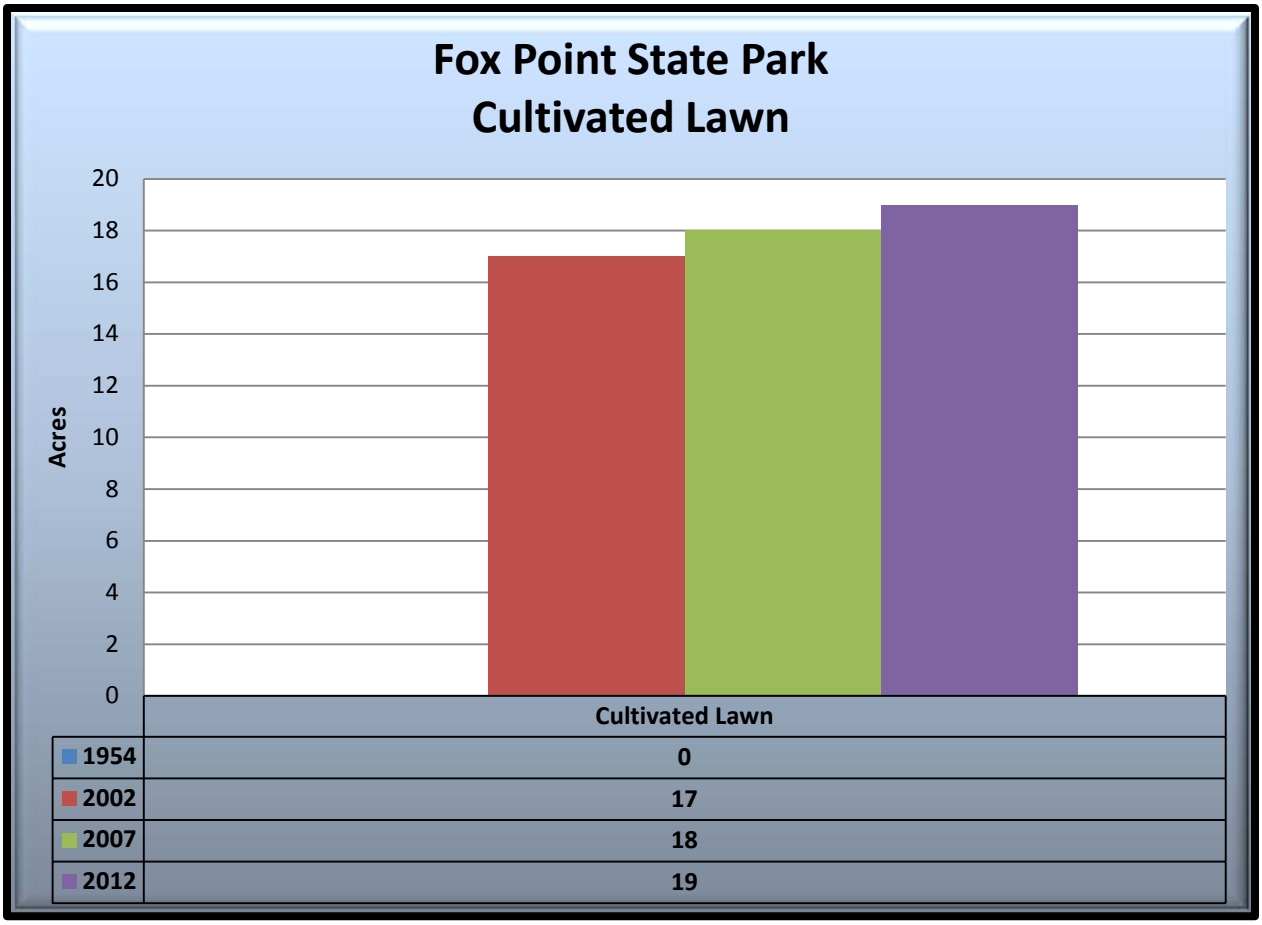


Figure 4.1. Cultivated Lawn at Fox Point State Park (1954, 2002, 2007, and 2012)

DNREC Sea Level Rise Analysis (Table 4.2)

About 0.1 acres of cultivated lawn will be inundated with 0.5 m of sea level rise. At 1.5 m of rise, about 0.4 acres will be inundated (Table 4.2).

Table 4.2. Projected acres of Cultivated Lawn Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	0.1 acres
1 m	0.2 acres
1.5 m	0.4 acres

Natural Capital

Cultivated lawn does not contain any capital value.

Eastern Reed Marsh **[3 acres (Figures 4.2, Tables 4.3-4.5)] GNA SNA**

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

Description

Eastern Reed Marsh is a monoculture of common reed (*Phragmites australis*) in a non-tidal situation.

Analysis of Condition at Fox Point State Park

Eastern Reed Marsh was not present in 1954 and has since populated some of the wetlands adjacent to the Delaware River by converting 2 acres of Northeastern Old Field, 1 acre of Freshwater Tidal Water, and 0.1 acres of Northeastern Successional Shrubland (Table 4.3).

Table 4.3. Eastern Reed Marsh has migrated into X since 1954	
X	**Acreage**
Northeastern Old Field	2 acres
Freshwater Tidal Water	1 acre
Northeastern Successional Shrubland	0.1 acres

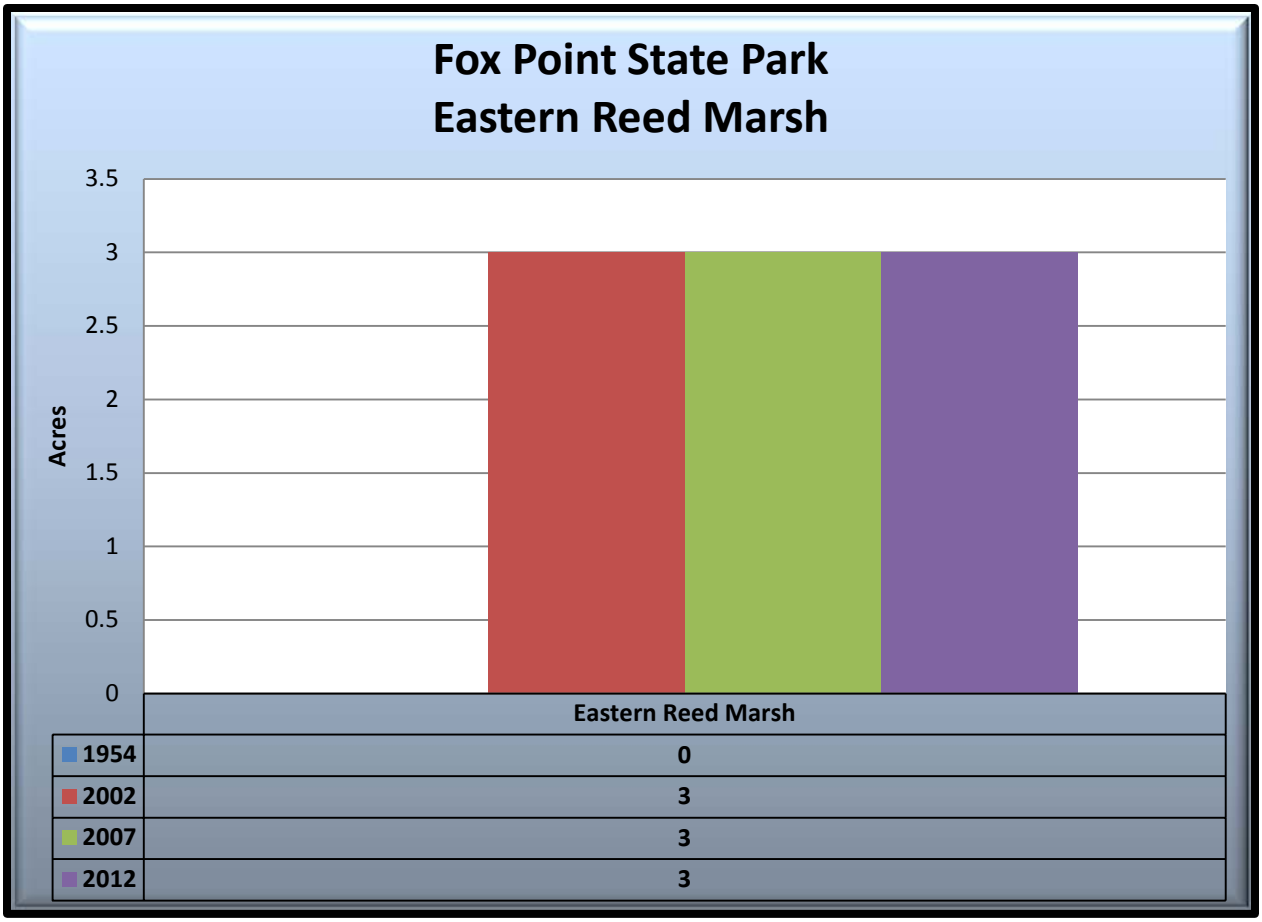


Figure 4.2. Eastern Reed Marsh at Fox Point State Park (1954, 2002, 2007, and 2012)

DNREC Sea Level Rise Analysis (Table 4.4)

All of the Eastern Reed Marsh currently present in the park will be inundated with 1.5 m of sea level rise (Table 4.4). About a third of the total will be flooded with 0.5 m of rise.

Table 4.4. Projected acres of Eastern Reed Marsh Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	1 acre
1 m	2 acres
1.5 m	3 acres

Natural Capital

Eastern Reed Marsh has gained capital since 1954 and has remained at the same amount since 2002 (Table 4.5). Since some of the capital transfer was from freshwater tidal water, this likely resulted in a net loss of capital for the park.

Table 4.5. Natural Capital of Eastern Reed Marsh	
Year	**Natural Capital (in 2012 dollars)**
1954	$0/year (not present)
2002	$27,844/year
2007	$27,844/year
2012	$27,844/year

Japanese Knotweed Gravel Bar **[2 acres (Figure 4.5, Tables 4.6-4.8)] GNA SNA**

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

Description

These communities are often completely covered by Japanese knotweed (*Polygonum cuspidatum*) with a few individuals of common reed (*Phragmites australis*). In Delaware they are found primarily along the banks of the Delaware River.

Analysis of Condition at Fox Point State Park

Japanese Knotweed Gravel Bar was not present in 1954 and has since migrated into about 2 acres of Northeastern Old Field, 1 acre of Northeastern Successional Shrubland, and 0.1 acres of Freshwater Tidal Water (Table 4.6).

Table 4.6. Japanese Knotweed Gravel Bar has migrated into X since 1954

X	**Acreage**
Northeastern Old Field	2 acres
Northeastern Successional Shrubland	1 acre
Freshwater Tidal Water	0.1 acres

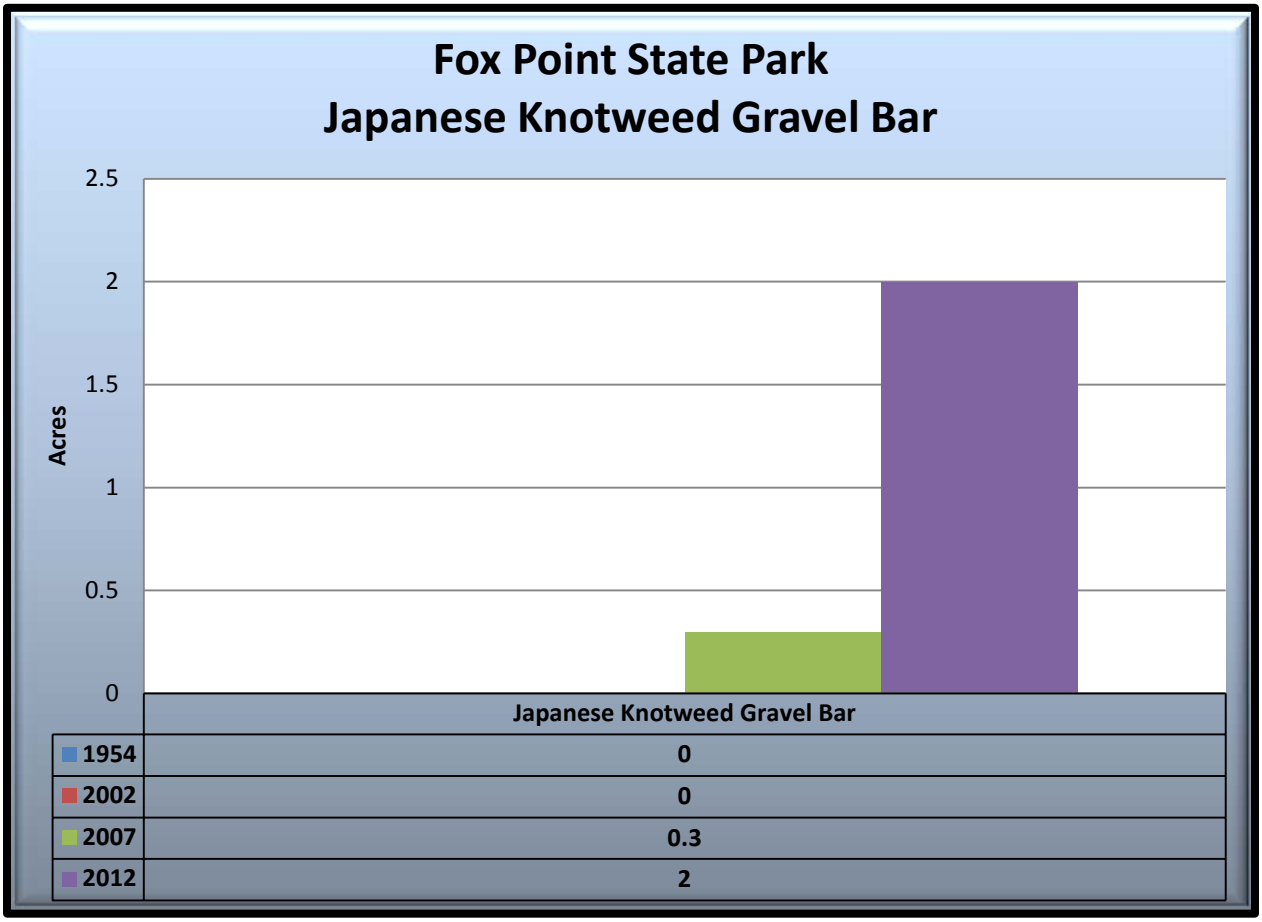


Figure 4.5. Japanese Knotweed Gravel Bar at Fox Point State Park (1954, 2002, 2007, and 2012)

DNREC Sea Level Rise Analysis (Table 4.6)

All of the current acreage of Japanese Knotweed Gravel Bar will be inundated with 1.5 m of sea level rise (Table 4.7).

Table 4.7. Projected acres of Japanese Knotweed Gravel Bar Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	0.3 acres
1 m	1 acre
1.5 m	2 acres

Natural Capital (Table 4.8)

Japanese Knotweed was not present in 1954 or 2002 and has since populated some of the former Northeastern Old Field. The capital of this community has also increased over the 2007 to 2012 period likely resulting in an overall capital increase for the park.

Table 4.8. Natural Capital of Japanese Knotweed Gravel Bar	
Year	**Natural Capital (in 2012 dollars)**
1954	$0/year (not present)
2002	$0/year (not present)
2007	$2,784/year
2012	$18,562/year

Northeastern Modified Successional Forest **[8 acres (Figures 4.6-4.7, Tables 4.10-4.13)] GNA SNA**

DEWAP: Coastal Plain Forested Floodplains and Riparian Swamps
NHC: Semi-natural/Altered Vegetation and Conifer Plantations

Description

Northeastern Modified Successional Forest is located on the larger floodplains of the park. Common canopy species include box elder (*Acer negundo*), sycamore (*Platanus occidentalis*), black willow (*Salix nigra*), green ash (*Fraxinus pensylvanica*), catalpa (*Catalpa speciosa*), red maple (*Acer rubrum*), black locust (*Robinia pseudoacacia*), and sweetgum (*Liquidambar styraciflua*). The understory contains smaller members of the canopy. The shrub and vine layer is thick with Japanese honeysuckle (*Lonicera japonica*), poison ivy (*Toxicodendron radicans*), Oriental bittersweet (*Celastrus orbiculatus*), summer grape (*Vitis aestivalis*), and wineberry (*Rubus pheonicalasius*). Garlic mustard (*Alliaria petiolata*) was the only herb noted at the time

Figure 4.6. Northeastern Modified Successional Forest

Analysis of Condition at Fox Point State Park

All of the original acreage from 1954 was still present in 2012 (Table 4.10). Since 1954 this forest has increased by growing into 3 acres of Northeastern Old Field, 2 acres of Northeastern Successional Shrubland, 1 acre of Mainland Beach, and 1 acre of Estuarine Tidal Riverine Coastal Water (Table 4.11).

Table 4.10. What was once Northeastern Modified Successional Forest in 1954 has become X in 2012	
X	**Acreage**
Northeastern Modified Successional Forest	1 acre
Other communities/land covers	2 acres

Table 4.11. Northeastern Modified Successional Forest has migrated into X since 1954	
X	**Acreage**
Northeastern Old Field	3 acres
Northeastern Successional Shrubland	2 acres
Beach	1 acre
Freshwater Tidal Water	1 acre
Northeastern Modified Successional Forest	1 acre
Other vegetation communities/land covers	0.3 acres

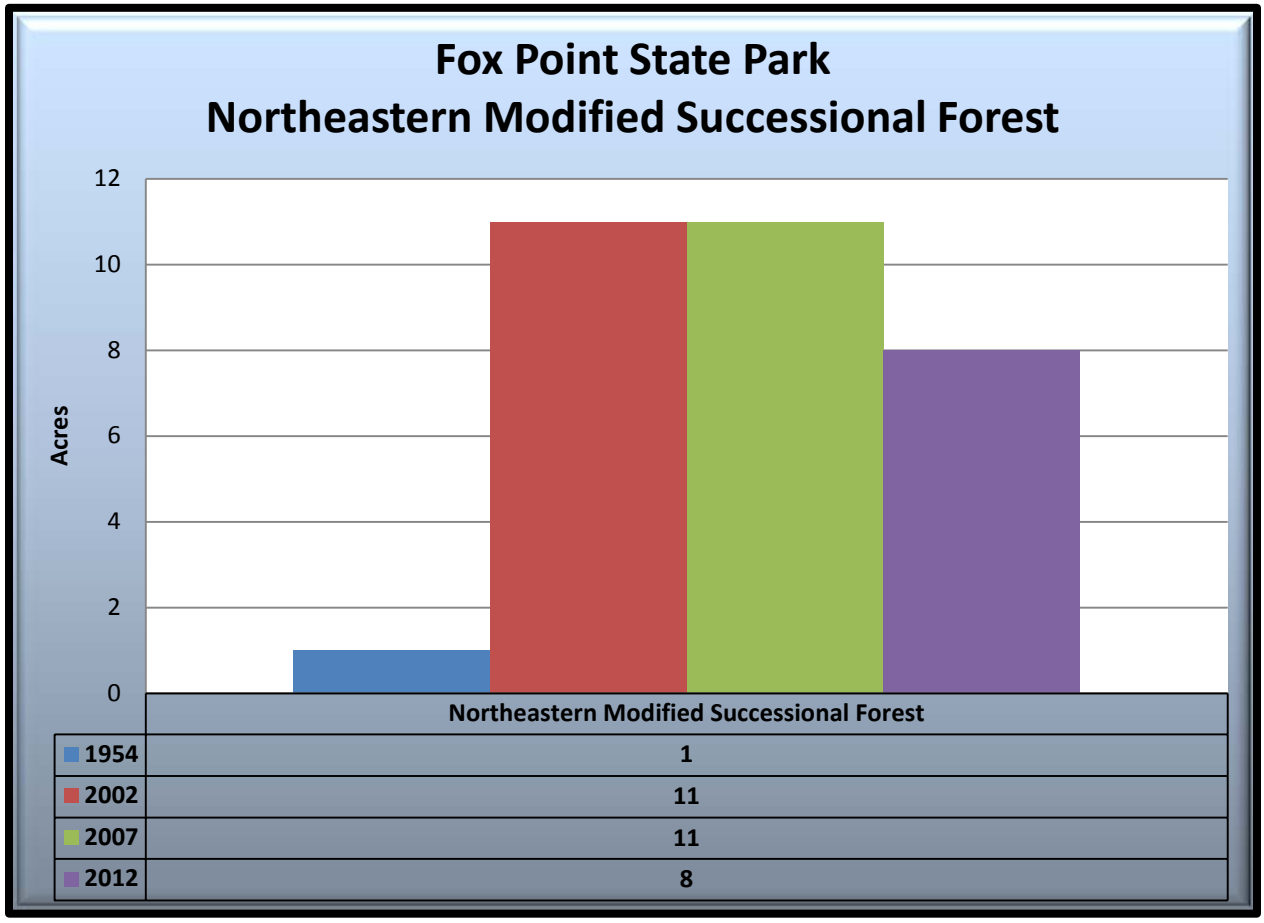


Figure 4.7. Northeastern Modified Successional Forest at Fox Point State Park (1954, 2002, 2007, and 2012)

DNREC Sea Level Rise Analysis (Table 4.12)

A little less than half of the current acreage of Northeastern Modified Successional Forest will be inundated with 1.5 m of sea level rise (Table 4.12).

Table 4.12. Projected acres of Northeastern Modified Successional Forest Inundated by Sea Level Rise

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

Natural Capital (Table 4.13)

Capital in Northeastern Modified Successional Forest has increased since 1954 but has decreased from its 2002 and 2007 levels.

Table 4.13. Natural Capital of Northeastern Modified Successional Forest	
Year	**Natural Capital (in 2012 dollars)**
1954	$189/year
2002	$2,080/year
2007	$2,080/year
2012	$1,513/year

Northeastern Old Field **[35 acres (Figures 5.8-5.9, Tables 4.14-4.17)] GNA SNA**

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

Description

Figure 4.8. Northeastern Old Field

This field community is similar to the cultivated lawn but it is only mowed once or less per year. Common species in the fields include Chinese bushclover (*Lespedeza cuneata*), Queen Anne's lace (*Daucus carota*), Kentucky fescue (*Festuca arundinacea*), Canada goldenrod (*Solidago canadensis*), crown vetch (*Coronilla varia*), and wormwood (*Artemisia* sp.).

Analysis of Condition at Fox Point State Park

Only 2 acres of the 16 acres of Northeastern Old Field present in 1954 still existed in 2012. The rest had become 3 acres of Northeastern Modified Successional Forest, 3 acres of cultivated lawn, 2 acres of Estuarine Tidal Riverine Coastal Oligohaline Water, and 2 acres of Japanese Knotweed Gravel Bar (Table 4.14).

Since 1954 this community has increased by converting 30 acres of Estuarine Tidal Riverine Coastal Oligohaline Water, through fill, and 1 acre each of sand and Northeastern Successional Shrubland (Table 4.15).

Table 4.14. What was once Northeastern Old Field in 1954 has become X in 2012	
X	**Acreage**
Northeastern Modified Successional Forest	3 acres
Cultivated Lawn	3 acres
Northeastern Old Field	2 acres
Estuarine Tidal Riverine Coastal Oligohaline Water	2 acres
Japanese Knotweed Gravel Bar	2 acres
Other communities/land covers	5 acres

Table 4.15. Northeastern Old Field has migrated into X since 1954	
X	**Acreage**
Estuarine Tidal Riverine Coastal Oligohaline Water	30 acres
Northeastern Old Field	2 acres
Sand	1 acre
Northeastern Successional Shrubland	1 acre
Modified Land	0.2 acres

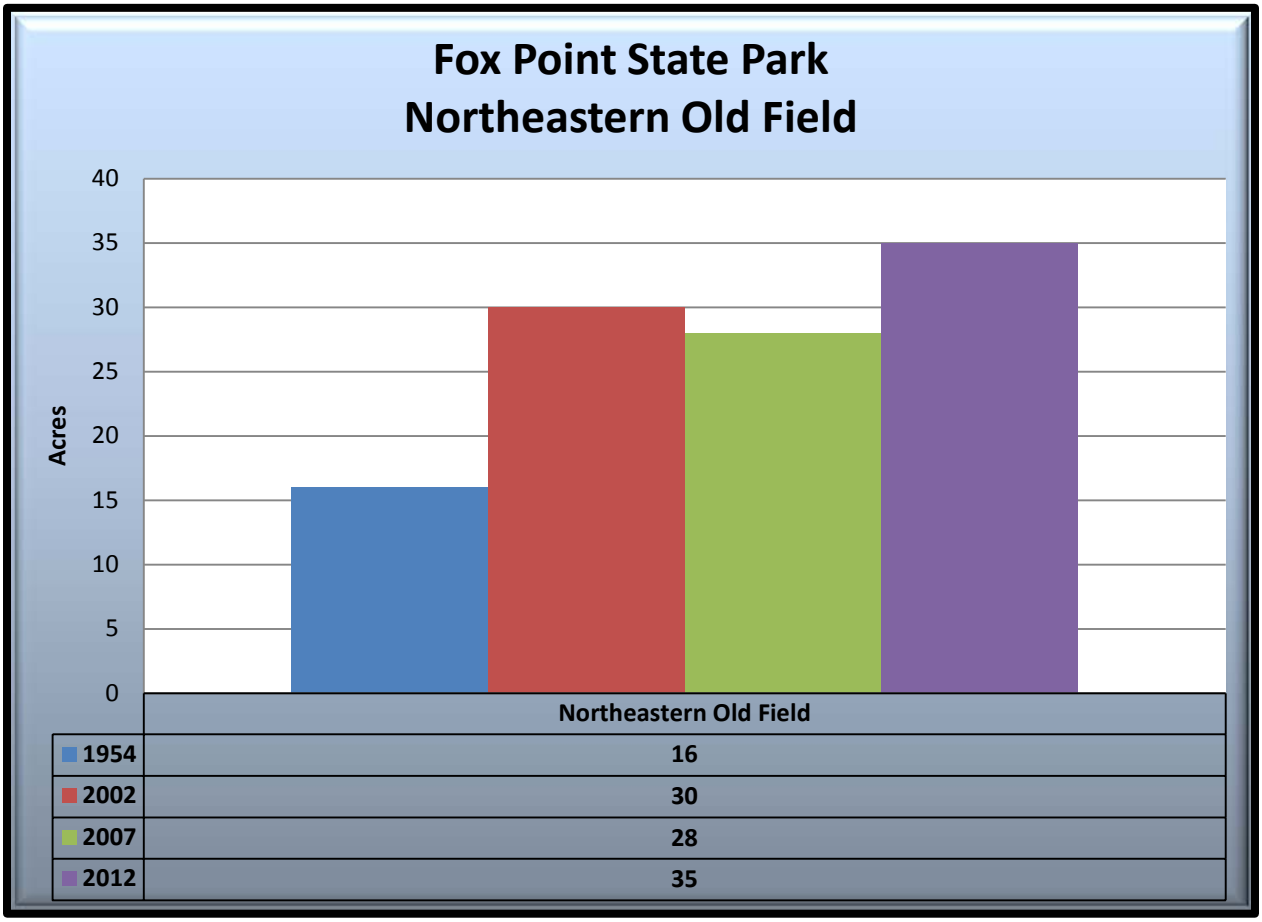


Figure 4.9. Northeastern Old Field at Fox Point State Park (1954, 2002, 2007, and 2012)

DNREC Sea Level Rise Analysis (Table 4.16)

Northeastern Old Field will be barely impacted even with 1.5 m of sea level rise (Table 4.16).

Table 4.16. Projected acres of Northeastern Old Field Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	0.3 acres
1 m	0.5 acres
1.5 m	1 acre

Natural Capital (Table 4.17)

Capital in Northeastern Old Field has been steadily increasing as more of the forests are cleared and as cultivated lawn is reverting to this community. The reversion of cultivated lawn is giving a net gain to the capital of the park as whole.

Table 4.17. Natural Capital of Northeastern Old Field	
Year	**Natural Capital (in 2012 dollars)**
1954	$2,331/year
2002	$4,371/year
2007	$3,211/year
2012	$5,100/year

Northeastern Successional Shrubland **[2 acres (Figures 4.10-4.11, Tables 4.18-4.21)] GNA SNA**

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

Description

Northeastern Successional Shrubland is located on the edges of the railroad right-of-way and often contains an assemblage of exotic invasive plant species. At Fox Point, black willow (*Salix nigra*) composes the sparse canopy and overtops a shrub layer of smooth sumac (*Rhus typhina*), Morrow's honeysuckle (*Lonicera morrowii*), poison ivy (*Toxicodendron radicans*), and false indigo-bush (*Amorpha fruticosa*). Japanese honeysuckle (*Lonicera japonica*) is located between the shrubs and Japanese stiltgrass (*Microstegium vimineum*), switchgrass (*Panicum virgatum*), path rush (*Juncus tenuis*), Chinese silver grass (*Miscanthus sinensis*), and Japanese knotweed (*Polygonum cuspidatum*) can be found underneath in the herb layer.

Figure 4.10. Northeastern Successional Shrubland

Analysis of Condition at Fox Point State Park

None of the Northeastern Successional Shrubland present in 1954 survived into 2012. The shrubland had become 2 acres of Northeastern Modified Successional Forest, 1 acre of Estuarine Tidal Riverine Coastal Oligohaline Water, 1 acre of Northeastern Old Field, and 1 acre of cultivated lawn (Table 4.18). This community has decreased in amount since 1954 but has still managed to populate 1 acre of beach, 1 acre of Northeastern Old Field, and 0.1 acres of Estuarine Tidal River Coastal Oligohaline Water (Table 4.19).

Table 4.18. What was once Northeastern Successional Shrubland in 1954 has become X in 2012

X	Acreage
Northeastern Modified Successional Forest	2 acres
Estuarine Tidal Riverine Coastal Oligohaline Water	1 acre
Northeastern Old Field	1 acre
Cultivated Lawn	1 acre
Other vegetation communities/land covers	3 acres

Table 4.19. Northeastern Successional Shrubland has migrated into X since 1954	
X	**Acreage**
Beach	1 acre
Northeastern Old Field	1 acre
Estuarine Tidal Riverine Coastal Oligohaline Water	0.1 acres

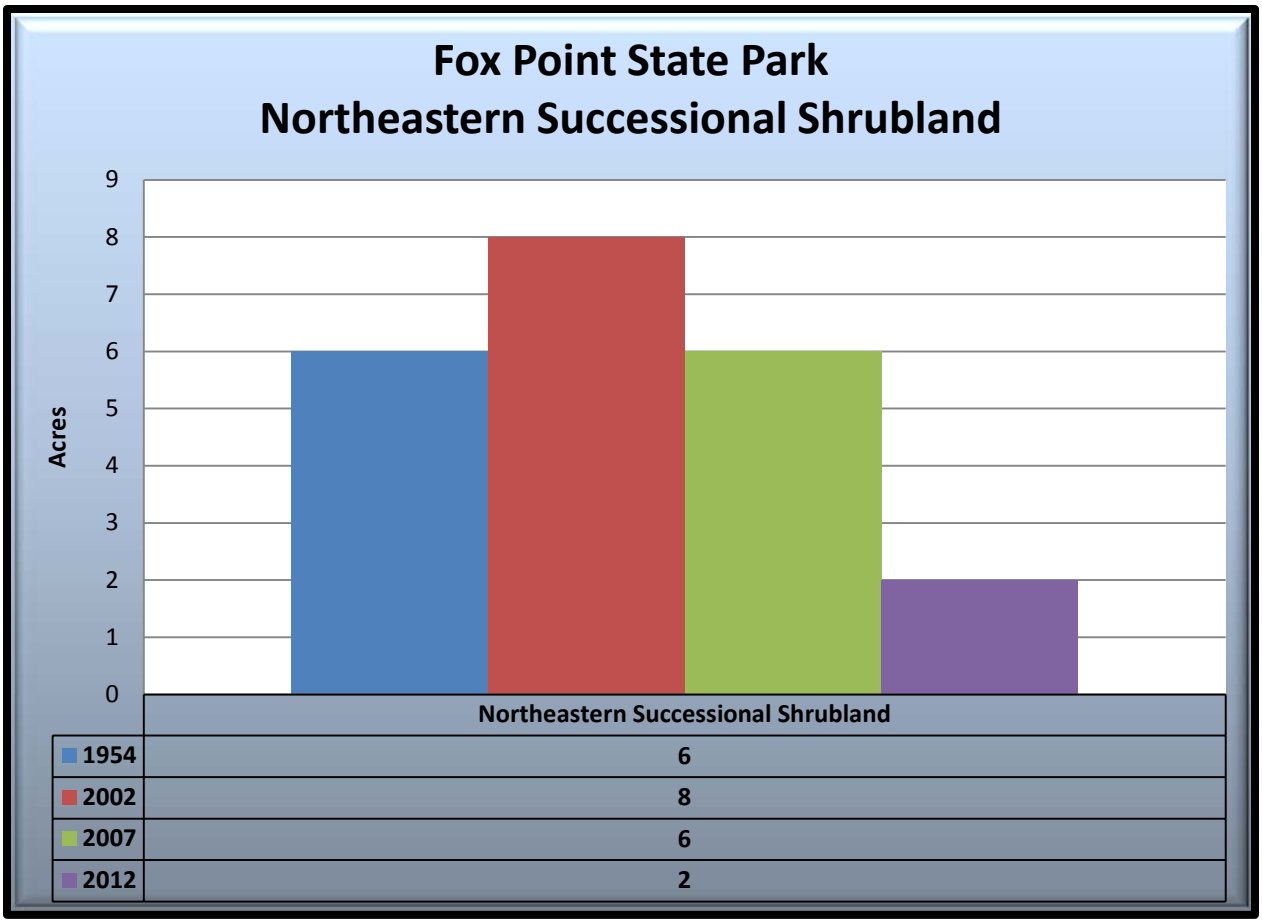


Figure 4.11. Northeastern Successional Shrubland at Fox Point State Park (1954, 2002, 2007, and 2012)

DNREC Sea Level Rise Analysis (Table 4.20)

Only about 10% of the current acreage of Northeastern Successional Shrubland will be impacted under the highest amount of sea level rise (Table 4.20).

Table 4.20. Projected acres of Northeastern Successional Shrubland Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	0.1 acres
1 m	0.1 acres
1.5 m	0.2 acres

Natural Capital (Table 4.21)

Natural capital of Northeastern Successional Shrubland has decreased since 1954, but had a high in capital in 2002.

Table 4.21. Natural Capital of Northeastern Successional Shrubland	
Year	**Natural Capital (in 2012 dollars)**
1954	$874/year
2002	$1,166/year
2007	$874/year
2012	$291/year

Reed Tidal Marsh **[1 acre (Figures 4.12-4.13, Tables 4.22-4.25)] GNA SNA**

DEWAP: Tidal Low Marshes
NHC: Semi-natural/Altered Vegetation and Conifer Plantations

Description

Figure 4.12. Reed Tidal Marsh

Reed Tidal Marsh is characterized by a monoculture of common reed (*Phragmites australis*) in a tidal situation.

Analysis of Condition at Fox Point State Park

Nearly all of the Reed Tidal Marsh from 1954 still existed in 2012 (Table 4.22). Since 1954 Reed Tidal Marsh has managed to populate 0.1 acres each of Northeastern Old Field and 0.1 acres of Northeastern Successional Shrubland (Table 4.23).

Table 4.22. What was once Reed Tidal Marsh in 1954 has become X in 2012	
X	**Acreage**
Reed Tidal Marsh	0.4 acres

Table 4.23. Reed Tidal Marsh has migrated into X since 1954	
X	**Acreage**
Reed Tidal Marsh	0.4 acres
Northeastern Old Field	0.1 acres
Northeastern Successional Shrubland	0.1 acres

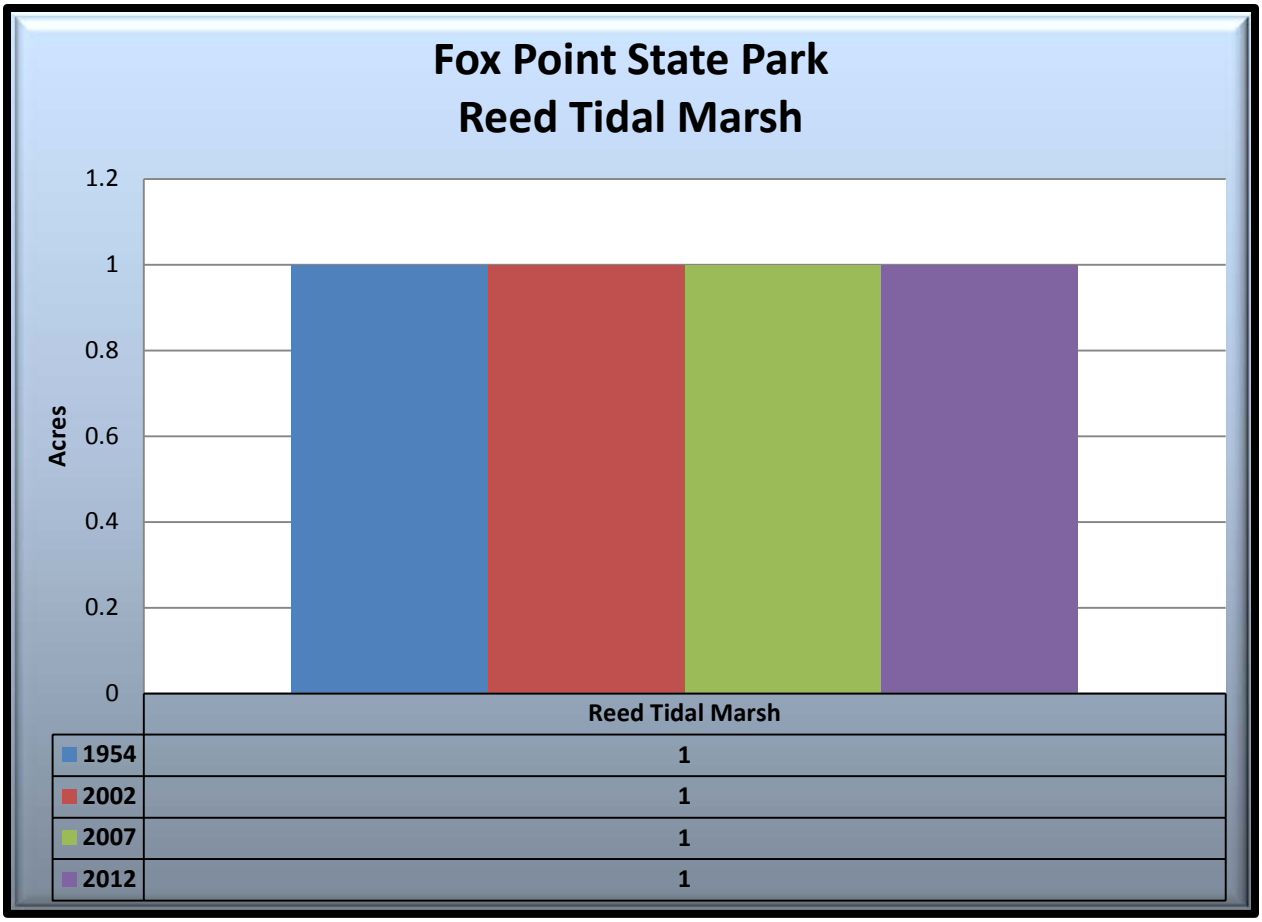


Figure 4.13. Reed Tidal Marsh at Fox Point State Park (1954, 2002, 2007, and 2012)

DNREC Sea Level Rise Analysis (Table 4.24)

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

Table 4.24. Projected acres of Reed Tidal Marsh Inundated by Sea Level Rise

Rise	Acres
0.5 m	0.3 acres
1 m	0.4 acres
1.5 m	0.6 acres

Natural Capital (Table 4.25)

Capital of Reed Tidal Marsh has remained the same throughout the study period.

Table 4.25. Natural Capital of Reed Tidal Marsh	
Year	**Natural Capital (in 2012 dollars)**
1954	$6,271/year
2002	$6,271/year
2007	$6,271/year
2012	$6,271/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—3 acres
2. Impervious Surface—10 acres
3. Modified Land—4 acres
4. Semi-impervious Surface—1 acre
5. Oligohaline Tidal Water—21 acres

***Beach* [3 acres, (Figure 5.1 Tables 5.1-5.3)]**

DEWAP: Nearshore Habitats
NHC: No Equivalent Classification

Description

Beach areas located at the land/water interface and are composed of sandy areas with "beached" floating woody, other debris, and one of the more unique habitats in the park containing an unusual assemblage of plant species. Species that can be found here include bald spikerush (*Eleocharis erythropoda*), river bulrush (*Scirpus fluviatilis*), marsh seedbox (*Ludwigia palustris*), multiflowered mud-plantain (*Heteranthera multiflora*), rusty flatsedge (*Cyperus odoratus*), tailed rush (*Juncus canadensis*), water-pepper smartweed (*Polygonum hydropiperoides*), roundfruit hedge hyssop (*Gratiola virginiana*), nodding tickseed (*Bidens cernua*), softstem bulrush (*Schoenoplectus tabernaemontani*), hibiscus (*Hibiscus moscheutos*), and pickerelweed (*Pontederia cordata*).

Analysis of Condition at Fox Point State Park

Just a very small portion of the beach (0.04 acres) from 1954 was still present in 2012 (Table 5.1). Since 1954 beach has formed in 1 acre each of Northeastern Old Field, Estuarine Tidal Riverine Coastal Oligohaline Water, and Northeastern Successional Shrubland, and 0.3 acres of Reed Tidal Marsh (Table 5.2).

Table 5.1. What was once Beach in 1954 has become X in 2012	
X	**Acreage**
Beach	0.04 acres

Table 5.2. Beach has migrated into X since 1954	
X	**Acreage**
Northeastern Old Field	1 acre
Estuarine Tidal Riverine Coastal Oligohaline Water	1 acre
Northeastern Successional Shrubland	1 acre
Reed Tidal Marsh	0.3 acres
Other vegetation communities/land covers	0.1 acres

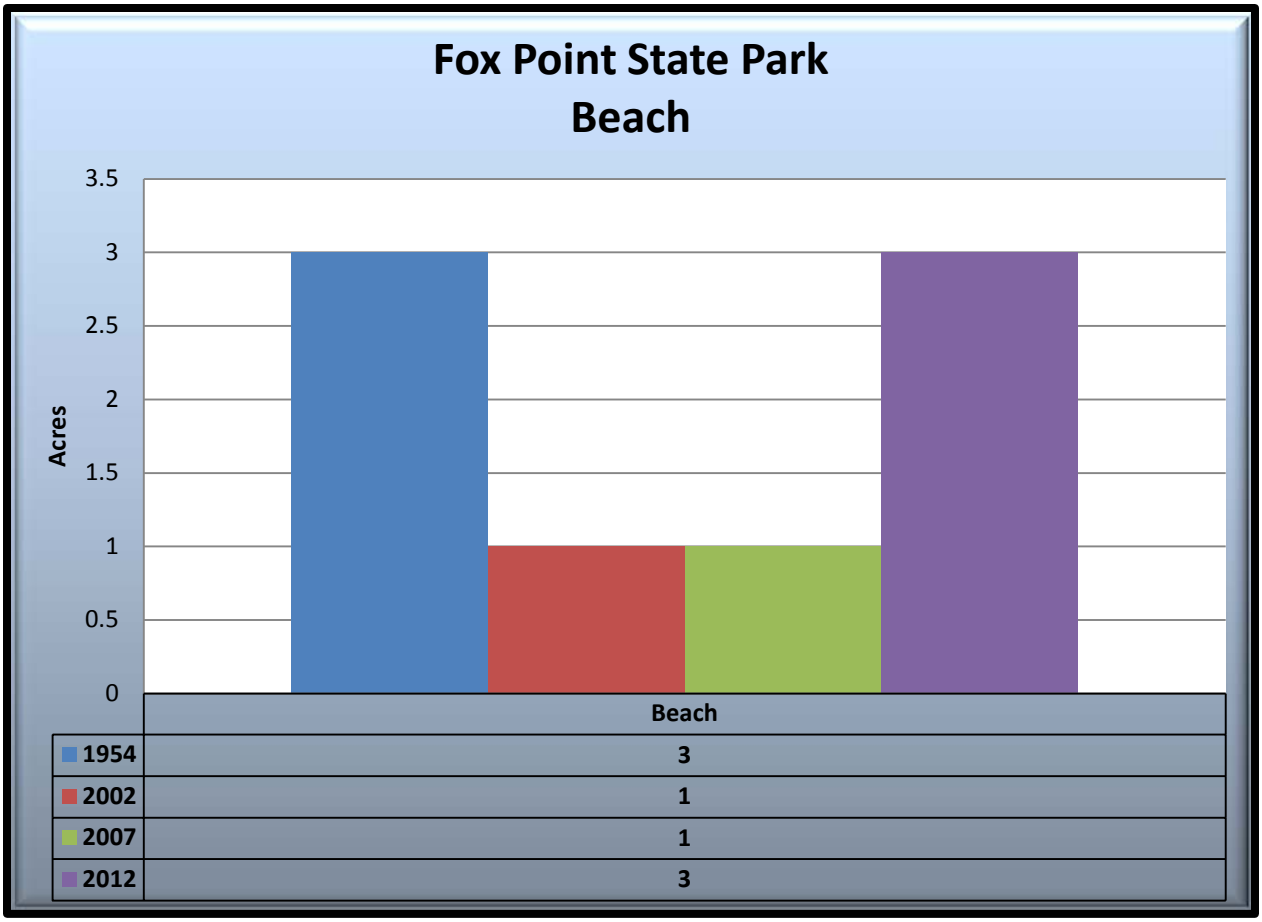


Figure 5.1. Beach at Fox Point State Park (1954, 2002, 2007, and 2012)

DNREC Sea Level Rise Analysis (Table 5.3)

All of the existing beach area in Fox Point State Park will be inundated with 1.5 m of sea level rise.

Table 5.3. Projected acres of Beach Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	2 acres
1 m	2 acres
1.5 m	3 acres

Natural Capital

Beach does not have any natural capital value.

Impervious Surface **[10 acres, (Figure 5.2, Tables 5.4-5.5)]**

DEWAP: No Equivalent Classification
NHC: No Equivalent Classification

Description

This land cover includes surfaces that are impervious to the flow of water such as parking lots, roads, and buildings.

Analysis of Condition at Fox Point State Park

Impervious surface has been developed in the park since 1954 and has generally increased by being developed in 6 acres of Estuarine Tidal River Coastal Oligohaline Water, 2 acres of Modified Land, and 1 acre each of Northeastern Old Field and Northeastern Successional Shrubland (Table 5.4).

Table 5.4. Impervious Surface has migrated into X since 1954	
X	**Acreage**
Estuarine Tidal Riverine Coastal Oligohaline Water	6 acres
Modified Land	2 acres
Northeastern Old Field	1 acre
Northeastern Successional Shrubland	1 acre

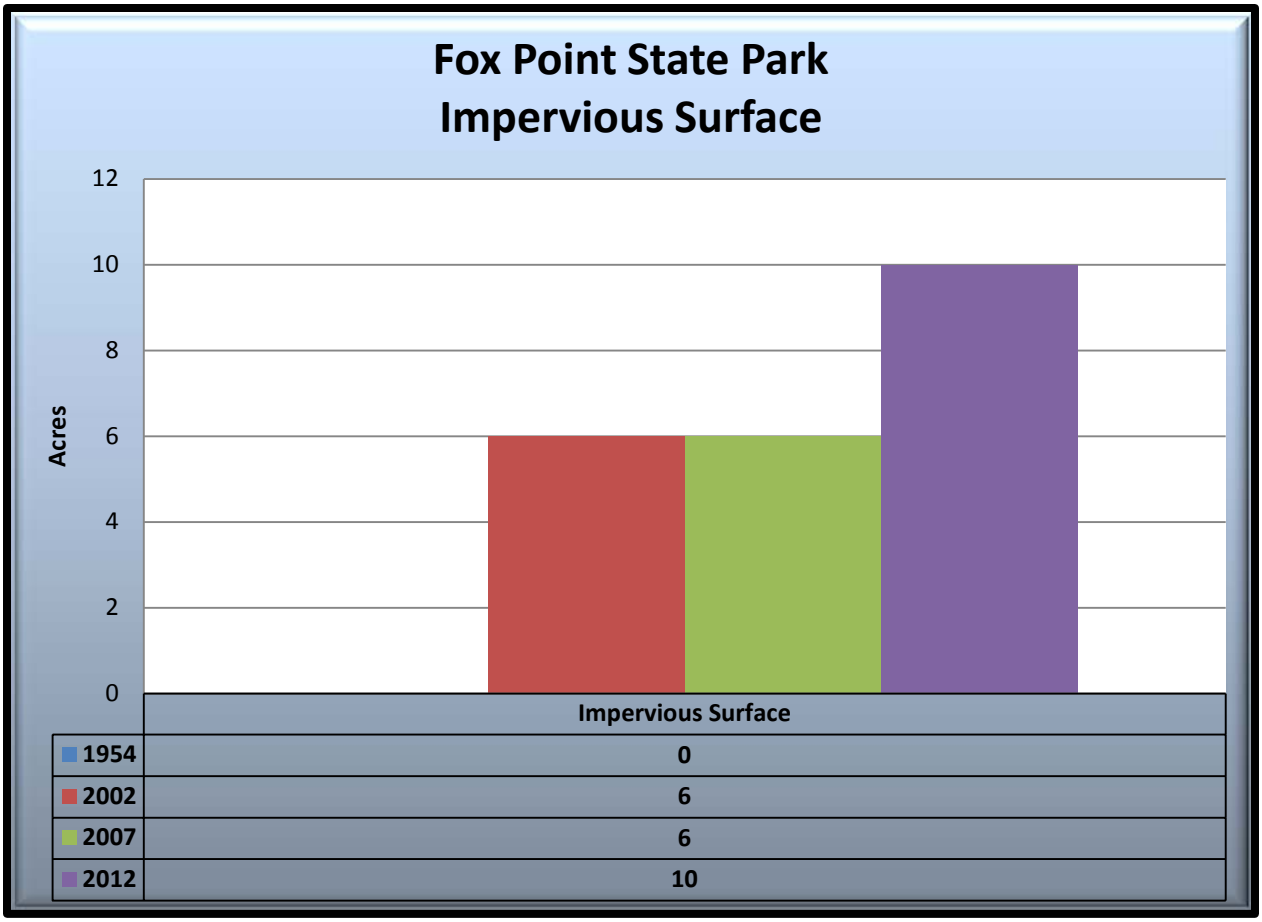


Figure 5.2. Impervious Surface at Fox Point State Park (1954, 2002, 2007, and 2012)

DNREC Sea Level Rise Analysis (Table 5.5)

Very little of the current impervious surface will be affected with even 1.5 m of sea level rise.

Table 5.5. Projected acres of Impervious Surface Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	0 acres
1 m	0.03 acres
1.5 m	0.1 acres

Natural Capital

Impervious Surface does not have any natural capital value.

Modified Land **[4 acres, (Figure 5.3, Tables 5.6-5.8)]**

DEWAP: No Equivalent Classification
NHC: No Equivalent Classification

Description

This land cover includes those places where the vegetation has been removed or is not present. Most areas contain bare dirt and are often a precursor of development.

Analysis of Condition at Fox Point State Park

Only 0.1 acres of the 1954 acres of Modified Land still existed in 2012. The rest had become 2 acres of impervious surface, 2 acres of cultivated lawn, and 0.2 acres of Northeastern Old Field (Table 5.6). Since 1954 Modified Land has been developed in 3 acres of Estuarine Tidal Riverine Coastal Oligohaline Water, 0.4 acres of Northeastern Old Field, and 0.2 acres of Northeastern Successional Shrubland (Table 5.7).

Table 5.6. What was once Modified Land in 1954 has become X in 2012	
X	**Acreage**
Impervious Surface	2 acres
Cultivated Lawn	2 acres
Northeastern Old Field	0.2 acres
Modified Land	0.1 acres

Table 5.7. Modified Land has migrated into X since 1954	
X	**Acreage**
Estuarine Tidal Riverine Coastal Oligohaline Water	3 acres
Northeastern Old Field	0.4 acres
Northeastern Successional Shrubland	0.2 acres
Modified land	0.1 acres

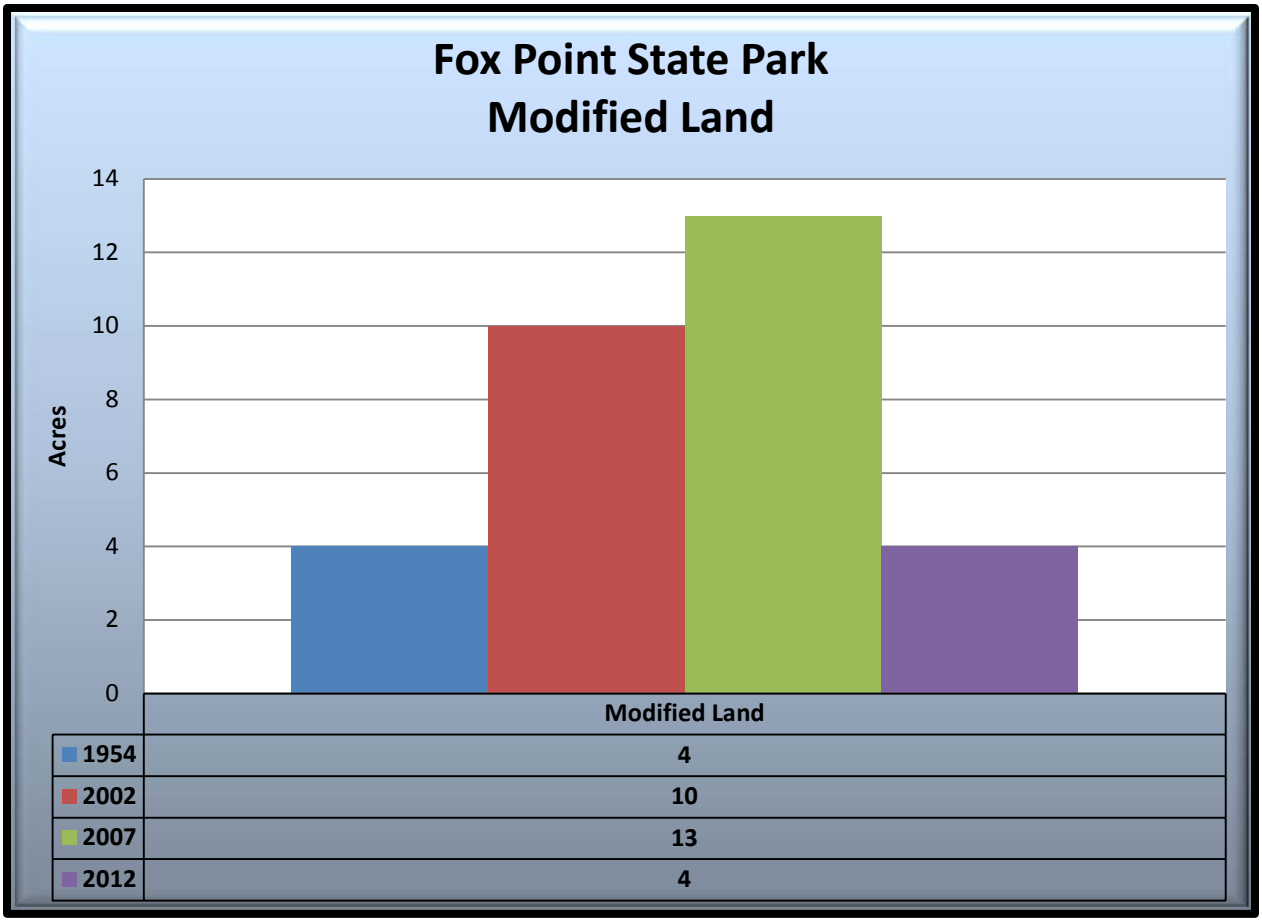


Figure 5.3. Modified Land at Fox Point State Park (1954, 2002, 2007, and 2012)

DNREC Sea Level Rise Analysis (Table 6.8)

About half of the current modified land will be inundated under all of the sea level rise scenarios.

Table 6.8. Projected acres of Modified Land Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	2 acres
1 m	2 acres
1.5 m	2 acres

Natural Capital

Modified Land does not contain any natural capital value.

Semi-impervious Surface **[1 acre, (Figure 6.4, Tables 5.8-5.10)]**

DEWAP: No Equivalent Classification
NHC: No Equivalent Classification

Description

Semi-impervious surface includes those places, such as dirt roads, that are semi-impermeable to the passage of water.

Analysis of Condition at Fox Point State Park

Semi-impervious surface was not present in 1954 and has since been developed in 0.2 acres of Estuarine Tidal River Coastal Oligohaline Water and 0.1 acres of Northeastern Successional Shrubland (Table 5.8).

Table 5.8. Semi-impervious Surface has been developed into X since 1954

X	**Acreage**
Estuarine Tidal Riverine Coastal Oligohaline Water	0.2 acres
Northeastern Successional Shrubland	0.1 acres

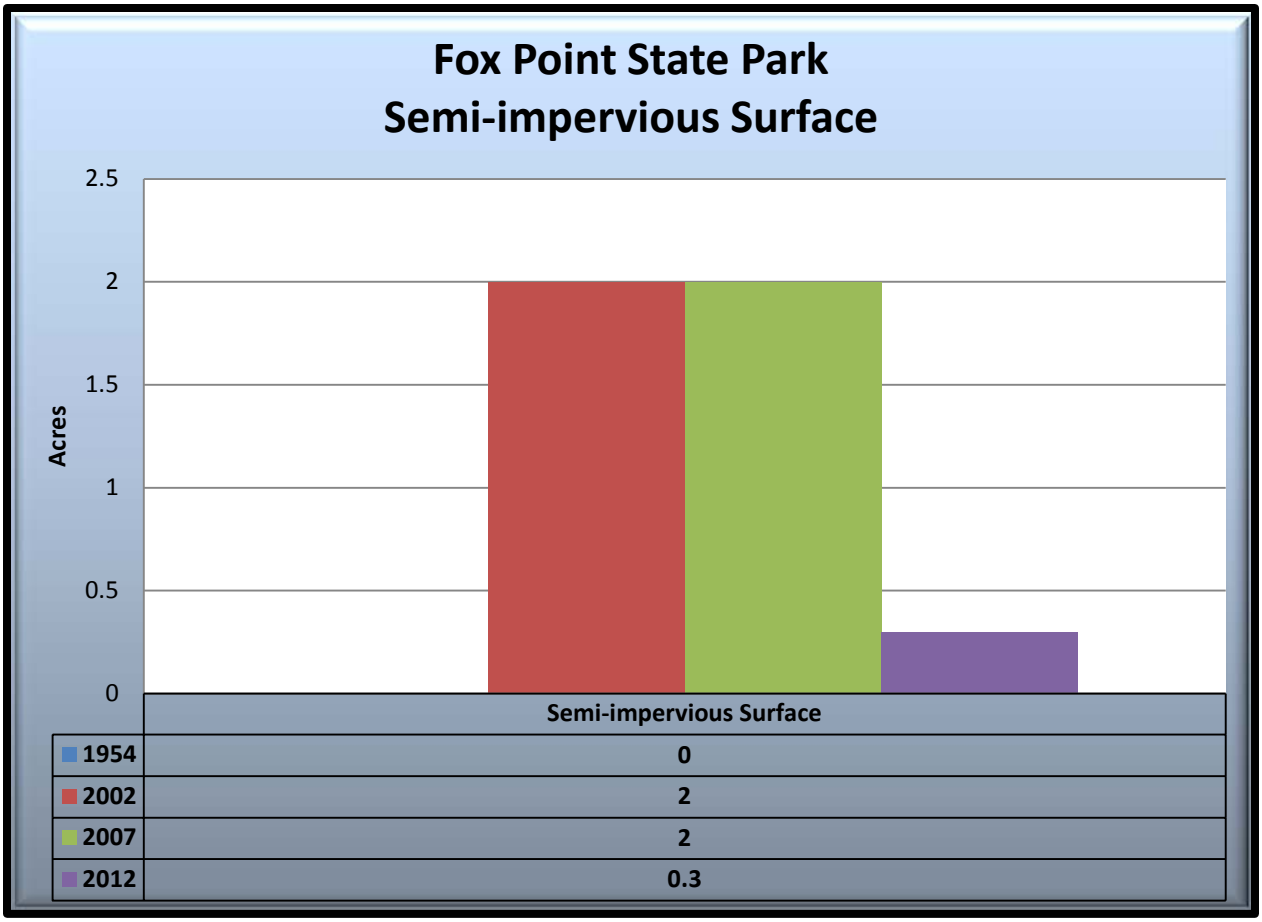


Figure 5.4. Semi-impervious Surface at Fox Point State Park (1954, 2002, 2007, and 2012)

DNREC Sea Level Rise Analysis (Table 5.11)

A little more than a tenth of the current acreage of semi-impervious surface will be impacted with 1.5 m of sea level rise (Table 5.11).

Table 5.11. Projected acres of Semi-impervious Surface Inundated by Sea Level Rise

Rise	Acres
0.5 m	0.02 acres
1 m	0.03 acres
1.5 m	0.04 acres

Natural Capital

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

Oligohaline Tidal Water **[21 acres, (Figure 5.5, Table 5.12-5.13)]**

DEWAP: Nearshore Open Water
NHC: No Equivalent Classification

Description

This land cover includes the tidal Delaware River water surface.

Analysis of Condition at Fox Point State Park

In 1954, the Delaware River in the area of Fox Point State Park was considered to be mostly fresh. By 2002 this water had gained some amount of salinity most of the time, except for the wettest of years. Since 2002 the amount of Oligohaline Tidal Water has increased. However the total amount of water since 1954, including fresh and oligohaline has decreased from 73 acres due to the placement of artificial fill.

In 2012 only 18 acres of the original water coverage still existed due to fill. Since 1954 Estuarine Tidal Riverine Coastal Oligohaline Water has covered 2 acres of Northeastern Old Field, 1 acre of Northeastern Successional Shrubland, and 0.2 acres of beach (Table 5.12)

Table 5.12. Estuarine Tidal Riverine Coastal Oligohaline Water has covered X since 1954

X	**Acreage**
Northeastern Old Field	2 acres
Northeastern Successional Shrubland	1 acre
Beach	0.2 acres

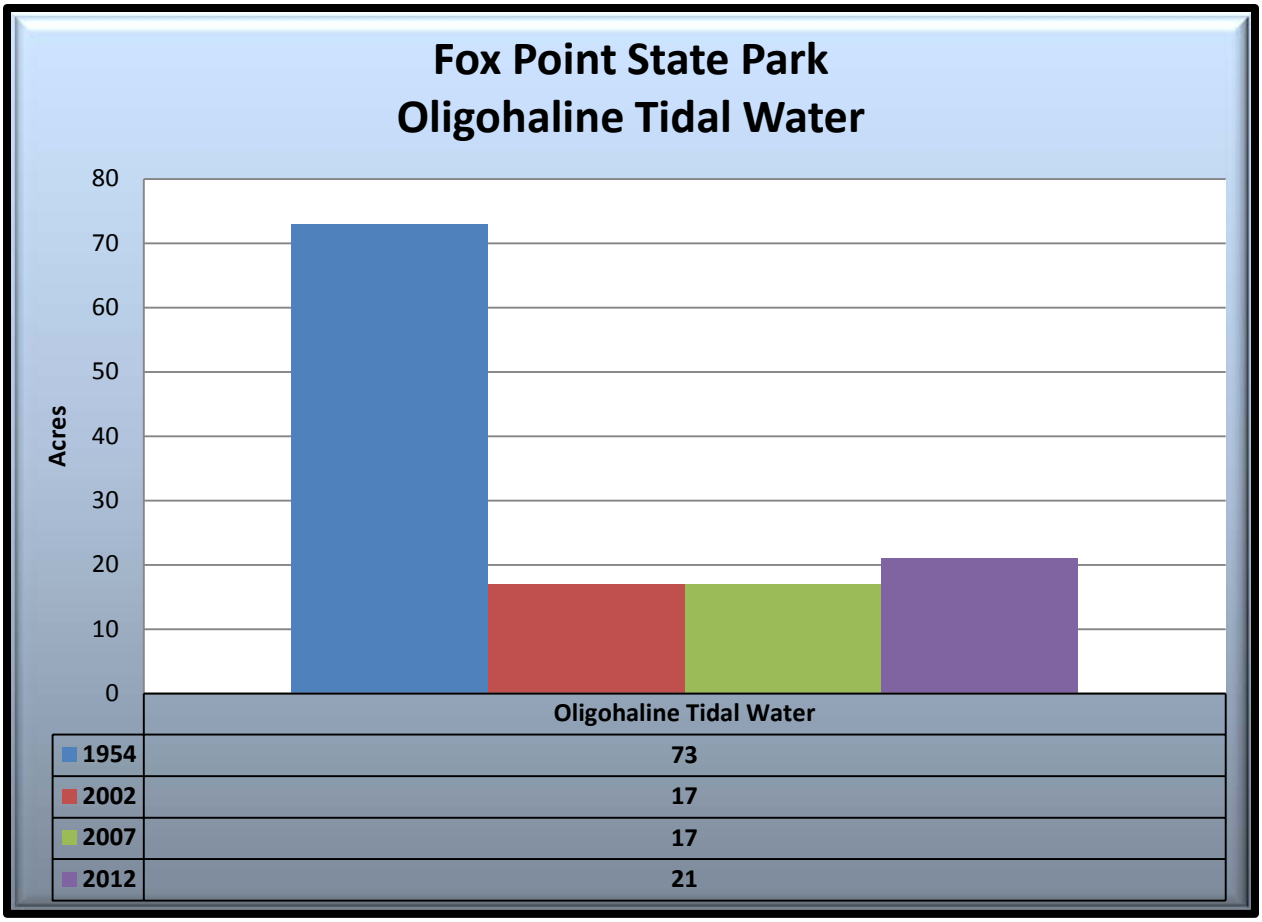


Figure 5.5. Oligohaline Tidal Water at Fox Point State Park (1954, 2002, 2007, and 2012)

Natural Capital

Capital of Oligohaline Tidal Water has decreased greatly from its 1954 high due to the filling in of the riverbank. Recently, however, from 2007 to 2012 the amount of water capital increased. This is likely due to sea level rise.

Table 5.13. Natural Capital of Estuarine Tidal Riverine Coastal Oligohaline Water	
Year	**Natural Capital (in 2012 dollars)**
1954	$1,046,298/year
2002	$243,659/year
2007	$243,659/year
2012	$300,990/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