Historical Analysis and Map of Vegetation Communities, Land Covers, and Habitats of Fenwick Island State Park Sussex County, Delaware

Assawoman Bay, Little Assawoman Bay, and Southern Atlantic Strand Watersheds

Submitted to:

Delaware State Parks
Delaware Division of State Parks
89 Kings Highway
Dover, DE 19901

Completed by:

Robert Coxe, Ecologist

Delaware Natural Heritage and Endangered Species Program
Wildlife Section, Delaware Division of Fish and Wildlife
Department of Natural Resources and Environmental Control
4876 Hay Point Landing Road
Smyrna, DE 19977

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CHAPTER 1: INTRODUCTION AND METHODS

Setting of Fenwick Island State Park

Fenwick Island State Park is located in southeastern Sussex County, Delaware (Figure 1.1). No formal tracts exist for the state park. Because of its size (379 acres) and linear shape, discussion purposes, and for mapping, the park was divided into three sections, South, Middle, and North. The South Section (8 acres) is the smallest and is located in the Town of Fenwick Island at the stateline of Delaware. The Middle Section (101 acres) is located to the north of the Town of Fenwick Island. The North Section (270 acres) is the largest and is located just south of Bethany Beach, DE. All of the sections are located on the coastal strand between Little Assawoman and Assawoman Bays, and the Atlantic Ocean.

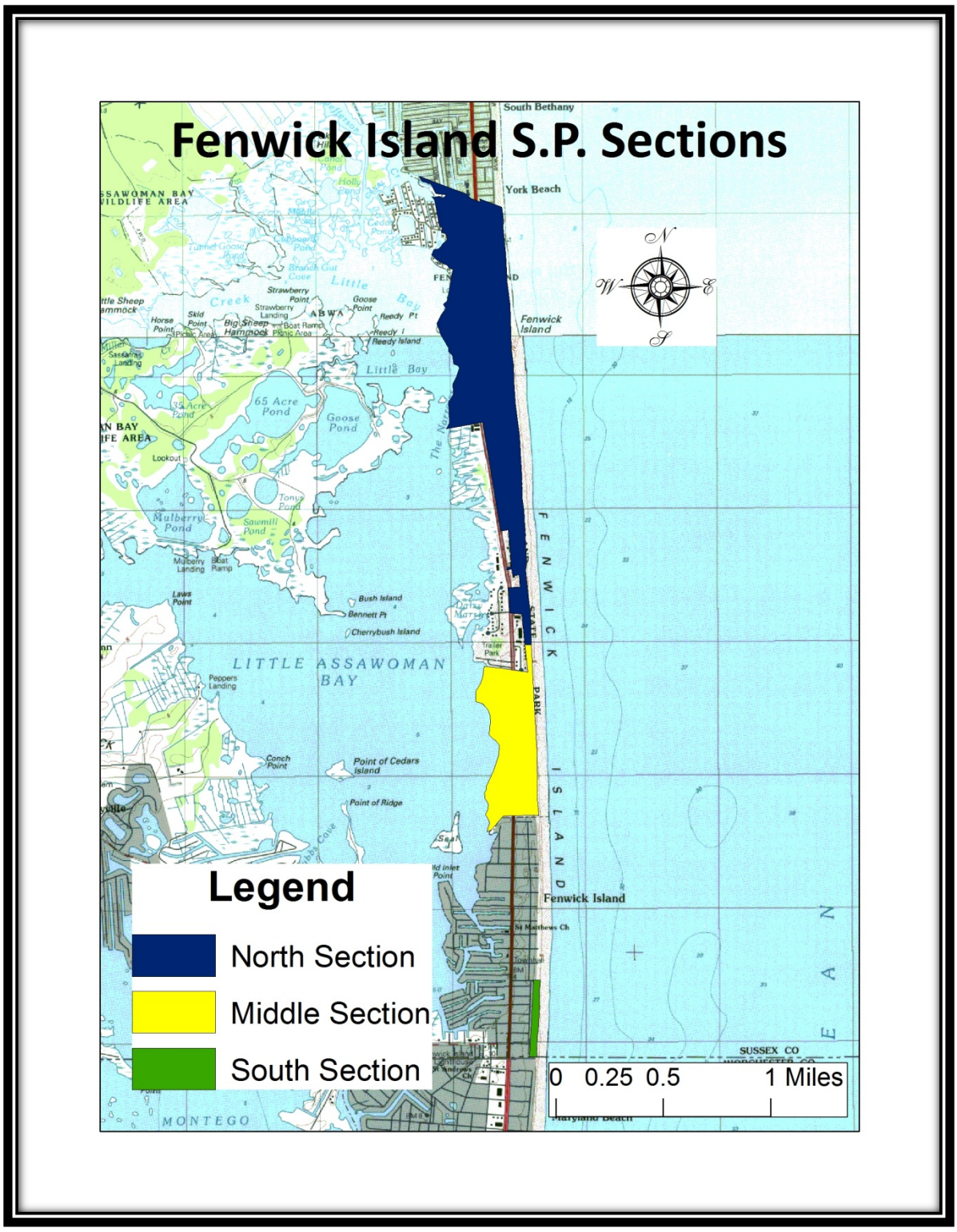

Figure 1.1. Fenwick Island State Park Section Map

Soils and Geology of Fenwick Island State Park

Underlying Geology

As best as can be told and given that a comprehensive geologic map has not been completed for this area, all of the sections of Fenwick Island State Park are underlain by the Omar Formation, a geological formation common to the Inland Bays region. The Omar Formation is described as "a heterogeneous unit consisting of fine to coarse sand, silty sand, clayey silt, and silty clay."[1]

Soils

One soil, Acquango-Beaches Complex, is prominent in the park. Other soils including Acquango-Urban Land Complex, Purnell Peat, and Saltpond mucky sand, are minor. The highest elevations of the park are located at the tops of dunes and range around 10 feet. The lowest elevations are at sea level on the bays and the ocean.

[1] Groot, Johan J., Kelvin W. Ramsey, and John F. Wehmiller. 1990. The Ages of the Bethany, Beaverdam, and Omar Formations of Southern Delaware. Delaware Geological Survey, Report of Investigations, No.47.

Middle Section Soils

One soil, Acquango-Beaches Complex (76 acres), is prominent in the Middle Section. Other minor soils include Brockatonorton-Urban Land Complex (5 acres), Acquango-Urban Land Complex (4 acres), and Purnell Peat (4 acres).

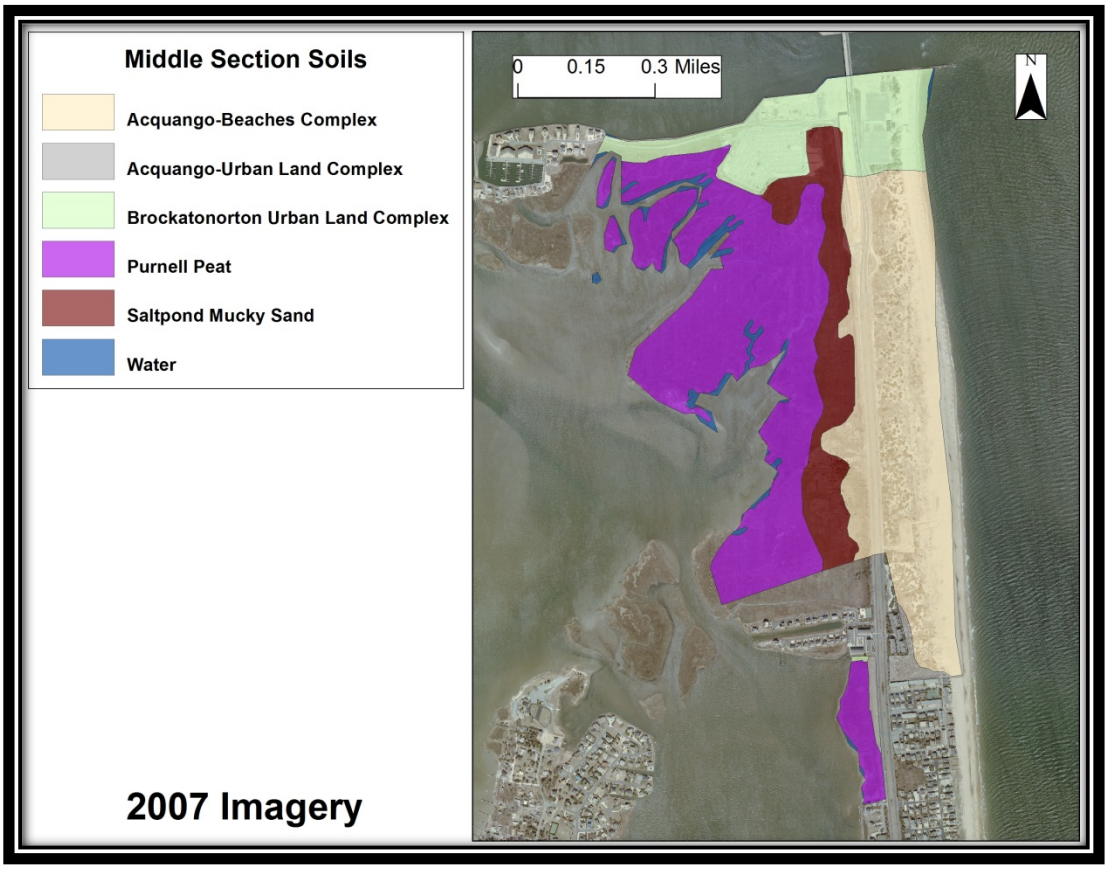

Figure 1.2. Middle Section Soil Map

North Section Soils

Acquango-Beaches Complex is prominent in the North Section with 206 acres. Other minor soils include Purnell Peat (34 acres), Saltpond Mucky Sand (10 acres), and Brockatonorton-Urban Land Complex (8 acres).

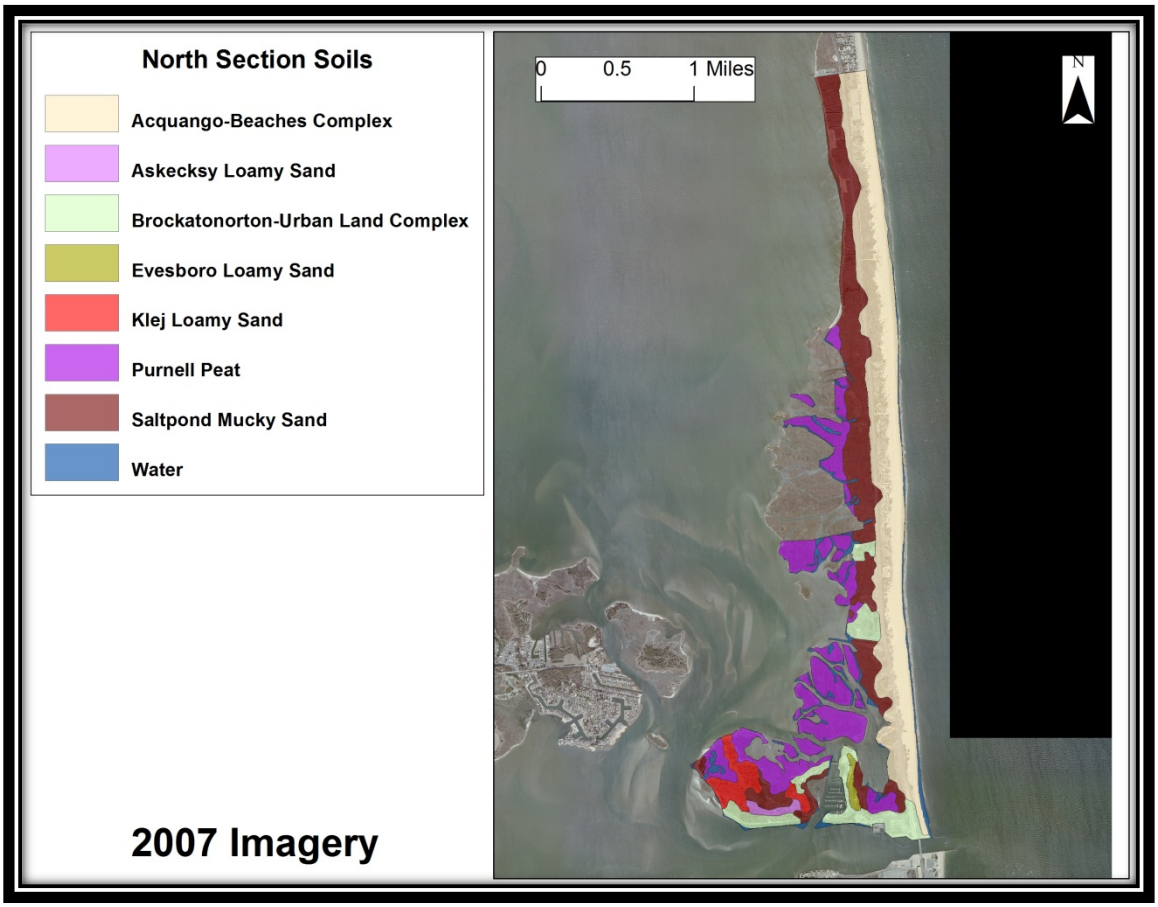

Figure 1.3. North Section Soil Map

South Section Soils

Acquango-Beaches Complex (8 acres) is the only soil type present in the South Section.

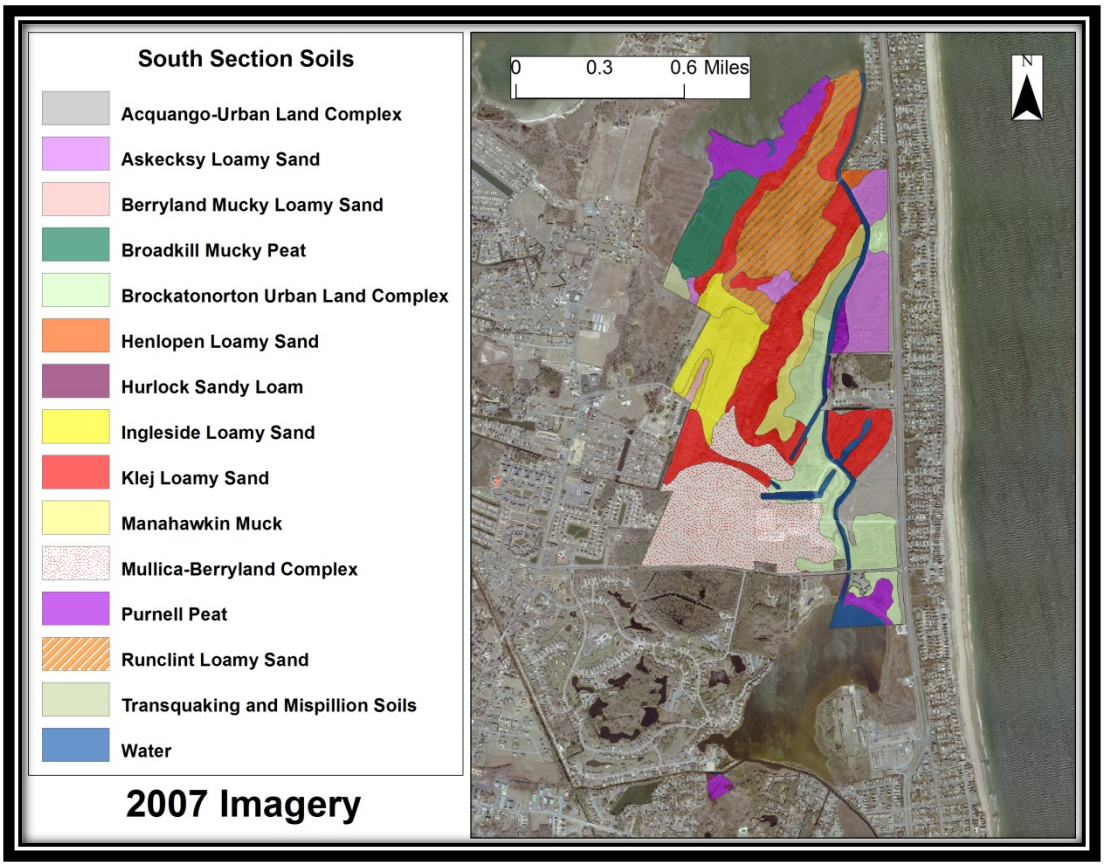

Figure 1.4. South Section Soil Map

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 Fenwick Island 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).[2] 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[3]. 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.[4] 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.[5] Sea-level rise can also cause water tables to rise, water logging swamps away from the coast, a fact that has been

[2] 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).
[3] Data from Permanent Service for Mean Sea Level website (www.psmsl.org)
[4] NASA Global Climate Change Website (http://climate.nasa.gov/keyindicators) December 12, 2010 update.
[5] Custer, Jay F. 1989. Prehistoric cultures of the Delmarva Peninsula: archaeological study. (Cranbury, NJ: Associated University Presses, Inc.), 447 pp.

stated in elsewhere in the Mid-Atlantic [6],[7], [8]. The rising rate of rise may factor into the difference 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[9] , 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 [10], 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[11]. 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.[12] 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. [13] 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[14]. Added to this is newer research that shows groundwater depletion

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[6] 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).

[7] Whitehead, D.R. 1972. Developmental and environmental history of the Dismal Swamp. Ecological Monographs 42:301-15 in Custer (1989).

[8] 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).

[9] Johnson, Zoe Pfahl. 2000. A Sea Level Rise Response Strategy for the State of Maryland. Maryland Department of Natural Resources.

[10] 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.

[11] 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.

[12] 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.

[13] Larsen, C.E. and I. Clark. 2006. A search for scale in sea-level studies. Journal of Coastal Research 22(4): 788-800.

[14] 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.

is adding 0.8 mm/year to sea level rise[15]. 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 the last half century which subtracts about 0.55 mm/year from the rise[16]. 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[17]. 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[18], 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[19]. 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[20].

Isostatic Rise

Geological land subsidence adds the most to the rise currently accounting for about 1.6 mm/year[21] in the Mid-Atlantic region. Another study has given an amount ranging from 1.02 to 1.53 mm/year[22]. 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%[23].

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= Eustastic (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)

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[15] 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

[16] 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.

[17] Ditto

[18] 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.

[19] 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.

[20] 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.

[21] 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.

[22] 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.

[23] 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[24]. 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[25]. Other papers have also used historical aerial imagery to map vegetation change[26],[27] and salinity factors can impact on those changes[28].

More recent studies looking at both changes in tidal marshes[29] and coastal forests[30] 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[31]. 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[32]. 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[33] 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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[24] 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.

[25] 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.

[26] 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.

[27] 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.

[28] 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.

[29] 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.

[30] Williams, Kimberlyn, et al. 1999. Sea-level rise and coastal forest retreat on the west coast of Florida, USA Ecology

[31] 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.

[32] Shirley, Laura and Lorretta L. Battaglia. 2006. Assessing vegetation change in coastal landscapes of the northern Gulf of Mexico. Wetlands 26(4): 1057-1070.

[33] 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 Fenwick Island State Park based on 1937, 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 1937, 2002, and 2007 imagery. Vegetation communities are named according to the *Guide to Delaware Vegetation Communities* [34]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 vegetation communities are provided in Chapter 5 and of land covers in Chapter 6. A crosswalk to the Delaware Wildlife Action Plan (DEWAP) and the Northeast Habitat Classification (NHC) are given at the top of each individual description.

Analysis of Historical Imagery

Historical imagery of Fenwick Island State Park from 1937 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, 65, and 70 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 section discussions. There is more imagery available (1954, 1961, 1968, 1992, and 1997) but these sets were not used due to geo-registration problems in the image tiles.

Ecological Integrity Assessment (EIA)

An EIA was conducted for those communities in the state park that are ranked S2 or higher in Delaware. EIAs are an analysis being developed by Natureserve to determine the relative quality of vegetation communities across North America. Using Natural Heritage methodology, communities are ranked according to rarity (Appendix I). The vegetation communities at Fenwick Island State Park included in the EIA analysis are listed in Table 2.3 and in Figures 2.1-2.2.

Sea Level Rise Analysis

An analysis was performed for the state park as whole, the sections, and the vegetation communities/land covers, using the DNREC Sea Level Rise Scenarios. Acreage lost under each of the scenarios is given.

[34] Coxe, Robert. 2011. Guide to Delaware Vegetation Communities-Fall 2011 Edition. Unpublished report.

Natural Capital Analysis

The natural capital of each vegetation community was determined using a table in Costanza, et al.[35] 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. Calculating the natural capital provides a consistent way to compare wildlife areas and state parks as far as value. Even if you do not agree with the values, it still provides a relative measure of the areas.

[35] 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:** Nineteen vegetation communities and six land covers were found at Fenwick Island State Park. Beachgrass-Panicgrass Dune Grassland (69 acres) is the largest vegetation community, followed by Loblolly Pine Dune Woodland with 58 acres. Beach (52 acres) is the largest land cover, followed by water with 26 acres.

2. **Rare Plants:** Nine rare plants are known to exist in Fenwick Island State Park (Table 2.1).

Scientific Name	Common Name	Rank	Last Observed
Amaranthus pumilus	Seabeach Amaranth		?
Centella erecta	Erect Coinleaf		?
Dichanthelium dichotomum var. *roanokense*	Small-fruited Panic Grass		1993
Eryngium aquaticum var. *aquaticum*	Rattlesnake Master		2003
Eupatorium leucolepis	White-bract Thoroughwort		?
Fimbristylis caroliniana	Carolina Fimbry		?
Oenothera humifusa	Seabeach Primrose		?
Sabatia campanulata	Slender Marsh Pink		2003
Spiranthes vernalis	Twisted Ladies'-tresses		1992

Table 2.1 Rare Plants at Fenwick Island State Park

3. **Rare Animals:** Five rare animals are known to exist in Fenwick Island State Park (Table 2.2).

Scientific Name	Common Name	Rank	Last Observed
Chordeiles minor	Common Nighthawk	S2B	1996
Haematopus palliatus	American Oystercatcher	S1B	1997
Papaipema maritima	Maritime Sunflower Borer Moth	S1	?
Photuris bethaniensis	A Firefly	S1	1998
Sterna antillarum	Least Tern	S1B	1997

Table 2.2 Rare Animals at Fenwick Island State Park

Ecological Integrity Assessment (EIA)

Nine vegetation communities are ranked S2 or higher and are listed below (Table 2.3). These areas are mapped by tract in Figures

Middle Section EIAs (Figure 2.1)

The Middle Section contains seven EIA communities, Beachgrass-Panicgrass Dune Grassland, Central Coast Beach Heather Dune Shrubland, Chesapeake Bay Maritime Shrubland, Forked Rush Dune Swale, Loblolly Pine Dune Woodland, Mid-Atlantic Coast Backdune Grassland, and Wax-Myrtle Shrub Swamp.

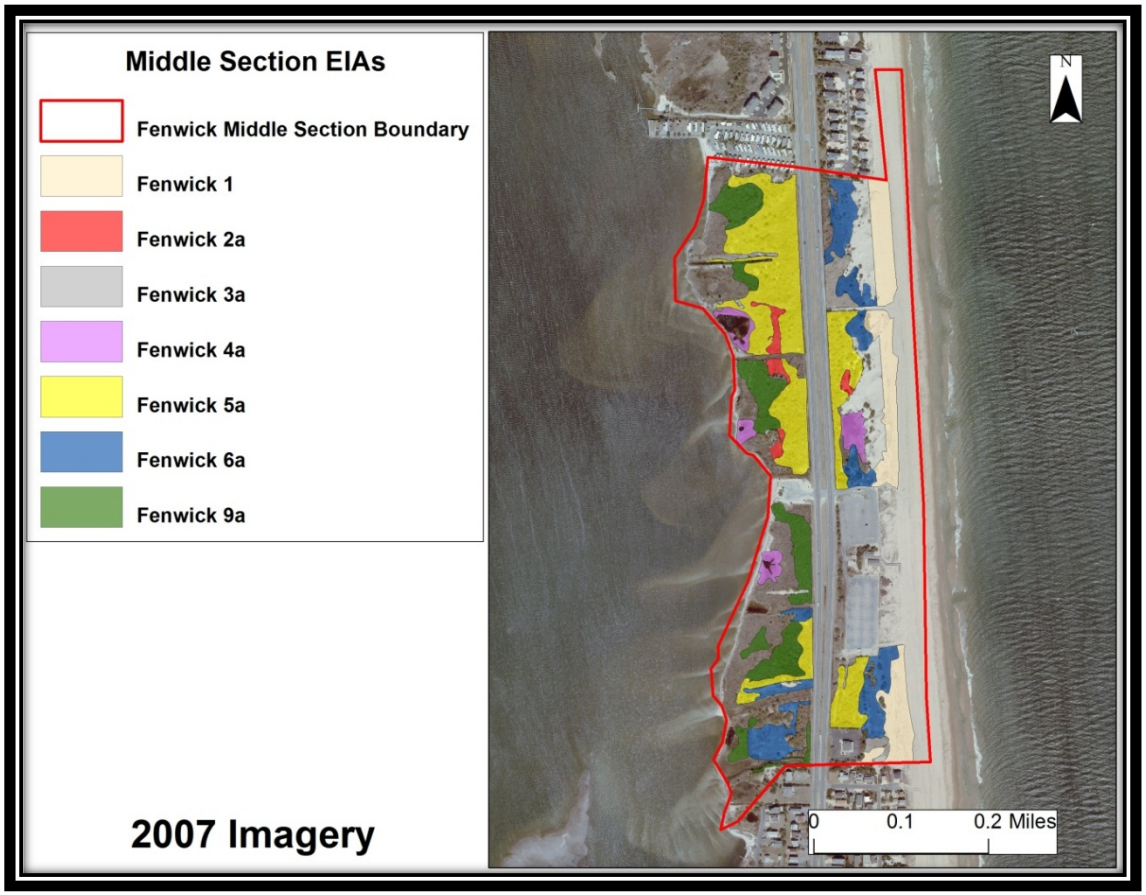


Figure 2.1. Middle Section EIA Communities

North Section EIAs (Figure 2.2)

The North Section contains nine EIA communities, Barrier Island Bog, Beachgrass-Panicgrass Dune Grassland, Central Coast Beach Heather Dune Shrubland, Chesapeake Bay Maritime Shrubland, Forked Rush Dune Swale, Loblolly Pine Dune Woodland, Mid-Atlantic Coast Backdune Grassland, Needlerush High Marsh, and Wax-Myrtle Shrub Swamp.

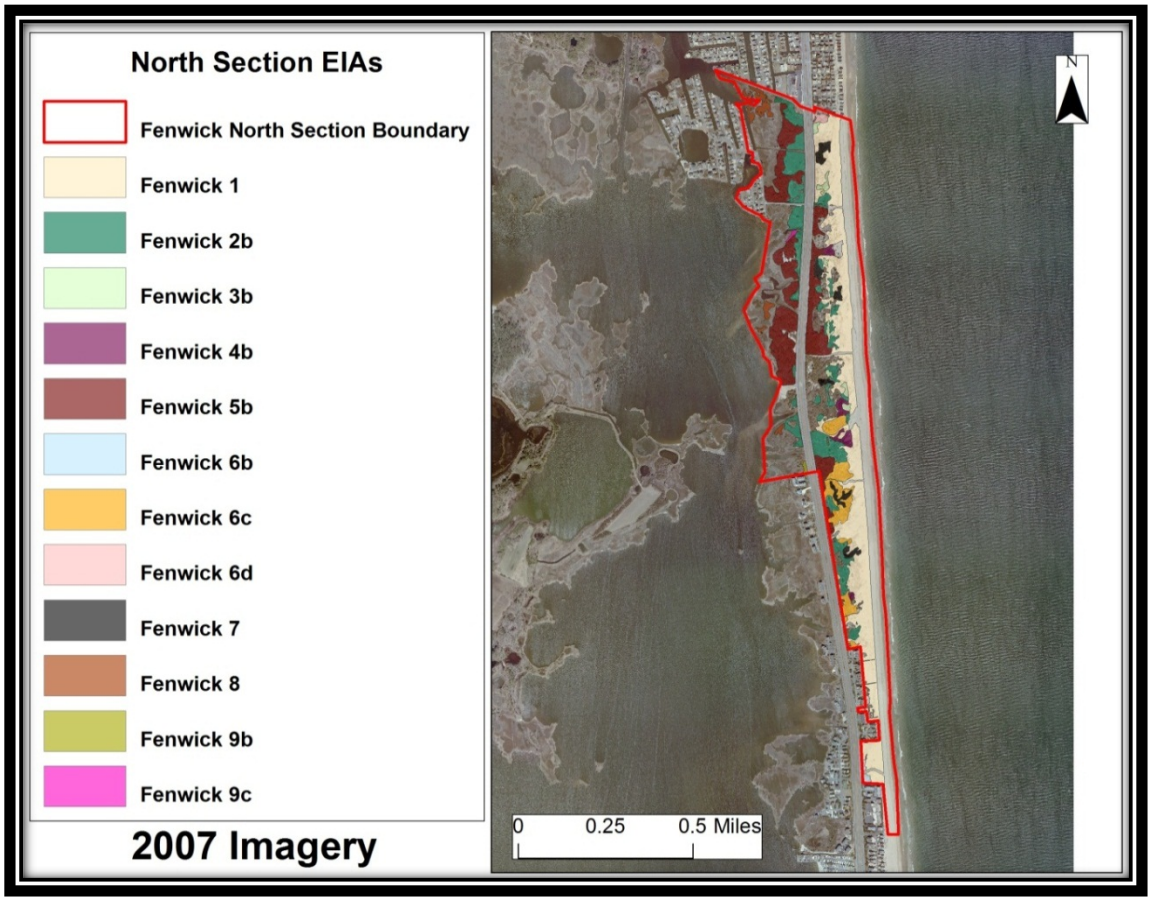
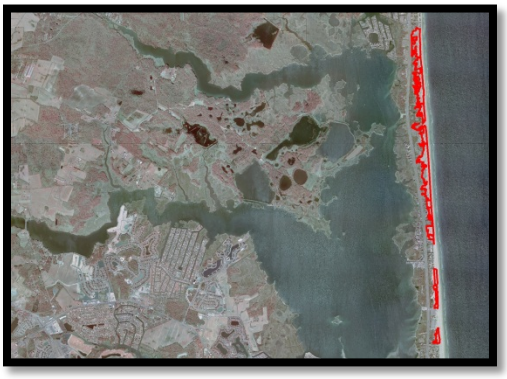
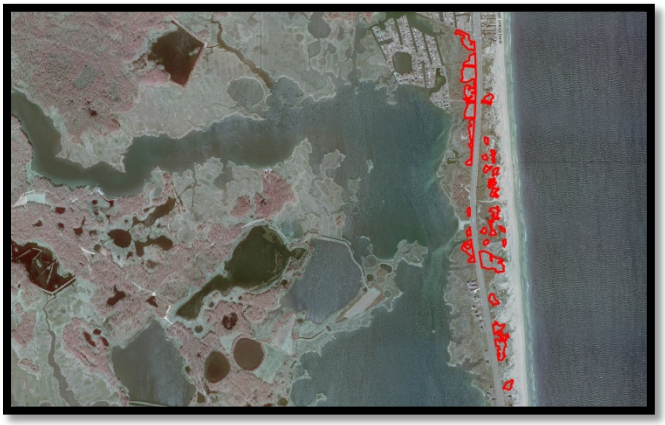


Figure 2.2. North Section EIA Communities

Table 2.3. EIA Vegetation Communities located in Fenwick Island State Park

Community Map	Community Name/EIA Score	Description
	**Fenwick 1** **Beachgrass-Panicgrass Dune Grassland (63.4 acres)** **EIA = 3.42 (C rank)**	This grassland is located on the tops of dunes between developed areas and the Atlantic Ocean.
	**Fenwick 2a** **Central Coast Beach Heather Dune Shrubland (1.02 acres)** **EIA = 3.82 (B rank)**	This dwarf shrubland is located west of DE 1 on sand hills in the marsh.
	**Fenwick 2b** **Central Coast Beach Heather Dune Shrubland (24.3 acres)** **EIA = 4.03 (B rank)**	This dwarf shrubland is located east and west of DE 1 in dune areas and sand hills.

Community Map	Community Name/EIA Score	Description
	**Fenwick 3a** **Chesapeake Bay Maritime Shrubland (1 acre)** **EIA = 3.36 (C rank)**	This maritime shrubland is located in the Fenwick Middle Section and is located between DE 1 and the Atlantic Ocean.
	**Fenwick 3b** **Chesapeake Bay Maritime Shrubland (2.2 acres)** **EIA = 4.03 (B rank)**	This maritime shrubland community is located on exposed dunes between DE 1 and the Atlantic Ocean.
	**Fenwick 4a** **Forked Rush Dune Swale (1.9 acres)** **EIA = 3.7 (B rank)**	Herbaceous dune swale community that is located in depressions on the coastal strand.
	**Fenwick 4b** **Forked Rush Dune Swale (2.4 acres)** **EIA = 4.36 (B rank)**	Herbaceous dune swale community that is located in depressions on the coastal strand.

Community Map	Community Name/EIA Score	Description
	**Fenwick 5a** **Loblolly Pine Dune Woodland (15 acres)** **EIA = 3.23 (C rank)**	This woodland community is located on areas of stable sand between Little Assawoman Bay and the Atlantic Ocean.
	**Fenwick 5b** **Loblolly Pine Dune Woodland (29.2 acres)** **EIA = 3.63 (B rank)**	This woodland community is located on areas of stable sand between Little Assawoman Bay and the Atlantic Ocean.
	**Fenwick 6a** **Mid-Atlantic Coast Backdune Grassland (6.8 acres)** **EIA = 3.9 (B rank)**	This grassland community is located on both the east and west sides of DE 1 behind the first line of dunes.
	**Fenwick 6b** **Mid-Atlantic Coast Backdune Grassland (0.5 acres)** **EIA = 3.36 (C rank)**	This grassland community is located between the first line of dunes and DE 1.

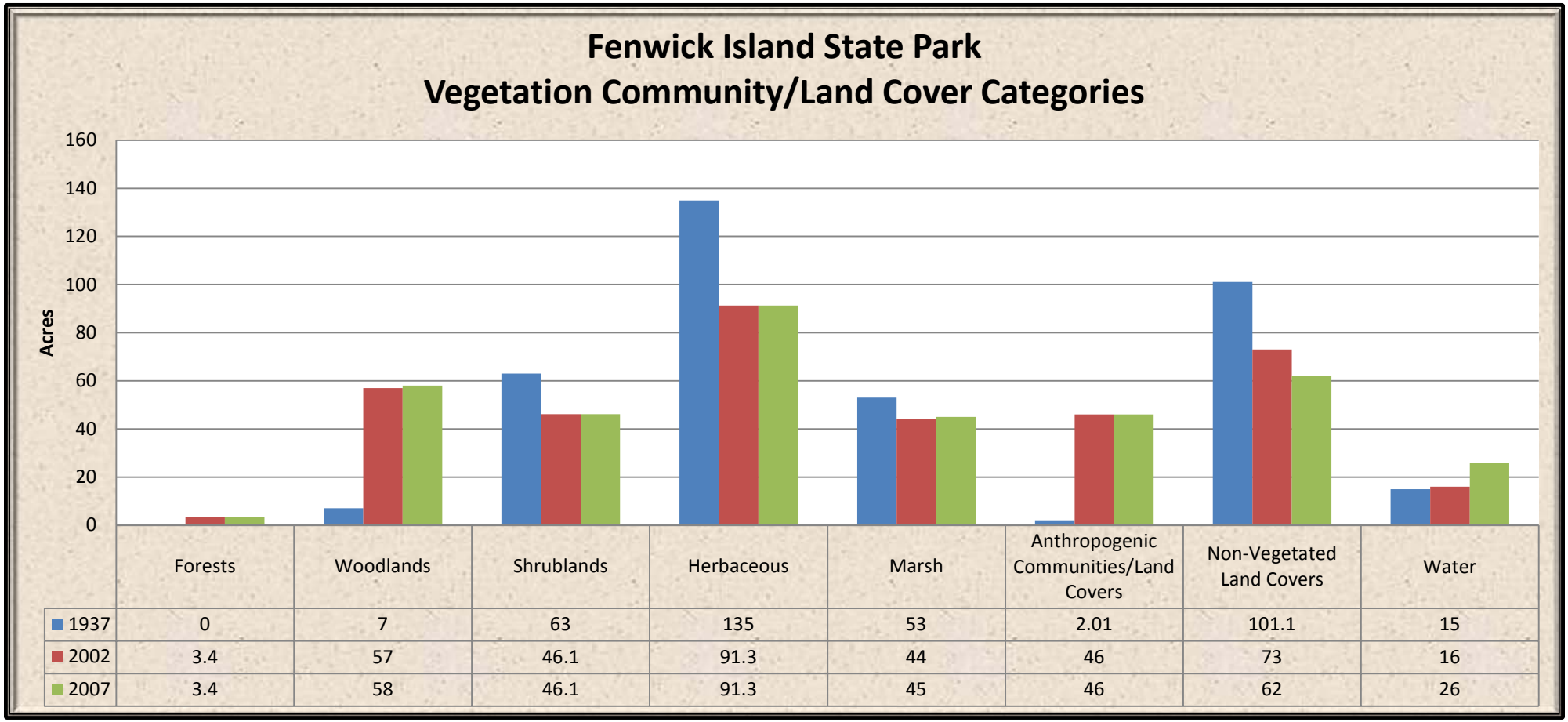
Community Map	Community Name/EIA Score	Description
	**Fenwick 6c** **Mid-Atlantic Coast Backdune Grassland (8.6 acres)** **EIA = 4.22 (B rank)**	This grassland community is located behind the first line of dunes and DE 1.
	**Fenwick 6d** **Mid-Atlantic Coast Backdune Grassland (0.6 acres)** **EIA = 3.62 (B rank)**	This grassland community is located behind the first line of dunes and DE 1.
	**Fenwick 7** **Barrier Island Bog (4.2 acres)** **EIA = 3.87 (B rank)**	This shrubland community is located in depressions between the first line of dunes and DE 1.

Community Map	Community Name/EIA Score	Description
	**Fenwick 8** **Needlerush High Marsh (3 acres)** **EIA = 3.87 (B rank)**	This high marsh community is located in marshland to the west of DE 1.
	**Fenwick 9a** **Wax-Myrtle Shrub Swamp (7.1 acres)** **EIA = 3.02 (C rank)**	This shrubland community is scattered throughout depressions west of DE 1.
	**Fenwick 9b** **Wax-Myrtle Shrub Swamp (0.3 acres)** **EIA = 2.83 (C rank)**	This shrubland community forms an edge west of DE 1.
	**Fenwick 9c** **Wax-Myrtle Shrub Swamp (0.2 acres)** **EIA = 2.88 (C rank)**	This shrubland is located at the edge of the marsh west of DE 1.

The Natural Progression of vegetation communities on the shores of the Inland Bays

Vegetation communities located adjacent to the shore of Delaware Bay or the Inland Bays go through 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.

At Fenwick Island State Park it was observed in places that the marsh is coming into the forested areas and appears to be largely skipping over the shrubland stage. Other areas of Coastal Loblolly Pine Wetland Forest are showing signs of salt stress. The amount of North Atlantic High Salt Marsh has decreased markedly from 1937 levels and has converted to North Atlantic Low Salt Marsh or water. Ditching in the marshes conducted in the early to middle part of the 20th century is helping to convert more marsh to water by acting as a direct injection mechanism into the marsh for high water events and for sea level rise.



	Forests	Woodlands	Shrublands	Herbaceous	Marsh	Anthropogenic Communities/Land Covers	Non-Vegetated Land Covers	Water
1937	0	7	63	135	53	2.01	101.1	15
2002	3.4	57	46.1	91.3	44	46	73	16
2007	3.4	58	46.1	91.3	45	46	62	26

Figure 3.1. Fenwick Island State Park Vegetation Categories/Land Covers (1937, 2002, and 2007)

Fenwick Island State Park Broad Trends (Figure 3.1): Most of Fenwick Island State Park is covered by herbaceous communities (Beachgrass-Panicgrass Dune Grassland) and non-vegetated land covers (Beach and Sand), most of which have declined from their acreages in 1937. Most of this decline is attributable to successional to woodland. Marshland is located on the bayside and sustained slight losses from 1937. Anthropogenic communities have greatly increased in area since 1937. A small amount of forest has entered into the park since 1937.

DNREC Sea Level Rise Analysis (Table 3.1)

A little more than 1/3 of the park will be inundated by 0.5 m of sea level rise. At 1 m of rise, more than ½ of the park will be flooded. About ¾ of the park will be inundated with 1.5 m of rise.

Table 3.1. Projected acres of Fenwick Island State Park Inundated by Sea Level Rise

Rise	Acres
0.5 m	138 acres
1 m	230 acres
1.5 m	282 acres

Natural Capital (Table 3.2)

Natural capital of Fenwick Island State Park is down from its high in 1937, but has started to increase from gains in water.

Table 3.2. Natural Capital of Fenwick Island State Park

Year	Natural Capital (in 2012 dollars)
1937	$818,460/year
2002	$589,224/year
2007	$609,256/year

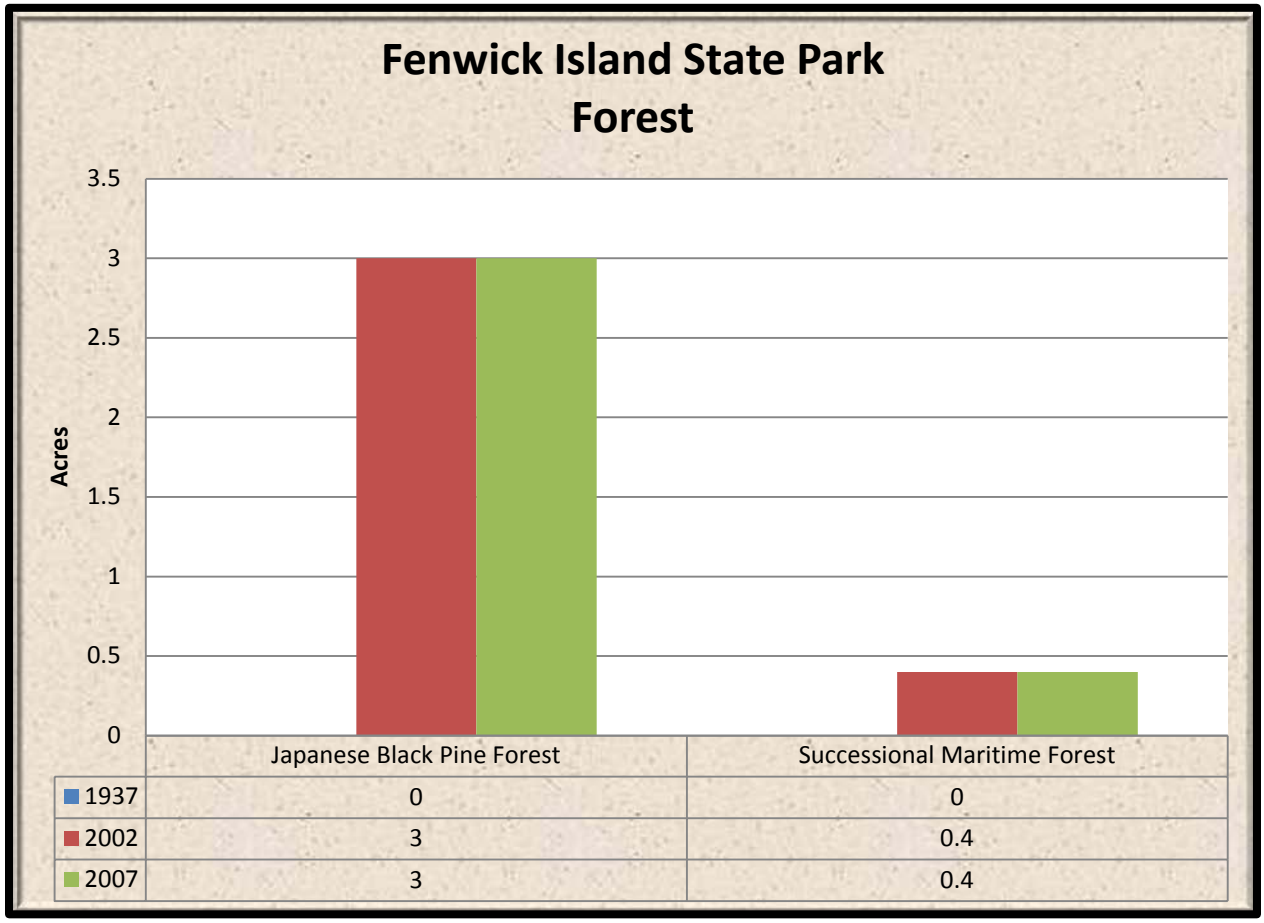


Figure 3.2. Forest at Fenwick Island State Park (1937, 2002, and 2007)

Fenwick Island State Park Forests (Figure 3.2): Japanese Black Pine Forest is the most common forest type and covers about three acres. A small amount of Successional Maritime Forest is located at the edge of the marsh on the bayside.

DNREC Sea Level Rise Analysis (Table 3.3)

Most of the forestland in Fenwick Island State Park would be inundated if the highest scenario of sea level rise happens.

Table 3.3. Projected acres of Fenwick Island State Park Forest Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	0.4 acres
1 m	1 acre
1.5 m	2 acres

Natural Capital (Table 3.4)

No forests were located in the north section in 1937. Since 1937 two forest communities, Japanese Black Pine Forest and Successional Maritime Forest, have grown into the tract and have increased the capital for the section and the park.

Table 3.4. Natural Capital of Fenwick Island State Park Forest	
Year	**Natural Capital (in 2012 dollars)**
1937	$0/year (not present)
2002	$643/year
2007	$643/year

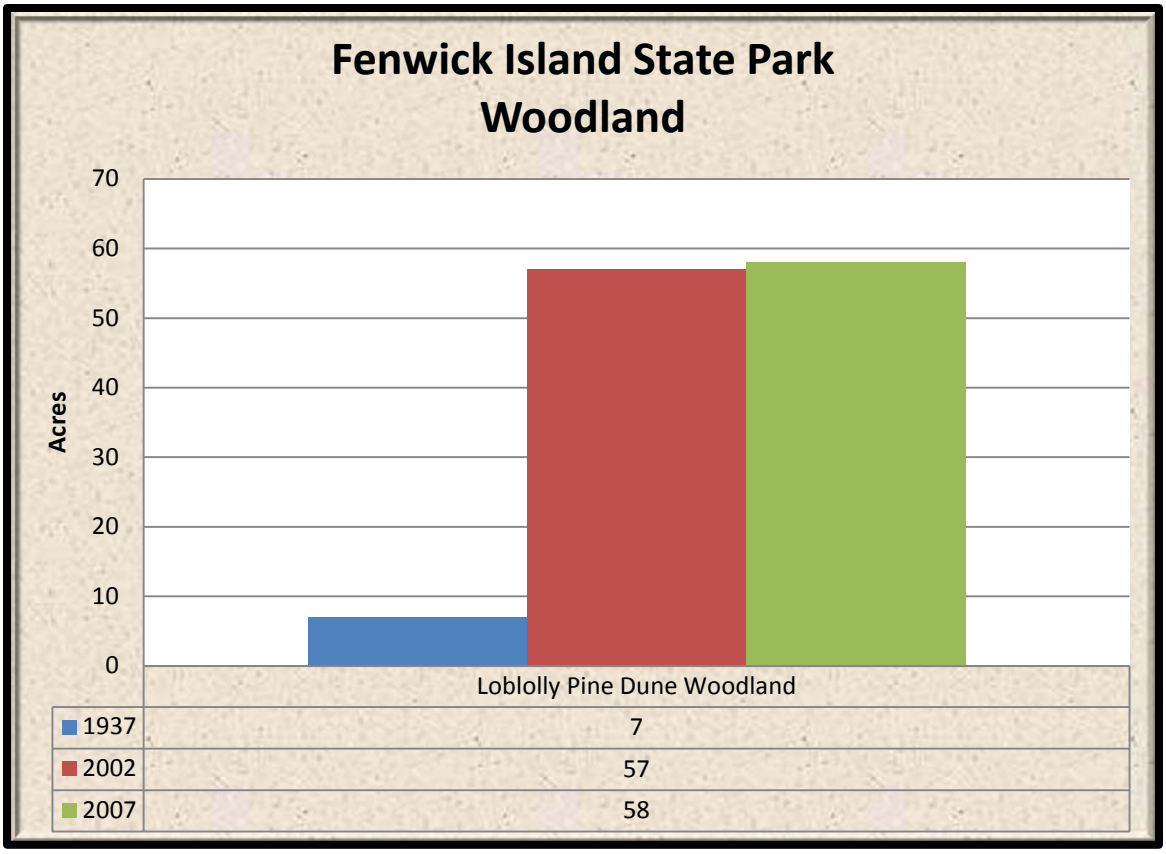


Figure 3.3. Woodland at Fenwick Island State Park (1937, 2002, and 2007)

Fenwick Island State Park Woodland (Figure 3.3): Loblolly Pine Dune Woodland is the only woodland present in Fenwick Island State Park. It has increased over time as it covers over former open areas and some of the grasslands in sheltered places.

DNREC Sea Level Rise Analysis (Table 3.5)

If the highest sea level rise scenario happens most of the woodland acreage in Fenwick Island State Park would be inundated.

Table 3.5. Projected acres of Fenwick Island State Park Woodland Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	28 acres
1 m	53 acres
1.5 m	56 acres

Natural Capital (Table 3.6)

The capital of woodland has been going up with increases in acreage.

Table 3.6. Natural Capital of Fenwick Island State Park Woodland	
Year	**Natural Capital (in 2012 dollars)**
1937	$1,324/year
2002	$10,779/year
2007	$10,968/year

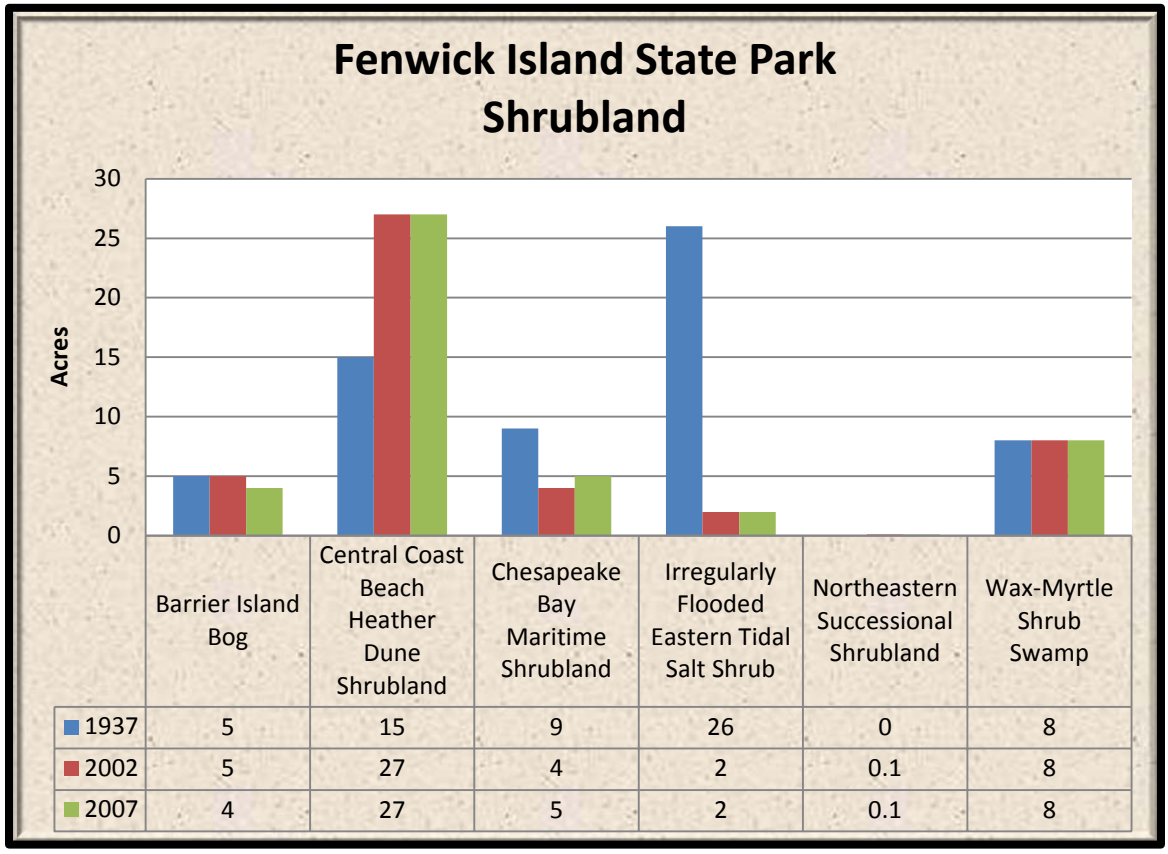


Figure 3.4. Shrubland at Fenwick Island State Park (1937, 2002, and 2007)

Fenwick Island State Park Shrubland (Figure 3.4): Central Coast Beach Heather Dune Shrubland is the most common shrubland in the park and has increased over time as the dunes have stabilized from development. Irregularly Flooded Eastern Tidal Salt Shrub which was once prominent in the park with 26 acres has declined to 2 acres. Chesapeake Bay Maritime Shrubland has declined slightly and Wax-Myrtle Shrub Swamp and Barrier Island Bog have remained at essentially the same amount.

DNREC Sea Level Rise Analysis (Table 3.7)

More than ¾ of the shrubland present at Fenwick Island State Park will be inundated with 1.5 m of sea level rise.

Table 3.7. Projected acres of Fenwick Island State Park Shrubland Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	13 acres
1 m	27 acres
1.5 m	38 acres

Natural Capital (Table 3.8)

Shrubland has lost a lot of capital to marshland due to losses in Irregularly Flooded Eastern Tidal Salt Shrub. The amount has been stable in the recent period (2002-2007).

Table 3.8. Natural Capital of Fenwick Island State Park Shrubland	
Year	**Natural Capital (in 2012 dollars)**
1937	$168,445/year
2002	$18,968/year
2007	$18,968/year

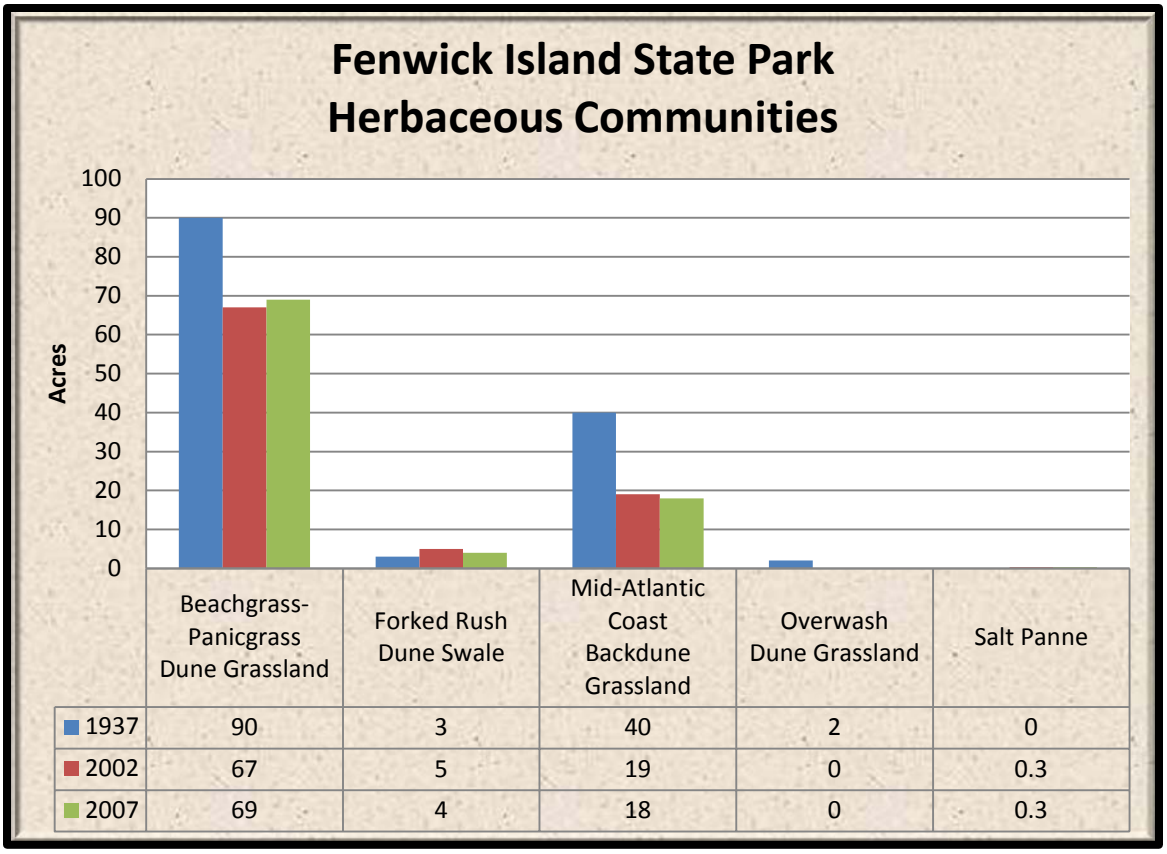


Figure 3.5. Herbaceous Communities at Fenwick Island State Park (1937, 2002, and 2007)

Fenwick Island State Park Herbaceous Communities (Figure 3.5): Beachgrass-Panicgrass Dune Grassland is the most common grassland in the park followed by Mid-Atlantic Coast Backdune Grassland. Both of these communities have declined from their amounts in 1937.

DNREC Sea Level Rise Analysis (Table 3.9)

About 1/3 of the herbaceous communities at Fenwick Island State Park will be inundated with 1.5 m of sea level rise. The smallest amount, 0.5 m, will only flood 5 acres.

Table 3.9. Projected acres of Fenwick Island State Park Herbaceous Communities Inundated by Sea Level Rise

Rise	Acres
0.5 m	5 acres
1 m	17 acres
1.5 m	31 acres

Natural Capital (Table 3.10)

Capital for herbaceous communities has decreased from losses in the dune grasslands over time. A lot of these losses were from development.

Table 3.10. Natural Capital of Fenwick Island State Park Herbaceous Communities	
Year	**Natural Capital (in 2012 dollars)**
1937	$19,670/year
2002	$15,140/year
2007	$15,140/year

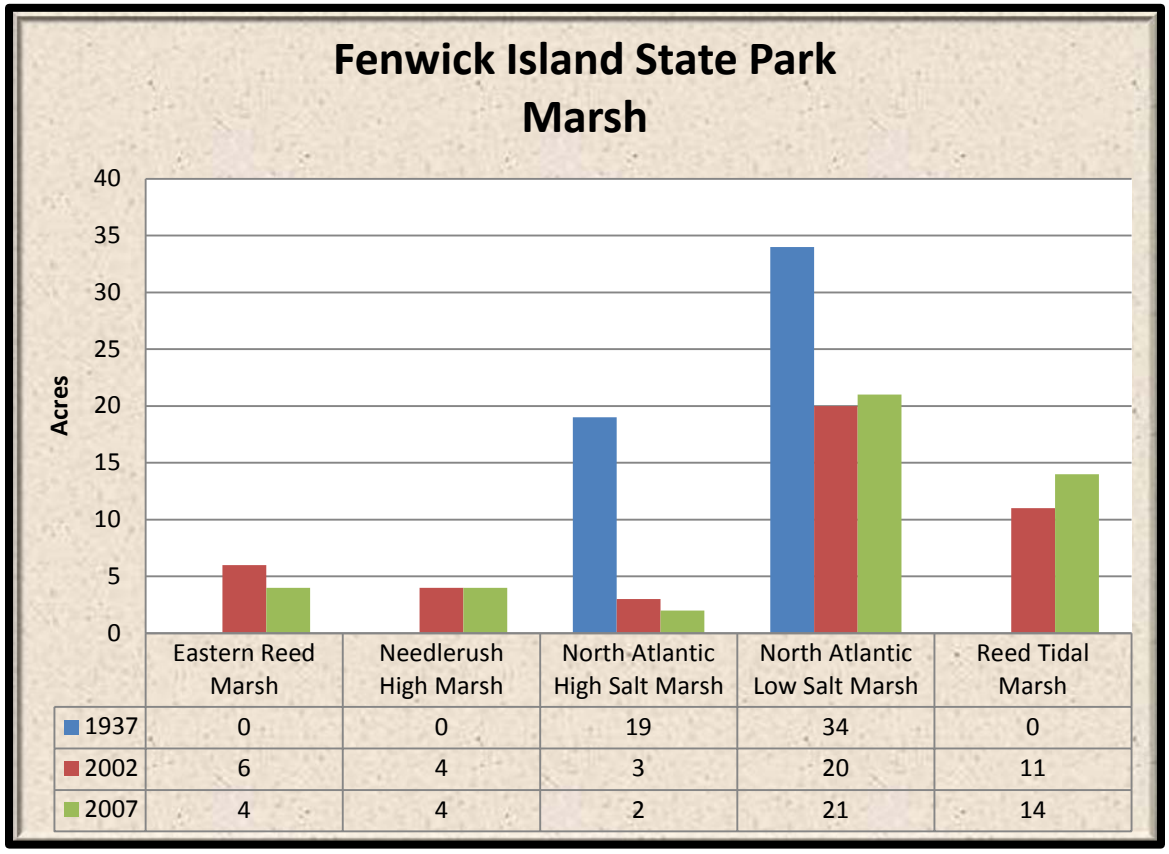


FIgure 3.7. Marsh at Fenwick Island State Park (1937, 2002, and 2007)

Fenwick Island State Park Marsh (Figure 3.7): North Atlantic Low Salt Marsh is the most prominent marsh type in the park, followed by Reed Tidal Marsh. North Atlantic High Salt Marsh was once prominent in the park but has declined through time and may no longer be present in the park. Needlerush High Marsh has come into the park since 1937 along with Eastern Reed Marsh and Reed Tidal Marsh.

DNREC Sea Level Rise Analysis (Table 3.11)

All of the tidal marsh acreage will be inundated with 0.5 m of sea level rise. An additional 0.5 m of rise will inundate the rest of the marshland.

Table 3.11. Projected acres of Fenwick Island State Park Marsh Inundated by Sea Level Rise

Rise	Acres
0.5 m	42 acres
1 m	45 acres
1.5 m	45 acres

Natural Capital (Table 3.12)

Capital of marshland has been declining because of losses in North Atlantic High Salt Marsh.

Table 3.12. Natural Capital of Fenwick Island State Park Marsh	
Year	**Natural Capital (in 2012 dollars)**
1937	$332,379/year
2002	$293,997/year
2007	$294,249/year

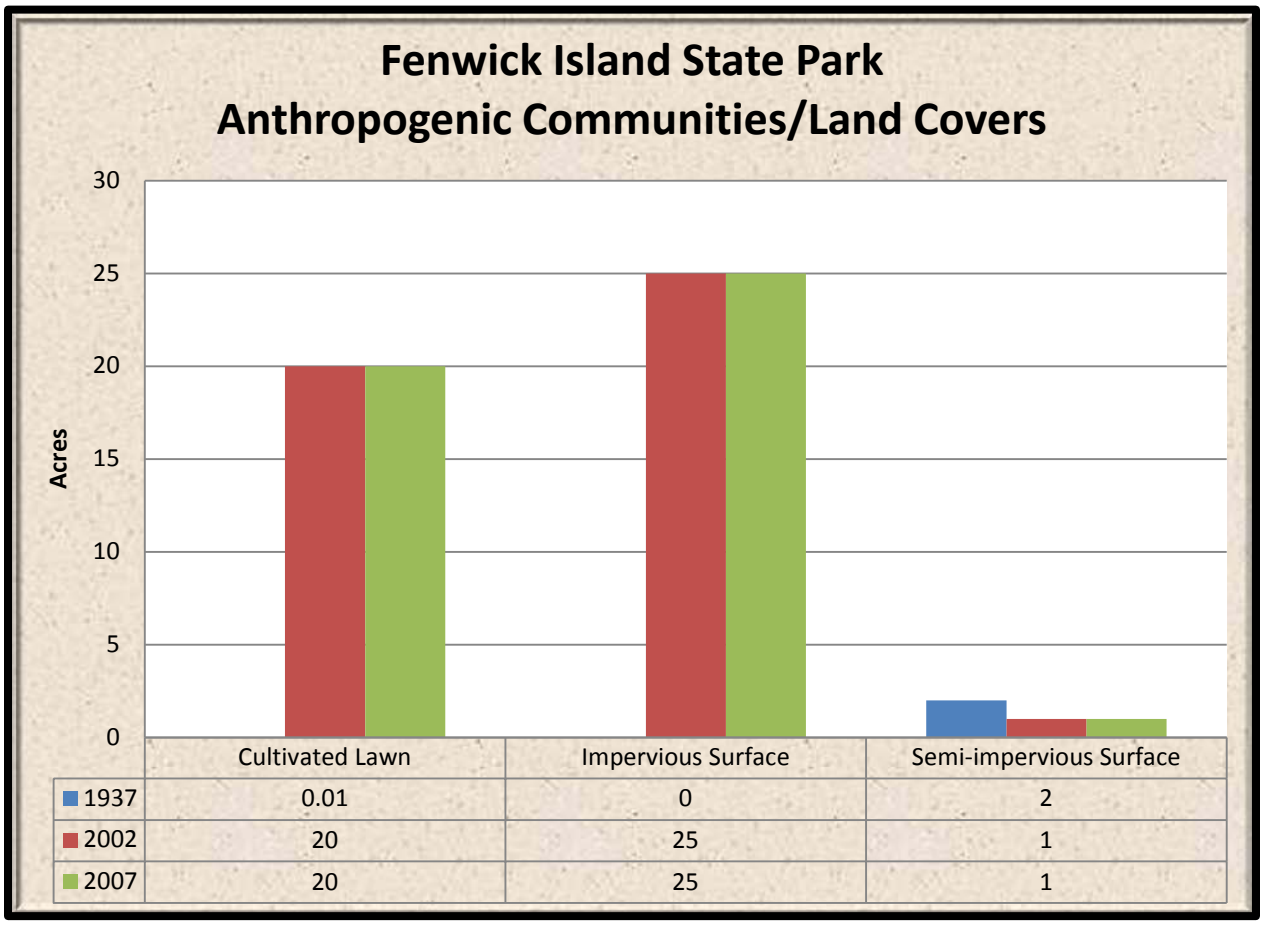


FIgure 3.8. Anthropogenic Communities/Land Covers at Fenwick Island State Park (1937, 2002, and 2007)

Fenwick Island State Park Anthropogenic Communities/Land Covers (Figure 3.8):
Anthropogenic communities/land covers have greatly increased from 1937 and have been stable in amount in the recent period (2002-2007). It is expected to remain this way in the short-term future.

DNREC Sea Level Rise Analysis (Table 3.14)

All of the anthropogenic communities/land covers will be inundated with 1.5 m of sea level rise, including DE 1. Because of this there will be external cost other than costs of the loss of ecosystem services. Once the estuary joins with the Atlantic Ocean the value of the estuary will drop greatly.

Table 3.14. Projected acres of Fenwick Island State Park Anthropogenic Communities/Land Covers Inundated by Sea Level Rise

Rise	Acres
0.5 m	10 acres
1 m	40 acres
1.5 m	46 acres

Natural Capital

None of the Anthropogenic communities/land covers have any capital value.

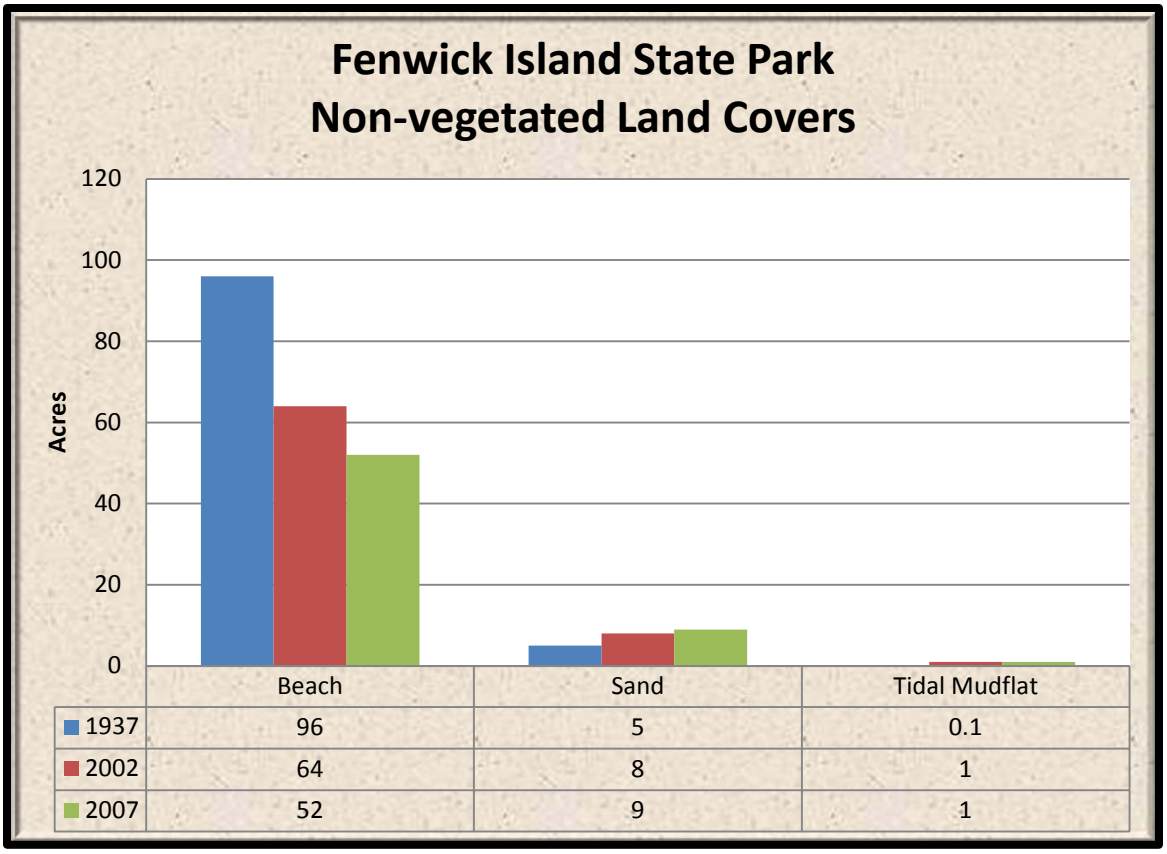


Figure 3.9. Non-vegetated Land Covers at Fenwick Island State Park (1937, 2002, and 2007)

Fenwick Island State Park Non-vegetated Land Covers (Figure 3.9): Beach acreage has been decreasing over time and development prevents the landward migration of the beach. Sand has increased somewhat but not enough to make for the beach losses.

DNREC Sea Level Rise Analysis (Table 3.15)

Non-vegetated communities will be moderately affected by sea level rise but will likely migrate landward with it. A little less than ¾ of the acreage will be inundated with 1.5 m of sea level rise.

Table 3.15. Projected acres of Fenwick Island State Park Non-vegetated communities Inundated by Sea Level Rise

Rise	Acres
0.5 m	15 acres
1 m	27 acres
1.5 m	43 acres

Natural Capital (Table 3.16)

Non-vegetated land covers in Fenwick Island State Park have been going up with increasing acreage in tidal mudflats.

Table 3.16. Natural Capital of Fenwick Island State Park Non-vegetated Communities	
Year	**Natural Capital (in 2012 dollars)**
1937	$627/year
2002	$6,271/year
2007	$6,271/year

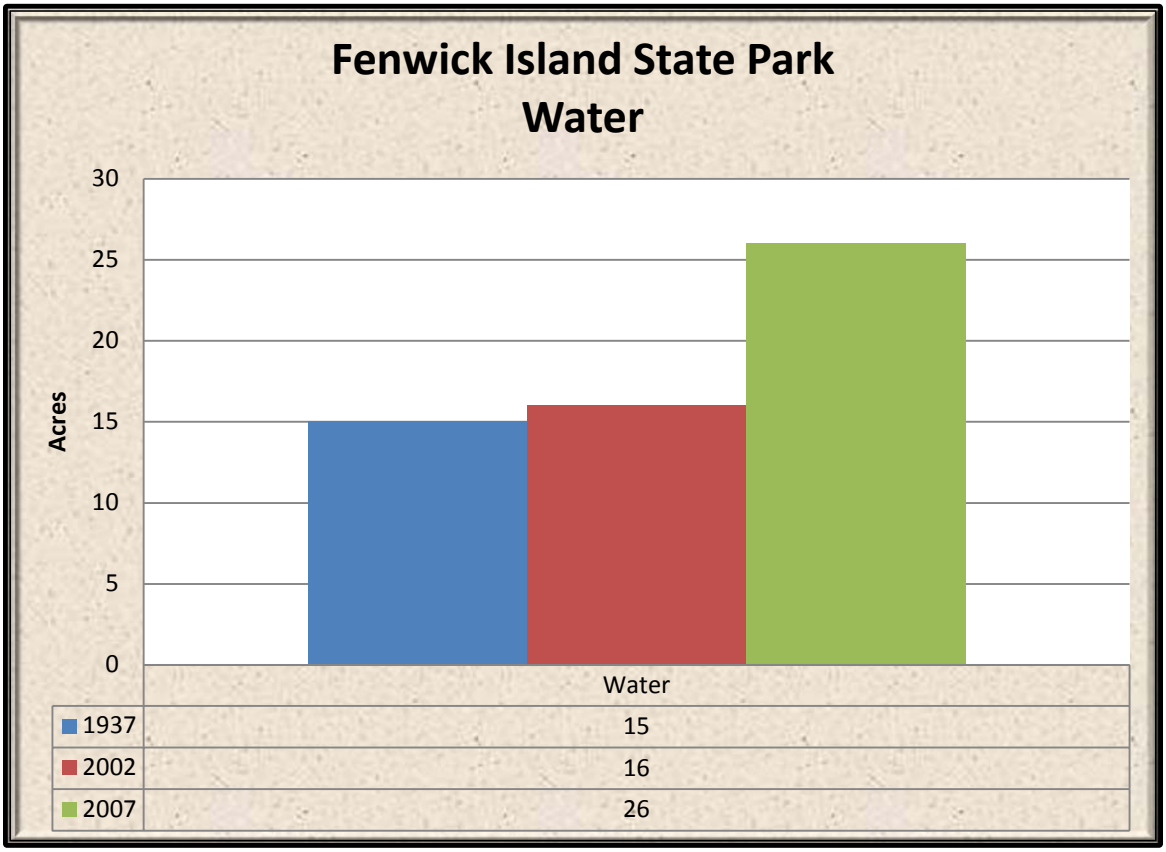


Figure 3.10. Water coverage (non-impoundment) at Fenwick Island State Park (1937, 2002, and 2007)

Fenwick Island State Park Water (Figure 3.10): Water coverage has been steadily increasing over time. The increases are expected to continue into the future and at a greater rate.

Natural Capital

Capital of water is down overall since 1937, but has been increasing recently with sea level rise and erosion.

Table 3.17. Natural Capital of Fenwick Island State Park Water	
Year	**Natural Capital (in 2012 dollars)**
1937	$214,993/year
2002	$186,801/year
2007	$188,382/year

CHAPTER 4: VEGETATION COMMUNITIES BY SECTION

1. South Section

Figure 4-1.1. 2007 Vegetation Community map of Fenwick Island S.P. South Section

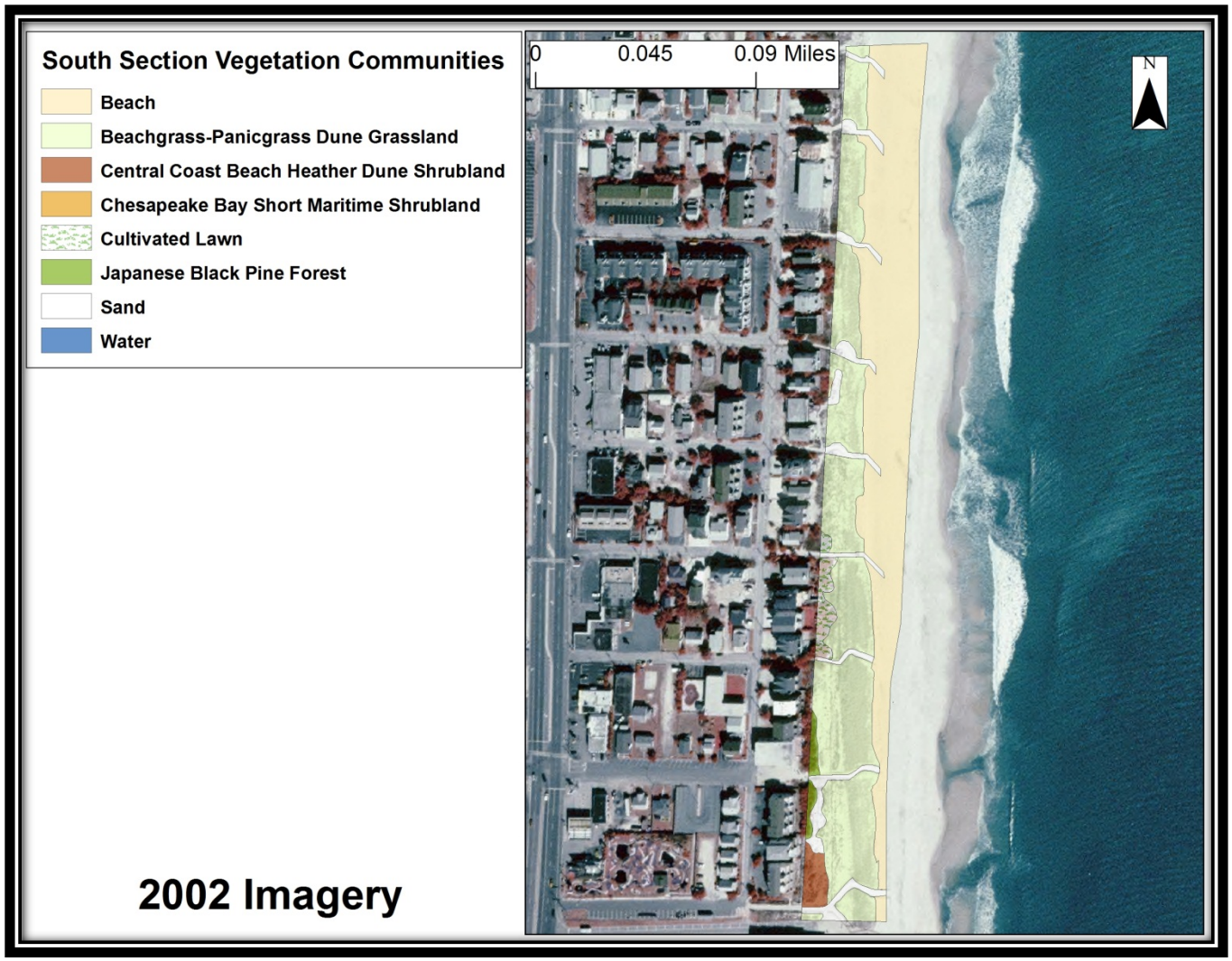


Figure 4-1.2. 2002 Vegetation Community map of Fenwick Island S.P. South Section

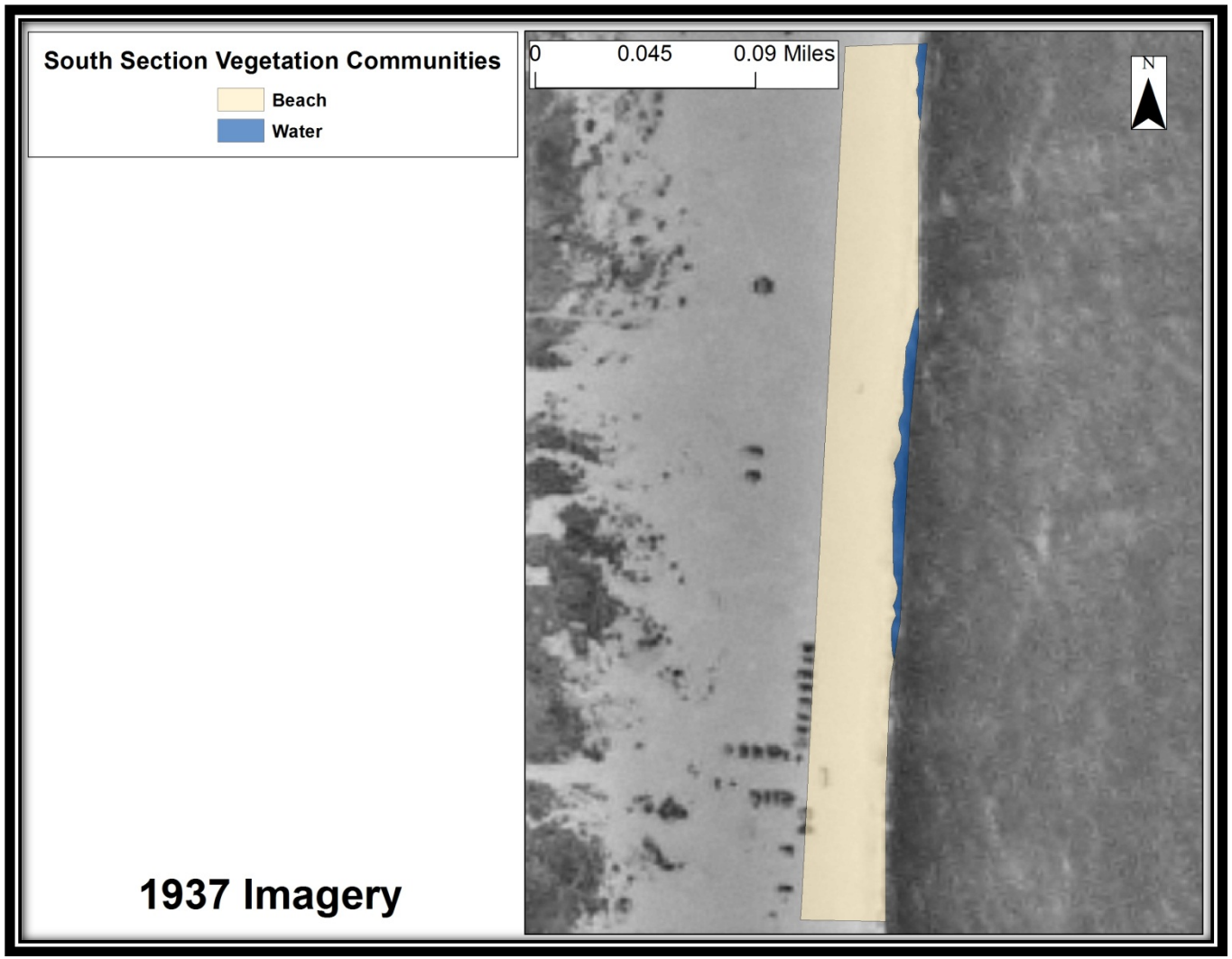


Figure 4-1.3. 1937 Vegetation Community map of Fenwick Island S.P. South Section

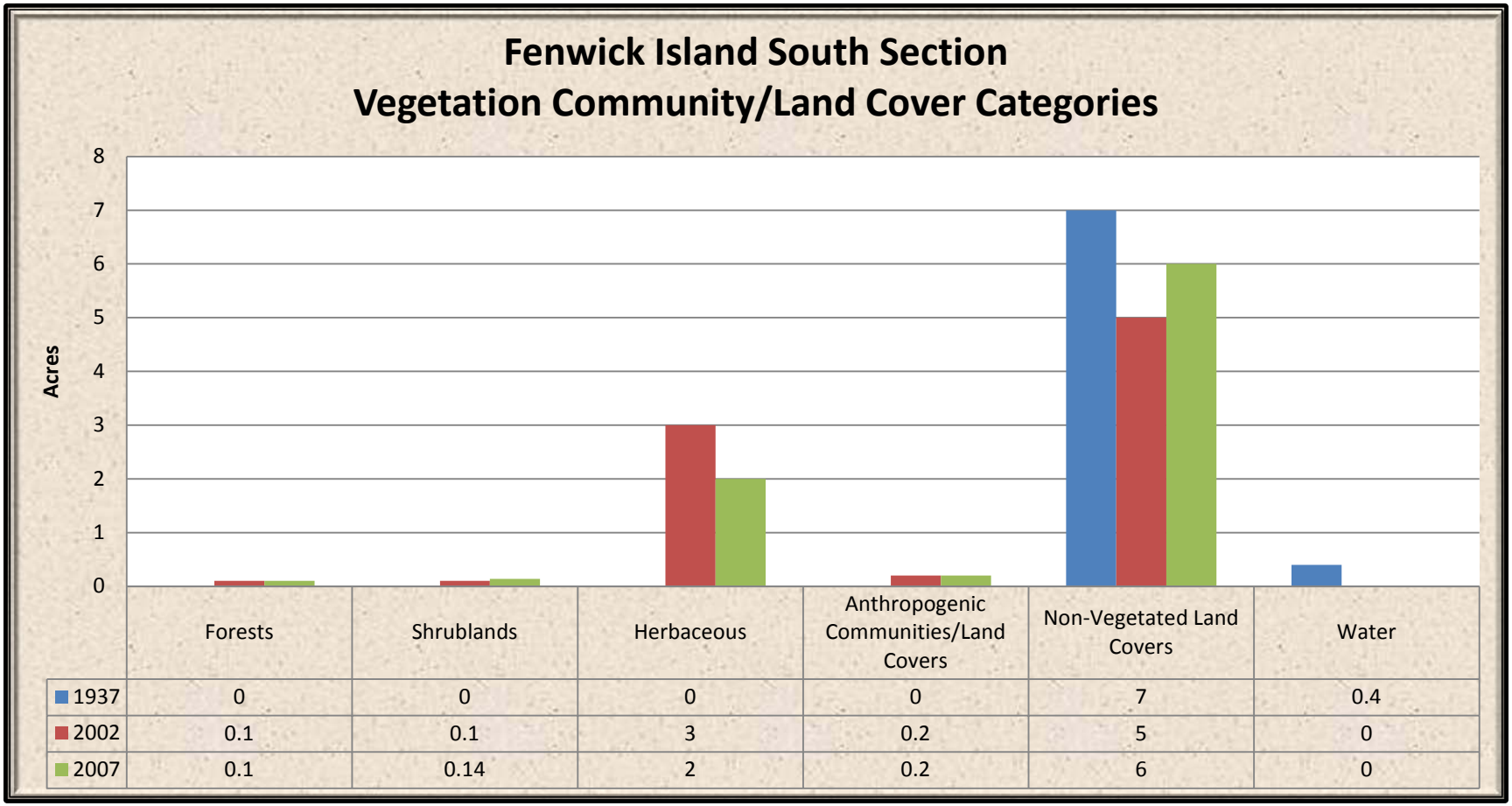


Figure 4-1.4. South Section Vegetation Categories/Land Covers (1937, 2002, and 2007)

South Section Broad Trends (Figure 4-1.4): The south section is mainly and access point to the beach at the stateline of Delaware with Maryland. Beach is the primary land cover in this section which is declining with erosion.

DNREC Sea Level Rise Analysis (Table 4-1.1)

The beaches of the Fenwick Island Tract are built and re-nourished and have a steep profile. The sea level rise analysis shows this with only 0.01 acres being affected with 0.5 m of sea level rise. At 1 m of rise, 0.4 acres will be inundated and at 1.5 m 1 acre will be flooded.

Table 4-1.1. Projected acres of the South Section Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	0.01 acres
1 m	0.4 acres
1.5 m	1 acre

Natural Capital (Table 4-1.2)

The South Section does not have much capital value. The value peaked in 2002 and has declined since.

Table 4-1.2. Natural Capital of the South Section	
Year	**Natural Capital (in 2012 dollars)**
1937	$63/year
2002	$471/year
2007	$325/year

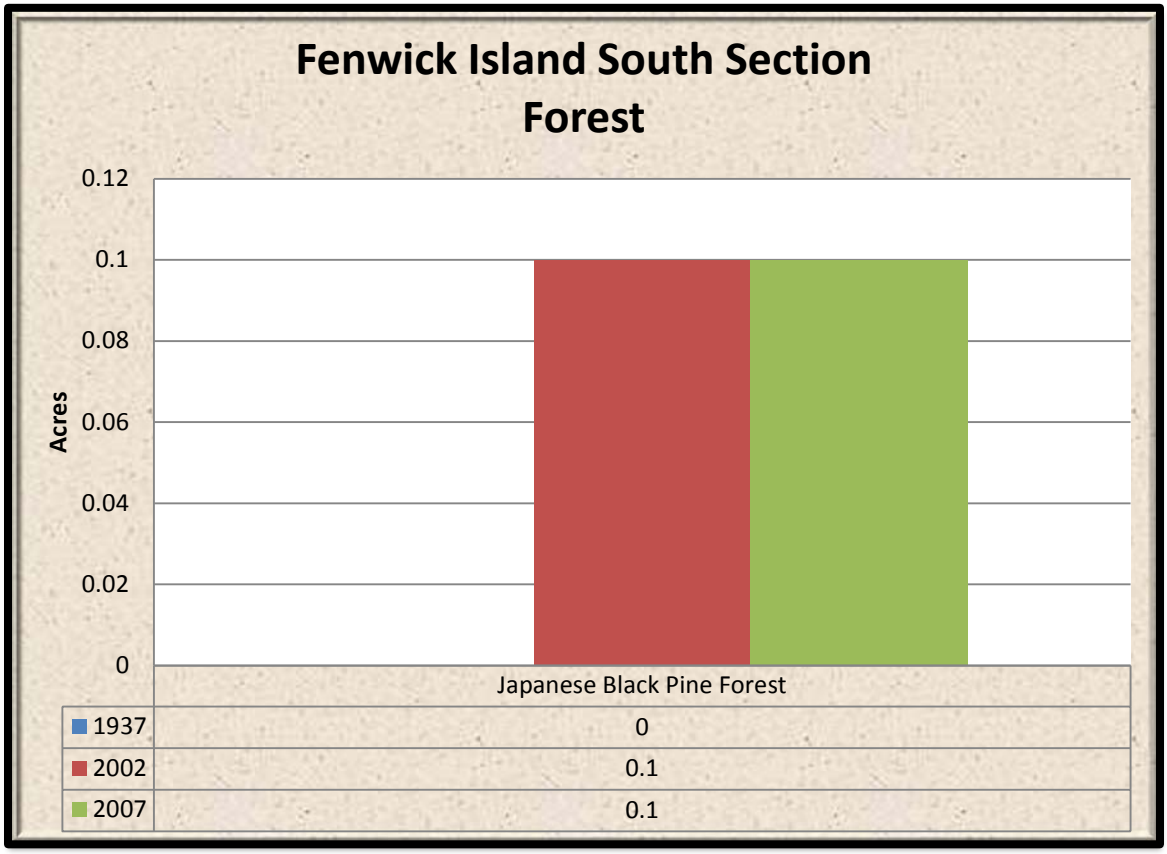


Figure 4-1.5. South Section Forest (1937, 2002, and 2007)

South Section Forest (Figure 4-1.5): A small area of forest is located within the south section and is composed of Japanese Black Pine (*Pinus thunbergiana*).

DNREC Sea Level Rise Analysis (Table 4-1.3)

None of the Japanese Black Pine Forests will be affected by the current sea level rise scenarios.

Table 4-1.3. Projected acres of South Section Forests Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	0 acres
1 m	0 acres
1.5 m	0 acres

Natural Capital (Table 4-1.4)

The forest area in the South Section accounts for $19.00/yr of capital value. The one forest here was not present in 1937.

Table 4-1.4. Natural Capital of South Section Forests	
Year	**Natural Capital (in 2012 dollars)**
1937	$0/year (not present)
2002	$19/year
2007	$19/year

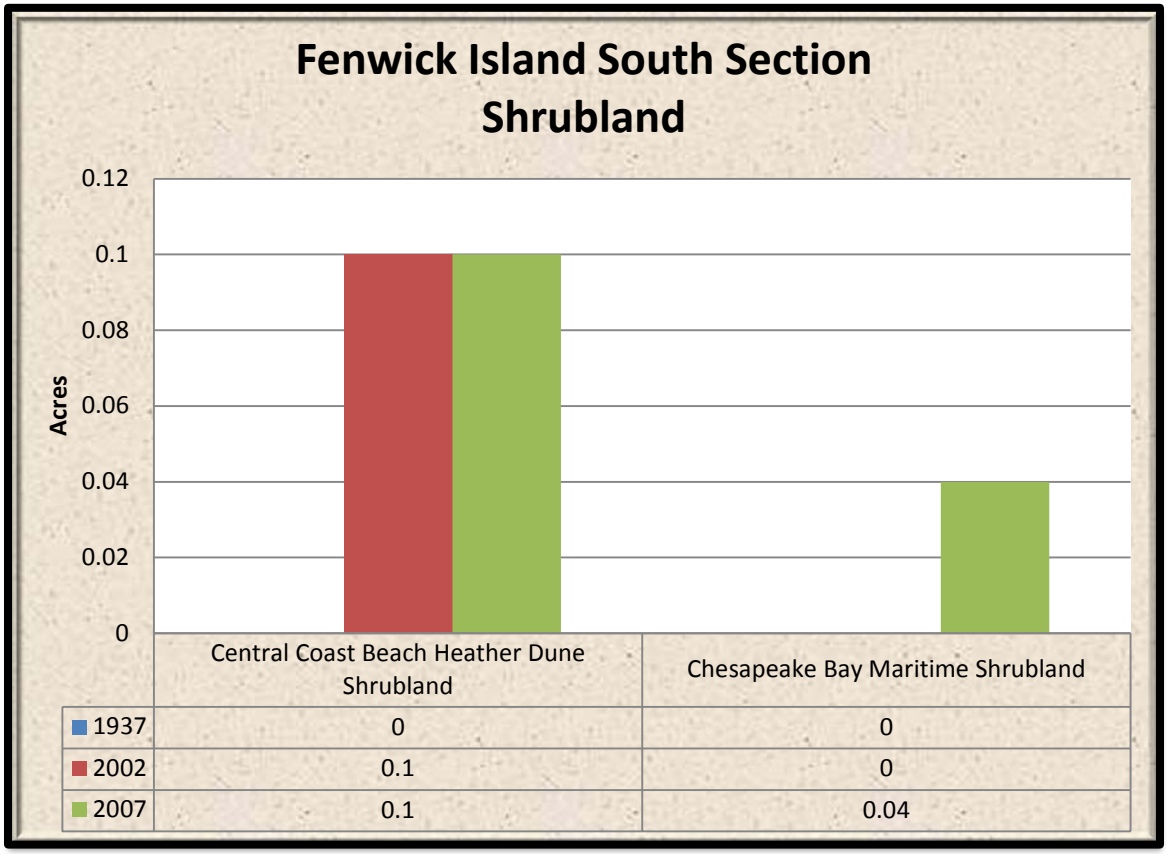


Figure 4-1.6. South Section Shrubland (1937, 2002, and 2007)

South Section Shrubland (Figure 4-1.6): A small amount of Central Coast Beach Heather Dune Shrubland is located on some of the dunes in the south section. There is no trend up or down for any of the shrublands.

DNREC Sea Level Rise Analysis (Table 4-1.5)

The beaches of the Fenwick Island Tract are built and re-nourished and have a steep profile. The sea level rise analysis shows this with only 0.01 acres being affected with 0.5 m of sea level rise. At 1 m of rise, 0.4 acres will be inundated and at 1.5 m 1 acre will be flooded.

Table 4-1.5. Projected acres of South Section Shrubland Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	0 acres
1 m	0 acres
1.5 m	0 acres

Natural Capital (Table 4-1.6)

Shrublands were not present in this section in 1937. Since this time a small amount of shrubland has appeared in the South Section.

Table 4-1.6. Natural Capital of South Section Shrubland	
Year	**Natural Capital (in 2012 dollars)**
1937	$0/year
2002	$15/year
2007	$20/year

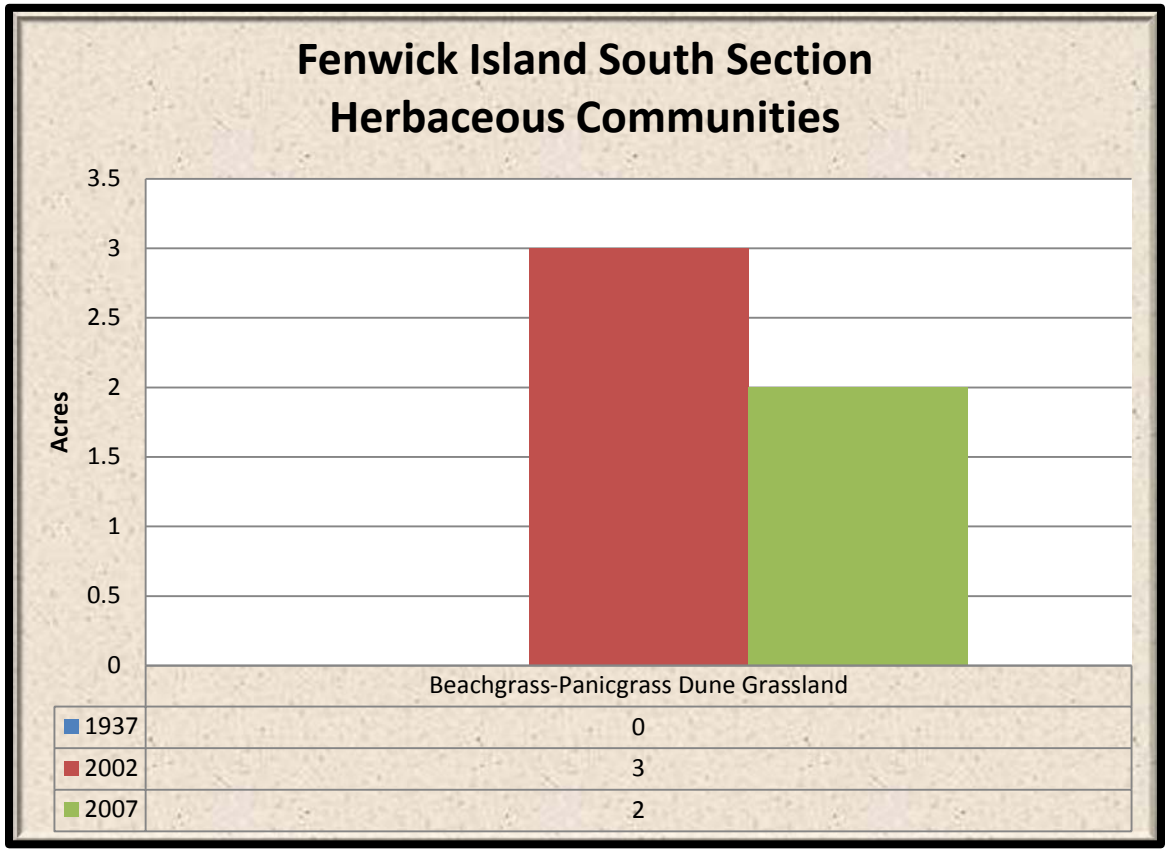


Figure 4-1.7. South Section Herbaceous Communities (1937, 2002, and 2007)

South Section Herbaceous Communities (Figure 4-1.7): Most of the dune areas in the south section are covered by Beachgrass-Panicgrass Dune Grassland. From 2002 to 2007 they declined presumably from erosion.

DNREC Sea Level Rise Analysis (Table 4-1.7)

None of the herbaceous communities in the South Section will be impacted by the current sea level rise scenarios.

Table 4-1.7. Projected acres of South Section Herbaceous Communities Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	0 acres
1 m	0 acres
1.5 m	0 acres

Natural Capital (Table 4-1.8)

Natural capital of herbaceous communities in the South Section peaked in 2002 and has declined since then. These communities were not present in 1937.

Table 4-1.8. Natural Capital of South Section Herbaceous Communities	
Year	**Natural Capital (in 2012 dollars)**
1937	$0/year (not present)
2002	$437/year
2007	$291/year

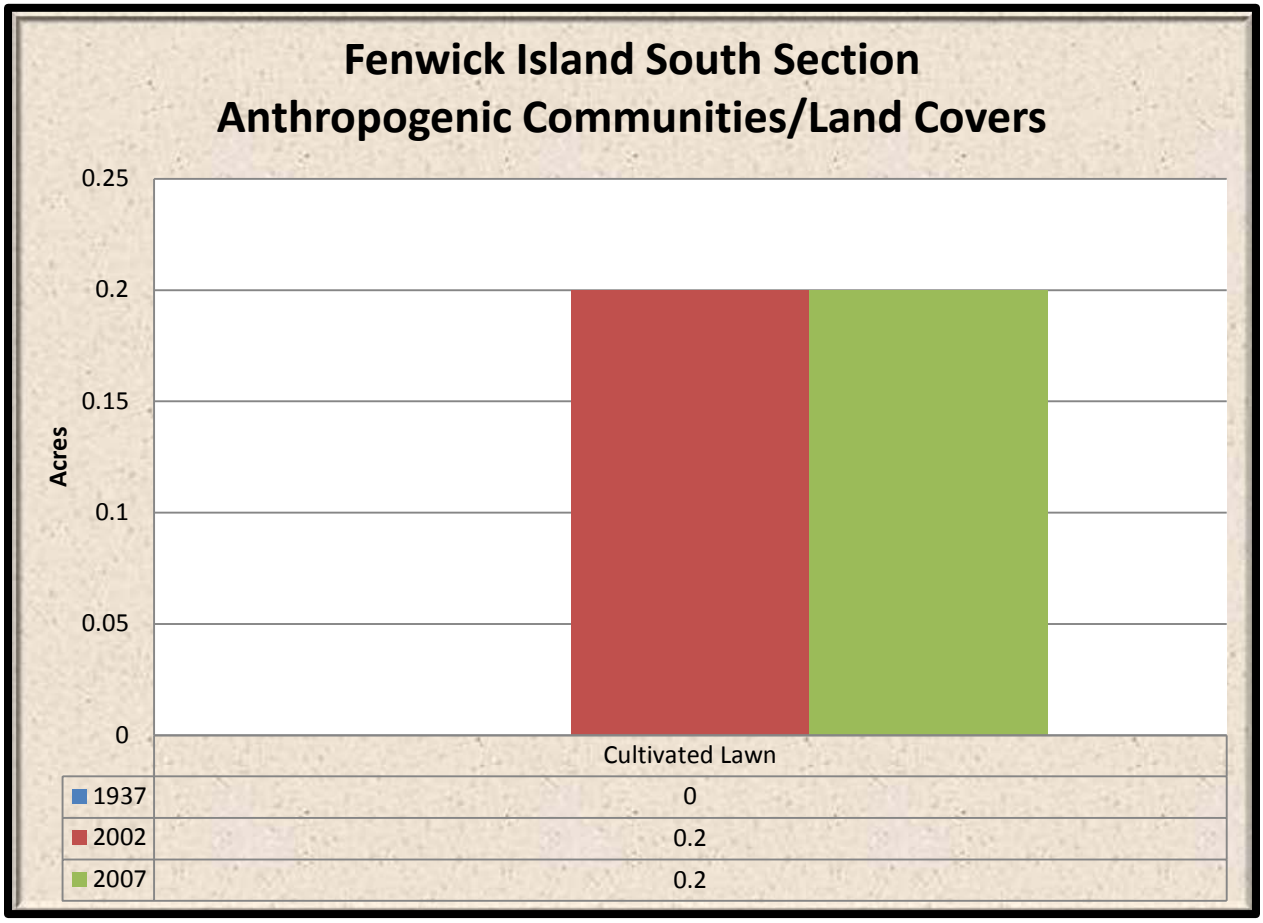


Figure 4-1.8. South Section Anthropogenic Communities/Land Covers (1937, 2002, and 2007)

South Section Anthropogenic Communities (Figure 4-1.8): A small amount of cultivated lawn is located around development to the west of the dunes.

DNREC Sea Level Rise Analysis (Table 4-1.9)

None of the anthropogenic communities/land covers in the South Section will be impacted by the current sea level rise scenarios.

Table 4-1.1. Projected acres of the South Section Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	0 acres
1 m	0 acres
1.5 m	0 acres

Natural Capital

Cultivated Lawn does not carry any capital value.

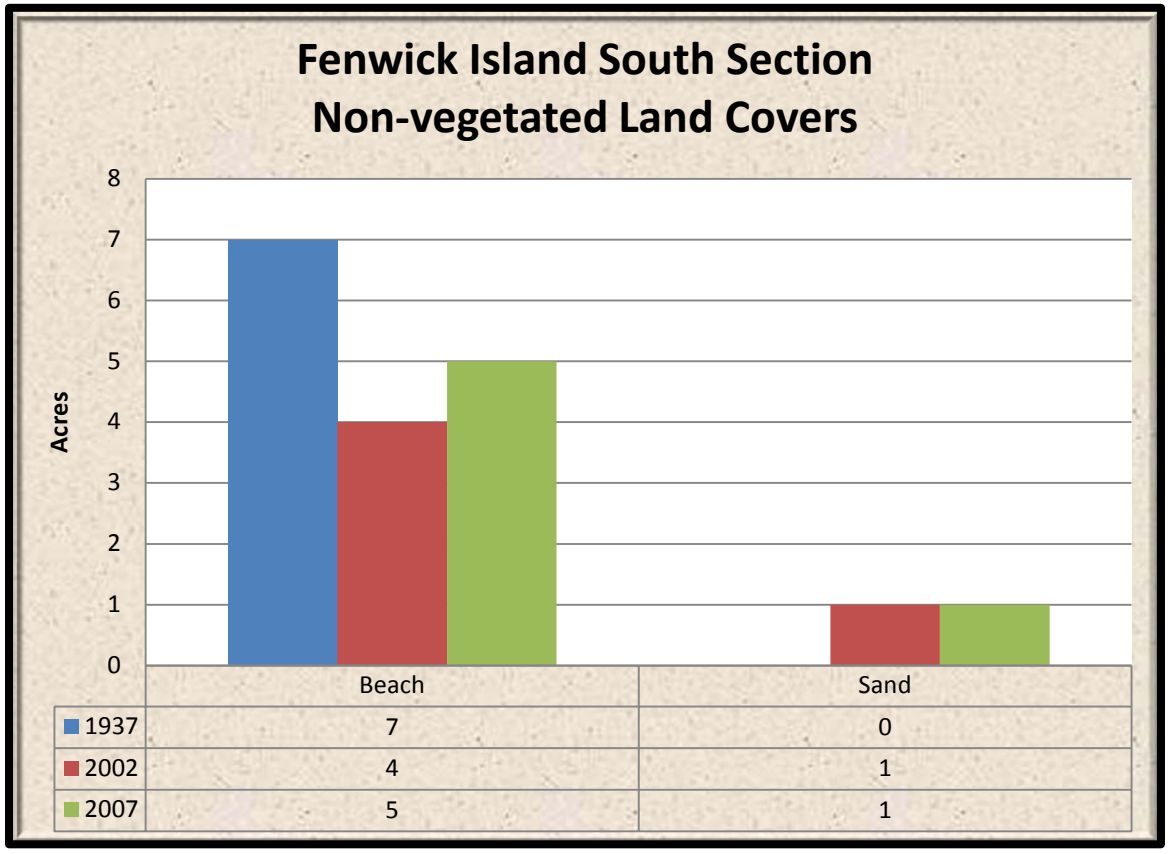


Figure 4-1.9. South Section Non-vegetated Land Covers (1937, 2002, and 2007)

South Section Non-vegetated Land Covers (Figure 4-1.9): Beach is the primary land cover in the south section. It has decreased over time and could be due to westward migration.

DNREC Sea Level Rise Analysis (Table 4-1.10)

Beach area is the only community affected by sea level rise in the current scenarios.

Table 4-1.10. Projected acres of the South Section Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	0.01 acres
1 m	0.4 acres
1.5 m	1 acre

Natural Capital

Beach and sand do not carry any capital value.

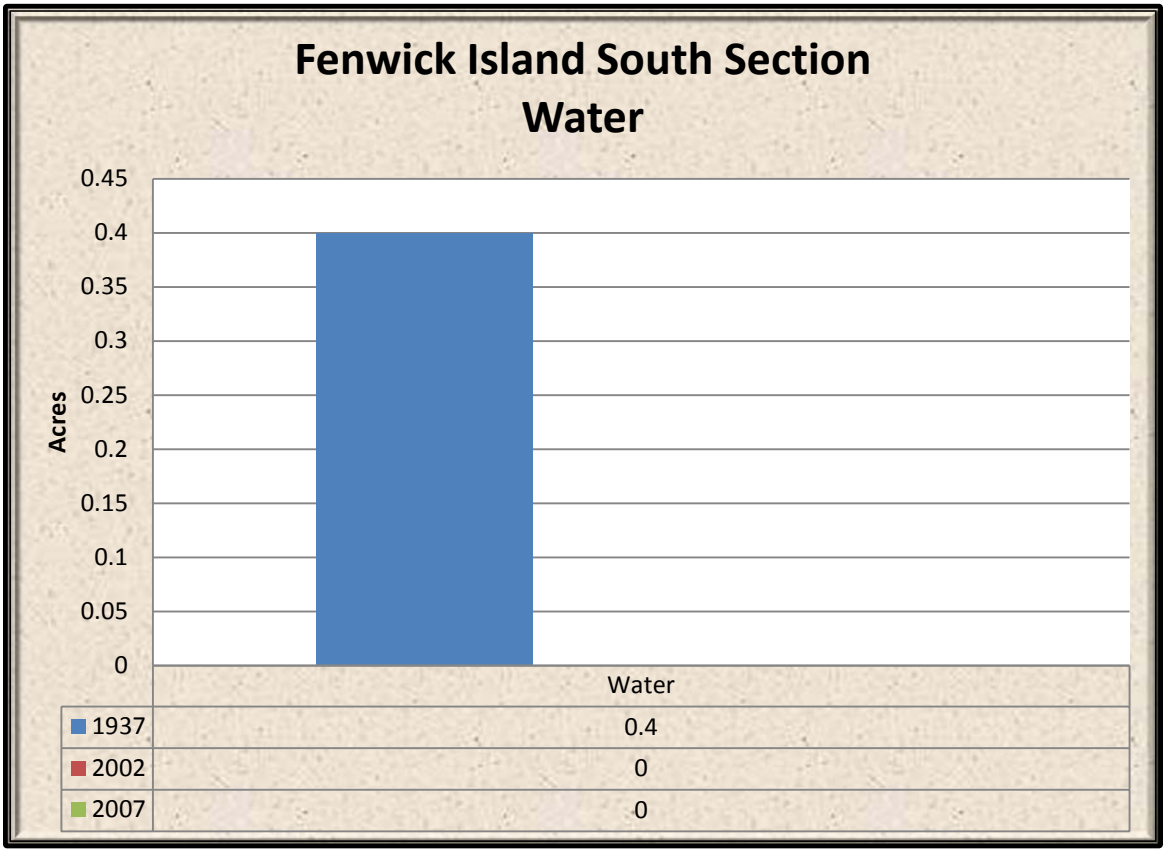


Figure 4-1.10. South Section water coverage (1937, 2002, and 2007)

South Section water coverage (Figure 4-1.10): In 1937 a small amount of water coverage was present in the section but it has since been covered over by beach nourishment.

Natural Capital (Table 4-1.11)

The only time water had any capitalization was in 1937. Since time water has likely been replaced by sand on the beach.

Table 4-1.11. Natural Capital of the South Section	
Year	**Natural Capital (in 2012 dollars)**
1937	$63/year
2002	$0/year (not present)
2007	$0/year (not present)

2. Middle Section

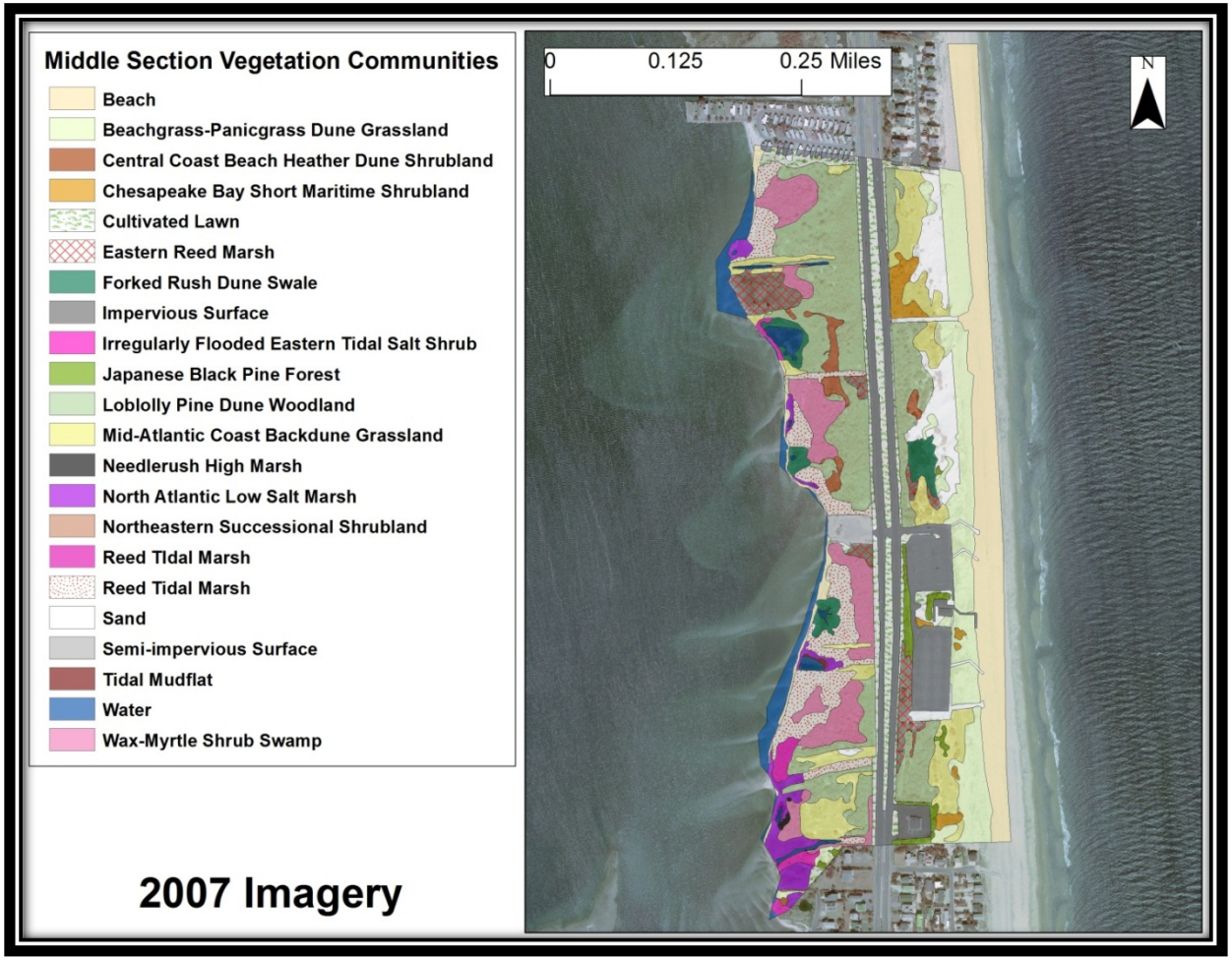


Figure 4-2.1. 2007 Vegetation Community map of Fenwick Island S.P. Middle Section

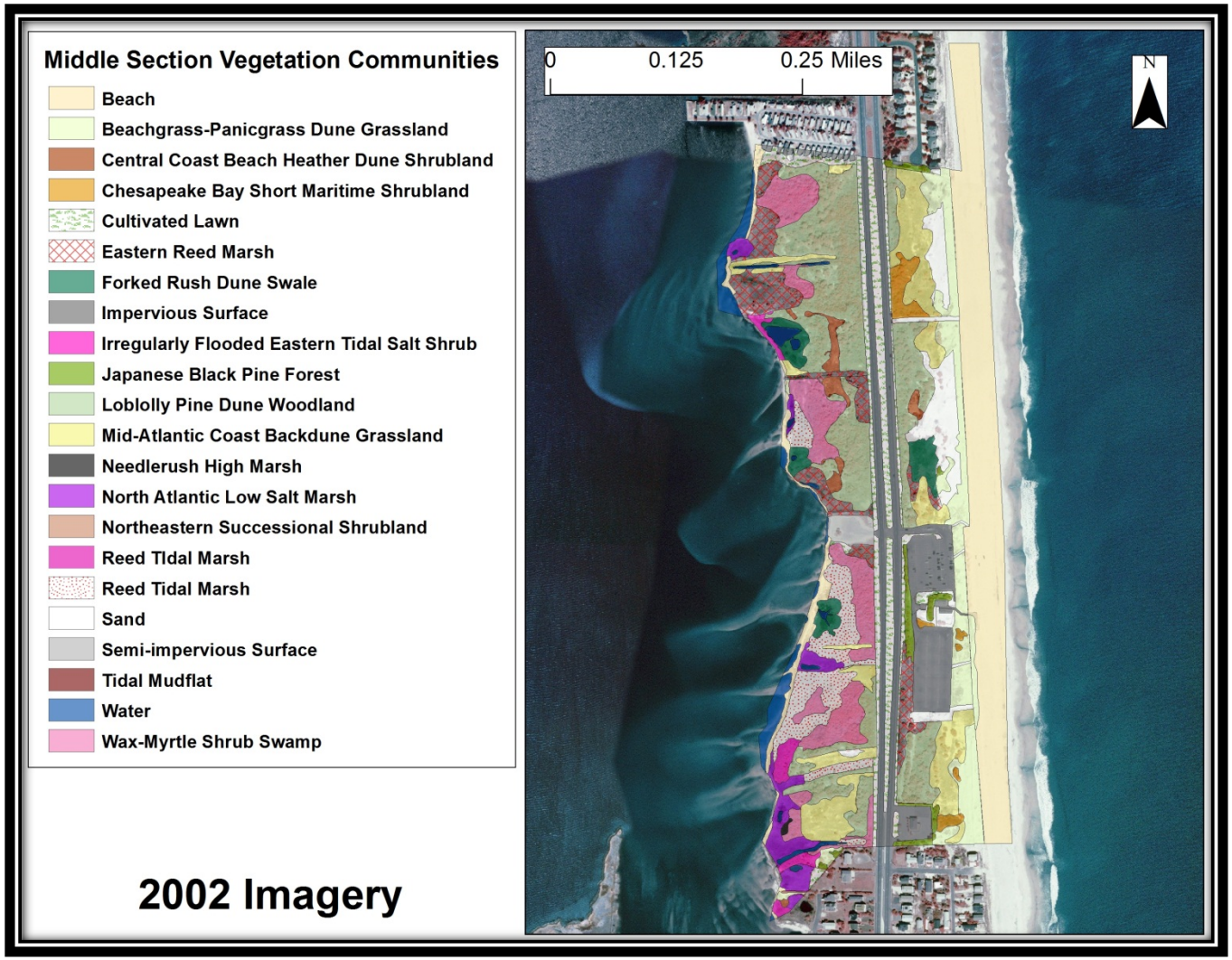


Figure 4-2.2. 2002 Vegetation Community map of Fenwick Island S.P. Middle Section

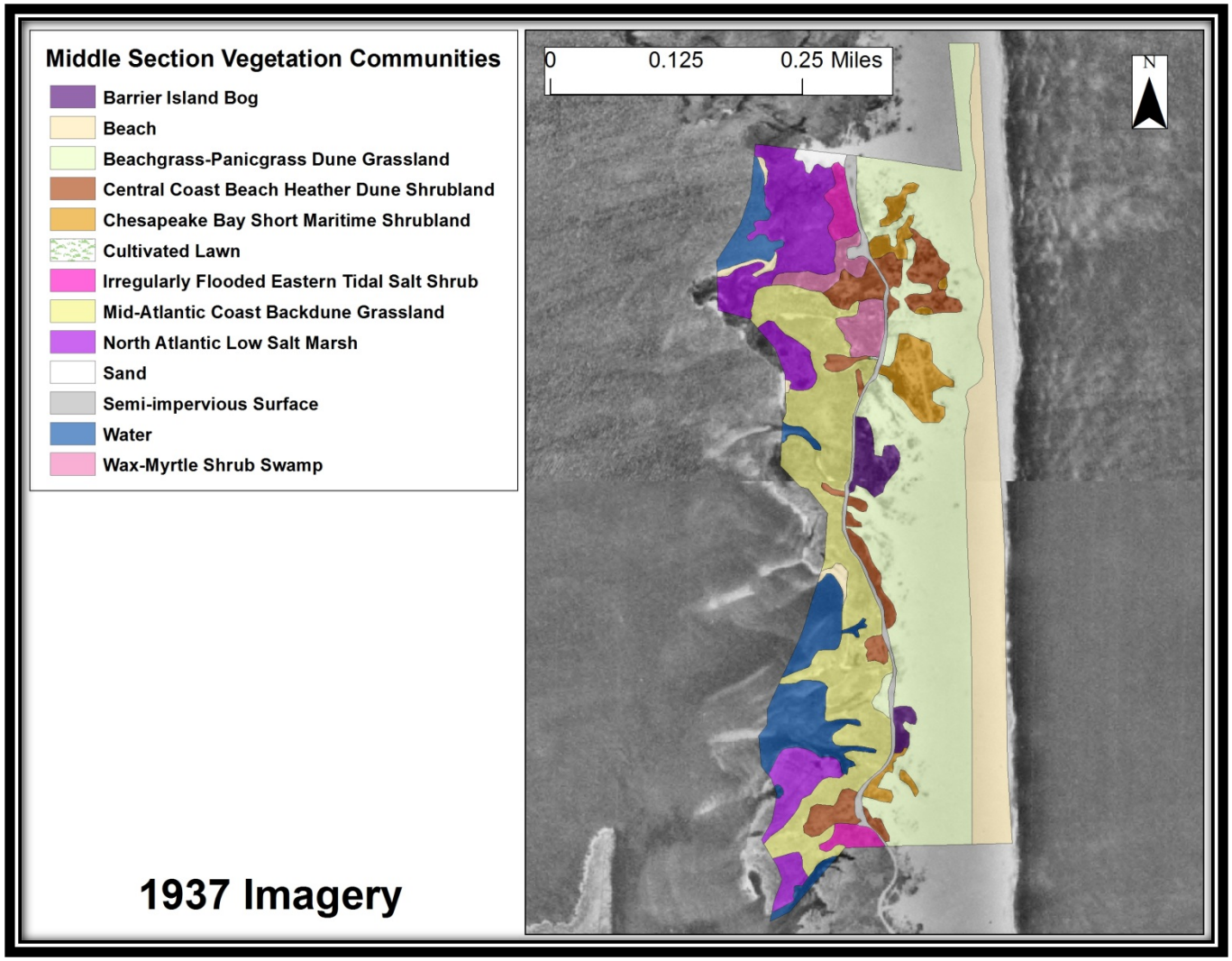


Figure 4-2.3. 1937 Vegetation Community map of Fenwick Island S.P. Middle Section

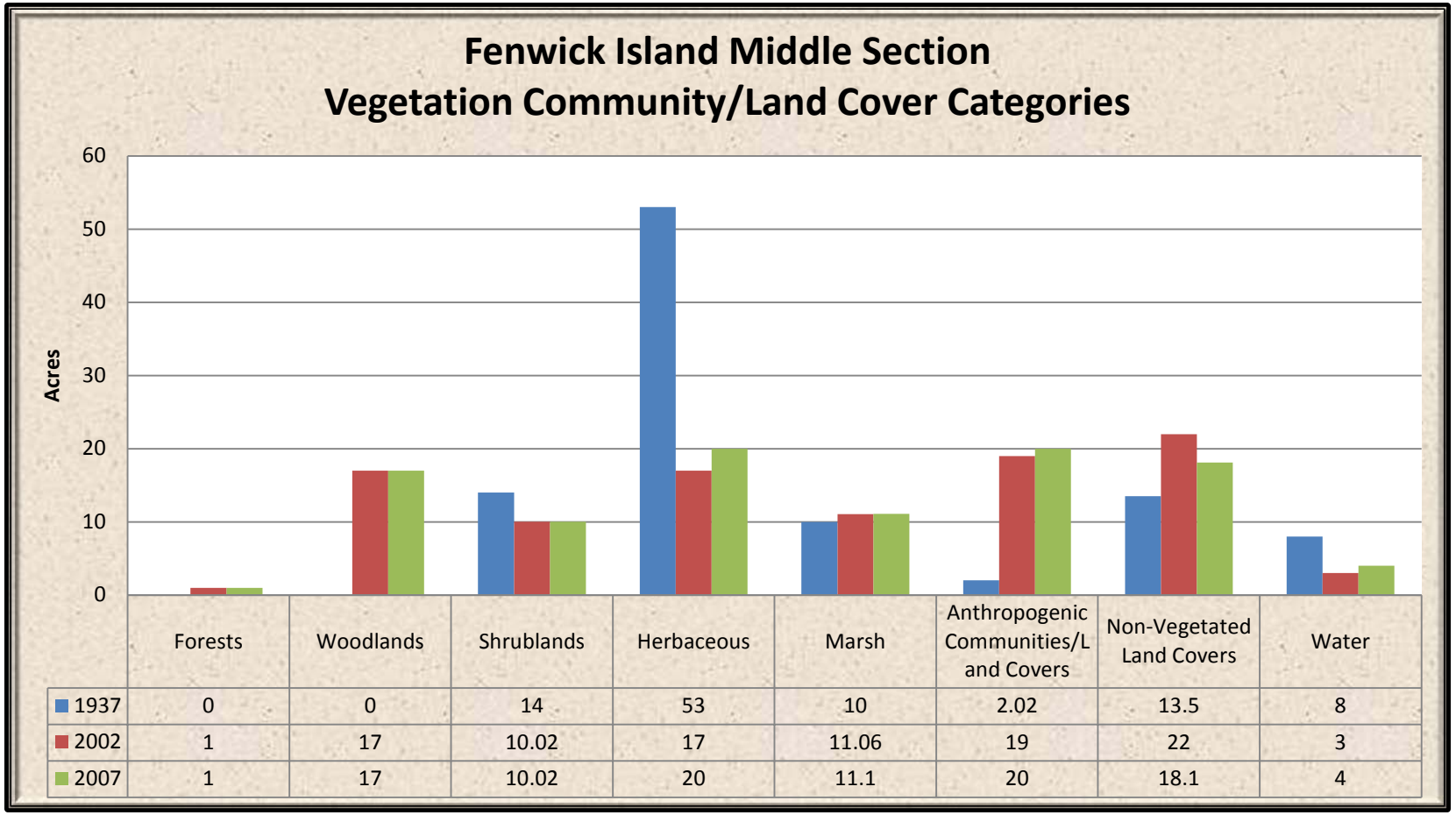


Figure 4-2.4. Middle Section Vegetation Community/Land Cover Categories (1937, 2002, and 2007)

Middle Section Broad Trends (Figure 4-2.4): The middle section is located roughly midway between the Town of Fenwick Island and the Town of Bethany Beach.

DNREC Sea Level Rise Analysis (Table 4-2.1)

A little less than half of the Middle Section will be inundated by water with 0.5 m of sea level rise. At 1 m of rise about ¾ of the section will be flooded. Another 0.5 m of rise will inundate an additional 8 acres for a total of 84 acres out of 101 acres.

Table 4-2.1. Projected acres of the Middle Section Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	43 acres
1 m	76 acres
1.5 m	84 acres

Natural Capital (Table 4-2.2)

The capitalization of the Middle Section was at its highest in 1937 and has declined somewhat though it has increased in the recent period (2002-2007). Most of the declines were from the loss of water coverage from 1937 to 2002, a situation that is likely temporary.

Table 4-2.2. Natural Capital of the Middle Section	
Year	**Natural Capital (in 2012 dollars)**
1937	$206,550/year
2002	$183,755/year
2007	$193,382/year

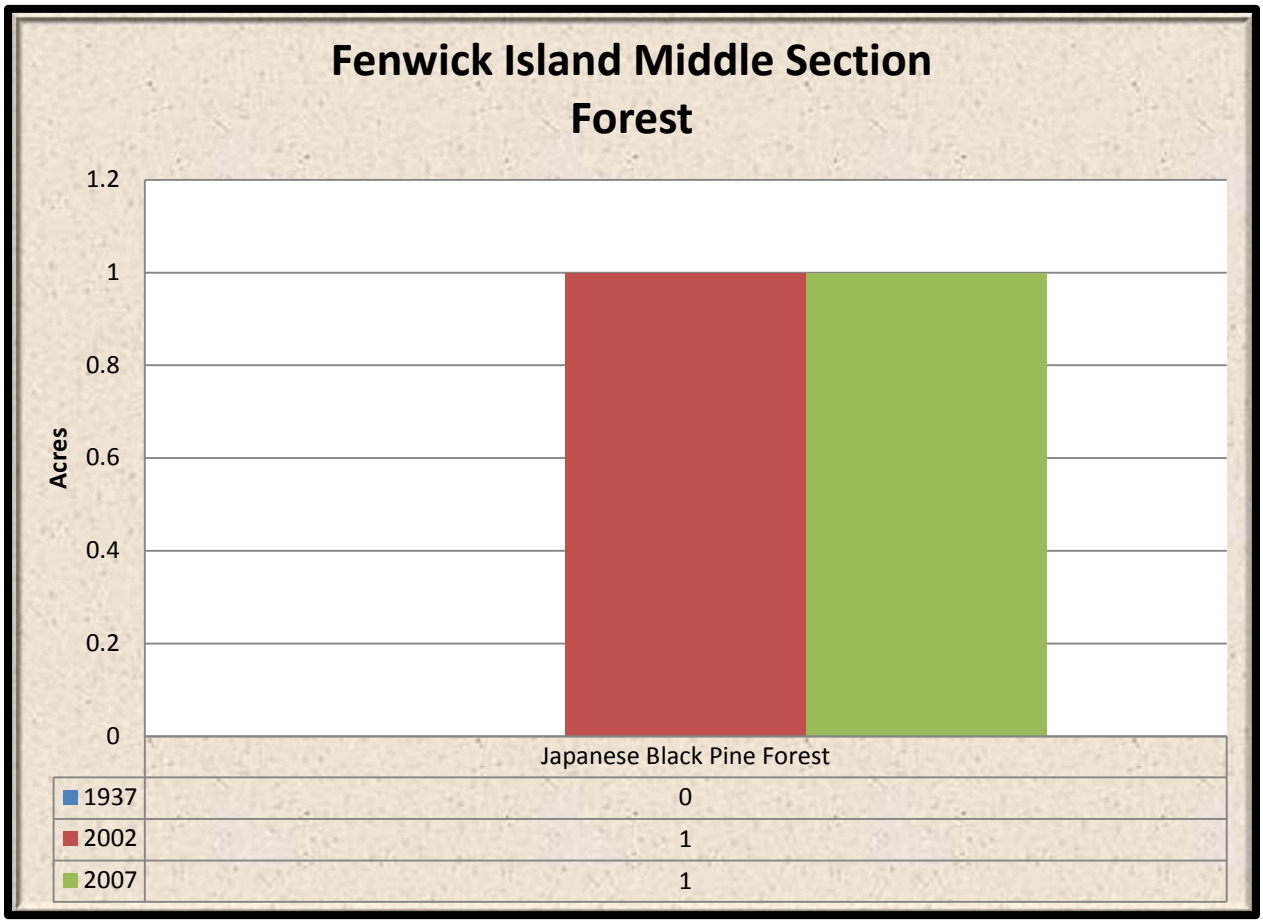


Figure 4-2.5. Middle Section Forest (1937, 2002, and 2007)

Middle Section Forest (Figure 4-2.5): Japanese Black Pine Forest is the only forest type present in the middle section of Fenwick Island State Park. It has come about since 1937 and has remained stable in amount through the 2002-2007 time period.

DNREC Sea Level Rise Analysis (Table 4-2.3)

All of the current extent of forestland in the Middle Section will be inundated with 1 m or greater of sea level rise.

Table 4-2.3. Projected acres of Middle Section Forest Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	0.1 acres
1 m	1 acre
1.5 m	1 acre

Natural Capital (Table 4-2.4)

Japanese Black Pine Forest is the only forest present in the Middle Section and has come into the section since 1937.

Table 4-2.4. Natural Capital of Middle Section Forest	
Year	**Natural Capital (in 2012 dollars)**
1937	$0/year (not present)
2002	$189/year
2007	$189/year

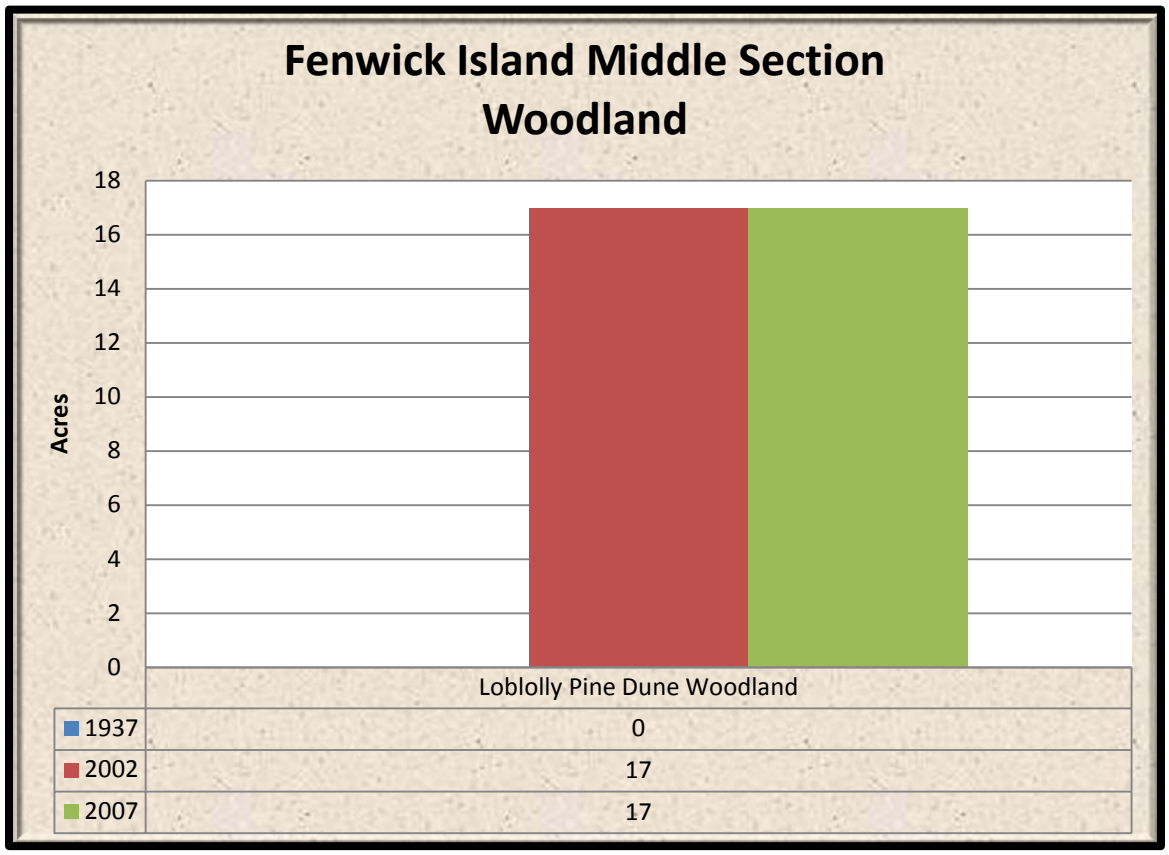


Figure 4-2.6. Middle Section Woodland (1937, 2002, and 2007)

Middle Section Woodland (Figure 4-2.6): Loblolly Pine Dune Woodland is the only woodland present in the middle section of Fenwick Island State Park. Like the Japanese Black Pine Forest it has come about since 1937 and has remained stable in amount through the 2002-2007 time period.

DNREC Sea Level Rise Analysis (Table 4-2.5)

More than half of the woodland acreage in the Middle Section will be inundated with 0.5 m of sea level rise. At 1 m of rise or greater, all of the current woodland extent will be flooded.

Table 4-2.5. Projected acres of Middle Section Woodland Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	11 acres
1 m	17 acres
1.5 m	17 acres

Natural Capital (Table 4-2.6)

Woodland was not present in the Middle Section in 1937. Since this time it has gained capital up to $3,215 which it has kept through the recent period (2002-2007).

Table 4-2.6. Natural Capital of Middle Section Woodland	
Year	**Natural Capital (in 2012 dollars)**
1937	$0/year (not present)
2002	$3,215/year
2007	$3,215/year

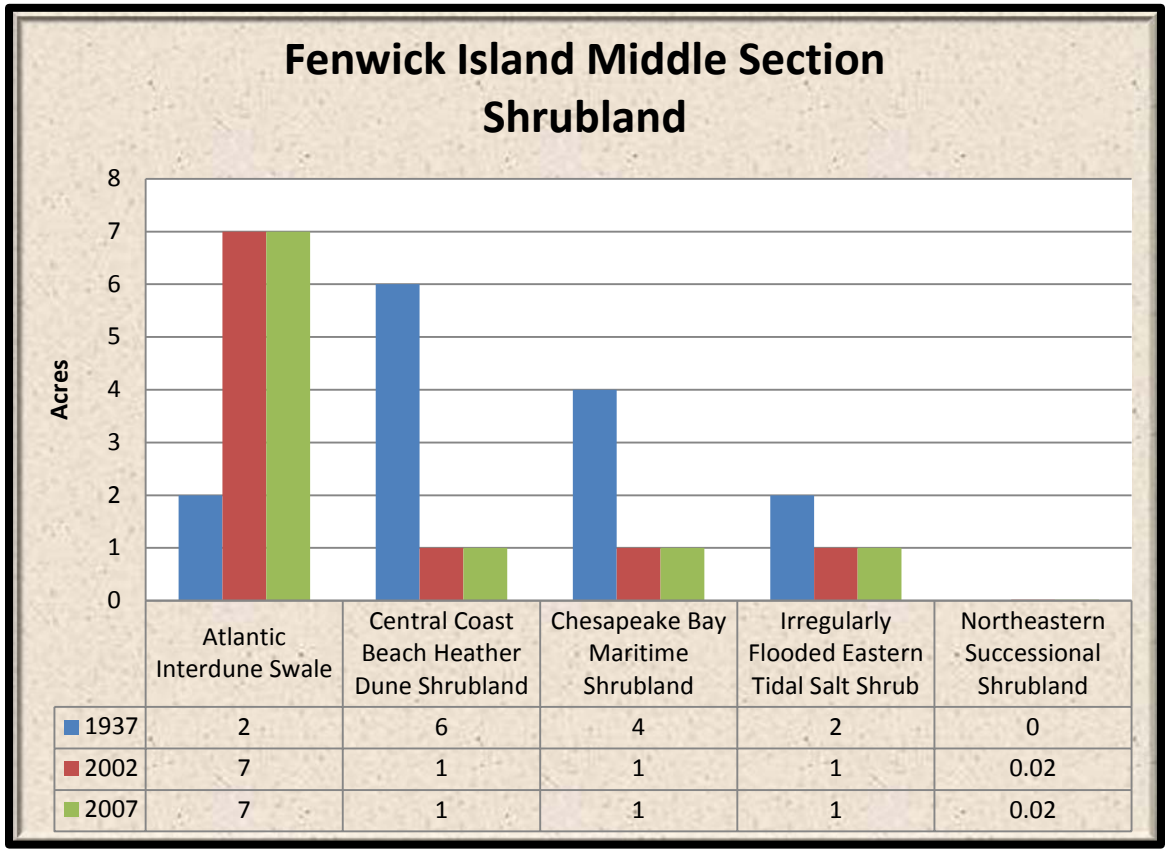


Figure 4-2.7. Middle Section Shrubland (1937, 2002, and 2007)

Middle Section Shrubland (Figure 4-2.7): Atlantic Interdune Swale is the most common shrubland in the middle section followed by three other communities, Central Coast Beach Heather Dune Shrubland, Chesapeake Bay Maritime Shrubland, and Irregularly Flooded Eastern Tidal Salt Shrub, with 1 acre each. All of these communities have declined in acreage since 1937. Northeastern Successional Shrubland has come about since 1937, but still covers a very small amount of area.

DNREC Sea Level Rise Analysis (Table 4-2.7)

Most of the shrubland acreage in the Middle Section will be flooded with 0.5 m of sea level rise. Past 1 m of rise all of the acreage will be flooded.

Table 4-2.7. Projected acres of Middle Section Shrubland Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	8 acres
1 m	10 acres
1.5 m	10 acres

Natural Capital (Table 4-2.8)

Middle Section Shrubland carries a lot of capital since some of the shrublands are located in the upper tidal zone and serve in a filtering capacity. The value has gone up over the years.

Table 4-2.8. Natural Capital of Middle Section Shrubland	
Year	**Natural Capital (in 2012 dollars)**
1937	$21,452/year
2002	$50,464/year
2007	$50,464/year

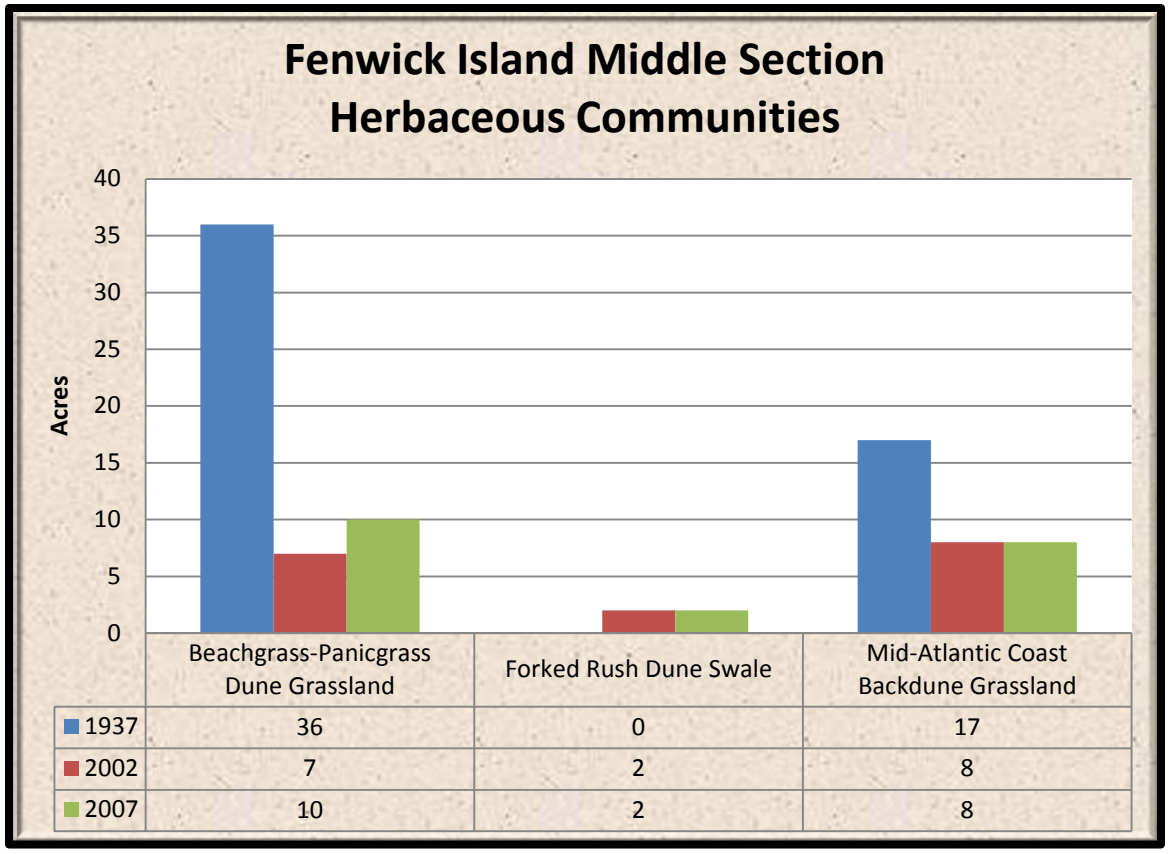


Figure 4-2.8. Middle Section Herbaceous Communities

Middle Section Herbaceous Communities (Figure 4-2.8): Beachgrass-Panicgrass Dune Grassland is the most common herbaceous community, followed by Mid-Atlantic Coast Backdune Grassland, both of which have declined in acreage since 1937. Forked Rush Dune Swale has appeared since 1937 and cover 2 acres.

DNREC Sea Level Rise Analysis (Table 4-2.9)

Exception one community, Forked Rush Dune Swale, all of the herbaceous communities are located towards the tops of dunes and are away from the effects of sea level rise. However, with 0.5 m of sea level 3 acres of will be flooded. At 1 m of rise, 8 acres will be flooded or a little under half. At 1.5 m of rise 10 acres will be flooded.

Table 4-2.9. Projected acres of Middle Section Herbaceous Communities Inundated by Sea Level Rise

Rise	Acres
0.5 m	3 acres
1 m	8 acres
1.5 m	10 acres

Natural Capital (Table 4-2.10)

The capital of herbaceous communities was at its highest in 1937 and declined to 2002. It has since come up some, likely due to replanting efforts.

Table 4-2.10. Natural Capital of Middle Section Herbaceous Communities	
Year	**Natural Capital (in 2012 dollars)**
1937	$7,722/year
2002	$2,477/year
2007	$2,914/year

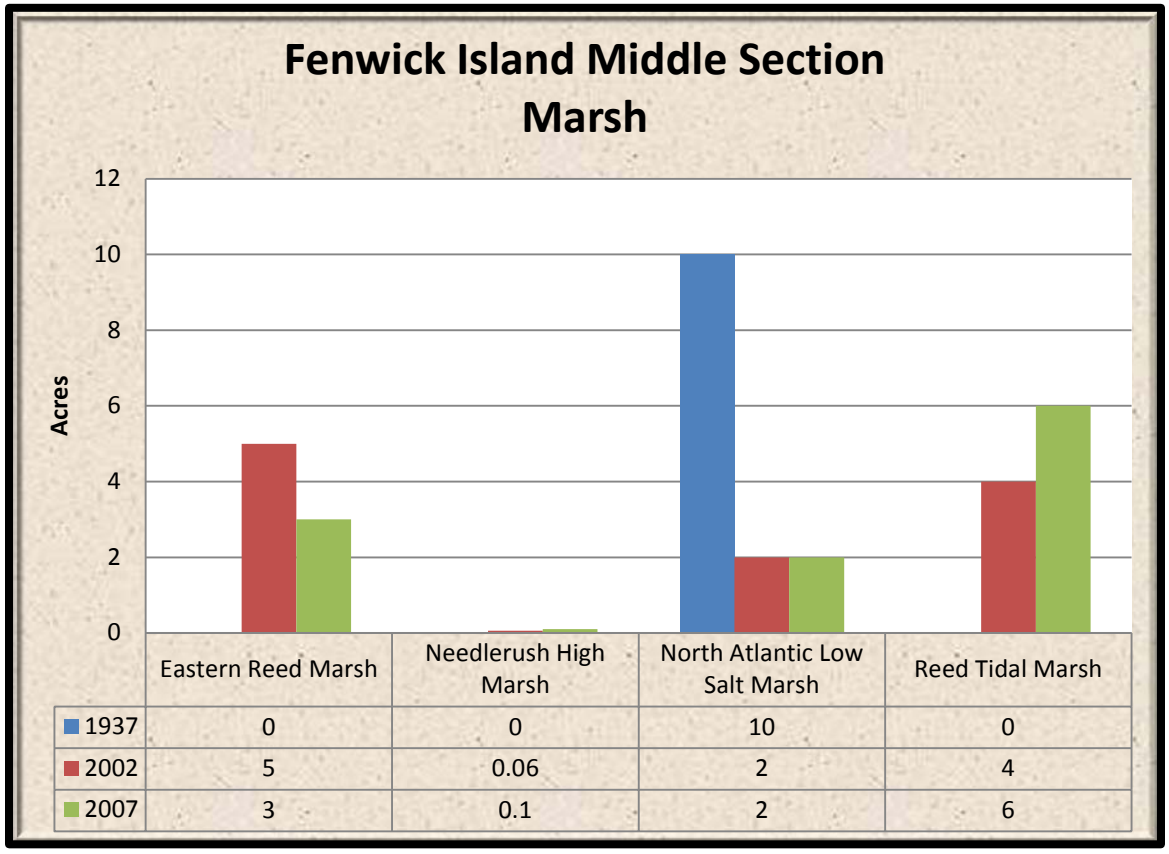


Figure 4-2.10. Middle Section Marsh (1937, 2002, and 2007)

Middle Section Marsh (Figure 4-2.10): Reed Tidal Marsh is the most common marsh community followed by Eastern Reed Marsh. Both of these communities are dominated by common reed (*Phragmites australis*) and are tidal and non-tidal, respectively. North Atlantic Low Salt Marsh has declined from its 1937 high of 10 acres to 2 acres and Needlerush High Marsh is gaining more of a foothold in this section.

DNREC Sea Level Rise Analysis (Table 4-2.11)

All of the tidal marsh will be inundated with 0.5 m of sea level in the Middle Section. Another 0.5 m of rise will flooded all of the marshland currently present.

Table 4-2.11. Projected acres of Middle Section Marsh Inundated by Sea Level Rise

Rise	Acres
0.5 m	10 acres
1 m	11 acres
1.5 m	11 acres

Natural Capital (Table 4-2.12)

The natural capital of Middle Section marsh reached its highest value in 2002 and has declined in the recent period (2002-2007).

Table 4-2.12. Natural Capital of Middle Section Marsh	
Year	**Natural Capital (in 2012 dollars)**
1937	$62,713/year
2002	$84,411/year
2007	$78,642/year

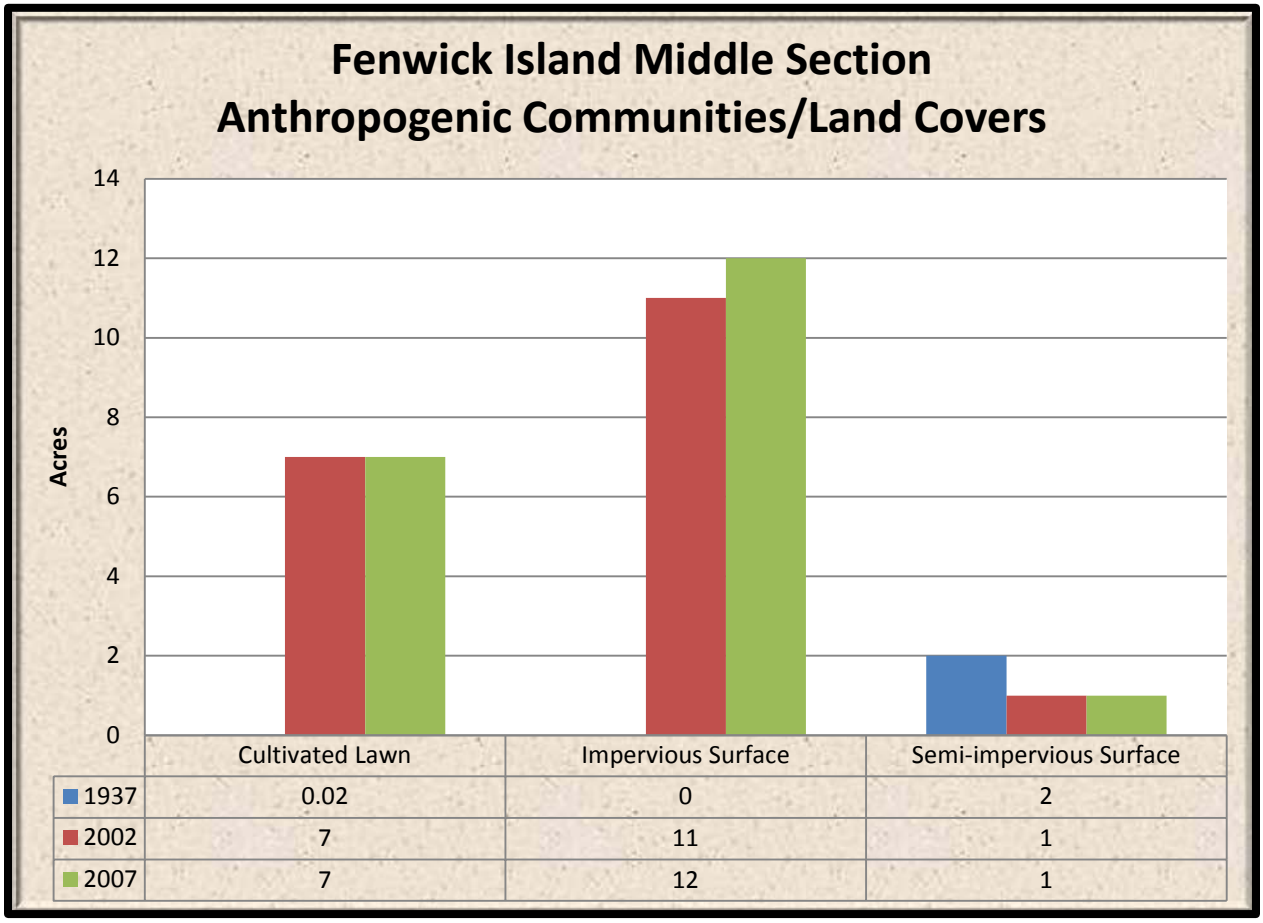


Figure 4-2.11. Middle Section Anthropogenic Communities/Land Covers (1937, 2002, and 2007)

Middle Section Anthropogenic Communities/Land Covers (Figure 4-2.11): Impervious surface is the predominant anthropogenic land cover followed closely by cultivated lawn with which is it often associated. Semi-impervious surface has declined since 1937, likely because part of it was paved to become impervious surface.

DNREC Sea Level Rise Analysis (Table 4-2.13)

Anthropogenic Communities/Land Covers will be slightly inundated with 0.5 m of sea level rise. At 1 m of rise most of them will be underwater and external damages will occur in the state park. At 1.5 m of rise, nearly all of these land covers will be inundated.

Table 4-2.13. Projected acres of Middle Section Anthropogenic Communities/Land Covers Inundated by Sea Level Rise

Rise	Acres
0.5 m	3 acres
1 m	18 acres
1.5 m	19 acres

Natural Capital

None of the anthropogenic communities/land covers in the Middle Section have any capital value.

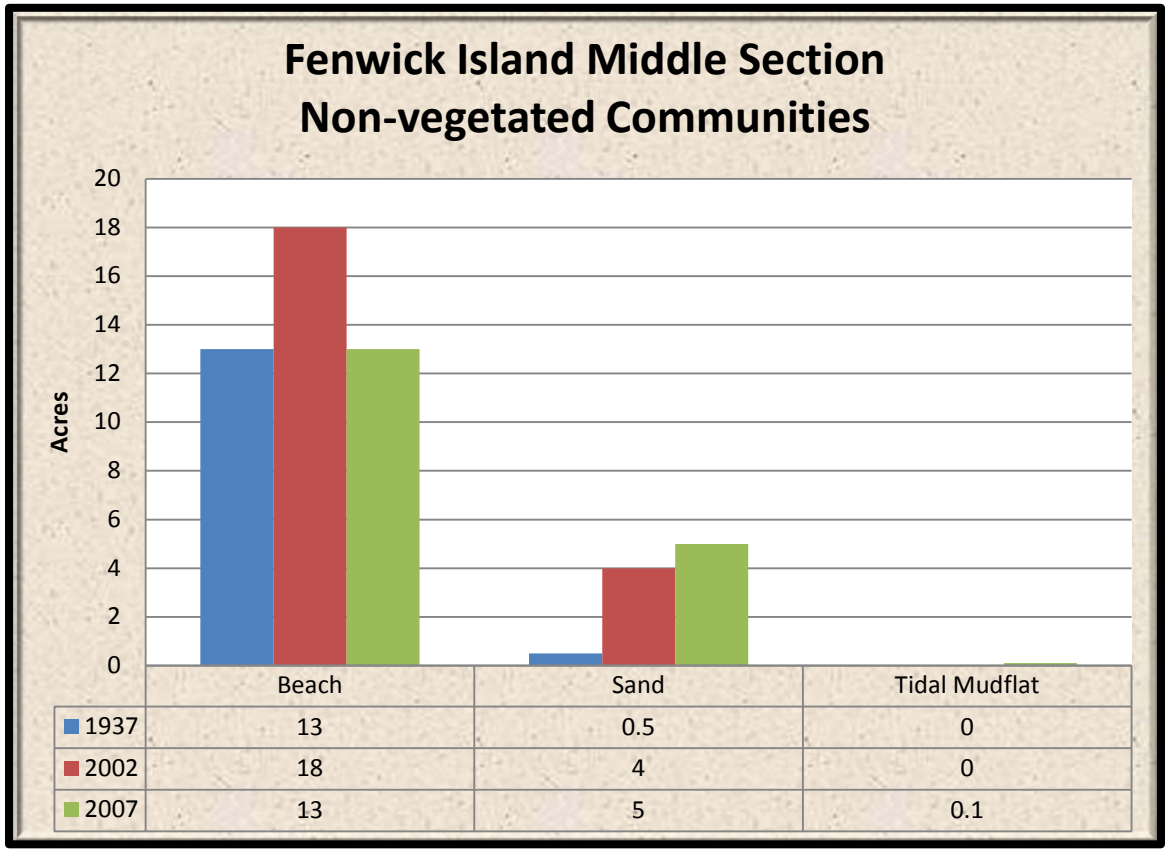


Figure 4-2.12. Middle Section Non-vegetated Land Covers (1937, 2002, and 2007)

Middle Section Non-vegetated Land Covers (Figure 4-2.12): Beach is the most common non-vegetated community, followed by non-vegetated sand in the dunes. Tidal mudflat is the newest community in the section and covers a very small amount.

DNREC Sea Level Rise Analysis (Table 4-2.14)

Excepting the tidal mudflat, quite a bit of the non-vegetated land covers are located in dunes or are high areas. Only 4 acres are affected with 0.5 m of sea level rise and at 1 m another 4 acres are added. At 1.5 m of rise about 12 acres are flooded accounting for ¾ of the current total acreage.

Table 4-2.14. Projected acres of Middle Section Non-vegetated Land Covers Inundated by Sea Level Rise

Rise	Acres
0.5 m	4 acres
1 m	8 acres
1.5 m	12 acres

Natural Capital (Table 4-2.15)

The only non-vegetated community with capital value is the tidal mudflat and it only gained capital in 2007.

Table 4-2.15. Natural Capital of the Middle Section	
Year	**Natural Capital (in 2012 dollars)**
1937	$0/year (not present)
2002	$0/year (not present)
2007	$627/year (not present)

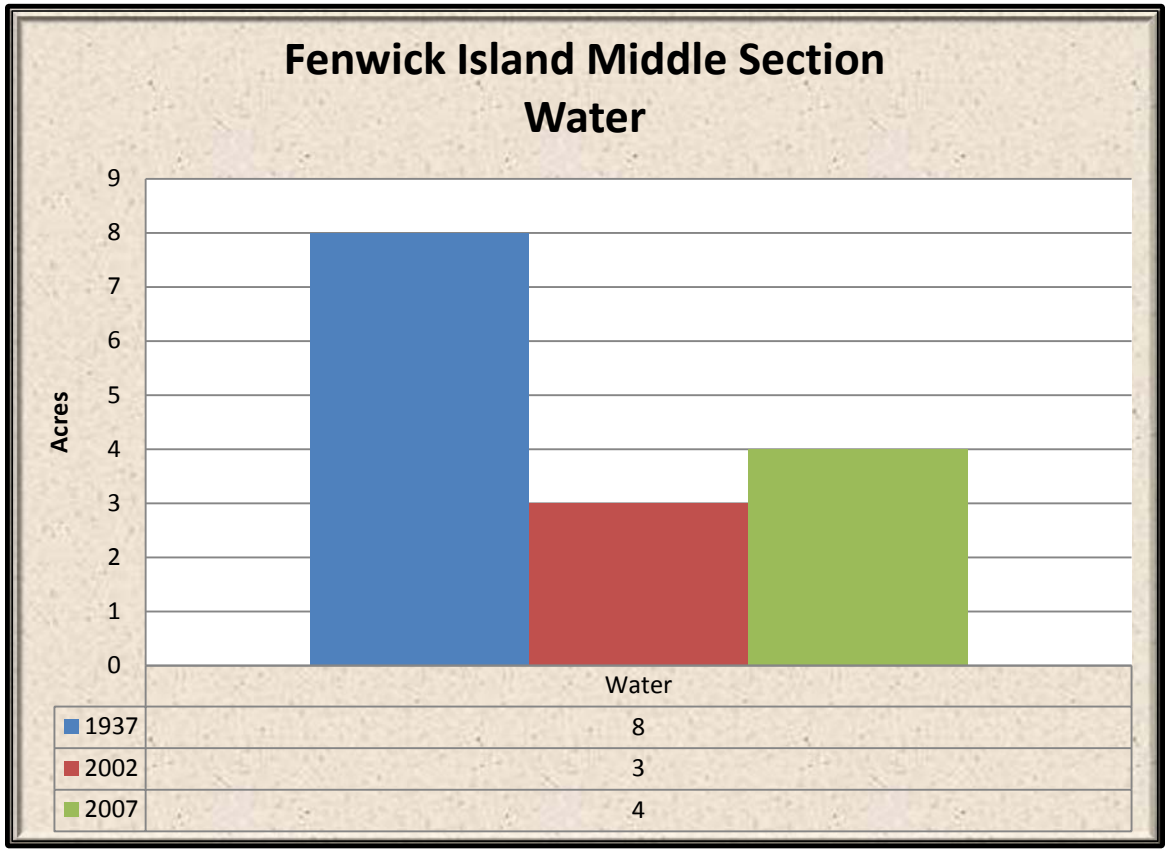


Figure 4-2.13. Middle Section Water Coverage (1937, 2002, and 2007)

Middle Section Water (Figure 4-2.13): The amount of water fluctuates in this section depending on beach re-nourishment activities.

Natural Capital (Table 4-2.16)

All of the water coverage in the Middle Section is located in Little Assawoman Bay giving it an Estuary value. The amount of water coverage has been oscillating, a trend that has been seen in other coastal areas in Delaware.

Table 4-2.16. Natural Capital of Middle Section Water	
Year	**Natural Capital (in 2012 dollars)**
1937	$114,663/year
2002	$42,999/year
2007	$57,331/year

3. North Section

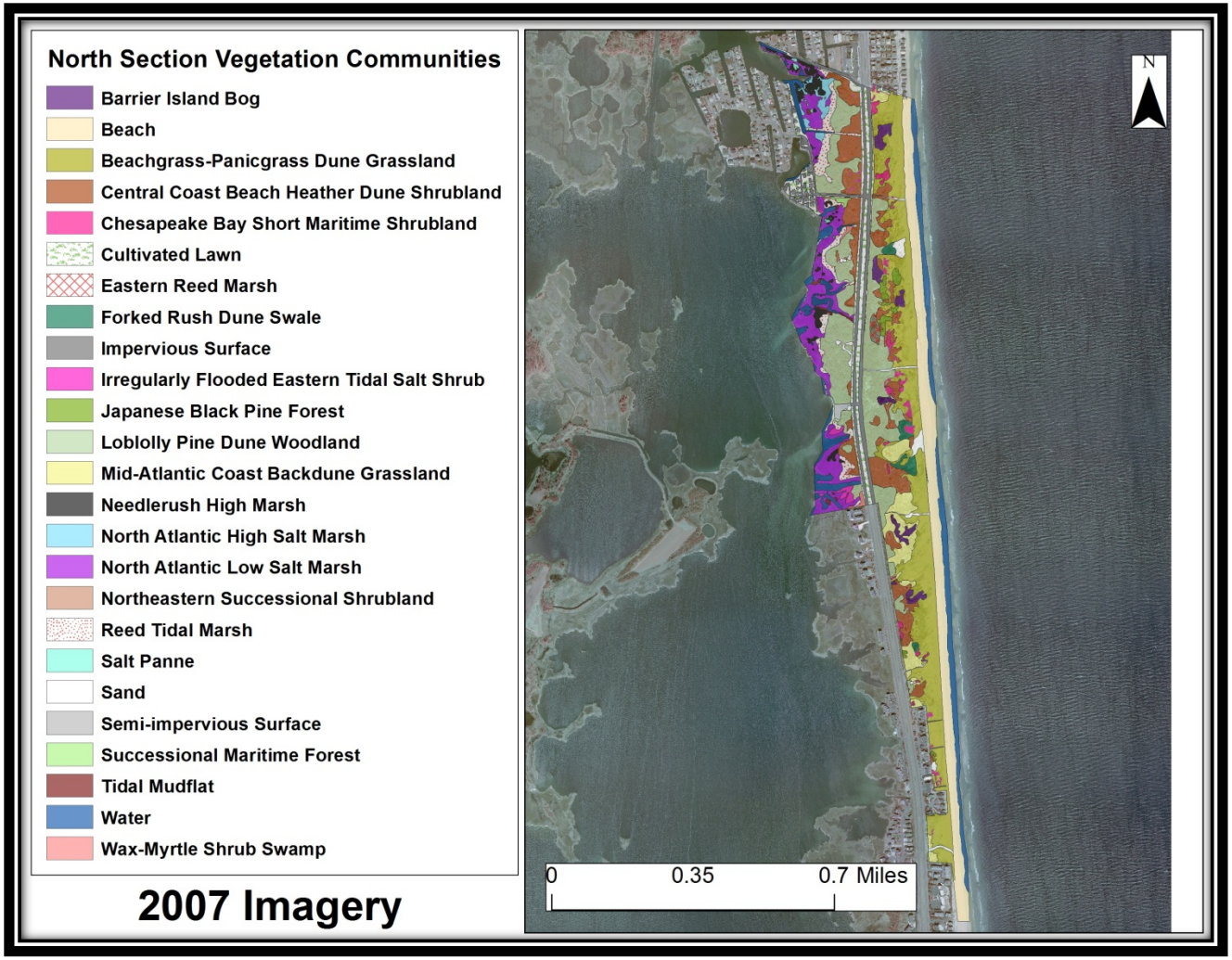


Figure 4-3.1. 2007 Vegetation Community map Fenwick Island S.P. North Section

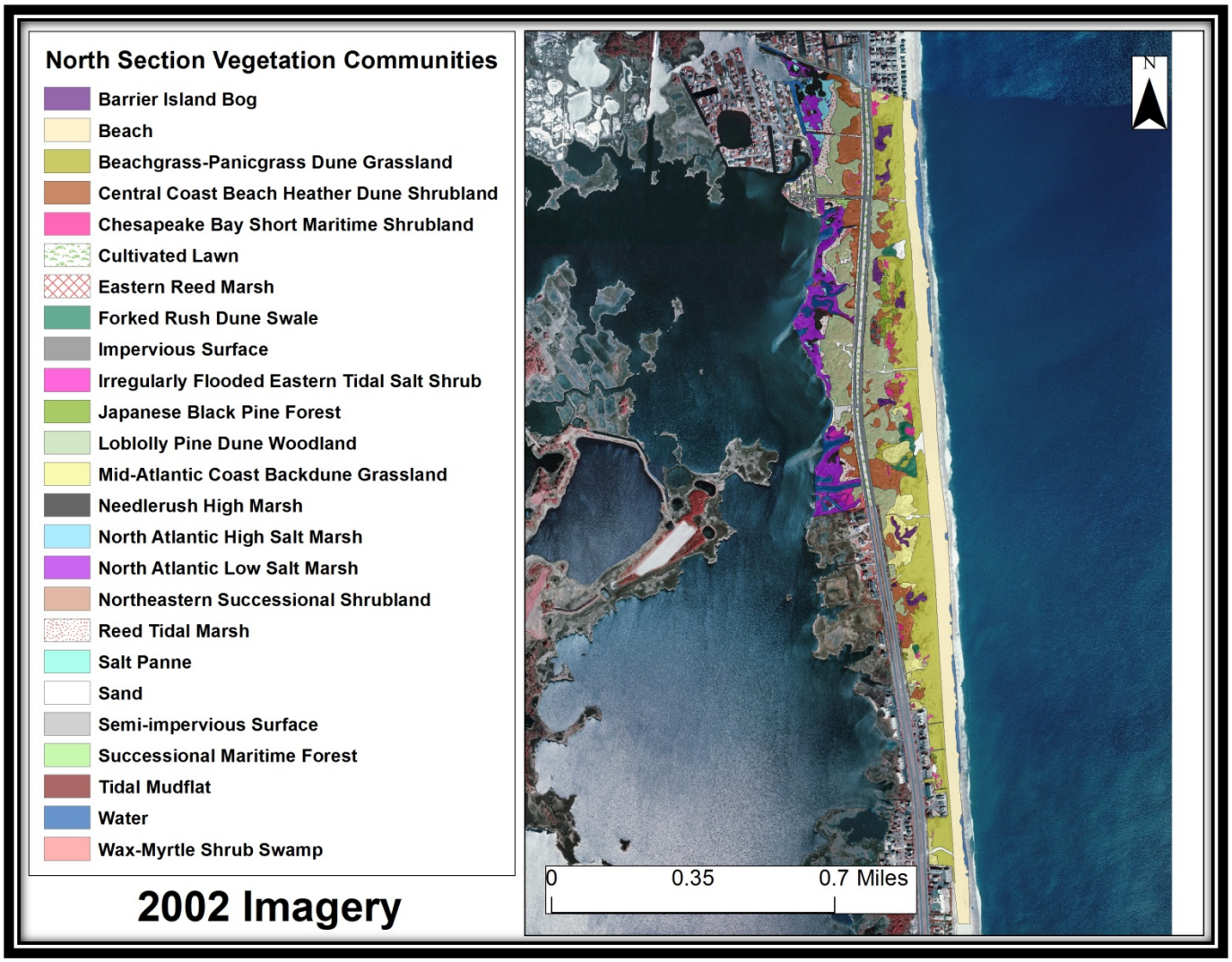


Figure 4-3.2. 2002 Vegetation Community map of Fenwick Island S.P. North Section

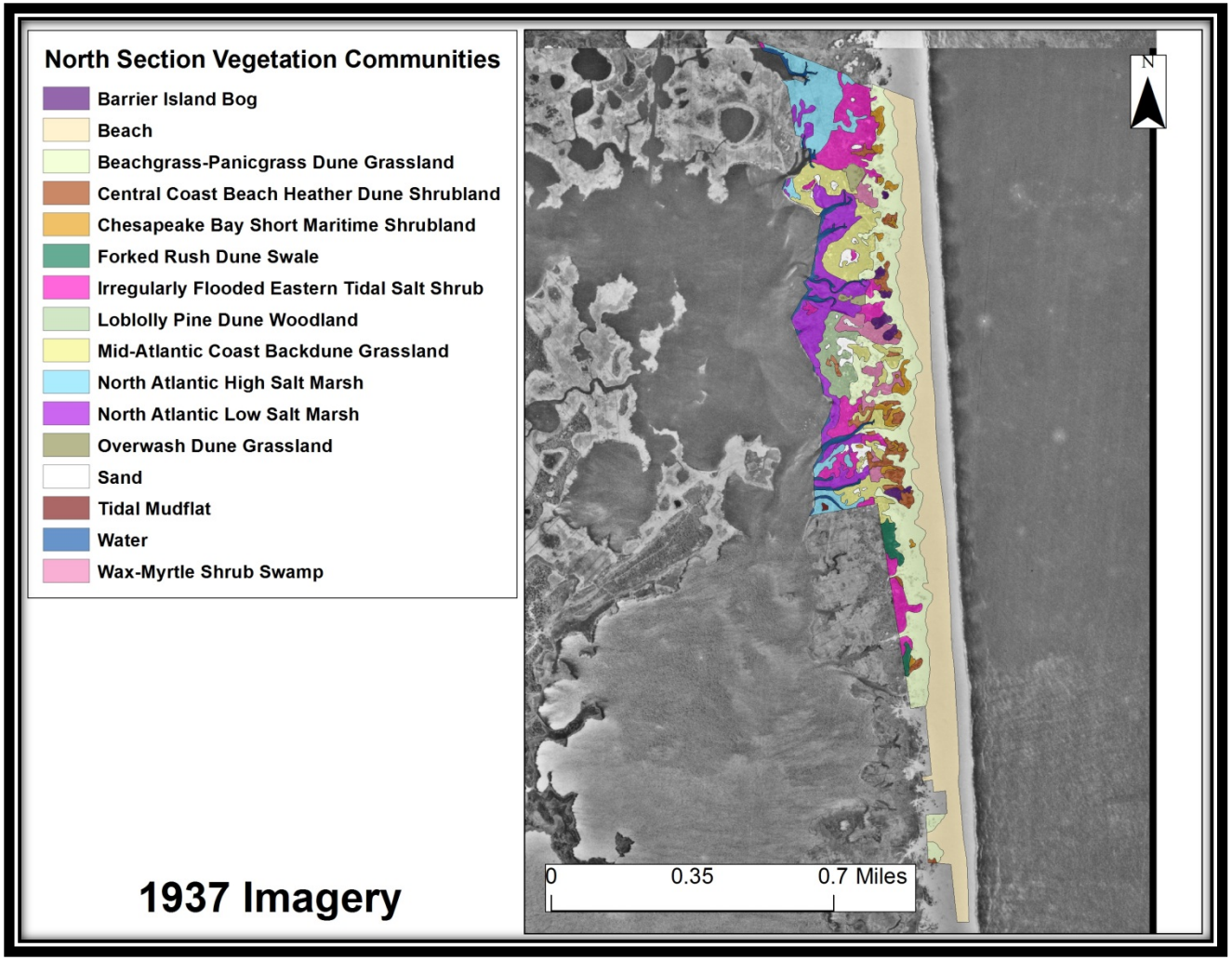
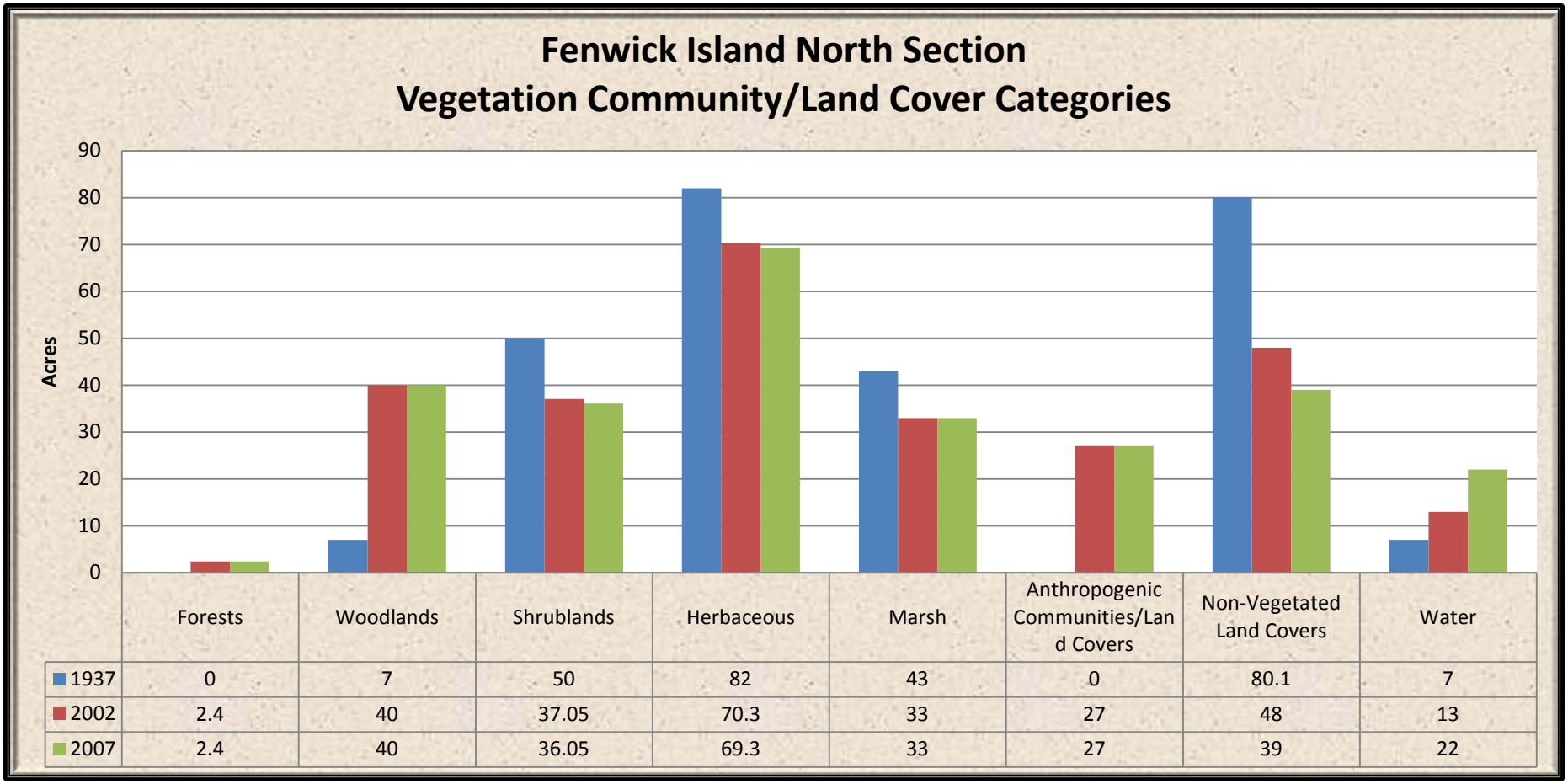


Figure 4-3.3. 1937 Vegetation Community map of Fenwick Island S.P. North Section



	Forests	Woodlands	Shrublands	Herbaceous	Marsh	Anthropogenic Communities/Land Covers	Non-Vegetated Land Covers	Water
1937	0	7	50	82	43	0	80.1	7
2002	2.4	40	37.05	70.3	33	27	48	13
2007	2.4	40	36.05	69.3	33	27	39	22

Figure 4-3.4. North Section Vegetation Communities/Land Covers (1937, 2002, and 2007)

North Section Broad Trends (Figure 4-3.4): The north section is covered mainly by herbaceous communities, but does also have a significant amount of woodland which has increased and non-vegetated land covers which have decreased. Shrubland and Marsh have both lost ground through time. Anthropogenic covers have come about since 1937 and more and more water is coming into the section.

DNREC Sea Level Rise Analysis (Table 4-3.1)

The North Section will lose about a 1/3 of its acreage with 0.5 m of sea level rise. At 1 m of rise a little more than half of the section will be inundated. At 1.5 m of rise about 2/3 of the tract will be inundated.

Table 4-3.1. Projected acres of the North Section Inundated by Sea Level Rise

Rise	Acres
0.5 m	95 acres
1 m	154 acres
1.5 m	197 acres

Natural Capital (Table 4-3.2)

The natural capital of the North Section was at its highest in 1937 and declined to 2002, where it has started to increase from sea level rise adding to the water coverage.

Table 4-3.2. Natural Capital of the North Section

Year	Natural Capital (in 2012 dollars)
1937	$611,847/year
2002	$404,998/year
2007	$409,549/year

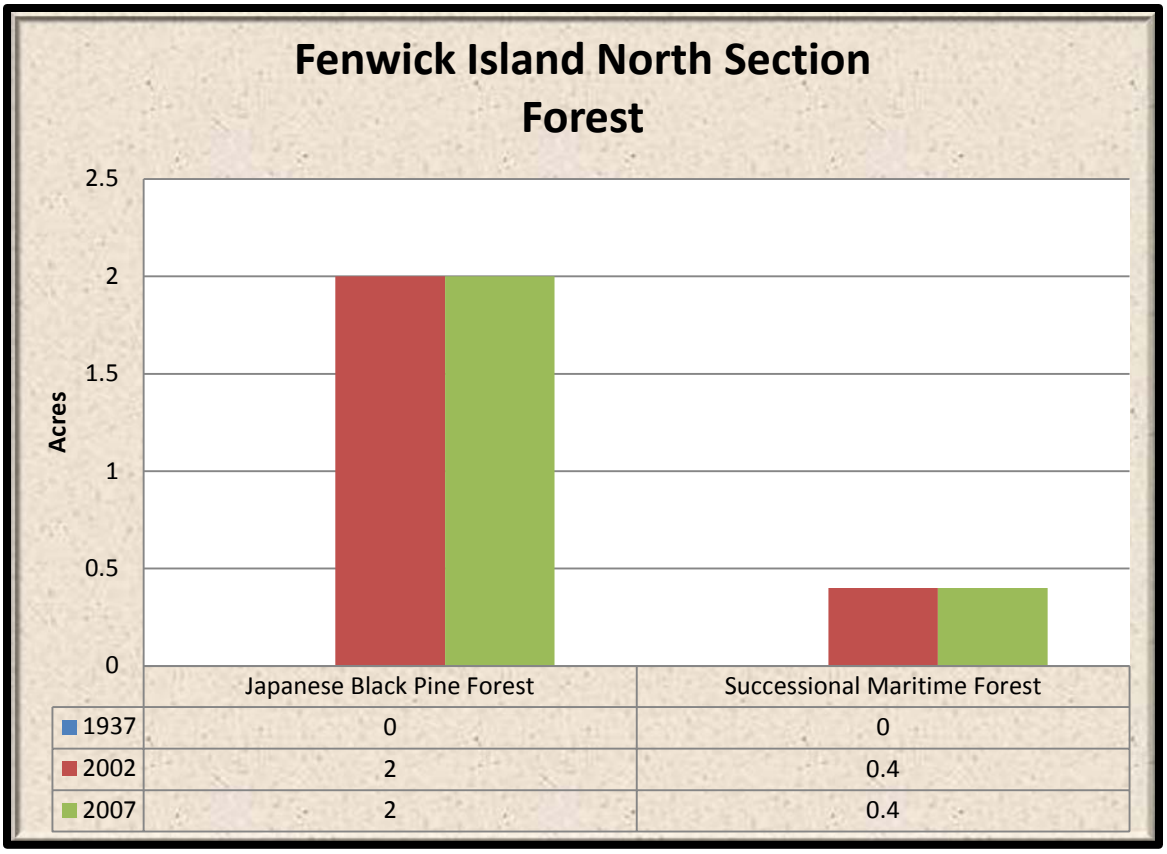


Figure 4-3.5. North Section Forests (1937, 2002, and 2007)

North Section Forests (Figure 4-3.5): Japanese Black Pine Forest is the only forest community present in the north section. This community has come about since 1937 and has remained stable in acreage in the 2002 to 2007 time period.

DNREC Sea Level Rise Analysis (Table 4-3.3)

A little less than half of the current forest acreage will be inundated by sea level rise at the highest scenario (1.5 m).

Table 4-3.3. Projected acres of North Section Forest Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	0.4 acres
1 m	0.5 acres
1.5 m	1 acre

Natural Capital (Table 4-3.4)

No forests were located in the north section in 1937. Since 1937 two forest communities have grown into the tract and have increased the capital for the section and the park.

Table 4-3.4. Natural Capital of North Section Forest	
Year	**Natural Capital (in 2012 dollars)**
1937	$0/year (not present)
2002	$454/year
2007	$454/year

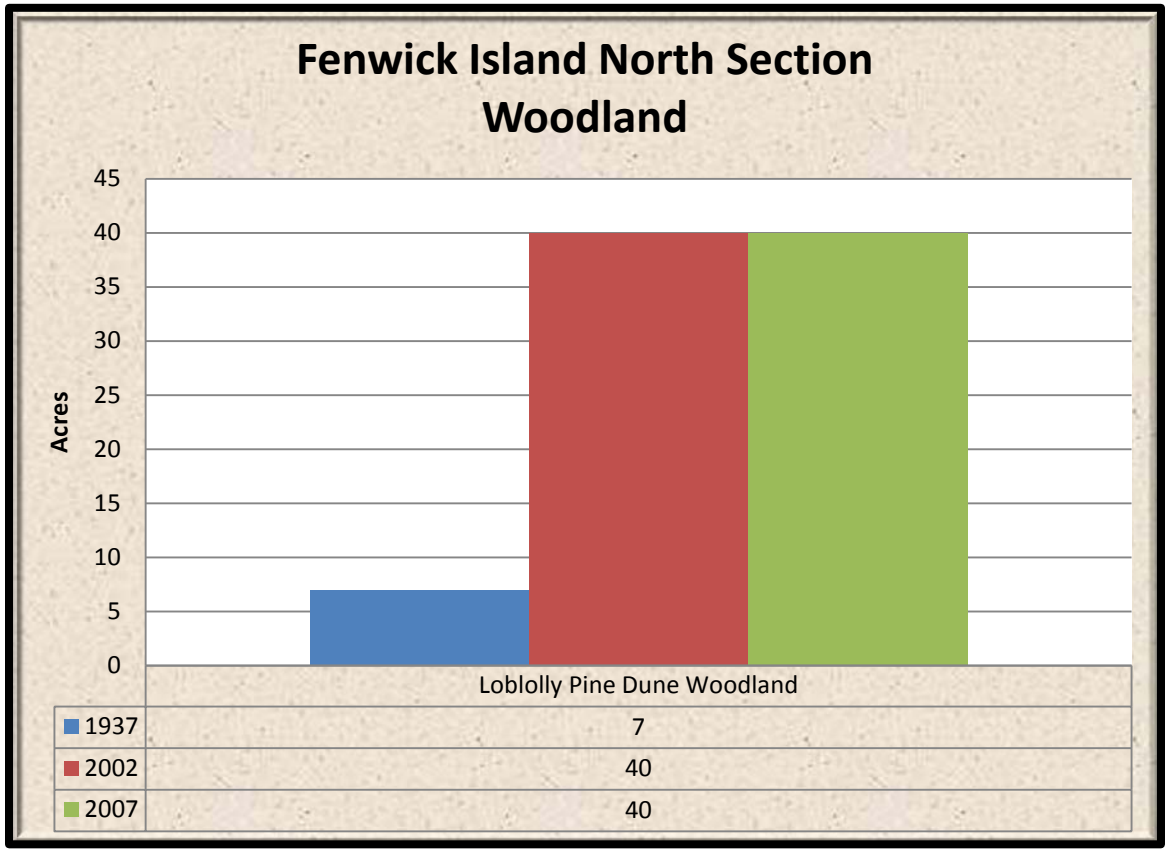


Figure 4-3.6. North Section Woodland (1937, 2002, and 2007)

North Section Woodland (Figure 4-3.6): Loblolly Pine Dune Woodland is the only woodland community in the north section and has increased in acreage as areas that were formerly sand have succeeded to this community.

DNREC Sea Level Rise Analysis (Table 4-3.5)

A little less than half of the current woodland acreage will be inundated by 0.5 m of sea level rise. At 1 m, woodlands will be greatly impacted and at 1.5 m of rise, woodlands will be practically inundated in the North Section.

Table 4-3.5. Projected acres of North Section Woodland Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	17 acres
1 m	36 acres
1.5 m	39 acres

Natural Capital (Table 4-3.6)

Woodlands have greatly increased their acreage in the North Section and as a result their capital has increased as well. Most of these increases represent increases for the section and the park.

Table 4-3.6. Natural Capital of North Section Woodland	
Year	**Natural Capital (in 2012 dollars)**
1937	$1,324/year
2002	$7,564/year
2007	$7,564/year

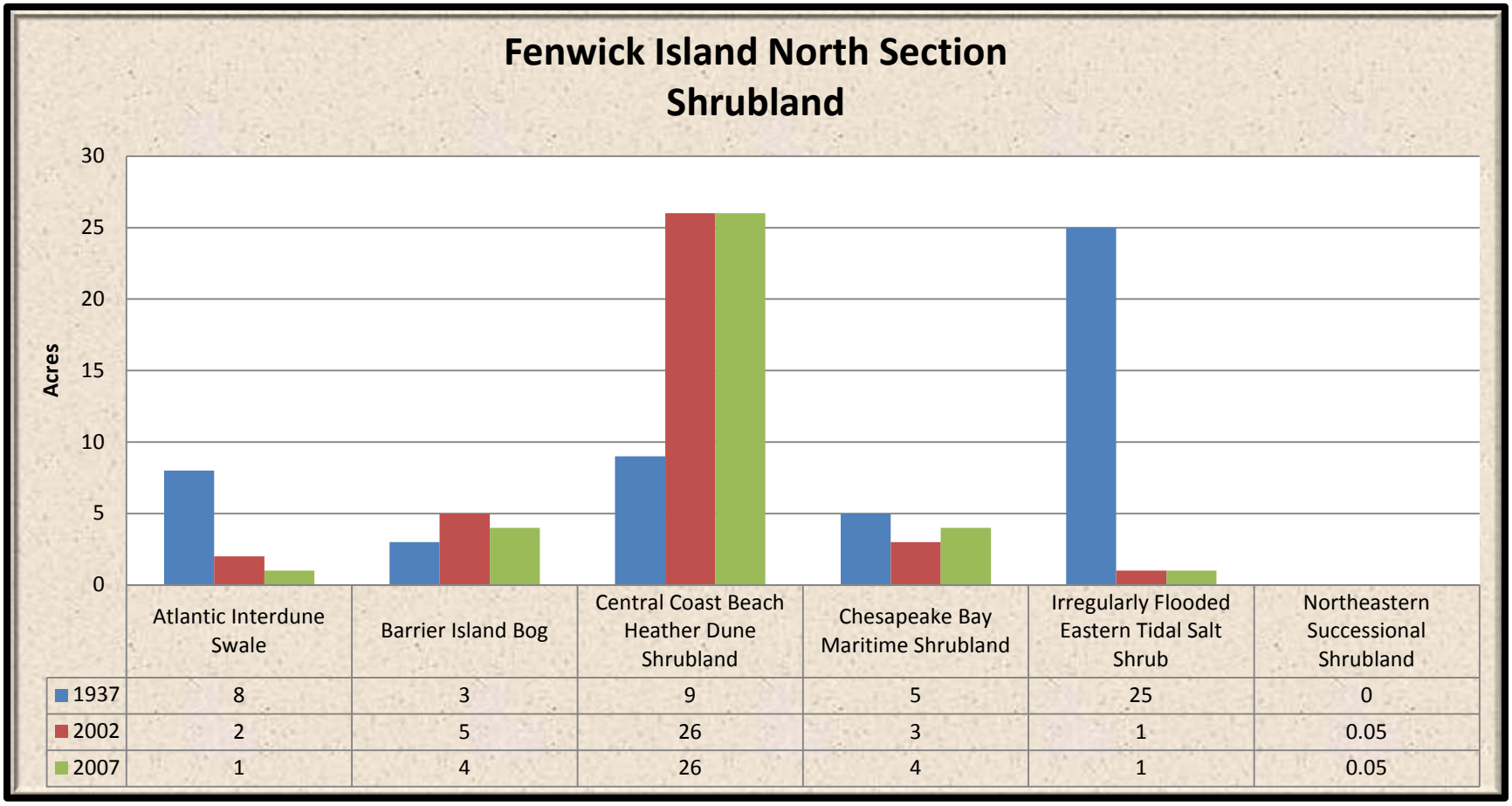


Figure 4-3.7. North Section Shrubland (1937, 2002, and 2007)

North Section Shrubland (Figure 4-3.7): Central Coast Beach Heather Dune Shrubland is the most common shrubland followed by Barrier Island Bog and Chesapeake Bay Maritime Shrubland with 4 acres each. Irregularly Flooded Eastern Tidal Salt Shrub has had the most losses of any community losing 24 acres since 1937. Atlantic Interdune Swale has also declined since 1937.

DNREC Sea Level Rise Analysis (Table 4-3.7)

A number of the shrublands in the North Section are located in the dunes and do not have too much exposure to sea level rise. At 0.5 m of rise, 5 acres will be inundated, and at 1 m of rise, 17 acres will be flooded. At 1.5 m of rise about 2/3 of the total acreage will be inundated.

Table 4-3.7. Projected acres of North Section Shrubland Inundated by Sea Level Rise

Rise	Acres
0.5 m	5 acres
1 m	17 acres
1.5 m	28 acres

Natural Capital (Table 4-3.8)

Shrubland capital has been decreasing mainly on losses from Irregularly Flooded Eastern Tidal Salt Shrub and recently a loss in Barrier Island Bog. These decreases may possibly continue in the future.

Table 4-3.8. Natural Capital of North Section Shrubland

Year	Natural Capital (in 2012 dollars)
1937	$227,807/year
2002	$53,212/year
2007	$42,312/year

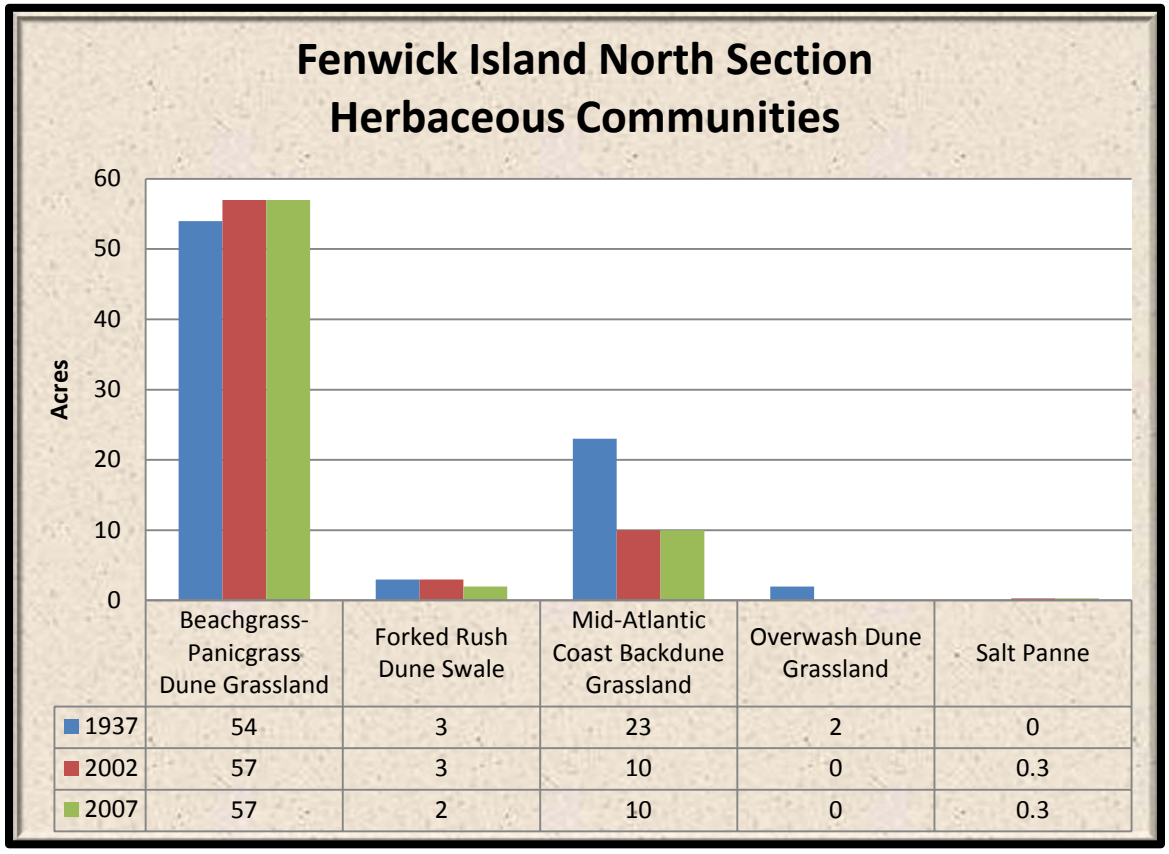


Figure 4-3.8. North Section Herbaceous Communities (1937, 2002, and 2007)

North Section Herbaceous Communities (Figure 4-3.8): Beachgrass-Panicgrass Dune Grassland is the most common herbaceous community followed distantly by Mid-Atlantic Coast Backdune Grassland. Mid-Atlantic Coast Backdune Grassland has suffered the most losses of any herbaceous community.

DNREC Sea Level Rise Analysis (Table 4-3.9)

Herbaceous communities will be lightly affected by the highest amount of sea level rise (1.5 m) with 17 acres inundated. This represents about ¼ of the total acreage.

Table 4-3.9. Projected acres of North Section Herbaceous Communities Inundated by Sea Level Rise

Rise	Acres
0.5 m	0.3 acres
1 m	4 acres
1.5 m	17 acres

Natural Capital (Table 4-3.10)

Herbaceous Communities have declined overall over the study period.

Table 4-3.10. Natural Capital of North Section Herbaceous Communities	
Year	**Natural Capital (in 2012 dollars)**
1937	$12,093/year
2002	$12,080/year
2007	$11,934/year

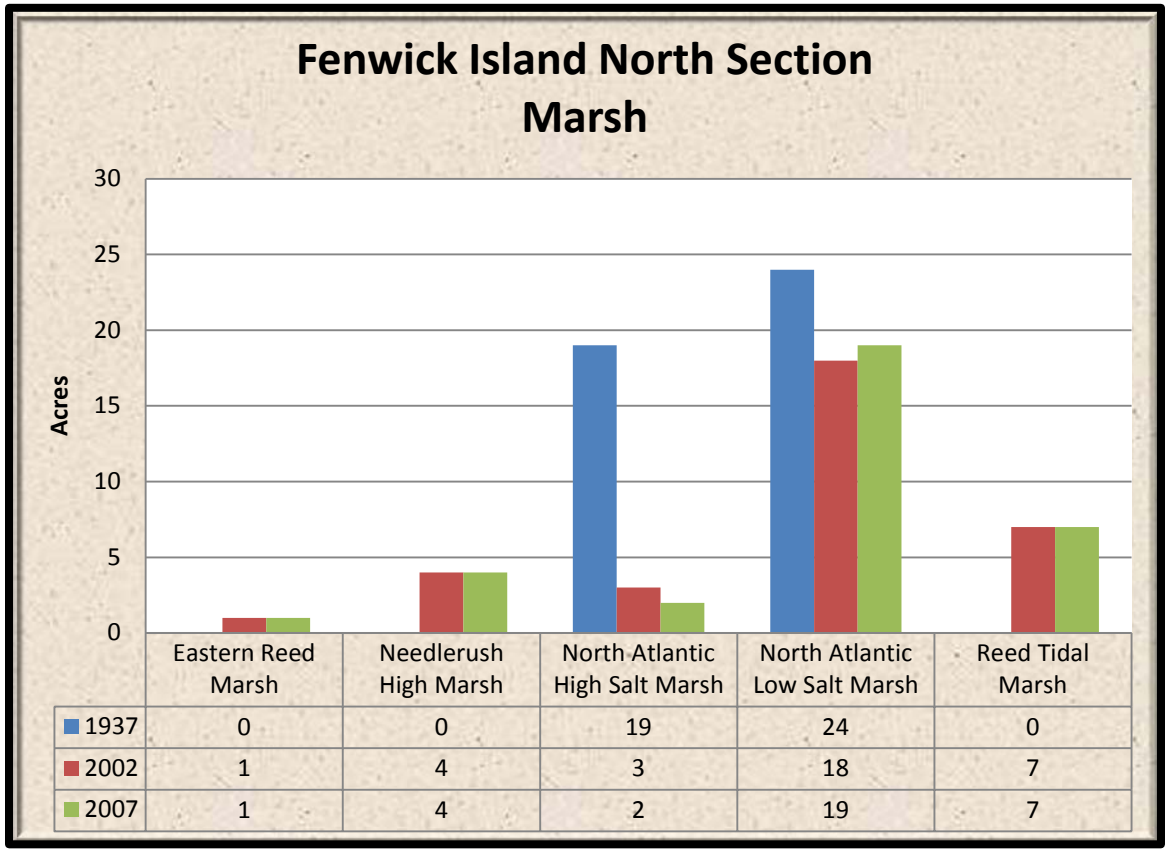


Figure 4-3.9. North Section Marsh (1937, 2002, and 2007)

North Section Marsh (Figure 4-3.9): North Atlantic Low Salt Marsh is the most common marsh community, followed by Needlerush High Marsh. North Atlantic High Salt Marsh has declined the most going from 19 acres in 1937 to 2 acres in 2007. Sea level rise may have some bearing in these losses.

DNREC Sea Level Rise Analysis (Table 4-3.11)

Most of the marshland in the North Section will be completely flooded with 0.5 m of sea level rise. An additional acre will be flooded with 1 m and greater rise.

Table 4-3.11. Projected acres of North Section Marsh Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	32 acres
1 m	33 acres
1.5 m	33 acres

Natural Capital (Table 4-3.12)

Losses to North Atlantic High Salt Marsh have decreased the capital of the marshland in the North Section. It has been stable in the recent period (2002-2007).

Table 4-3.12. Natural Capital of North Section Marsh	
Year	**Natural Capital (in 2012 dollars)**
1937	$269,666/year
2002	$209,963/year
2007	$209,963/year

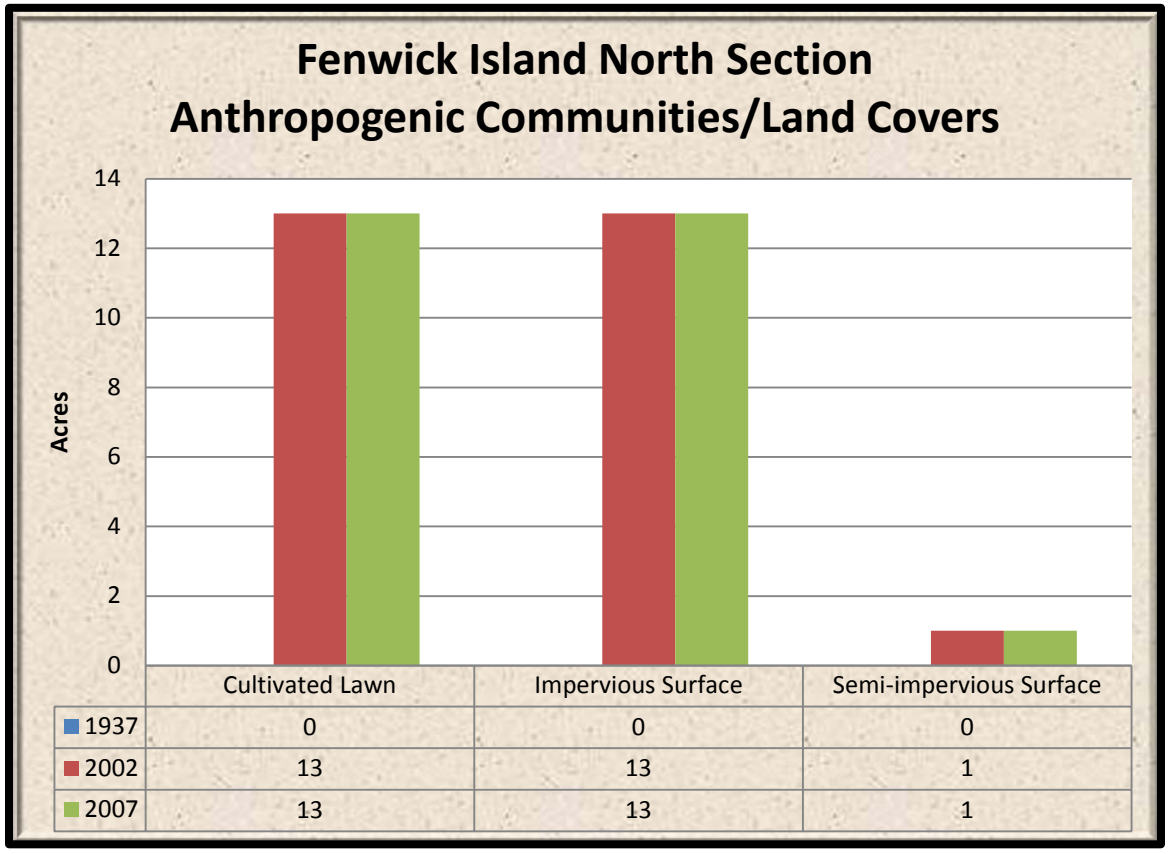


Figure 4-3.10. North Section Anthropogenic Communities/Land Covers (1937, 2002, and 2007)

North Section Anthropogenic Communities/Land Covers (Figure 4-3.10): Impervious surface and cultivated lawn are tied with 13 acres each. Cultivated lawn and impervious surface often walk hand to hand since there are generally cultivated lawns around buildings.

DNREC Sea Level Rise Analysis (Table 4-3.13)

Anthropogenic Communities/Land Covers will be partially inundated with 0.5 m of sea level rise at 8 acres. At 1 m of rise, however, heavy losses will be incurred from inundation. Another 0.5 m of rise will inundate all of them.

Table 4-3.13. Projected acres of North Section Anthropogenic Communities/Land Covers Inundated by Sea Level Rise

Rise	Acres
0.5 m	8 acres
1 m	23 acres
1.5 m	27 acres

Natural Capital

None of the Anthropogenic Communities/Land Covers have any capital value.

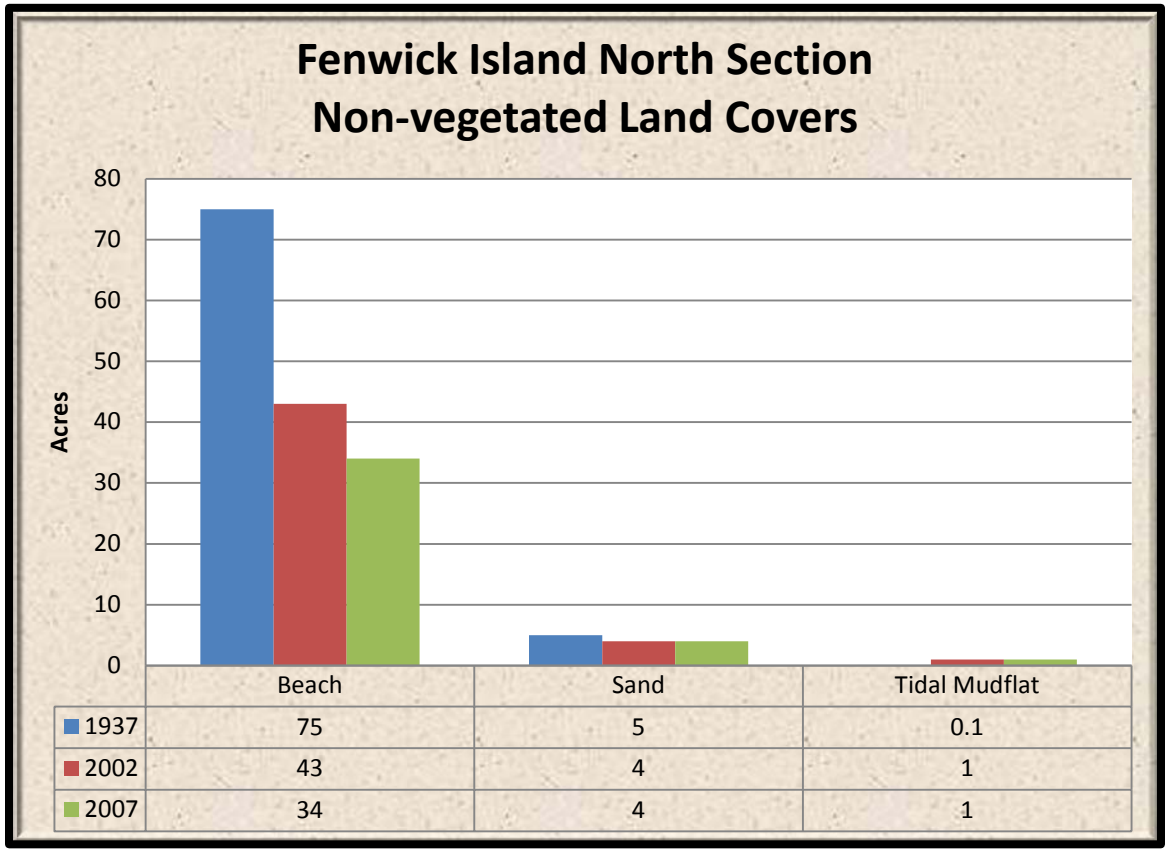


Figure 4-3.11. North Section Non-vegetated Land Covers (1937, 2002, and 2007)

North Section Non-vegetated Land Covers (Figure 4-3.11): Beach area is the most common non-vegetated land cover followed by sand. Tidal mudflat takes up a very small portion of the section.

DNREC Sea Level Rise Analysis (Table 4-3.14)

10 acres of non-vegetated communities will be flooded with 0.5 m of sea level rise. Another 0.5 m of rise will inundate 8 more acres and 1.5 of rise will flood a total of 30 acres or ¾ of the total.

Table 4-3.14. Projected acres of North Section Non-vegetated Communities Inundated by Sea Level Rise

Rise	Acres
0.5 m	10 acres
1 m	18 acres
1.5 m	30 acres

Natural Capital (Table 4-3.15)

Tidal mudflat is the only non-vegetated community with capital value. The increase in acreage of this community has increased the capital of this community.

Table 4-3.15. Natural Capital of North Section Non-vegetated Communities	
Year	**Natural Capital (in 2012 dollars)**
1937	$627/year
2002	$6,271/year
2007	$6,271/year

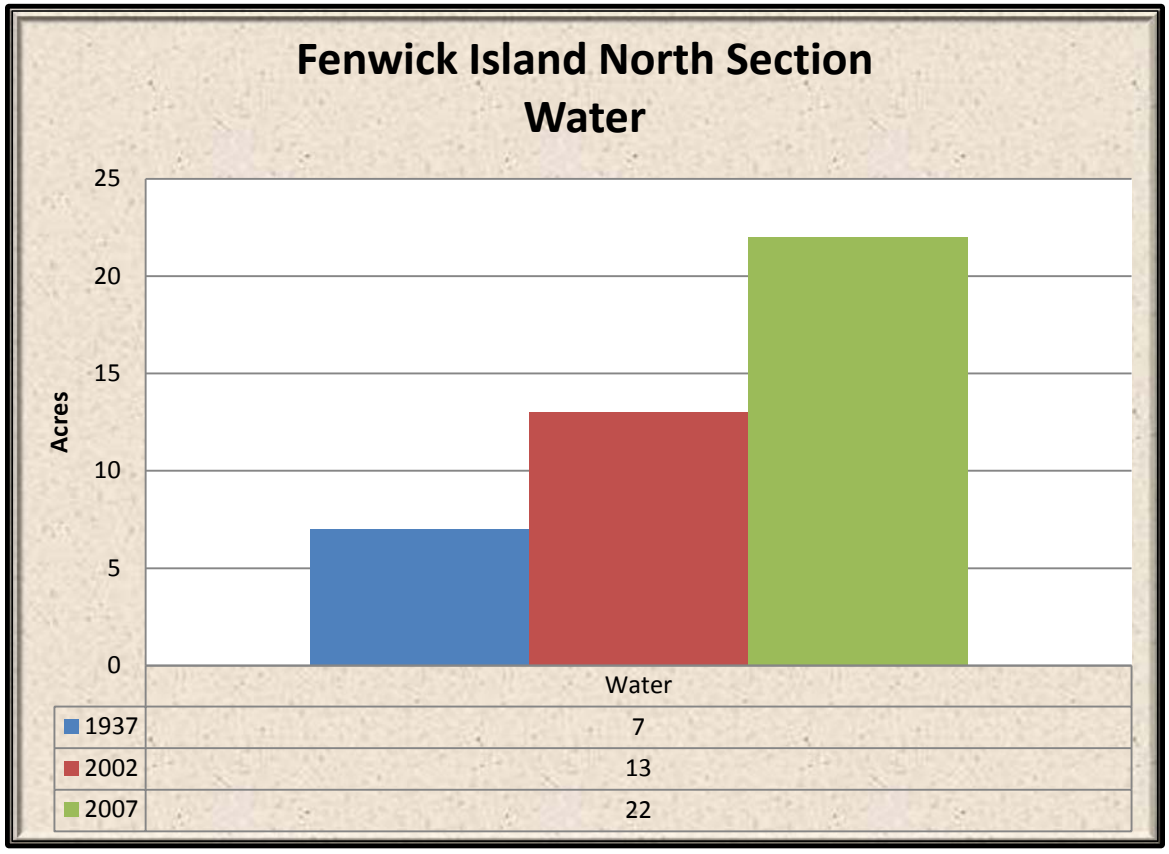


Figure 4-3.12. North Section Water Coverage (1937, 2002, and 2007)

North Section Water Coverage (Figure 4-3.12): Unlike the other two sections, the north section has a substantial amount of area exposed to the bay side of the strand. Water coverage on the ocean side is maintained artificially by beach re-nourishment project which place more sand back on the shore when the amount gets too low. On the bay side, however, there is more water coverage appeared as time goes on and it may be due to sea level rise and erosion.

Natural Capital (Table 4-3.16)

The capital of water has steadily increased being driven by gains in water on the estuary (Little Assawoman Bay) side of the park.

Table 4-3.16. Natural Capital of North Section Water	
Year	**Natural Capital (in 2012 dollars)**
1937	$100,330/year
2002	$115,454/year
2007	$131,051/year

CHAPTER 5: DESCRIPTIONS AND ANALYSIS OF THE VEGETATION COMMUNITIES

Nineteen vegetation communities and six land covers were noted in the survey (Figures 4-1.1-1.3, 4-2.1-2.3, and 4-3.1.-3.3). 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.

An analysis of the change over time is provided for those communities that are considered to be affected most immediately by sea level rise. For Fenwick Island State Park these include the North Atlantic High Salt Marsh, North Atlantic Low Salt Marsh, Needlerush High Marsh, and Irregularly Flooded Eastern Tidal Salt Shrub.

The vegetation communities include:

1. Atlantic Coast Interdune Swale (CEGL003839)—8 acres
2. Barrier Island Bog (CEGL003906)--4 acres
3. Beachgrass-Panicgrass Dune Grassland (CEGL004043)—69 acres
4. Central Coast Beach Heather Dune Shrubland (CEGL003950)—27 acres
5. Chesapeake Bay Maritime Shrubland (CEGL003881)—5 acres
6. Cultivated Lawn (CEGL008462)—20 acres
7. Eastern Reed Marsh (CEGL004141)—4 acres
8. Forked Rush Dune Swale (CEGL004111)—4 acres
9. Irregularly Flooded Eastern Tidal Salt Shrub (CEGL003921)—2 acres
10. Japanese Black Pine Forest (CEGL006012)—3 acres
11. Loblolly Pine Dune Woodland (CEGL006052)—58 acres
12. Mid-Atlantic Coast Backdune Grassland (CEGL004240)—18 acres
13. Needlerush High Marsh (CEGL004186)—4 acres
14. North Atlantic High Salt Marsh (CEGL006006)—2 acres
15. North Atlantic Low Salt Marsh (CEGL004192)—21 acres
16. Northeastern Successional Shrubland (CEGL006451)—0.1 acres
17. Reed Tidal Marsh (CEGL004187)—14 acres
18. Salt Panne (CEGL004308)—0.3 acres
19. Successional Maritime Forest (CEGL006154)—0.4 acres

The land covers include:

1. Beach—52 acres
2. Impervious Surface—25 acres
3. Sand—10 acres
4. Semi-impervious Surface—2 acres
5. Tidal Mudflat—1 acre
6. Water—26 acres

Barrier Island Bog **[4 acres (Figure 5.1, Tables 5.1-5.4)] G2G4 S1**

DEWAP: Interdunal Wetlands
NHC: Northern Atlantic Coastal Plain Dune and Swale

Description

This community was determined to be present from aerial imagery analysis and a direct field observation was not made. Barrier Island Bogs often occurs in dune depressions where there is some shelter from salt spray and high fresh groundwater table. Species typical to this community include southern bayberry (*Morella cerifera*) and highbush blueberry (*Vaccinium corymbosum*) dominating the shrub layer. Associates may include swamp rose (*Rosa palustris*) and inkberry (*Ilex glabra*). Common herbs include yellow-eyed grass (*Xyris torta*), royal fern (*Osmunda regalis*), and spoon-leaved sundew (*Drosera intermedia*).

Analysis of Condition at Fenwick Island State Park

Barrier Island Bog is a shrubby interdunal swale community that forms in dune depressions. This community had the same amount in 2002 as in 1937 but has recently declined. In 2007, only 0.2 acres of the five acres of Barrier Island Bog from 1937 still existed. The rest of the acreage had become 1 acre each of Loblolly Pine Dune Woodland, Central Coast Beach Heather Dune Shrubland, and Japanese Black Pine Forest, and 0.5 acres each of Beachgrass-Panicgrass Dune Grassland and Eastern Reed Marsh (Table 5.1).

Since 1937, this community has migrated into 3 acres of Beachgrass-Panicgrass Dune Grassland, 0.4 acres of Chesapeake Bay Maritime Shrubland, and 0.2 acres each of beach and Central Coast Beach Heather Dune Shrubland (Table 5.2).

Table 5.1. What was once Barrier Island Bog in 1937 has become X or remained in 2007

X	**Acreage**
Loblolly Pine Dune Woodland	1 acre
Central Coast Beach Heather Dune Shrubland	1 acre
Japanese Black Pine Forest	1 acre
Beachgrass-Panicgrass Dune Grassland	0.5 acres
Eastern Reed Marsh	0.5 acres
Other communities/land covers	1 acre

Table 5.2. Barrier Island Bog has migrated into X or remained since 1937	
X	**Acreage**
Beachgrass-Panicgrass Dune Grassland	3 acres
Chesapeake Bay Maritime Shrubland	0.4 acres
Barrier Island Bog	0.2 acres
Beach	0.2 acres
Central Coast Beach Heather Dune Shrubland	0.2 acres
Other communities/land covers	0.3 acres

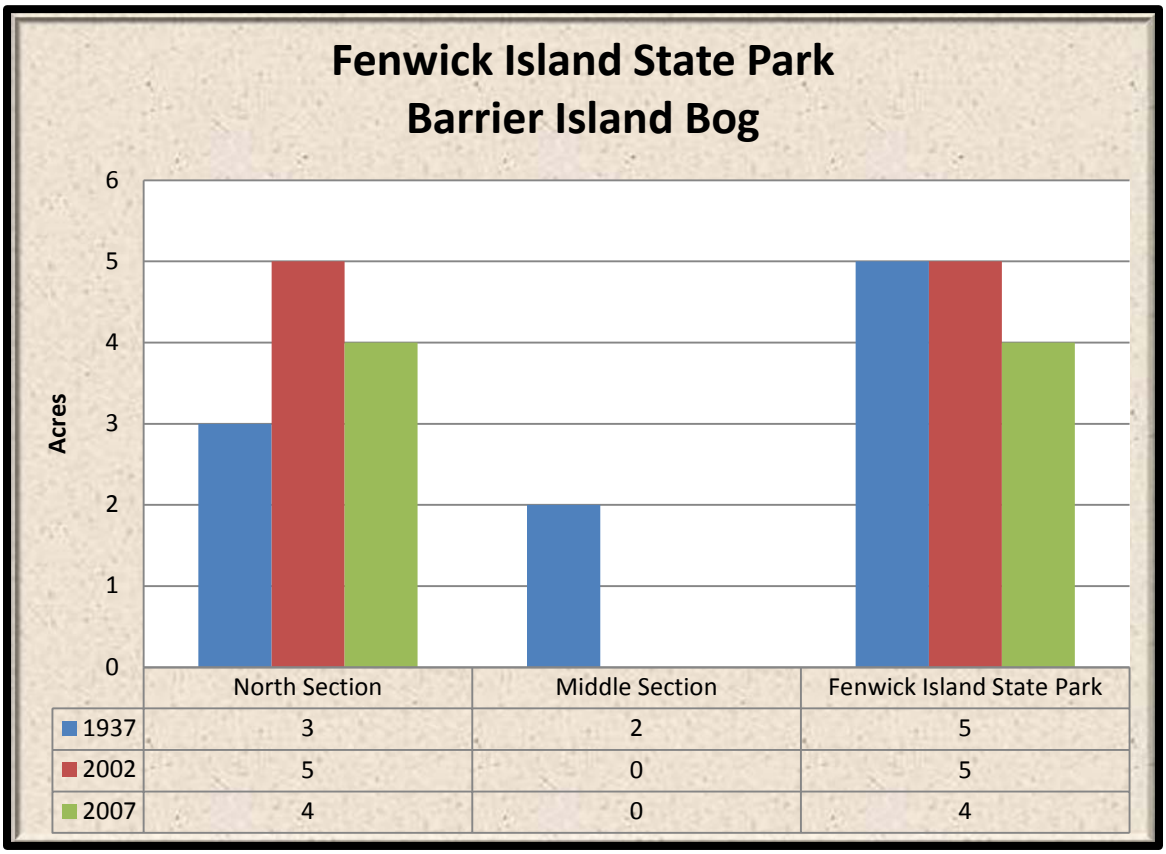


Figure 5.1. Barrier Island Bog at Fenwick Island State Park (1937, 2002, and 2007)

DNREC Sea Level Rise Scenarios (Table 5.3)

The current Barrier Island Bogs in Fenwick Island State Park will be inundated with 1.5 m of sea level rise.

Table 5.3. Projected acres of Barrier Island Bog Impacted by Sea Level Rise	
Rise	**Acres**
0.5 m	0 acres
1 m	1 acre
1.5 m	4 acres

Natural Capital (Table 5.4)

Barrier Island Bogs carry a higher capitalization rate than uplands because of being a wetland making these communities valuable for ecosystem services.

Table 5.4. Natural Capital of Barrier Island Bog	
Year	**Natural Capital (in 2012 dollars)**
1937	$46,407/year
2002	$46,407/year
2007	$37,126/year

Beachgrass-Panicgrass Dune Grassland **[69 acres (Figures 5.2-5.3, Tables 5.5-5.9)]**
G2 S2

DEWAP: Beach and Dune Habitats
NHC: Northern Atlantic Coastal Plain Dune and Swale

Description

Figure 5.2. Beachgrass-Panicgrass Dune Grassland (South Section)

Beachgrass-Panicgrass Dune Grassland is one of the few native type grasslands in Delaware. These grasslands are co-dominated by beachgrass (*Ammophila breviligulata*) and panicgrass (*Panicum amarum*) and associated by scattered individuals of seaside goldenrod (*Solidago sempervirens*), purple sand grass (*Triplasis purpurea*), sand dune sandbur (*Cenchrus tribuloides*), and seaside sandmat (*Chamaesyce polygonifolia*).

Analysis of Condition at Fenwick Island State Park

Beachgrass-Panicgrass Dune Grassland is often threatened by development in places where it is not protected. Within the confines of the park however it has found refuge on the dunes and has increased by covering areas that were once just sand.

In 2007, 33 acres of the original 90 acres from 1937 still survived. The rest of the acreage had become Impervious surface (11 acres), Loblolly Pine Dune Woodland (10 acres), Mid-Atlantic Coast Backdune Grassland (9 acres), and Central Coast Beach Heather Dune Shrubland (5 acres) (Table 5.5).

Since 1937, Beachgrass-Panicgrass Dune Grassland has populated 29 acres of beach, 2 acres each of Chesapeake Bay Maritime Shrubland and Central Coast Beach Heather Dune Shrubland, and 1 acre of Irregularly Flooded Eastern Tidal Salt Shrub (Table 5.6).

Table 5.5. What was once Beachgrass-Panicgrass Dune Grassland in 1937 has become X or remained in 2007	
X	**Acreage**
Beachgrass-Panicgrass Dune Grassland	33 acres
Impervious Surface	11 acres
Loblolly Pine Dune Woodland	10 acres
Mid-Atlantic Coast Backdune Grassland	9 acres
Central Coast Beach Heather Dune Shrubland	5 acres
Other communities/land covers	23 acres

Table 5.6. Beachgrass-Panicgrass Dune Grassland has migrated into X or remained since 1937	
X	**Acreage**
Beachgrass-Panicgrass Dune Grassland	33 acres
Beach	29 acres
Chesapeake Bay Maritime Shrubland	2 acres
Central Coast Beach Heather Dune Shrubland	2 acres
Irregularly Flooded Eastern Tidal Salt Shrub	1 acre
Other communities/land covers	2 acres

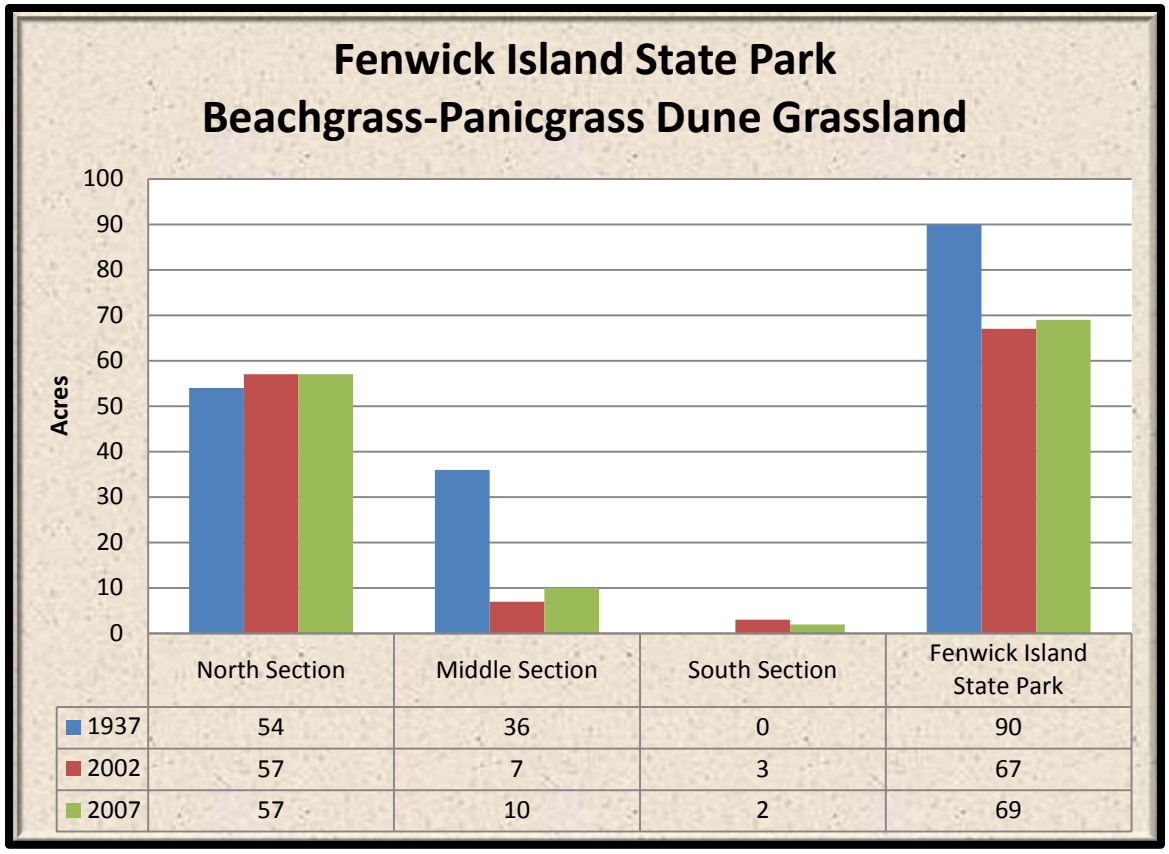


Figure 5.3. Beachgrass-Panicgrass Dune Grassland at Fenwick Island State Park (1937, 2002, and 2007)

DNREC Sea Level Rise Scenarios (Table 5.7)

A lot of the occurrences of this community are located at the tops of dunes that elevated above where most tides reach. At 0.5 m of sea level this community will be slightly impacted in its current extent with 0.2 acres inundated. At 1 m about 1 acre will be impacted and 1.5 m of rise will inundate 10 acres.

Table 5.7. Projected acres of Beachgrass-Panicgrass Dune Grassland Impacted by Sea Level Rise

Rise	Acres
0.5 m	0.2 acres
1 m	1 acres
1.5 m	10 acres

Natural Capital (Table 5.8)

Beachgrass-Panicgrass Dune Grassland are considered upland communities since they are located high above the water on the dunes. This community had its highest capitalization in 1937 and has declined overall but has increased in the short-term (2002-2007).

Table 5.8. Natural Capital of Beachgrass-Panicgrass Dune Grassland	
Year	**Natural Capital (in 2012 dollars)**
1937	$13,113/year
2002	$9,762/year
2007	$10,053/year

Central Coast Beach Heather Dune Shrubland **[27 acres (Figures 5.4-5.5, Tables 5.9-5.12)] G2 S2**

DEWAP: Beach and Dune Habitats
NHC: Northern Atlantic Coastal Plain Dune and Swale

Description

Figure 5.4. Central Coast Beach Heather Dune Shrubland (North Section)

Central Coast Beach Heather Dune Shrubland is a dwarf shrub community that is dominated by beach heather (*Hudsonia tomentosa*). Other species that may occur in scattered numbers around the beach heather include seaside bluestem (*Schizachyrium scoparium* ssp. *littorale*), poison ivy (*Toxicodendron radicans*), seaside goldenrod (*Solidago sempervirens*), and rough buttonweed (*Diodia teres*).

Analysis of Condition at Fenwick Island State Park

Central Coast Beach Heather Dune Shrubland has increased overall since 1937. This may be due to the increase in sand from replenishment projects. The amount has been stable in the near-term. Two acres of the original 15 acres from 1937 still existed in 2007. The rest of the acreage has converted to 3 acres each of Mid-Atlantic Coast Backdune Grassland and Loblolly Pine Dune Woodland, 2 acres of Beachgrass-Panicgrass Dune Grassland, and 1 acre of Impervious Surface (Table 5.9).

Since 1937, this community has migrated into 7 acres of Irregularly Flooded Eastern Tidal Salt Shrub, 5 acres of Beachgrass-Panicgrass Dune Grassland, 4 acres of Mid-Atlantic Coast Backdune Grassland, and 2 acres of North Atlantic Low Salt Marsh (Table 5.10).

Table 5.9. What was once Central Coast Beach Heather Dune Shrubland in 1937 has become X or remained in 2007	
X	**Acreage**
Mid-Atlantic Coast Backdune Grassland	3 acres
Loblolly Pine Dune Woodland	3 acres
Central Coast Beach Heather Dune Shrubland	2 acres
Beachgrass-Panicgrass Dune Grassland	2 acres
Impervious Surface	1 acre
Other communities/land covers	4 acres

Table 5.10. Central Coast Beach Heather Dune Shrubland has migrated into X or remained since 1937	
X	**Acreage**
Irregularly Flooded Eastern Tidal Salt Shrub	7 acres
Beachgrass-Panicgrass Dune Grassland	5 acres
Mid-Atlantic Coast Backdune Grassland	4 acres
Central Coast Beach Heather Dune Shrubland	2 acres
North Atlantic Low Salt Marsh	2 acres
Other communities/land covers	8 acres

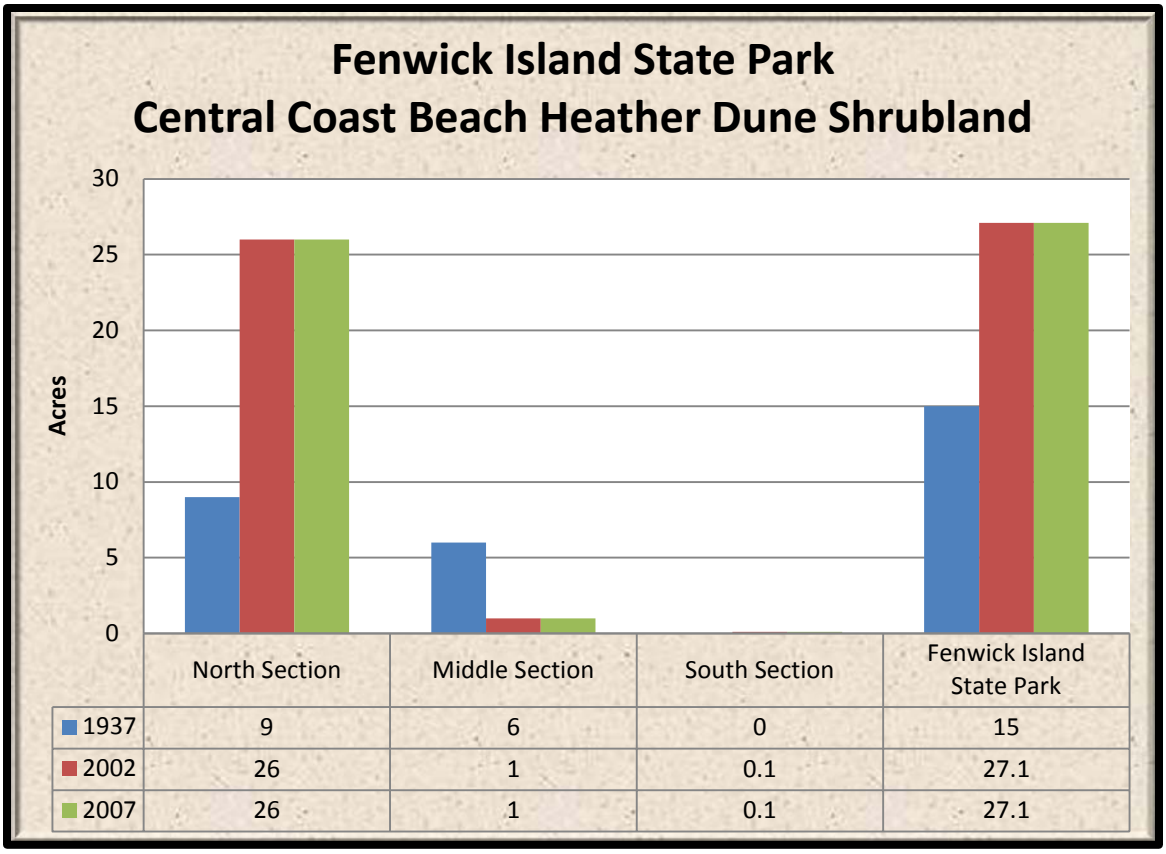


Figure 5.5. Central Coast Beach Heather Dune Shrubland at Fenwick Island State Park (1937, 2002, and 2007)

DNREC Sea Level Rise Scenarios (Table 5.11)

About 4 acres of this community will inundated with 0.5 am of sea level rise in its current extent. At 1 m of rise 14 acres will be impacted. It will almost be eliminated at 1.5 m of rise but since this community is fairly mobile it will likely colonize new areas as sea level rises.

Table 5.11. Projected acres of Central Coast Beach Heather Dune Shrubland Impacted by Sea Level Rise

Rise	Acres
0.5 m	4 acres
1 m	14 acres
1.5 m	21 acres

Natural Capital (Table 5.12)

Central Coast Beach Heather Dune Shrubland has gained in acreage making its capitalization go up as well.

Table 5.12. Natural Capital of Central Coast Beach Heather Dune Shrubland	
Year	**Natural Capital (in 2012 dollars)**
1937	$2,186/year
2002	$3,948/year
2007	$3,948/year

Chesapeake Bay Maritime Shrubland **[5 acres (Figures 5.6-5.7, Tables 5.13-5.16)] G2 S1**

DEWAP: Beach and Dune Habitats
NHC: Northern Atlantic Coastal Plain Dune and Swale

Description

Like other maritime communities, this community is easily determined from aerial imagery analysis, which was done here. In Delaware this community is generally composed of northern bayberry (*Morella pensylvanica*) and beach plum (*Prunus maritima*). Other woody associates may include salt shrub (*Baccharis halimifolia*), winged sumac (*Rhus copallina*), sassafras (*Sassafras albidum*), poison ivy (*Toxicodendron radicans*), and common greenbrier (*Smilax rotundifolia*). Common herbs may include American beachgrass (*Ammophila breviligulata*), American sea-rocket (*Cakile edentula*), dune sandbur (*Cenchrus tribuloides*), seaside spurge (*Chamaesyce polygonifolia*), Gray's sedge (*Carex grayi*), beach heather (*Hudsonia tomentosa*), and sea beach evening primrose (*Oenothera humifusa*).

Figure 5.6. Chesapeake Bay Maritime Shrubland (North Section)

Analysis of Condition at Fenwick Island State Park

This shrub community comes and goes as it is covered and uncovered by sand in the dunes. This cyclical nature can be seen in the chart below. Currently there are about five acres of this community in the park. This community is expected to remain at about the same amount the future.

Only 0.5 acres of the original 9 acres from 1937, was still present in 2007. The rest of the acreage has converted to 2 acres each of Loblolly Pine Dune Woodland and Beachgrass-Panicgrass Dune Grassland, and 1 acre each of Central Coast Beach Heather Dune Shrubland, Mid-Atlantic Coast Backdune Grassland, and Sand (Table 5.13).

Since 1937, this community has migrated into 2 acres of Beachgrass-Panicgrass Dune Grassland, 1 acre each of Beach and Central Coast Beach Heather Dune Shrubland, and 0.4 acres of Wax-Myrtle Shrub Swamp (Table 5.14).

Table 5.13. What was once Chesapeake Bay Maritime Shrubland in 1937 has become X or remained in 2007	
X	**Acreage**
Loblolly Pine Dune Woodland	2 acres
Beachgrass-Panicgrass Dune Grassland	2 acres
Central Coast Beach Heather Dune Shrubland	1 acre
Mid-Atlantic Coast Backdune Grassland	1 acre
Sand	1 acre
Other communities/land covers	2 acres

Table 5.14. Chesapeake Bay Maritime Shrubland has migrated into X or remained since 1937	
X	**Acreage**
Beachgrass-Panicgrass Dune Grassland	2 acres
Beach	1 acre
Central Coast Beach Heather Dune Shrubland	1 acre
Chesapeake Bay Maritime Shrubland	0.5 acres
Wax-Myrtle Shrub Swamp	0.4 acres
Other communities/land covers	1 acre

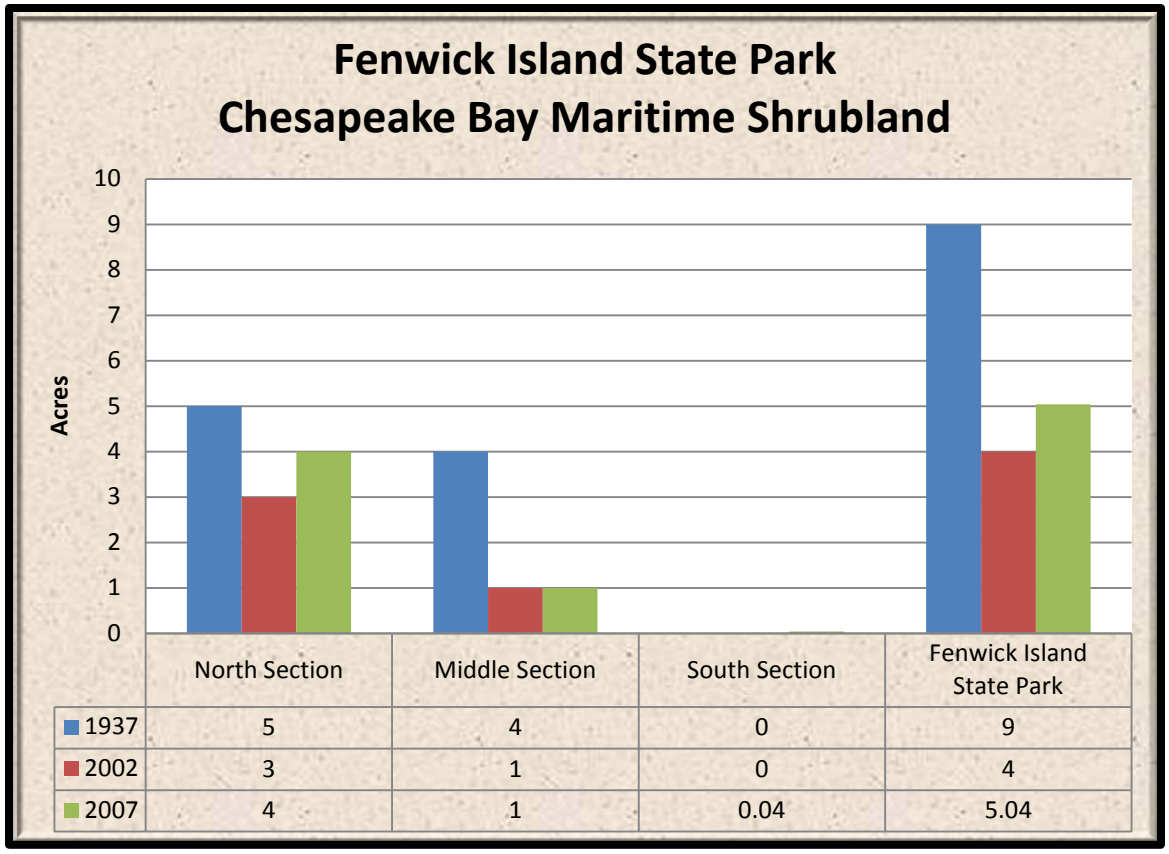


Figure 5.7. Chesapeake Bay Maritime Shrubland at Fenwick Island State Park (1937, 2002, and 2007)

DNREC Sea Level Rise Scenarios (Table 5.15)

Chesapeake Bay Maritime Shrubland will still be present with 1.5 m of sea level rise with about 2/3 of the current acreage inundated. It will not be affected with 0.5 m of sea level rise.

Table 5.15. Projected acres of Chesapeake Bay Maritime Shrubland Impacted by Sea Level Rise	
Rise	**Acres**
0.5 m	0 acres
1 m	2 acres
1.5 m	3 acres

Natural Capital (Table 5.16)

Natural capital has declined overall since 1937 with a slight uptick in the recent period (2002-2007).

Table 5.16. Natural Capital of Chesapeake Bay Maritime Shrubland	
Year	**Natural Capital (in 2012 dollars)**
1937	$1,311/year
2002	$583/year
2007	$734/year

Cultivated Lawn **[20 acres (Figure 5.8, Tables 5.17-5.19)] GNA SNA**

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

Description

This man-made community is most often composed of tall fescue (*Festuca arundinacea*) that is mowed more than once a year. Cultivated lawns are often found in concert with the impervious surface of developed areas.

Analysis of Condition at Fenwick Island State Park

This community is human made and often edges developed area. Cultivated lawn like development (impervious surface) has increased markedly since 1937 but has been stable in the short-term in the park.

Practically all of the cultivated lawn present in 1937 is now covered by impervious surface (Table 5.17). However, since 1937 this community has expanded into 5 acres of Beachgrass-Panicgrass Dune Grassland, 4 acres of Mid-Atlantic Coast Backdune Grassland, 3 acres of Irregularly Flooded Eastern Tidal Salt Shrub, 2 acres of North Atlantic Low Salt Marsh, and 1 acre of North Atlantic High Salt Marsh.

Table 5.17. What was once Cultivated Lawn in 1937 has become X or remained in 2007	
X	**Acreage**
Impervious Surface	0.01 acres

Table 5.18. Cultivated Lawn has migrated into X or remained since 1937	
X	**Acreage**
Beachgrass-Panicgrass Dune Grassland	5 acres
Mid-Atlantic Coast Backdune Grassland	4 acres
Irregularly Flooded Eastern Tidal Salt Shrub	3 acres
North Atlantic Low Salt Marsh	2 acres
North Atlantic High Salt Marsh	1 acre
Other communities/land covers	6 acres

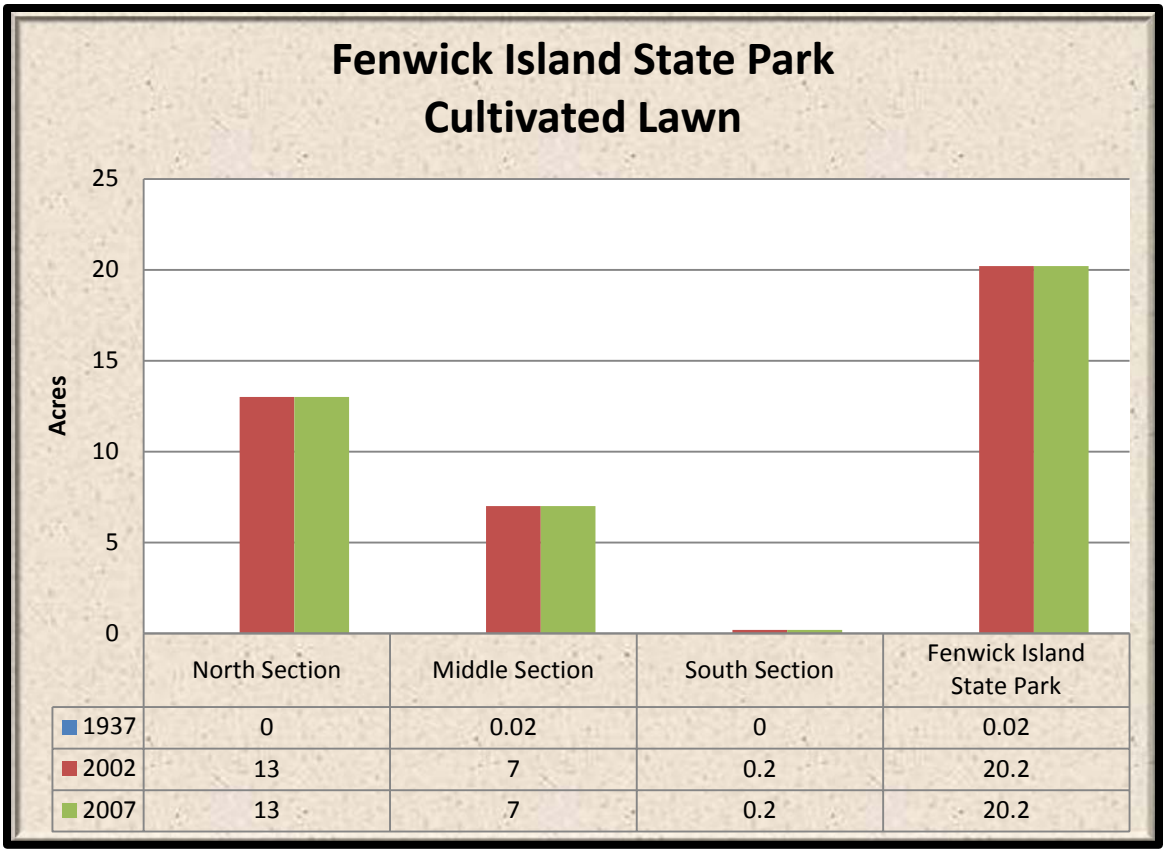


Figure 5.8. Cultivated Lawn at Fenwick Island State Park (1937, 2002, and 2007)

DNREC Sea Level Rise Scenarios (Table 5.19)

Six acres of Cultivated Lawn will be inundated with 0.5 m of sea level rise. Cultivated Lawn will essentially be eliminated with 1 m of rise and higher in its current extent. This has a lot of implications for human infrastructure since this community is closely related and adjacent.

Table 5.19. Projected acres of Cultivated Lawn Impacted by Sea Level Rise

Rise	Acres
0.5 m	6 acres
1 m	19 acres
1.5 m	20 acres

Natural Capital

Cultivated Lawn does carry any natural capital value.

Eastern Reed Marsh **[4 acres (Figure 5.9, Tables 5.20-5.22)] GNA SNA**

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

Description

This marsh community is composed entirely an exotic invasive plant, common reed (*Phragmites australis*). This particular community is located in non-tidal wetlands.

Analysis of Condition at Fenwick Island State Park

Eastern Reed Marsh has decreased in extent with control efforts in the park. It is hoped that continued efforts will eliminate this community from the park. This community was not present in 1937 but has migrated into 1 acre each of Beachgrass-Panicgrass Dune Grassland, Mid-Atlantic Coast Backdune Grassland, Wax-Myrtle Shrub Swamp, and North Atlantic Low Salt Marsh and 0.5 acres of Barrier Island Bog.

Table 5.20. Eastern Reed Marsh has migrated into X or remained since 1937

X	Acreage
Beachgrass-Panicgrass Dune Grassland	1 acre
Mid-Atlantic Coast Backdune Grassland	1 acre
Wax-Myrtle Shrub Swamp	1 acre
North Atlantic Low Salt Marsh	1 acre
Barrier Island Bog	0.5 acres
Other communities/land covers	0.4 acres

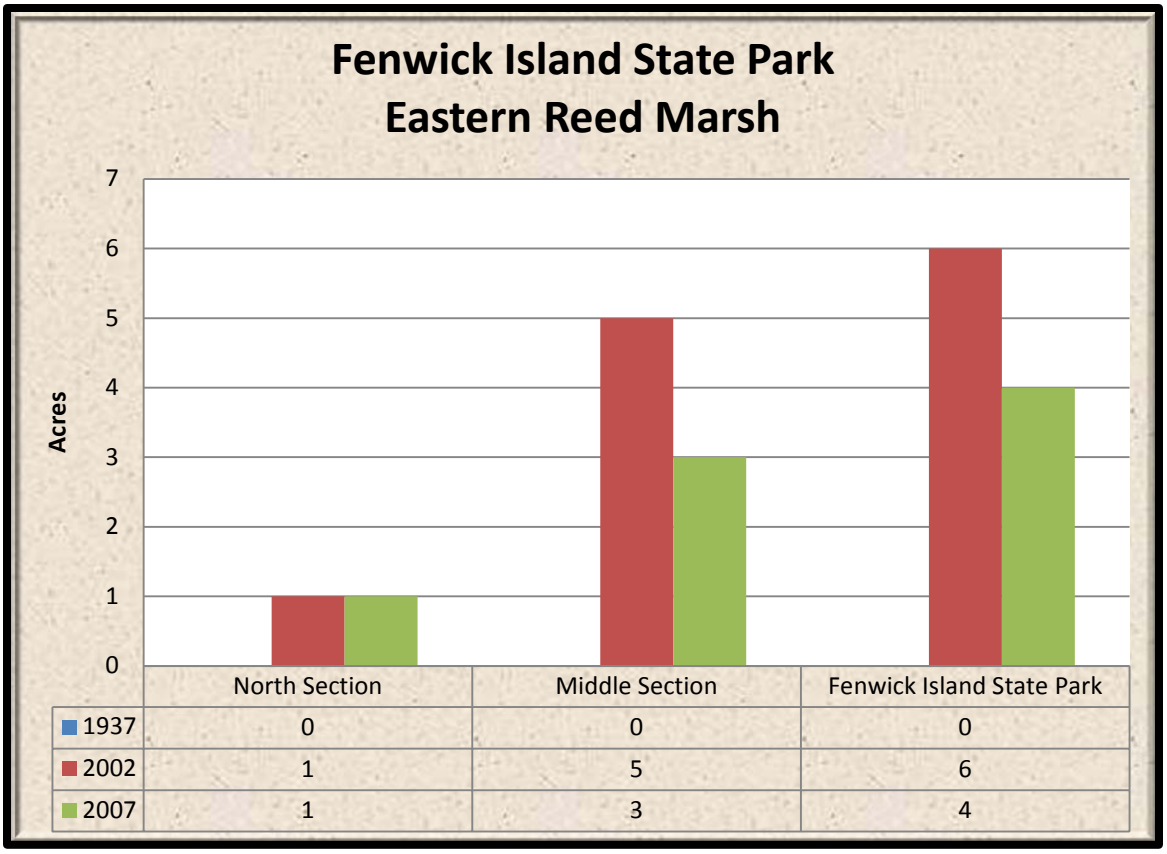


Figure 5.9. Eastern Reed Marsh at Fenwick Island State Park (1937, 2002, and 2007)

DNREC Sea Level Rise Scenarios

Half of the current acreage of Eastern Reed Marsh will be inundated with 0.5 m of sea level and will be eliminated in its current extent with 1 m of rise or higher.

Table 5.21. Projected acres of Eastern Reed Marsh Impacted by Sea Level Rise	
Rise	**Acres**
0.5 m	2 acres
1 m	4 acres
1.5 m	4 acres

Natural Capital (Table 5.22)

In spite of being a community dominated by an exotic invasive plant species, this community is still a wetland and still filters nutrient, though probably not as well as a native wetland. The highest capitalization for this community was reached in 2002.

Table 5.22. Natural Capital of Eastern Reed Marsh

Year	Natural Capital (in 2012 dollars)
1937	$0/year (not present)
2002	$55,688/year
2007	$37,126/year

Forked Rush Dune Swale **[4 acres (Figure 5.10, Tables 5.23-5.26)] G2 S2**

DEWAP: Beach and Dune Habitats
NHC: Northern Atlantic Coastal Plain Dune and Swale

Description [36]

This interdunal swale community is dominated by forked rush (*Juncus dichotomus*) and associated by grassleaf rush (*Juncus biflorus*), Canada rush (*Juncus canadensis*), round-head rush (*J. scirpoides*), broom-sedge (*Andropogon virginicus*), spoon-leaved sundew (*Drosera intermedia*), and three-square bulrush (*Schoenoplectus pungens*). It is generally the most common herbaceous interdunal community.

Analysis of Condition at Fenwick Island State Park

This community has been oscillating in amount as it is covered and uncovered and by shifting sand. These communities will likely be around for the long-term just not in the same places or amounts.

None of the Forked Rush Dune Swale from 1937 was still present in 2007 showing a lot of change in this community. The area that was once this community has become 2 acres each of Mid-Atlantic Coast Backdune Grassland, 1 acre of Central Coast Beach Heather Dune Shrubland, 0.4 acres of Loblolly Pine Dune Woodland, and 0.1 acres each of Beachgrass-Panicgrass Dune Grassland, and Japanese Black Pine Forest (Table 5.23).

Since 1937, Forked Rush Dune Swale has populated 3 acres of Beachgrass-Panicgrass Dune Shrubland, 0.5 acres each of Mid-Atlantic Coast Backdune Grassland and water, 0.3 acres of Central Coast Beach Heather Dune Shrubland, and 0.2 acres of North Atlantic Low Salt Marsh (Table 5.24).

Table 5.23. What was once Forked Rush Dune Swale in 1937 has become X or remained in 2007

X	**Acreage**
Mid-Atlantic Coast Backdune Grassland	2 acres
Central Coast Beach Heather Dune Shrubland	1 acre
Loblolly Pine Dune Woodland	0.4 acres
Beachgrass-Panicgrass Dune Grassland	0.1 acres
Japanese Black Pine Forest	0.1 acres
Other communities/land covers	0.1 acres

[36] McAvoy, Bill. 1995. Interdune bog description from site survey report.

Table 5.24. Forked Rush Dune Swale has migrated into X or remained since 1937	
X	**Acreage**
Beachgrass-Panicgrass Dune Grassland	3 acres
Mid-Atlantic Coast Backdune Grassland	0.5 acres
Water	0.5 acres
Central Coast Beach Heather Dune Shrubland	0.3 acres
North Atlantic Low Salt Marsh	0.2 acres
Other communities/land covers	0.2 acres

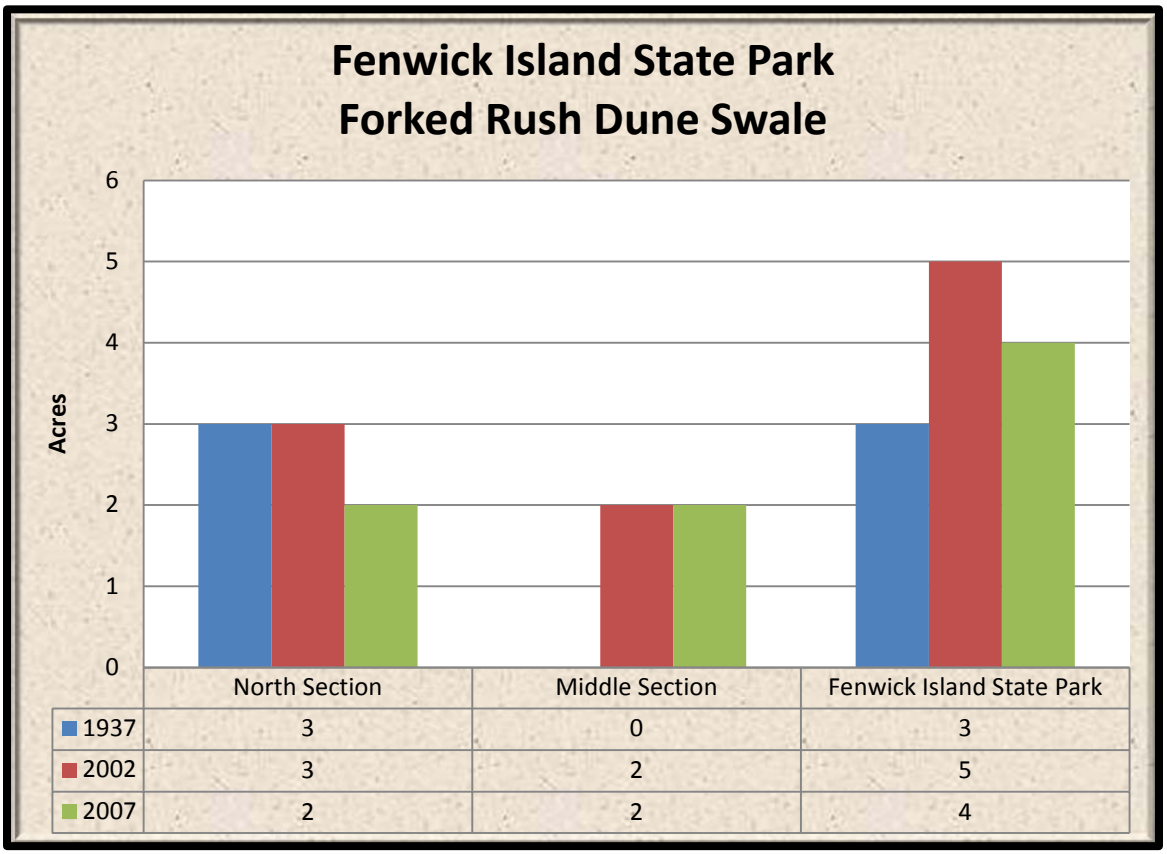


Figure 5.10. Forked Rush Dune Swale at Fenwick Island State Park (1937, 2002, and 2007)

DNREC Sea Level Rise Scenarios (Table 5.25)

About 1 acre of Forked Rush Dune Swale will be inundated with 0.5 m of sea level rise. This community will be eliminated in its current extent with 1 m or above. Since this community is found in low places in the dunes and requires a freshwater wetland it is unlikely that it will be able to migrate much if at all.

Table 5.25. Projected acres of Forked Rush Dune Swale Impacted by Sea Level Rise	
Rise	**Acres**
0.5 m	1 acre
1 m	4 acres
1.5 m	4 acres

Natural Capital (Table 5.26)

Forked Rush Dune Swale reached its greatest capitalization in 2002 and has declined from here.

Table 5.26. Natural Capital of Forked Rush Dune Swale	
Year	**Natural Capital (in 2012 dollars)**
1937	$27,844/year
2002	$46,407/year
2007	$37,126/year

Irregularly Flooded Eastern Tidal Salt Shrub **[2 acres (Figures 5.11-5.12, Tables 5.27-5.30)]**
G5 S5

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

Description

This shrub community lies at an elevation just higher than the North Atlantic High Salt Marsh. It is composed of salt shrub (*Baccharis halimifolia*) and marsh elder (*Iva frutescens*) in about equal amounts. Scattered clumps of salt meadow hay (*Spartina patens*) and individuals of seaside goldenrod (*Solidago sempervirens*) and sea lavender (*Pluchea odorata*) may be present underneath.

Analysis of Condition at Fenwick Island State Park

This community appears to be in decline or is stable in acreage throughout the Delaware coast. If the marshes are retreating landward there would be some losses but there should also be some gains going into the adjacent forests. Field observations seem to suggest that sea level rise is happening so fast that this community is not able to retreat landward fast enough and is being overrun. In 1937 there 27 acres of this community present within the park but in the recent period (2002-2007) it has declined to two acres where it has remained. Between 1937 and 2002 period this community lost acreage at an average rate of 0.39 acres/year in the park with the north section losing the most (Figure 4.9). Between 1937 and 2007 it lost acreage at an average rate of 0.36 acres/year in the park with the north section losing the most (Figure 4.9). In the 2002 to 2007 period the acreage was stable (Figure 4.9).

Irregularly Flooded Eastern Tidal Salt Shrub has changed quite a bit since 1937, with only 0.3 acres of the original 27 acres still existing in 2007. The rest of the acreage has become 8 acres of Loblolly Pine Dune Woodland, 7 acres of Central Coast Beach Heather Dune Shrubland, 3 acres of Cultivated Lawn, and 2 acres each of impervious surface and Eastern Reed Marsh (Table 5.27). This generally shows a migration of the land westward since most of these occurrences are located on the west side of the park.

Since 1937, this community has migrated into 1 acre each of Mid-Atlantic Coast Backdune Grassland and North Atlantic Low Salt Marsh, 0.2 acres of water, and 0.1 acres of North Atlantic High Salt Marsh (Table 5.28).

In the near term the acreage appears to be stable, but judging from the long-term loses, the prospects for this community do not look good. It may eventually transition to a North Atlantic High Salt Marsh or may go straight to a North Atlantic Low Salt Marsh.

Table 5.27. What was once Irregularly Flooded Eastern Tidal Salt Shrub in 1937 has become X or remained in 2007	
X	**Acreage**
Loblolly Pine Dune Woodland	8 acres
Central Coast Beach Heather Dune Shrubland	7 acres
Cultivated Lawn	3 acres
Impervious Surface	2 acres
Reed Tidal Marsh	2 acres
Other communities/land covers	5 acres

Table 5.28. Irregularly Flooded Eastern Tidal Salt Shrub has migrated into X or remained since 1937	
X	**Acreage**
Mid-Atlantic Coast Backdune Grassland	1 acre
North Atlantic Low Salt Marsh	1 acre
Irregularly Flooded Eastern Tidal Salt Shrub	0.3 acres
Water	0.2 acres
North Atlantic High Salt Marsh	0.1 acres

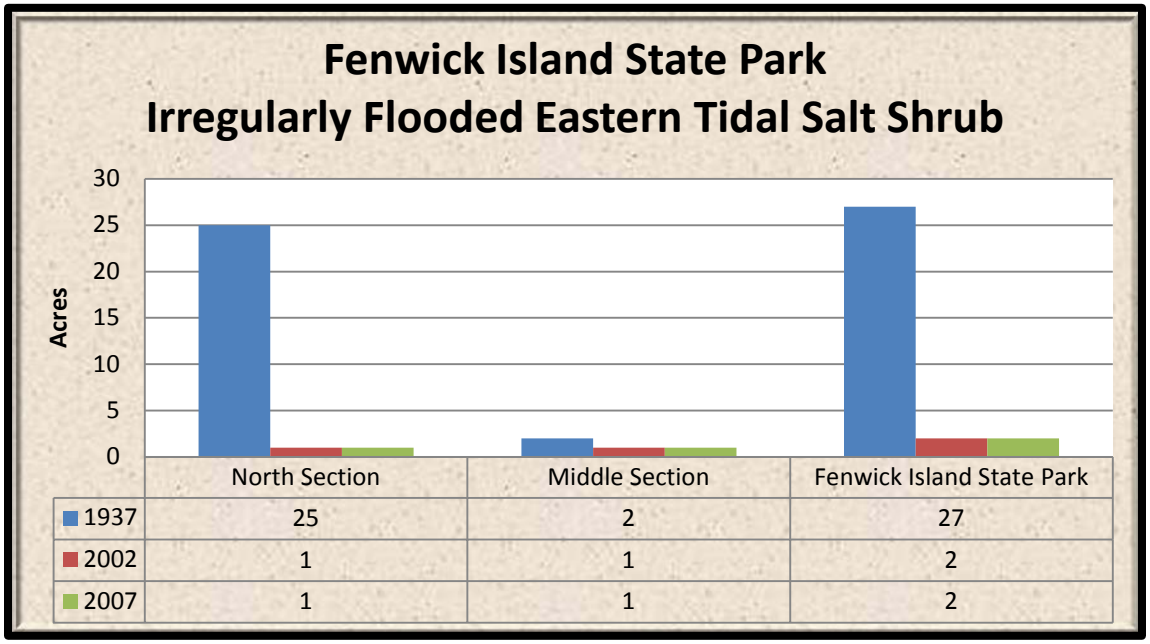


Figure 5.11. Irregularly Flooded Eastern Tidal Salt Shrub at Fenwick Island State Park (1937, 2002, and 2007)

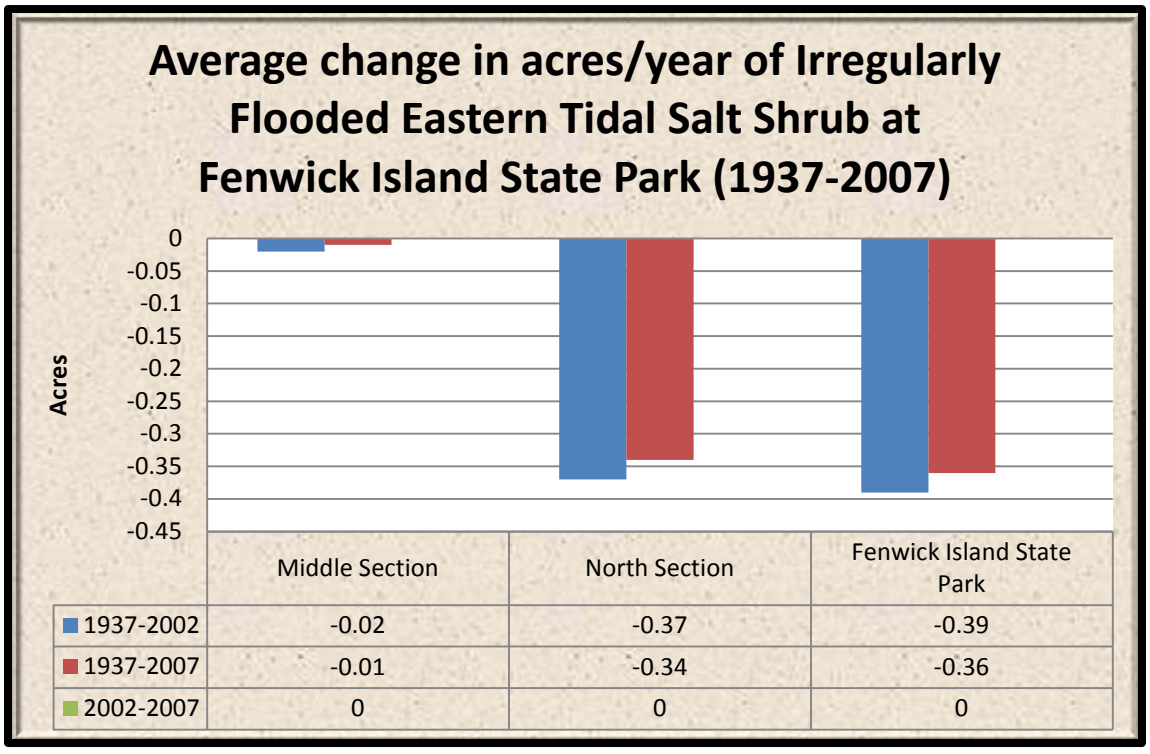


Figure 5.12. Average change in acres/year of Irregularly Flooded Eastern Tidal Salt Shrub (1937-2007)

DNREC Sea Level Rise Scenarios (Table 5.29)

All of the current extent of Irregularly Flooded Eastern Tidal Salt Shrub will be inundated with 0.5 m of sea level rise.

Table 5.29. Projected acres of Irregularly Flooded Eastern Tidal Salt Shrub Impacted by Sea Level Rise

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

Natural Capital (Table 5.30)

Capitalization of Irregularly Flooded Eastern Tidal Salt Shrub has markedly fallen with decreases in acreage.

Table 5.30. Natural Capital of Irregularly Flooded Eastern Tidal Salt Shrub

Year	Natural Capital (in 2012 dollars)
1937	$169,325/year
2002	$12,543/year
2007	$12,543/year

Japanese Black Pine Forest **[3 acres (Figure 5.13, Tables 5.31-5.33)] GNA SNA**

DEWAP: Beach and Dune Habitats
NHC: Northern Atlantic Coastal Plain Dune and Swale

Description

This forest is composed of exotic species, Japanese Black Pine (*Pinus thunbergiana*). Beachgrass (*Ammophila breviligulata*) may grow underneath the pine in some cases.

Analysis of Condition at Fenwick Island State Park

The species comprising this community, Japanese Black Pine (*Pinus thunbergiana*) was planted in the 1940's since it could withstand the salt spray that is prevalent in the beach area. This species is an exotic species to the area and there are currently efforts underway to reduce the amount of this species on the coast.

This community was not present in 1937 and has since converted or migrated into 2 acres of Beachgrass-Panicgrass Dune Grassland, 1 acre of Barrier Island Bog, 0.4 acres of Beach, 0.3 acres of Central Coast Beach Heather Dune Shrubland, and 0.2 acres of Wax-Myrtle Shrub Swamp (Table 5.31).

Table 5.31. Japanese Black Pine Forest has migrated into X or remained since 1937

X	**Acreage**
Beachgrass-Panicgrass Dune Grassland	2 acres
Barrier Island Bog	1 acre
Beach	0.4 acre
Central Coast Beach Heather Dune Shrubland	0.3 acres
Wax-Myrtle Shrub Swamp	0.2 acres
Other communities/land covers	0.2 acres

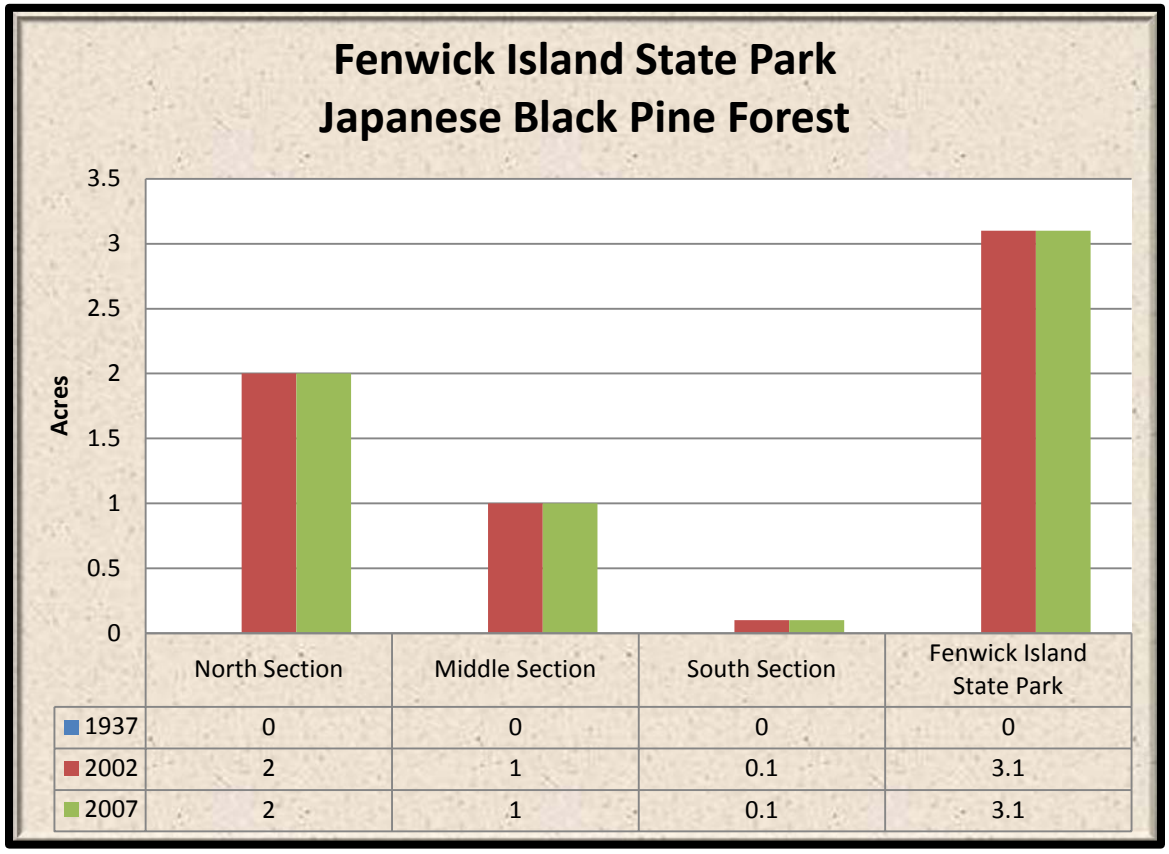


Figure 5.13. Japanese Black Pine Forest at Fenwick Island State Park (1937, 2002, and 2007)

DNREC Sea Level Rise Scenarios (Table 5.32)

All of the current extent of this community will be inundated with 0.5 m of sea level rise.

Table 5.32. Projected acres of Japanese Black Pine Forest Impacted by Sea Level Rise	
Rise	**Acres**
0.5 m	2 acres
1 m	2 acres
1.5 m	2 acres

Natural Capital (Table 5.33)

Japanese Black Pine Forest appeared at some point between 1937 and 2002. The capitalization has remained stable in the 2002 to 2007 period.

Table 5.33. Natural Capital of Japanese Black Pine Forest	
Year	**Natural Capital (in 2012 dollars)**
1937	$0/year (not present)
2002	$586/year
2007	$586/year

Loblolly Pine Dune Woodland **[58 acres (Figures 5.14-5.15, Tables 5.34-5.37)] G1G2 S1**

DEWAP: Beach and Dune Habitats
NHC: Northern Atlantic Coastal Plain Maritime Forest

Description

This woodland community is located in large to the west of DE 1, where there is some shelter from the direct effects of salt spray. Loblolly pine (*Pinus taeda*) associated by red maple (*Acer rubrum*) in a canopy overtopping sweetgum (*Liquidambar styraciflua*), southern red oak (*Quercus falcata*), serviceberry (*Amelanchier arborea*), and wild black cherry (*Prunus serotina*). Shrubs include inkberry (*Ilex glabra*), southern bayberry (*Morella cerifera*), highbush blueberry (*Vaccinium corymbosum*), lowbush blueberry (*Vaccinium stamineum*), and red chokeberry (*Aronia arbutifolia*) typify this community. Cinnamon fern (*Osmunda cinnamomea*) and roundleaf thoroughwort (*Eupatorium rotundifolium*) were the only herbs noted.

Figure 5.14. Loblolly Pine Dune Woodland (North Section)

All of the occurrences of this community could be considered to be mature. Layers (canopy, understory, and shrub) are separated well. The widths of trees range from range from 0.5 feet to about 1.5 feet diameter-at-breast height in most cases.

Analysis of Condition at Fenwick Island State Park

This community has increased by a large margin since 1937 when there was a lot of open area at the coast. Some this resurgence may be due to DE 1 creating a more stable area to the west of the road which does not likely receive as much sand as it once did.

Table 5.34. What was once Loblolly Pine Dune Woodland in 1937 has become X or remained in 2007

X	**Acreage**
Loblolly Pine Dune Woodland	6 acres
North Atlantic Low Salt Marsh	0.3 acres
Reed Tidal Marsh	0.3 acres
Cultivated Lawn	0.3 acres
Impervious Surface	0.3 acres
Other communities/land covers	0.4 acres

Table 5.35. Loblolly Pine Dune Woodland has migrated into X or remained since 1937	
X	**Acreage**
Mid-Atlantic Coast Backdune Grassland	13 acres
Beachgrass-Panicgrass Dune Grassland	10 acres
Irregularly Flooded Eastern Tidal Salt Shrub	8 acres
Loblolly Pine Dune Woodland	6 acres
North Atlantic Low Salt Marsh	5 acres
Other communities/land covers	16 acres

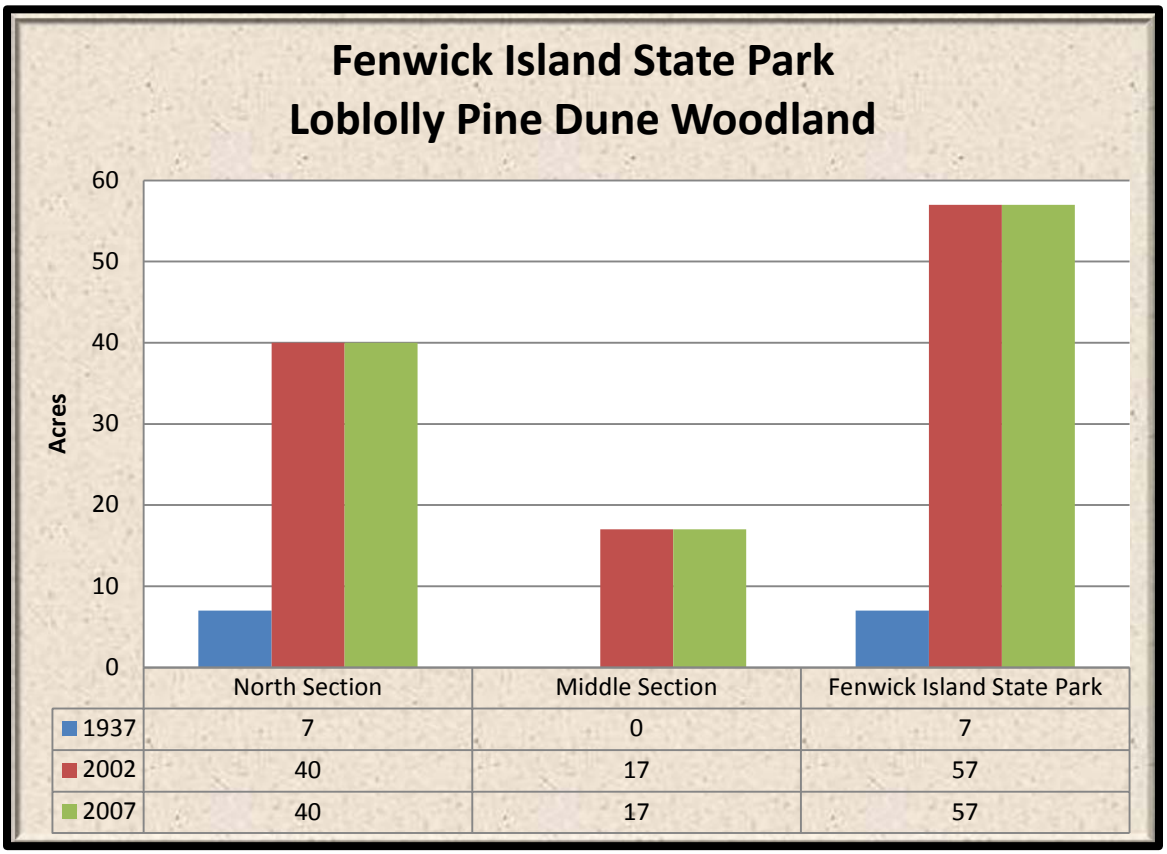


Figure 5.15. Loblolly Pine Dune Woodland at Fenwick Island State Park (1937, 2002, and 2007)

DNREC Sea Level Rise Scenarios (Table 5.36)

Loblolly Pine Dune Woodland will be completely inundated in its current extent with 1.5 m of sea level rise.

Table 5.36. Projected acres of Loblolly Pine Dune Woodland Impacted by Sea Level Rise	
Rise	**Acres**
0.5 m	28 acres
1 m	53 acres
1.5 m	56 acres

Natural Capital (Table 5.37)

Capitalization of Loblolly Pine Dune Woodland has increased as these communities mature from former grasslands.

Table 5.37. Natural Capital of Loblolly Pine Dune Woodland	
Year	**Natural Capital (in 2012 dollars)**
1937	$1,324/year
2002	$10,779/year
2007	$10,779/year

Mid-Atlantic Coast Backdune Grassland **[18 acres (Figure 5.16, Tables 5.38-5.41)]**
G2 S1

DEWAP: Beach and Dune Habitats
NHC: Northern Atlantic Coastal Plain Dune and Swale

Description

This herbaceous community is found in the backdunes away from the immediate beach area on islands in the marsh. It contains more species diversity than the closely related Beachgrass-Panicgrass Dune Grassland. The dominance of seaside bluestem (*Schizachyrium littorale*) gives this community a tawny hue in color aerial imagery. The examples present at Fenwick Island were found through imagery analysis and visually confirmed in the field but a specific species was not obtained. The species list below is of the community in Delaware. Other common associates include broom-sedge (*Andropogon virginicus*), beach panicgrass (*Panicum amarum*), and American beachgrass (*Ammophila breviligulata*). Less common associates include seaside goldenrod (*Solidago sempervirens*), fragrant cudweed (*Pseudognaphalium obtusifolium*), rough buttonweed (*Diodia teres*), and eastern prickly pear cactus (*Opuntia humifusa*). A scattered woody layer of northern bayberry (*Morella pensylvanica*) and poison ivy (*Toxicodendron radicans*) may be present.

Analysis of Condition at Fenwick Island State Park

This community has declined in all localities and more land is converted to marsh, especially those areas where it occurs on an island in the marsh. This community may persist in some amount in the long term but it may still decline over time.

Table 5.38. What was once Mid-Atlantic Coast Backdune Grassland in 1937 has become X or remained in 2007	
X	**Acreage**
Loblolly Pine Dune Woodland	13 acres
Central Coast Beach Heather Dune Shrubland	4 acres
Cultivated Lawn	4 acres
Wax-Myrtle Shrub Swamp	4 acres
Impervious Surface	4 acres
Other communities/land covers	11 acres

Table 5.39. Mid-Atlantic Coast Backdune Grassland has migrated into X or remained since 1937	
X	**Acreage**
Beachgrass-Panicgrass Dune Grassland	9 acres
Central Coast Beach Heather Dune Shrubland	3 acres
Forked Rush Dune Swale	2 acres
Mid-Atlantic Coast Backdune Grassland	1 acre
Chesapeake Bay Maritime Shrubland	1 acre
Other communities/land covers	2 acres

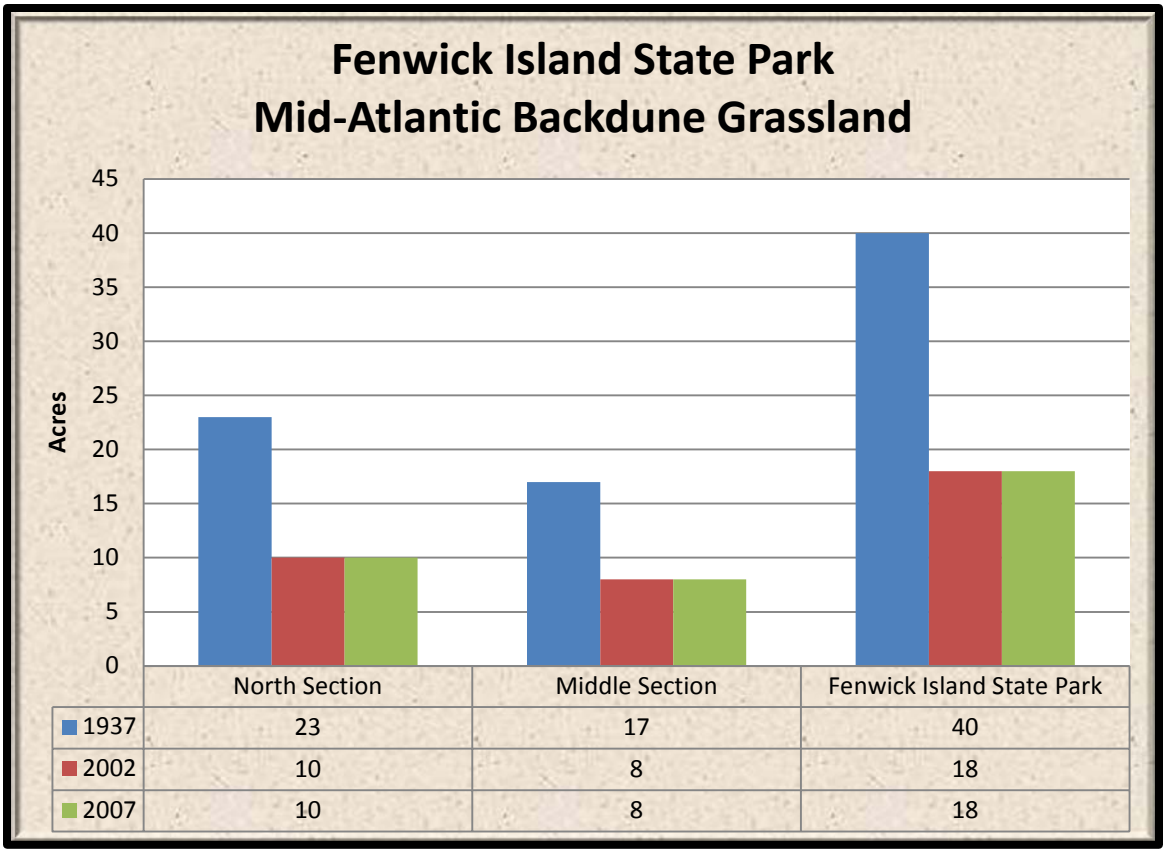


Figure 5.16. Mid-Atlantic Coast Backdune Grassland (1937, 2002, and 2007)

DNREC Sea Level Rise Scenarios (Table 5.40)

Most of this community will be inundated with 1.5 m of sea level rise, but it will still remain in some areas. This community will also likely migrate with exposed sand and the sea level rises.

Table 5.40. Projected acres of Mid-Atlantic Coast Backdune Grassland Impacted by Sea Level Rise

Rise	Acres
0.5 m	2 acres
1 m	7 acres
1.5 m	12 acres

Natural Capital (Table 5.41)

This community has lost capitalization to woodland and shrubland as they have matured. It has been stable, however, in the recent period (2002-2007).

Table 5.41. Natural Capital of Mid-Atlantic Coast Backdune Grassland	
Year	**Natural Capital (in 2012 dollars)**
1937	$5,828/year
2002	$2,623/year
2007	$2,623/year

Needlerush High Marsh **[4 acres (Figures 5.17-5.19, Tables 5.42-5.44)] G5 S2**

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

Description

Figure 5.17. Needlerush High Marsh (North Section)

This herbaceous marsh community occurs at roughly the same elevation as the North Atlantic High Salt Marsh. It is dominated nearly entirely by needlerush (*Juncus roemerianus*) and reaches the northern limit of its range on the Delaware Bay in Delaware and much more common to the south.

Analysis of Condition at Fenwick Island State Park

As best as can be told this community has come into the park since 1937. The dark aerial signature that is typical for this community is not present in the 1937 aerial imagery. Over time this community may increase somewhat from the very small amount it occupies today with climate change but it faces the same threats as North Atlantic High Salt Marsh with sea level rise and invasion by common reed (*Phragmites australis*). The prospects for this community over the long term are unknown but it may follow the same fate as the North Atlantic High Salt and experience massive declines and extirpation in spite of warming temperatures making the climate more favorable for it.

Looking at the averages (Figure 5.19), in the 1937 to 2002 period this community increased at an average rate of 0.061 acres/year in the park with the north section seeing the most increases at 0.06 acres/year and the middle gaining by 0.001 acres/year. Between 1937 and 2007, the average was same for the park and both sections. Between 2002 and 2007, this community increased by 0.002 acres/year with the north section being stable and the middle section gaining the balance for the park. It is unknown whether the north section will remain stable, gain acreage or lose acreage, but it is an ominous sign that the long term gains have appeared to have abated. It is also unknown whether the middle section will continue to increase in rate and continue gaining acreage. Either way the community is barely holding on in the park and covers a very small amount of acreage currently.

This community was not present in 1937 and has since populated or converted 2 acres of North Atlantic High Salt Marsh, 1 acre of North Atlantic Low Salt Marsh, 0.3 acres of water, and 0.1 acres of Irregularly Flooded Eastern Tidal Salt Shrub (Table 5.42)

Table 5.42. Needlerush High Marsh has migrated into X or remained since 1937	
X	**Acreage**
North Atlantic High Salt Marsh	2 acres
North Atlantic Low Salt Marsh	1 acre
Water	0.3 acres
Irregularly Flooded Eastern Tidal Salt Shrub	0.1 acres
Mid-Atlantic Coast Backdune Grassland	0.02 acres
Other communities/land covers	1 acre

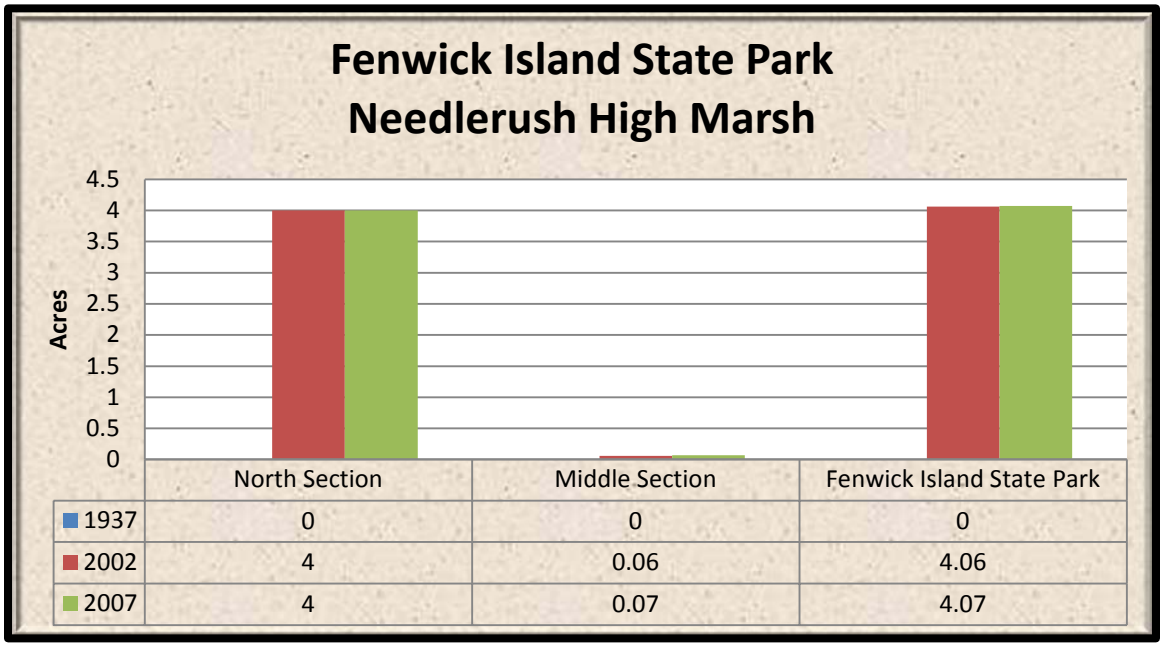


Figure 5.18. Needlerush High Marsh at Fenwick Island State Park (1937, 2002, and 2007)

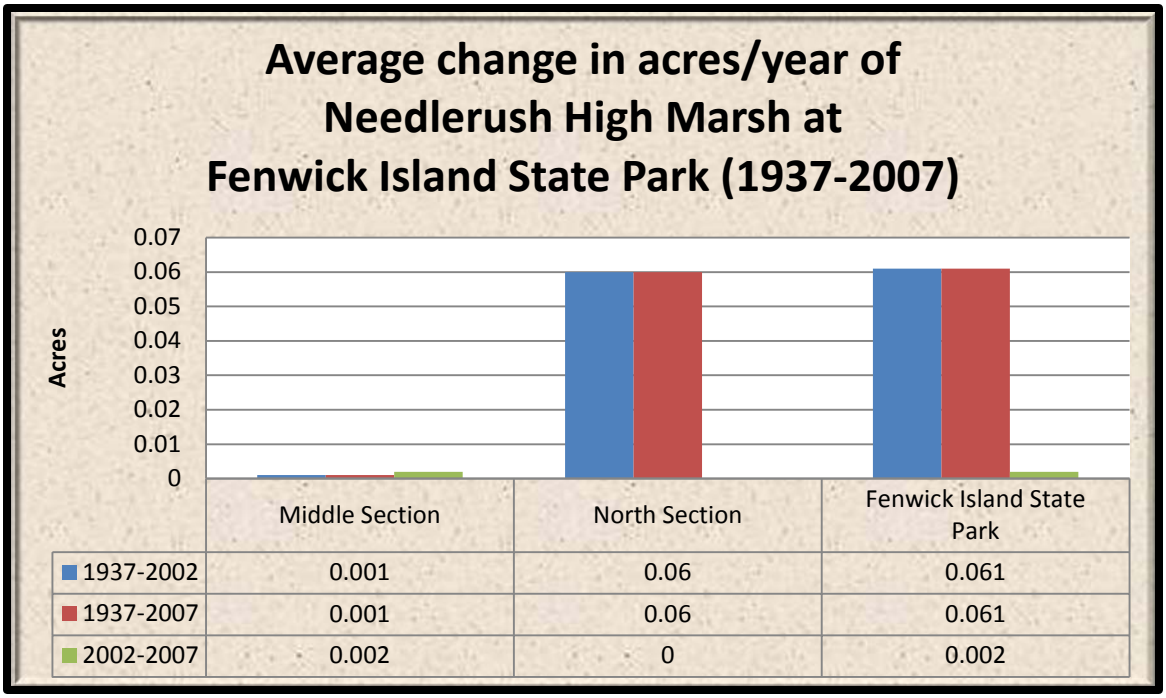


Figure 5.19. Average change in acres/year of Needlerush High Marsh at Fenwick Island State Park (1937-2007)

DNREC Sea Level Rise Scenarios (Table 5.43)

All of the current extent of this community will be inundated with 0.5 m of sea level rise.

Table 5.43. Projected acres of Needlerush High Marsh Impacted by Sea Level Rise	
Rise	**Acres**
0.5 m	4 acres
1 m	4 acres
1.5 m	4 acres

Natural Capital (Table 5.44)

Capitalization of Needlerush High Marsh has been increasing with a slightly increase of acreage.

Table 5.44. Natural Capital of Needlerush High Marsh	
Year	**Natural Capital (in 2012 dollars)**
1937	$0/year (not present)
2002	$25,461/year
2007	$25,524/year

***North Atlantic High Salt Marsh* [2 acres (Figures 5.20-5.21, Tables 5.45-5.48)] G5 S4**

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

Description

This marsh is community is located at an elevation just slightly higher than the North Atlantic Low Salt Marsh. It does not receive tide daily but instead gets vernal and storm tides. This community is dominated by salt meadow hay (*Spartina patens*) which form "cowlicks" in the marsh. Other less common associates include sea lavender (*Pluchea odorata*), salt meadow cordgrass (*Spartina alterniflora*), salt shrub (*Baccharis halimifolia*), and seaside goldenrod (*Solidago sempervirens*).

Analysis of Condition at Fenwick Island State Park

This high marsh community is perhaps the most imperiled in Delaware. In almost every place in Delaware it has declined except for those places that have been reclaimed from common reed (*Phragmites australis*) such as at Little Creek Wildlife Area[37]. In spite of the reclamation gains there are still losses to sea level rise which are still evident in analysis. The population in the north section of the park that was noted and mapped in 2007 was noted in the field in 2010 to be no longer present (it is still recorded here since it was present in 2007 imagery). Based on the field observations this community is no longer present in the park. It remains to be seen if it reappears in time for the 2012 imagery. If it does reappear, its foothold will be tenuous at best and if it does not it is likely gone.

This community only occurs in the north section of the park so historical figures apply to the section and park (Figure 5.16). Between 1937 and 2002, North Atlantic High Salt Marsh lost an average of 0.25 acres/year. Between 1937 and 2007, it lost 0.24 acres/year indicating a slowing in rate and is confirmed by the figure of losing 0.2 acres/year in the 2002 to 2007 period. It is unknown what may have caused the sudden disappearance as going by the rate it still could have survived about 10 more years.

North Atlantic High Salt Marsh is one of the most imperiled communities in the park and only 2 acres of the original 19 from 1937 survived into 2007. The rest of the North Atlantic High Salt Marsh became 5 acres of North Atlantic Low Salt Marsh and 2 acres each of Needlerush High Marsh, Reed Tidal Marsh, and water (Table 5.45). Despite the losses this community has managed to migrate into 0.2 acres of North Atlantic Low Salt Marsh and 0.1 acres of water (Table 5.46).

[37] Coxe, Robert. 2012. Vegetation Community and Land Use Change Analysis of Little Creek Wildlife Area, Kent County, Delaware. Delaware Division of Fish and Wildlife.

Table 5.45. What was once North Atlantic High Salt Marsh in 1937 has become X or remained in 2007	
X	**Acreage**
North Atlantic Low Salt Marsh	5 acres
Needlerush High Marsh	2 acres
North Atlantic High Salt Marsh	2 acres
Reed Tidal Marsh	2 acres
Water	2 acres
Other communities/land covers	6 acres

Table 5.46. North Atlantic High Salt Marsh has migrated into X or remained since 1937	
X	**Acreage**
North Atlantic High Salt Marsh	2 acres
North Atlantic Low Salt Marsh	0.2 acres
Water	0.1 acres

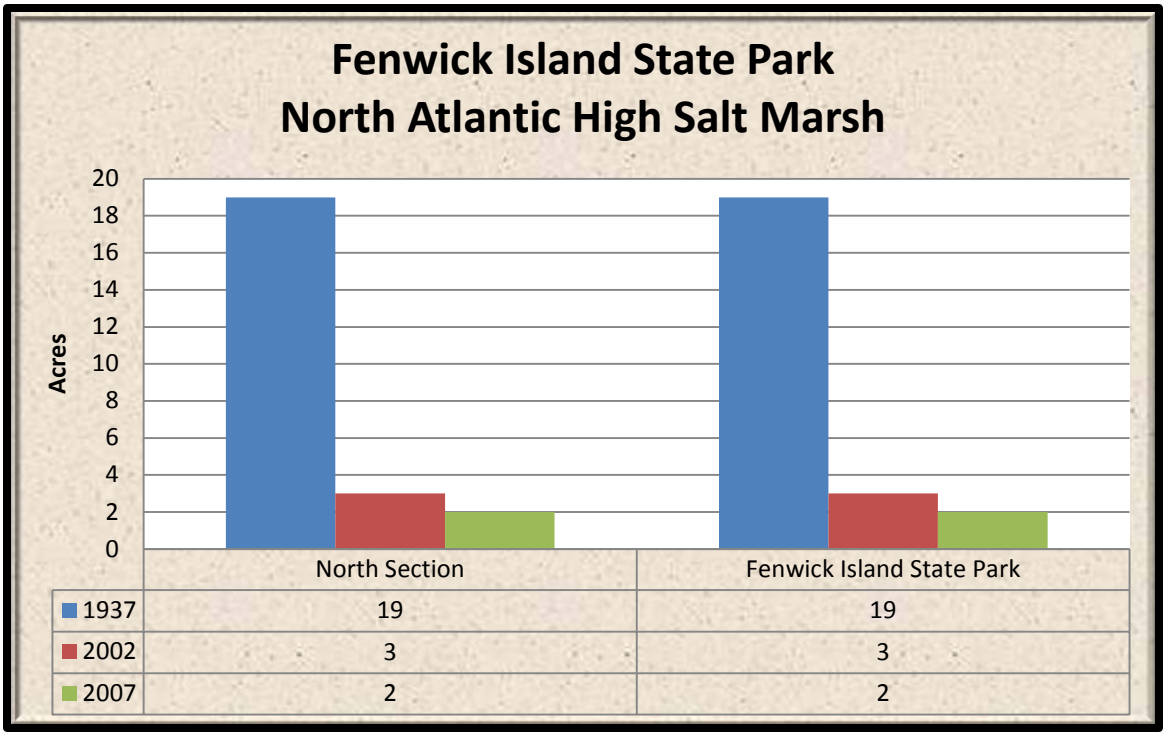


Figure 5.20. North Atlantic High Salt Marsh at Fenwick Island State Park (1937, 2002, and 2007)

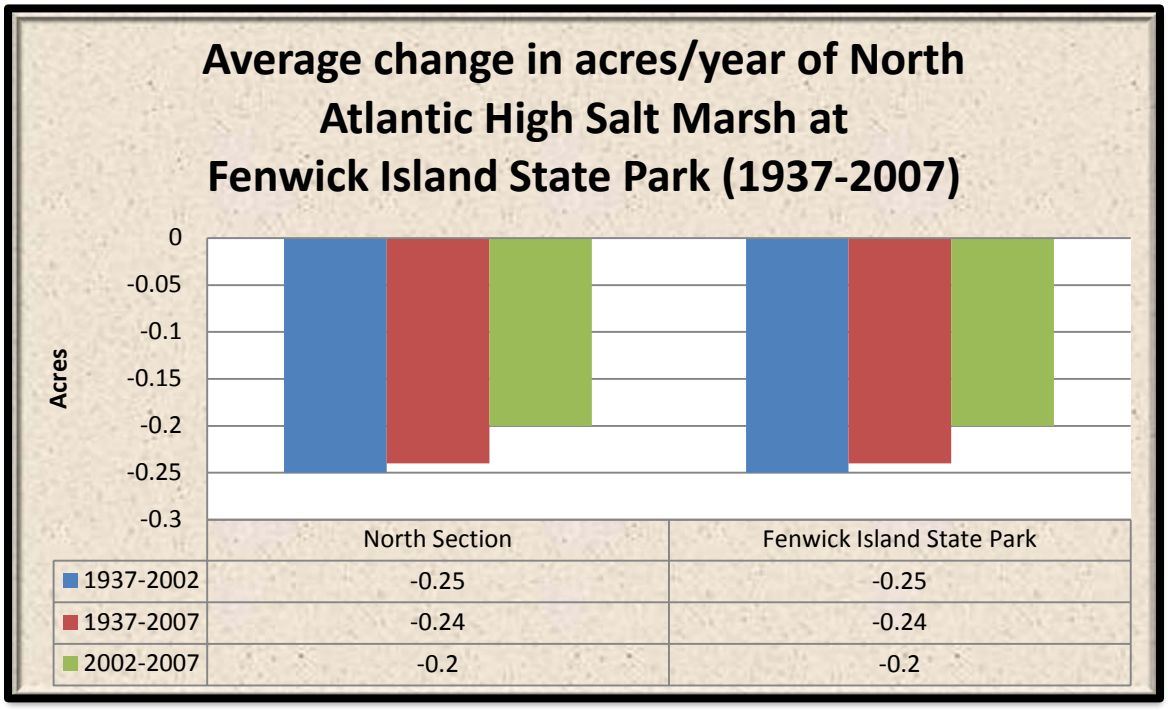


Figure 5.21. Average change in acres/year of North Atlantic High Salt Marsh at Fenwick Island State Park (1937-2007)

DNREC Sea Level Rise Scenarios (Table 5.47)

All of the current extent of this community will be inundated with 0.5 m of sea level rise.

Table 5.47. Projected acres of North Atlantic High Salt Marsh Impacted by Sea Level Rise	
Rise	**Acres**
0.5 m	2 acres
1 m	2 acres
1.5 m	2 acres

Natural Capital (Table 5.48)

Capitalization of North Atlantic High Salt Marsh has markedly fallen with decreases in acreage and is one of the most imperiled communities in the park.

Table 5.48. Natural Capital of North Atlantic High Salt Marsh	
Year	**Natural Capital (in 2012 dollars)**
1937	$119,155/year
2002	$18,814/year
2007	$12,543/year

***North Atlantic Low Salt Marsh* [21 acres (Figure 5.22-5.24, Tables 5.49-5.52)] G5 S5**

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

Description

Figure 5.22. North Atlantic Low Salt Marsh (North Section)

This community is the lowest elevation marsh community in the park with the exception of salt panne. As such it receives diurnal tides and is the saltiest marsh community. Salt meadow cordgrass (*Spartina alterniflora*) dominates the community and may be joined by salt meadow hay (*Spartina patens*) in higher places.

Analysis of Condition at Fenwick Island State Park

This community is suffering declines due to sea level rise but has been making some gains from conversion of other communities to this type, namely North Atlantic High Salt Marsh and Irregularly Flooded Eastern Tidal Salt Shrub. This community is likely to persist in the short term but over the very long term it may decline significantly from conversion to water with sea level rise.

Looking at the historical trends (Figure 5.18), North Atlantic Low Salt Marsh has lost 0.22 acres/year in the park in the 1937-2002 period with the middle section losing 0.12 acres/year and the north section losing 0.09 acres/year. In the 1937-2007 period 0.19 acres/year were lost in the park indicating a slowing in loss rates. The middle section lost 0.11 acres/year and the north section lost 0.07 acres/year. This change in rate turned to a gain of 0.2 acres/year in the 2002 to 2007 period. The north section made the gains while the middle section remained stable. It is unknown whether the gains will continue or if the losses will start again but the long term trend favors the losses and this would be the projection with rising rates of sea level rise.

Table 5.49. What was once North Atlantic Low Salt Marsh in 1937 has become X or remained in 2007	
X	**Acreage**
North Atlantic Low Salt Marsh	11 acres
Loblolly Pine Dune Woodland	5 acres
Water	4 acres
Reed Tidal Marsh	3 acres
Central Coast Beach Heather Dune Shrubland	2 acres
Other communities/land covers	10 acres

Table 5.50. North Atlantic Low Salt Marsh has migrated into X or remained since 1937	
X	**Acreage**
North Atlantic Low Salt Marsh	11 acres
North Atlantic High Salt Marsh	5 acres
Water	2 acres
Irregularly Flooded Eastern Tidal Salt Shrub	1 acre
Mid-Atlantic Coast Backdune Grassland	1 acre
Other communities/land covers	0.5 acres

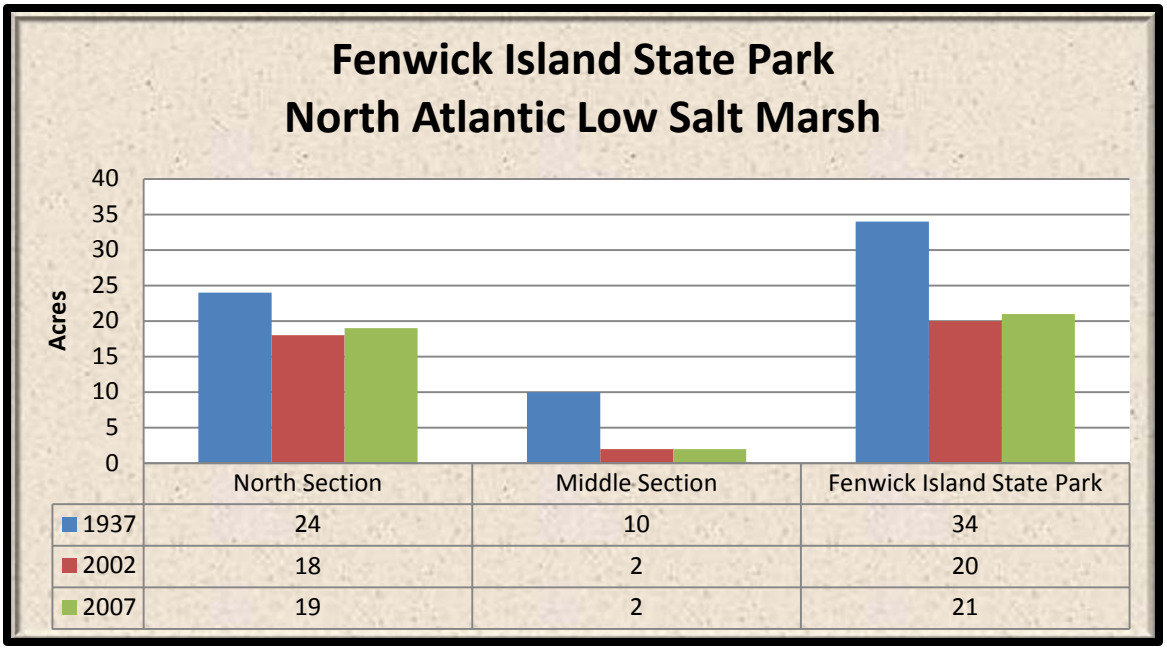


Figure 5.23. North Atlantic Low Salt Marsh at Fenwick Island State Park (1937, 2002, and 2007)

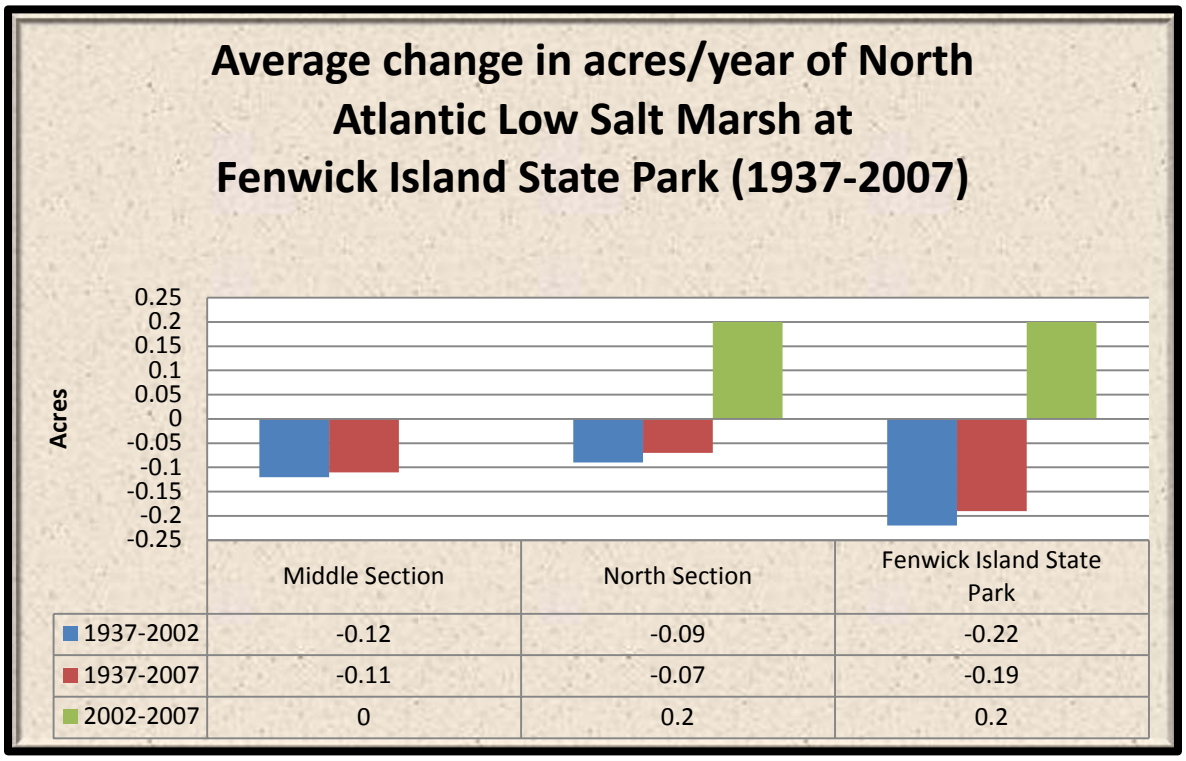


Figure 5.24. Average change in acres/year of North Atlantic Low Salt Marsh at Fenwick Island State Park (1937-2007)

DNREC Sea Level Rise Scenarios (Table 5.51)

All of the current extent of this community will be inundated with 0.5 m of sea level rise.

Table 5.51. Projected acres of North Atlantic Low Salt Marsh Impacted by Sea Level Rise	
Rise	**Acres**
0.5 m	21 acres
1 m	21 acres
1.5 m	21 acres

Natural Capital (Table 5.52)

Capitalization of North Atlantic Low Salt Marsh has gone down overall by has increased in the recent period (2002-2007).

Table 5.52. Natural Capital of North Atlantic Low Salt Marsh	
Year	**Natural Capital (in 2012 dollars)**
1937	$213,224/year
2002	$125,426/year
2007	$131,697/year

Northeastern Successional Shrubland **[0.07 acres (Figure 5.25, Tables 5.53-5.55)]** **GNA SNA**

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

Description

Northeastern Successional Shrubland is intermediate between a Northeastern Old Field and a forested or woodland community. In a lot of places this community is composed of invasive exotic shrubs such as …

Analysis of Condition at Fenwick Island State Park

Northeastern Successional Shrubland occupies a small part of Fenwick Island State Park in two sections. The acreage is currently stable in amount and it may remain in the short term but in the long term it may succeed to mature communities.

Table 5.53. Northeastern Successional Shrubland has migrated into X or remained since 1937	
X	**Acreage**
North Atlantic Low Salt Marsh	0.1 acres

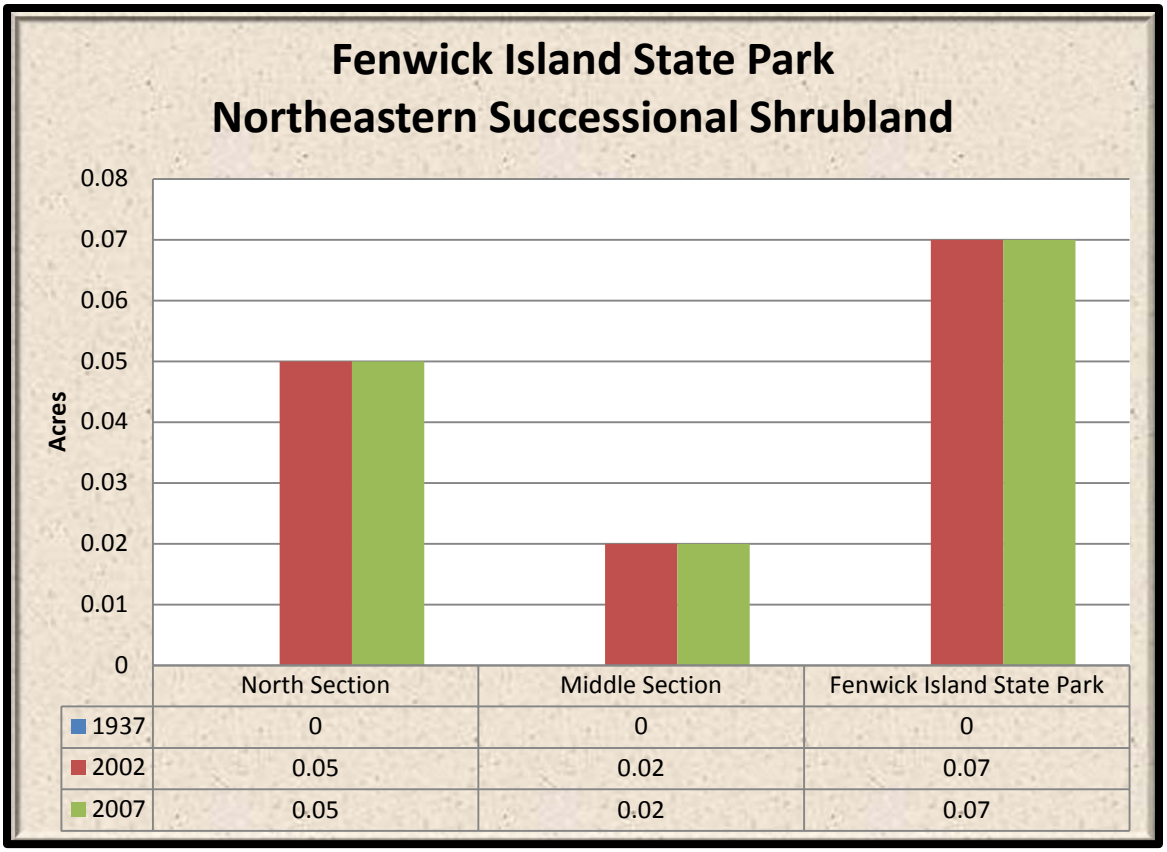


Figure 5.25. Northeastern Successional Shrubland at Fenwick Island State Park (1937, 2002, and 2007)

DNREC Sea Level Rise Scenarios (Table 5.54)

All of the current extent of this community will be inundated with 0.5 m of sea level rise.

Table 5.54. Projected acres of Northeastern Successional Shrubland Impacted by Sea Level Rise

Rise	Acres
0.5 m	0.07 acres
1 m	0.07 acres
1.5 m	0.07 acres

Natural Capital (Table 5.55)

Capitalization of Northeastern Successional Shrubland barely registers in the park because of its small size. It was not present in 1937.

Table 5.55. Natural Capital of Northeastern Successional Shrubland	
Year	**Natural Capital (in 2012 dollars)**
1937	$0/year (not present)
2002	$10/year
2007	$10/year

Reed Tidal Marsh **[14 acres (Figure 5.26, Tables 5.56-5.59)] GNA SNA**

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

Description

This marsh is community dominated nearly entirely by common reed (*Phragmites australis*) in a tidal situation.

Analysis of Condition at Fenwick Island State Park

This community has been stable or increasing as more area is invaded at the expense of North Atlantic High Salt Marsh and maybe Needlerush High Marsh. It is hoped that eradication efforts may eliminate this community and its dominant species and help the North Atlantic High Salt gain some ground and provide more habitat for Needlerush High Marsh to expand.

This community was not present in 1937 and has since populated and converted 4 acres of Mid-Atlantic Coast Backdune Grassland, 3 acres of water, 3 acres of North Atlantic Low Salt Marsh, and 2 acres each of North Atlantic High Salt Marsh and Irregularly Flooded Eastern Tidal Salt Shrub (Table 5.56).

Table 5.56. Reed Tidal Marsh has migrated into X or remained since 1937

X	Acreage
Mid-Atlantic Coast Backdune Grassland	4 acres
Water	3 acres
North Atlantic Low Salt Marsh	3 acres
North Atlantic High Salt Marsh	2 acres
Irregularly Flooded Eastern Tidal Salt Shrub	2 acres
Other communities/land covers	1 acre

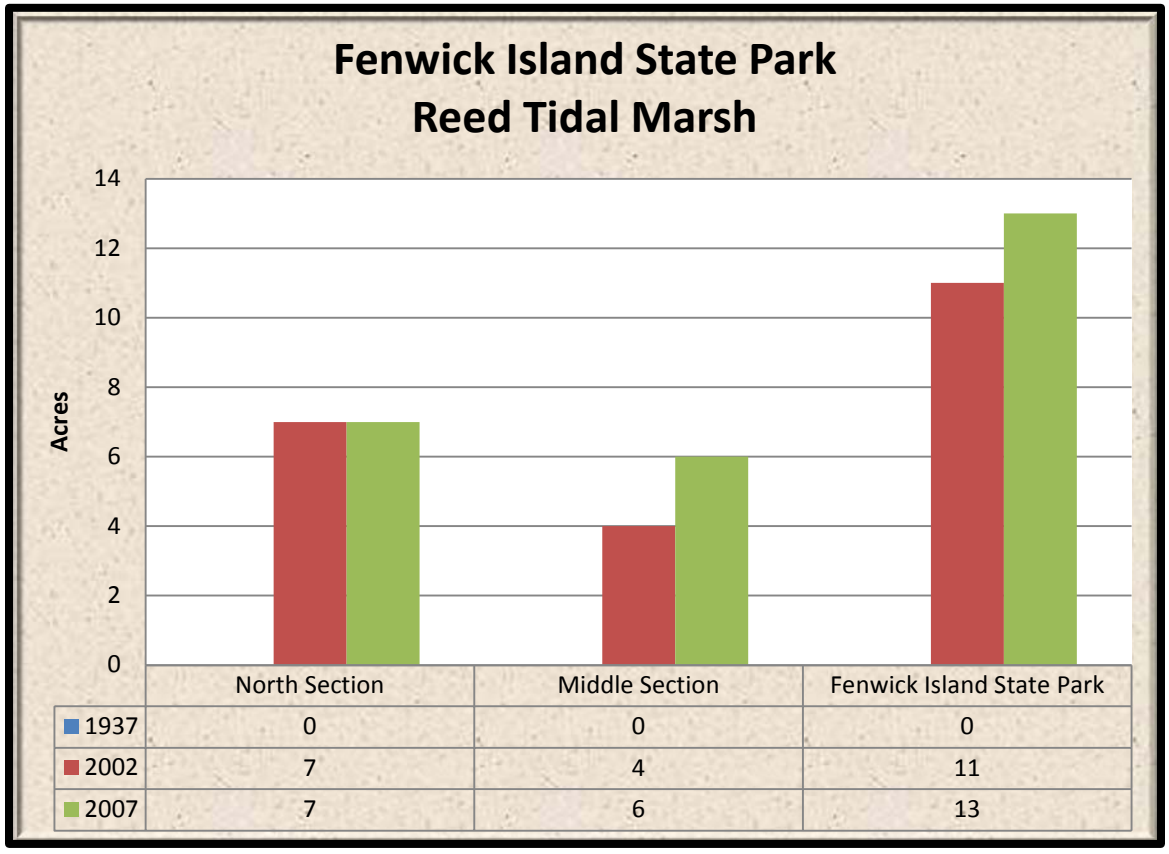


Figure 5.26. Reed Tidal Marsh at Fenwick Island State Park (1937, 2002, and 2007)

DNREC Sea Level Rise Scenarios (Table 5.57)

All of the current extent of this community will be inundated with 0.5 m of sea level rise.

Table 5.57. Projected acres of Reed Tidal Marsh Impacted by Sea Level Rise	
Rise	**Acres**
0.5 m	13 acres
1 m	13 acres
1.5 m	13 acres

Natural Capital (Table 5.58)

Capitalization of Reed Tidal Marsh has increased as it becomes more common in the park.

Table 5.58. Natural Capital of Reed Tidal Marsh	
Year	**Natural Capital (in 2012 dollars)**
1937	$0/year (not present)
2002	$68,984/year
2007	$81,527/year

***Salt Panne* [0.3 acres (Figure 5.27, Tables 5.59-5.63)] G5 S3**

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

Description

This herbaceous community is the saltiest in Delaware. It exists in isolated bodies of water in the North Atlantic Low Salt Marsh where water is evaporated in a panne. The loss of water makes the water that is left saltier than it otherwise would be. Because of its location in the marsh direct field observations were not made and locations where determined through aerial imagery analysis. Common species in this community include glasswort (*Salicornia virginica*), dwarf glasswort (*Salicornia bigelovii*), sea lavender (*Limonium carolinianum*), and halbeard-leaf orache (*Atriplex patula*).

Analysis of Condition at Fenwick Island State Park

This community is barely present within the park. Because of its transitional nature from marsh to water and back to marsh or to open water, these communities tend to ephemeral. This community may appear and disappear in the park or wax and wane. As long as the North Atlantic Low Salt Marsh is present this community will likely be too.

Salt Panne was not present in 1937, but has since populated 0.2 acres of North Atlantic High Salt Marsh and 0.1 acres of North Atlantic Low Salt Marsh (Table 5.59).

Table 5.59. Salt Panne has migrated into X or remained since 1937	
X	**Acreage**
North Atlantic High Salt Marsh	0.2 acres
North Atlantic Low Salt Marsh	0.1 acres

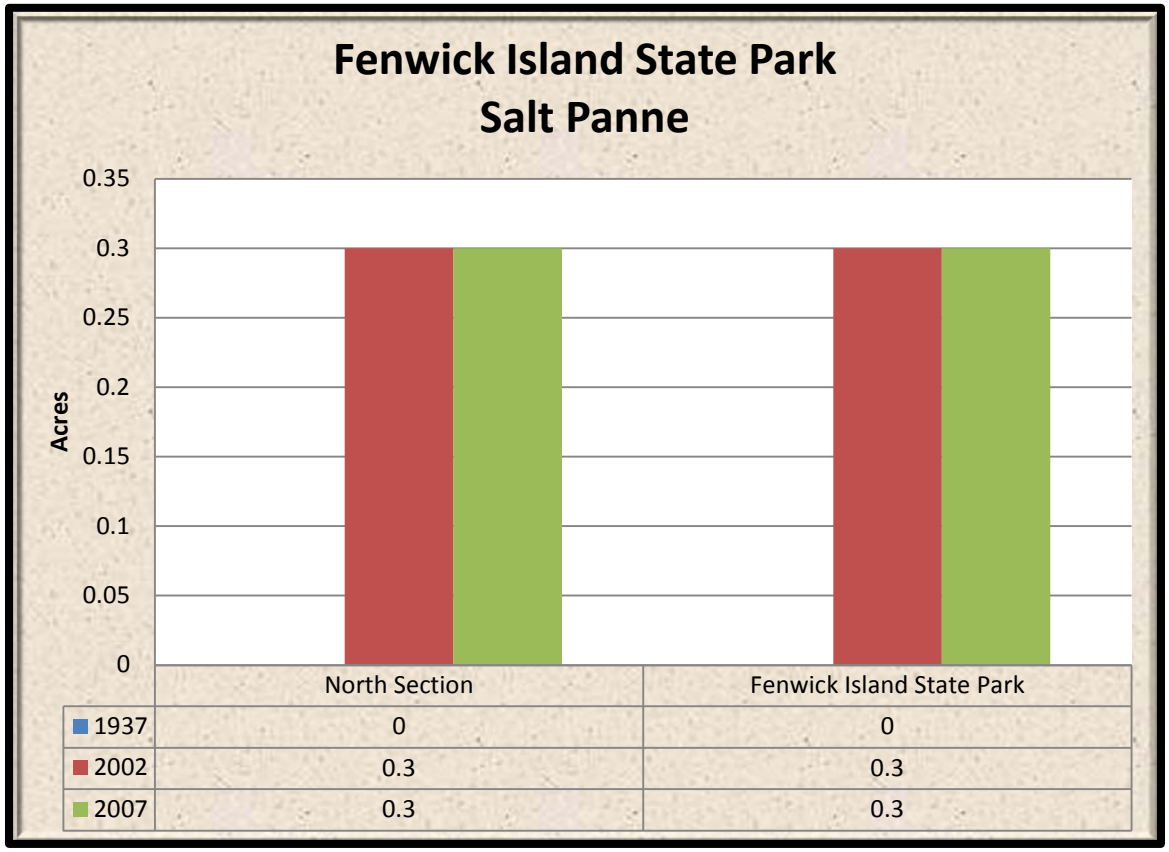


Figure 5.27. Salt Panne at Fenwick Island State Park (1937, 2002, and 2007)

DNREC Sea Level Rise Scenarios

All of the current extent of this community will be inundated with 0.5 m of sea level rise.

Table 5.60. Projected acres of Salt Panne Impacted by Sea Level Rise	
Rise	**Acres**
0.5 m	0.3 acres
1 m	0.3 acres
1.5 m	0.3 acres

Natural Capital

Capitalization of salt panne has been stable in the recent period (2002-2007) and was not present in 1937.

Table 5.61. Natural Capital of Salt Panne	
Year	**Natural Capital (in 2012 dollars)**
1937	$0/year
2002	$1,881/year
2007	$1,881/year

Successional Maritime Forest **[0.4 acres (Figure 5.28, Tables 5.62-5.64)] G2G3 S3**

DEWAP: Beach and Dune Habitats
NHC: Northern Atlantic Coastal Plain Maritime Forest

Description

This community is located on edge of the marsh in the north section of the park and was located through aerial imagery analysis. Typically these communities have a canopy of wild black cherry (*Prunus serotina*), persimmon (*Diospyros virginiana*), water oak (*Quercus nigra*), and loblolly pine (*Pinus taeda*). Eastern red cedar (*Juniperus virginiana*) appears to compose the understory. The shrub layer appears to have salt shrub (*Baccharis halimifolia*) with some common reed (*Phragmites australis*) mixed in the herbaceous layer.

Analysis of Condition at Fenwick Island State Park

Successional Maritime Forest covers a very small part of the park. There are only two locations since it has come about since 1937. The acreage is stable but it is unknown what the long term prospects for this community.

This community was not present in 1937 and has since populated and converted 0.3 acres of North Atlantic Low Salt Marsh and 0.1 acres of water.

Table 5.62. Successional Maritime Forest has migrated into X or remained since 1937	
X	**Acreage**
North Atlantic Low Salt Marsh	0.3 acres
Water	0.1 acres

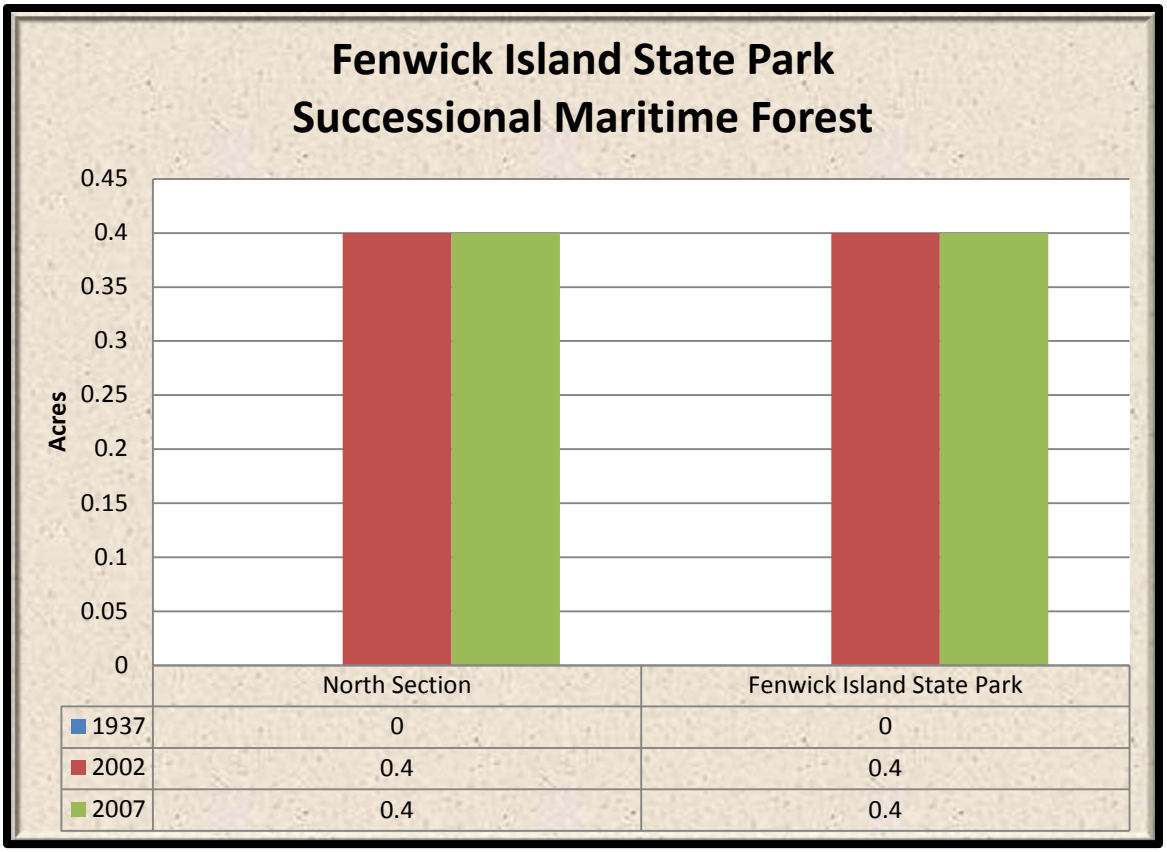


Figure 5.28. Successional Maritime Forest at Fenwick Island State Park (1937, 2002, and 2007)

DNREC Sea Level Rise Scenarios (Table 5.63)

All of the current extent of this community will be inundated with 0.5 m of sea level rise.

Table 5.63. Projected acres of Successional Maritime Forest Impacted by Sea Level Rise	
Rise	**Acres**
0.5 m	0.4 acres
1 m	0.4 acres
1.5 m	0.4 acres

Natural Capital (Table 5.64)

Capitalization of Successional Maritime Forest has been stable in the recent period (2002-2007) with no changes in acreage.

Table 5.64. Natural Capital of Successional Maritime Forest	
Year	**Natural Capital (in 2012 dollars)**
1937	$0/year (not present)
2002	$76/year
2007	$76/year

CHAPTER 6: DESCRIPTIONS AND ANALYSIS OF THE LAND COVERS

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—52 acres
2. Impervious Surface—25 acres
3. Sand—10 acres
4. Semi-impervious Surface—2 acres
5. Tidal Mudflat—1 acre
6. Water—26 acres

***Beach* [52 acres, (Figure 6.1, Tables 6.1-6.3)]**

Description

This land cover includes the area between the Beachgrass-Panicgrass Dune Grassland and ocean water.

Analysis of Condition at Fenwick Island State Park

Most of the beaches at Fenwick Island State Park are nourished with sediment from offshore and hence are an artificial construct. Based on the chart below it could be concluded that the beach is decreasing but it could be the beach is moving westward or has not been replaced as much.

In 2007, 48 of the original 95 acres from 1937 still existed in the park. The rest of the beach has become Beachgrass-Panicgrass Dune Grassland (29 acres), Water (13 acres), Sand (2 acres), and Chesapeake Bay Maritime Shrubland (1 acre) (Table 6.1).

Since 1937, beach has developed in 3 acres of Beachgrass-Panicgrass Dune Grassland, 1 acre of water, 0.5 acres of North Atlantic Low Salt Marsh, and 0.3 acres of Mid-Atlantic Coast Backdune Grassland (Table 6.2).

Table 6.1. What was once Beach in 1937 has become X or remained in 2007	
X	**Acreage**
Beach	48 acres
Beachgrass-Panicgrass Dune Grassland	29 acres
Water	13 acres
Sand	2 acres
Chesapeake Bay Maritime Shrubland	1 acre
Other communities/land covers	2 acres

Table 6.2. Beach has migrated into X or remained since 1937	
X	**Acreage**
Beach	48 acres
Beachgrass-Panicgrass Dune Grassland	3 acres
Water	1 acre
North Atlantic Low Salt Marsh	0.5 acres
Mid-Atlantic Coast Backdune Grassland	0.3 acres

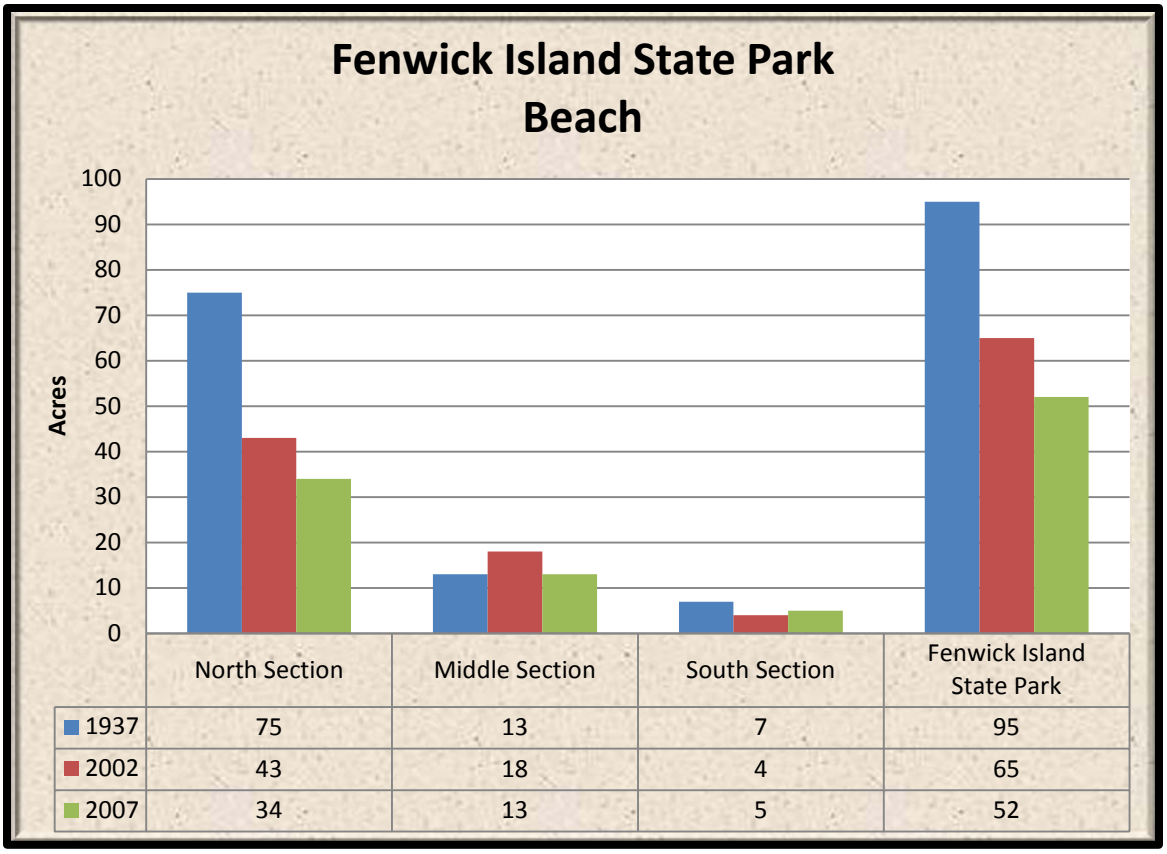


Figure 6.1. Beach at Fenwick Island State Park (1937, 2002, and 2007)

DNREC Sea Level Rise Scenarios

About ¾ of the current acreage of beach will be flooded with 1.5 m of sea level rise.

Table 6.3. Projected acres of Beach Impacted by Sea Level Rise	
Rise	**Acres**
0.5 m	14 acres
1 m	24 acres
1.5 m	39 acres

Natural Capital

Beach does not carry any natural capital value.

Impervious Surface **[25 acres, (Figure 6.2, Tables 6.4-6.5)]**

This land cover includes roads and buildings that are impervious to the flow of water to the ground surface. In 1937, no impervious surface was present, but it has since covered 11 acres of Beachgrass-Panicgrass Dune Grassland, 4 acres of Mid-Atlantic Coast Backdune Grassland, 2 acres of Irregularly Flooded Eastern Tidal Salt Shrub, and 1 acre each of North Atlantic Low Salt Marsh, and Wax-Myrtle Shrub Swamp (Table 6.4).

Table 6.4. Impervious Surface has migrated into X or remained since 1937	
X	**Acreage**
Beachgrass-Panicgrass Dune Grassland	11 acres
Mid-Atlantic Coast Backdune Grassland	4 acres
Irregularly Flooded Eastern Tidal Salt Shrub	2 acres
North Atlantic Low Salt Marsh	1 acre
Wax-Myrtle Shrub Swamp	1 acre
Other communities/land covers	6 acres

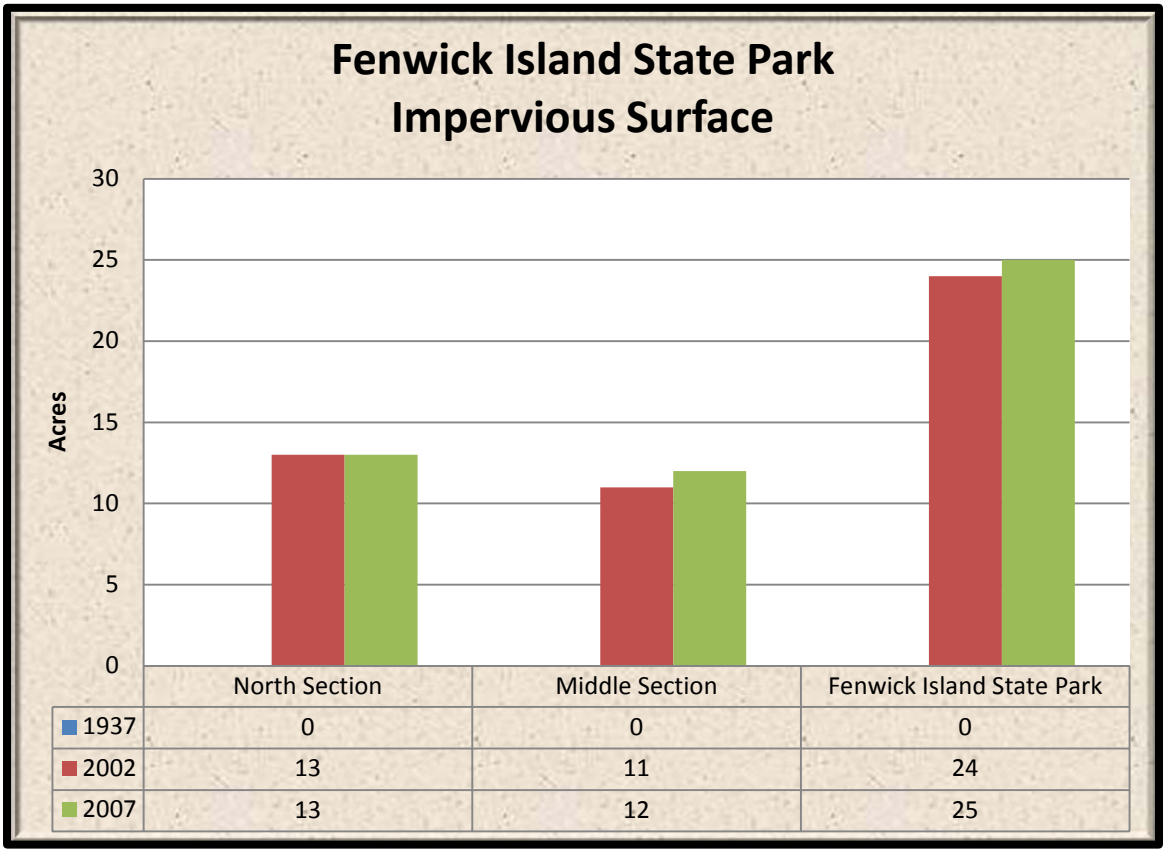


Figure 6.2. Impervious Surface at Fenwick Island State Park (1937, 2002, and 2007)

DNREC Sea Level Rise Scenarios (Table 6.5)

All of the current impervious surface area in the park will be flooded with 1.5 m of sea level rise. This means all of the developed areas. This will come at some expense to access and infrastructure.

Table 6.5. Projected acres of Impervious Surface Impacted by Sea Level Rise	
Rise	**Acres**
0.5 m	3 acres
1 m	20 acres
1.5 m	25 acres

Natural Capital

Impervious surface does not have any natural capital value.

Sand **[10 acres, (Figure 6.3, Tables 6.6-6.8)]**

This land cover includes those areas that are bare sand (un-vegetated) and not part of the beach.

Of the 5.5 acres that was sand in 1937, only 0.4 acres remained in 2007. The rest has become Loblolly Pine Dune Woodland (2 acres), Cultivated lawn (1 acre), impervious surface (1 acre), and Central Coast Beach Heather Dune Shrubland (1 acre) (Table 6.6).

Sand has developed in 4 acres of Beachgrass-Panicgrass Dune Grassland, 2 acres of beach, 1 acre of Central Coast Beach Heather Dune Shrubland, and 1 acre of Chesapeake Bay Maritime Shrubland since 1937 (Table 6.7).

Table 6.6. What was once Sand in 1937 has become X or remained in 2007

X	Acreage
Loblolly Pine Dune Woodland	2 acres
Cultivated Lawn	1 acre
Impervious Surface	1 acre
Central Coast Beach Heather Dune Shrubland	1 acre
Sand	0.4 acres
Other communities/land covers	0.2 acres

Table 6.7. Sand has migrated into X or remained since 1937

X	Acreage
Beachgrass-Panicgrass Dune Grassland	4 acres
Beach	2 acres
Central Coast Beach Heather Dune Shrubland	1 acre
Chesapeake Bay Maritime Shrubland	1 acre
Sand	0.4 acres
Other communities/land covers	1 acre

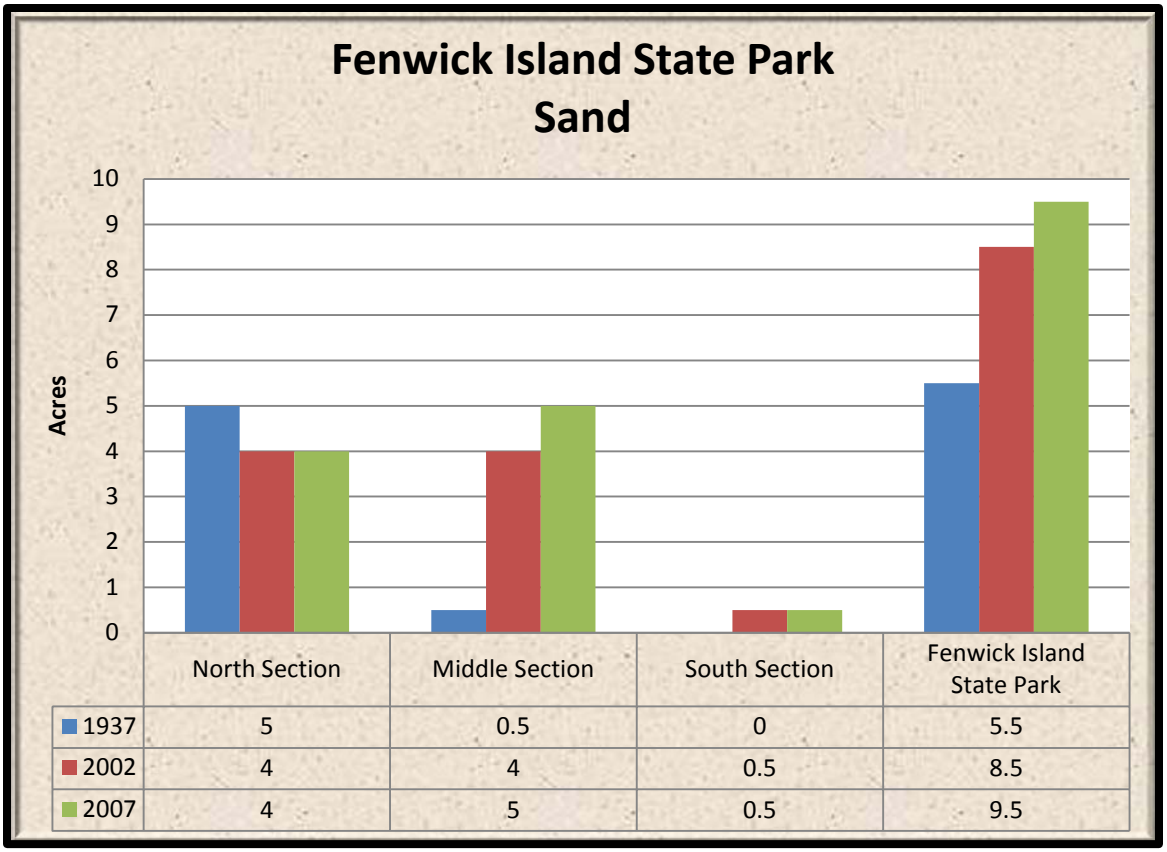


Figure 6.3. Sand at Fenwick Island State Park (1937, 2002, and 2007)

DNREC Sea Level Rise Scenarios (Table 6.8)

Sand will not be as affected as other communities by sea level rise. A lot of the occurrences are located at the tops of dunes away from the lower elevations.

Table 6.8. Projected acres of Sand Impacted by Sea Level Rise	
Rise	**Acres**
0.5 m	0.2 acres
1 m	1 acre
1.5 m	3 acres

Natural Capital

Sand does not carry any natural capital value.

Semi-impervious Surface **[2 acres, (Figure 6.4, Tables 6.9-6.11)]**

This land covers includes hard packed sand which is often found around vehicle access points on the beach. The amount of semi-impervious has remained the same through the study period but it has moved around. Only a tenth of an acre remained in 2007 of the 2 acres present in 1937. The rest has become 1 acre of Loblolly Pine Dune Woodland, 1 acre of impervious surface, 0.4 acres of cultivated lawn, and 0.1 acres of Wax-Myrtle Shrub Swamp (Table 6.9).

Since 1937, semi-impervious surface has been developed in 0.3 acres of North Atlantic Low Salt Marsh, 0.3 acres of Beachgrass-Panicgrass Dune Grassland, 0.3 acres of Mid-Atlantic Coast Backdune Grassland, 0.2 acres of Irregularly Flooded Eastern Tidal Salt Shrub, and 0.2 acres of Central Coast Beach Heather Dune Shrubland (Table 6.10).

Table 6.9. What was once Semi-impervious Surface in 1937 has become X or remained in 2007

X	Acreage
Loblolly Pine Dune Woodland	1 acre
Impervious Surface	1 acre
Cultivated Lawn	0.4 acres
Wax-Myrtle Shrub Swamp	0.1 acres
Semi-impervious Surface	0.1 acres
Other communities/land covers	0.1 acres

Table 6.10. Semi-impervious Surface has migrated into X or remained since 1937

X	Acreage
North Atlantic Low Salt Marsh	0.3 acres
Beachgrass-Panicgrass Dune Grassland	0.3 acres
Mid-Atlantic Coast Backdune Grassland	0.3 acres
Irregularly Flooded Eastern Tidal Salt Shrub	0.2 acres
Central Coast Beach Heather Dune Shrubland	0.2 acres
Other communities/land covers	0.1 acres

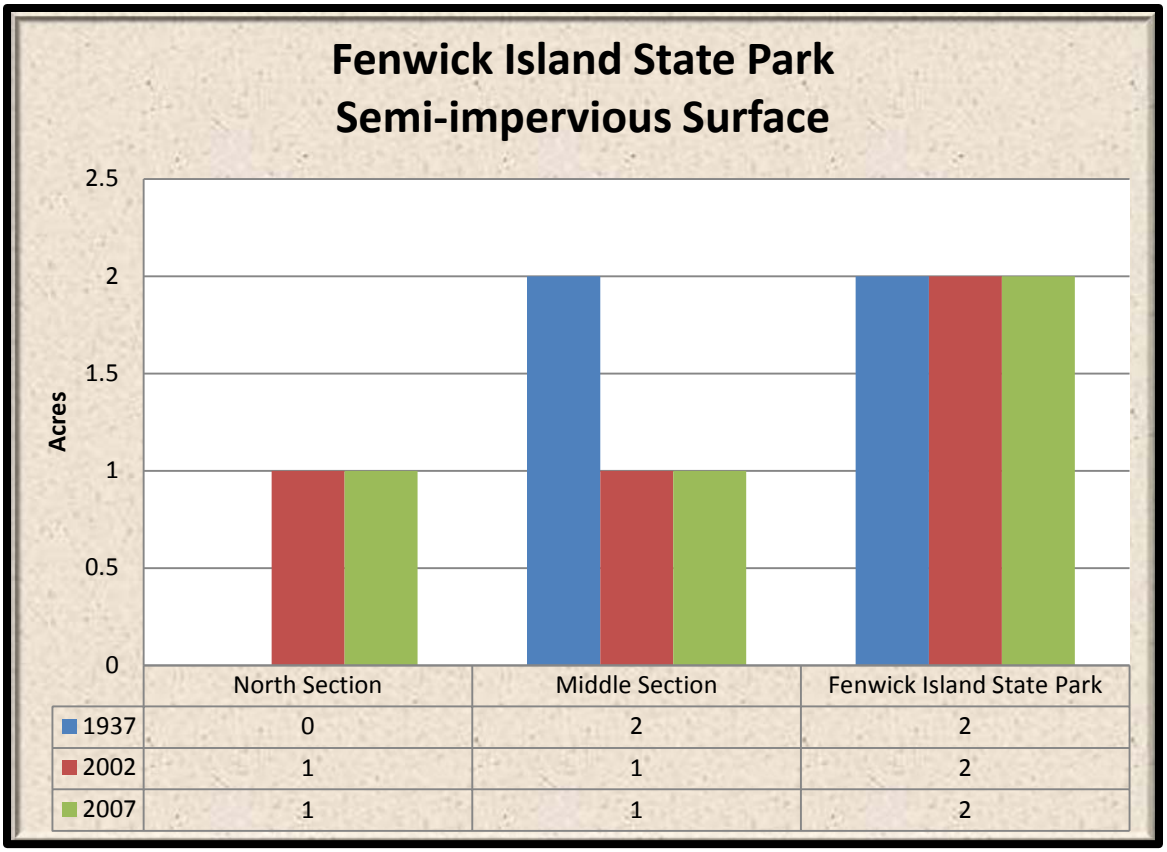


Figure 6.4. Semi-impervious Surface at Fenwick Island State Park (1937, 2002, and 2007)

DNREC Sea Level Rise Scenarios (Table 6.11)

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

Table 6.11. Projected acres of Semi-impervious Surface Impacted by Sea Level Rise	
Rise	**Acres**
0.5 m	1 acre
1 m	1 acre
1.5 m	1 acre

Natural Capital

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

Tidal Mudflat **[1 acre, (Figure 6.5, Tables 6.12-6.15)]**

Tidal mudflats can be similar to the salt pannes but are not vegetated and they often drain of their water on a regular basis. This is often the transition cover in the conversion from marsh to open water.

None of the tidal mudflats from 1937 have remained into 2007. What was tidal mudflat has become water (Table 6.12). Tidal Mudflats have formed in 0.3 acres of North Atlantic Low Salt Marsh, 0.2 acres of North Atlantic High Salt Marsh, and 0.1 acres each of water, Loblolly Pine Dune Woodland, and Wax-Myrtle Shrub Swamp (Table 6.13).

Table 6.12. What was once Tidal Mudflat in 1937 has become X or remained in 2007	
X	**Acreage**
Water	0.1 acres

Table 6.13. Tidal Mudflat has migrated into X or remained since 1937	
X	**Acreage**
North Atlantic Low Salt Marsh	0.3 acres
North Atlantic High Salt Marsh	0.2 acres
Water	0.1 acres
Loblolly Pine Dune Woodland	0.1 acres
Wax-Myrtle Shrub Swamp	0.1 acres
Other communities/land covers	0.1 acres

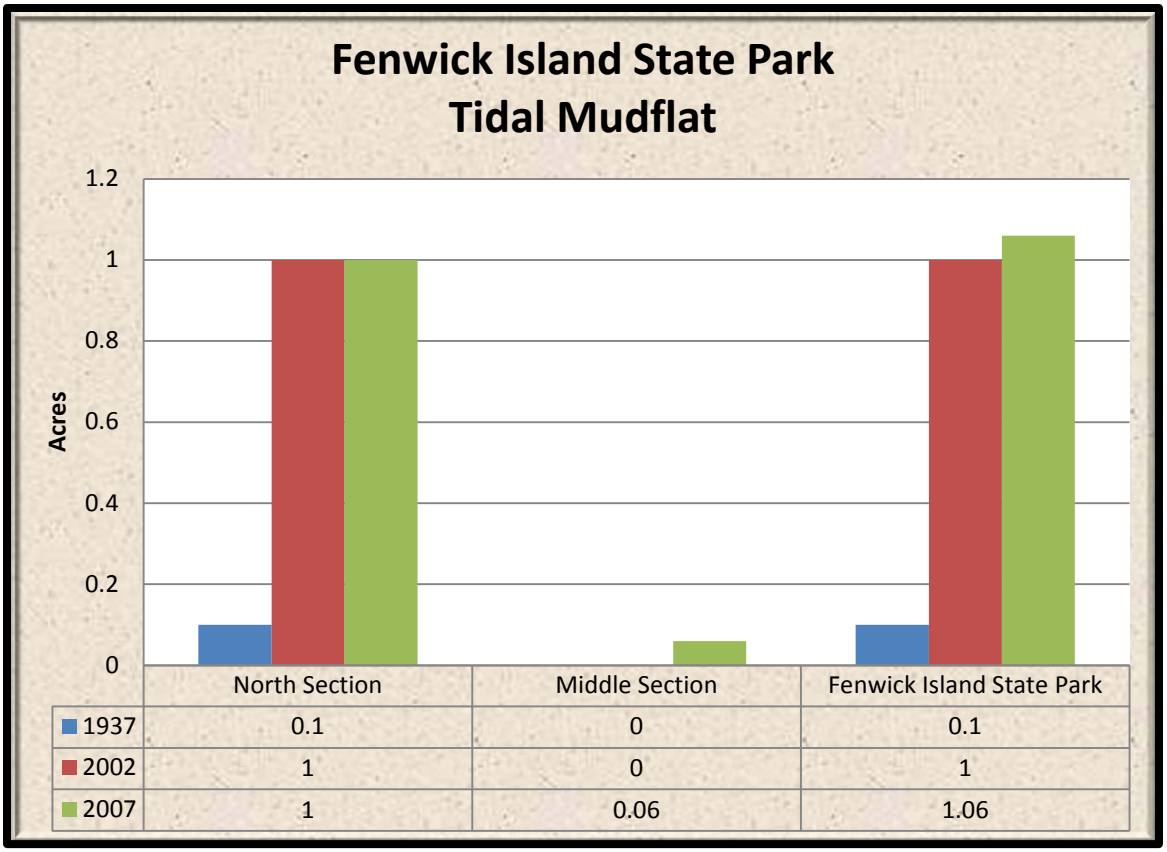


Figure 6.5. Tidal Mudflat at Fenwick Island State Park (1937, 2002, and 2007)

DNREC Sea Level Rise Scenarios

All of the current extent of this community will be inundated with 0.5 m of sea level rise.

Table 6.14. Projected acres of Tidal Mudflat Impacted by Sea Level Rise	
Rise	**Acres**
0.5 m	2 acres
1 m	2 acres
1.5 m	2 acres

Natural Capital (Table 6.15)

Tidal mudflats have been increasing slightly causing the capital to increase.

Table 6.15. Natural Capital of Tidal Mudflat	
Year	**Natural Capital (in 2012 dollars)**
1937	$627/year
2002	$6,271/year
2007	$6,648/year

***Water* [26 acres (Figure 6.6, Tables)]**

This land cover includes those areas where there is water inundation.

Table 6.16. What was once Water in 1937 has become X or remained in 2007	
X	**Acreage**
Water	5 acres
Reed Tidal Marsh	3 acres
North Atlantic Low Salt Marsh	2 acres
Wax-Myrtle Shrub Swamp	1 acre
Beach	1 acre
Other communities/land covers	3 acres

Table 6.17. Water has migrated into X or remained since 1937	
X	**Acreage**
Beach	13 acres
Water	5 acres
North Atlantic Low Salt Marsh	4 acres
North Atlantic High Salt Marsh	2 acres
Mid-Atlantic Coast Backdune Grassland	1 acre
Other communities/land covers	1 acre

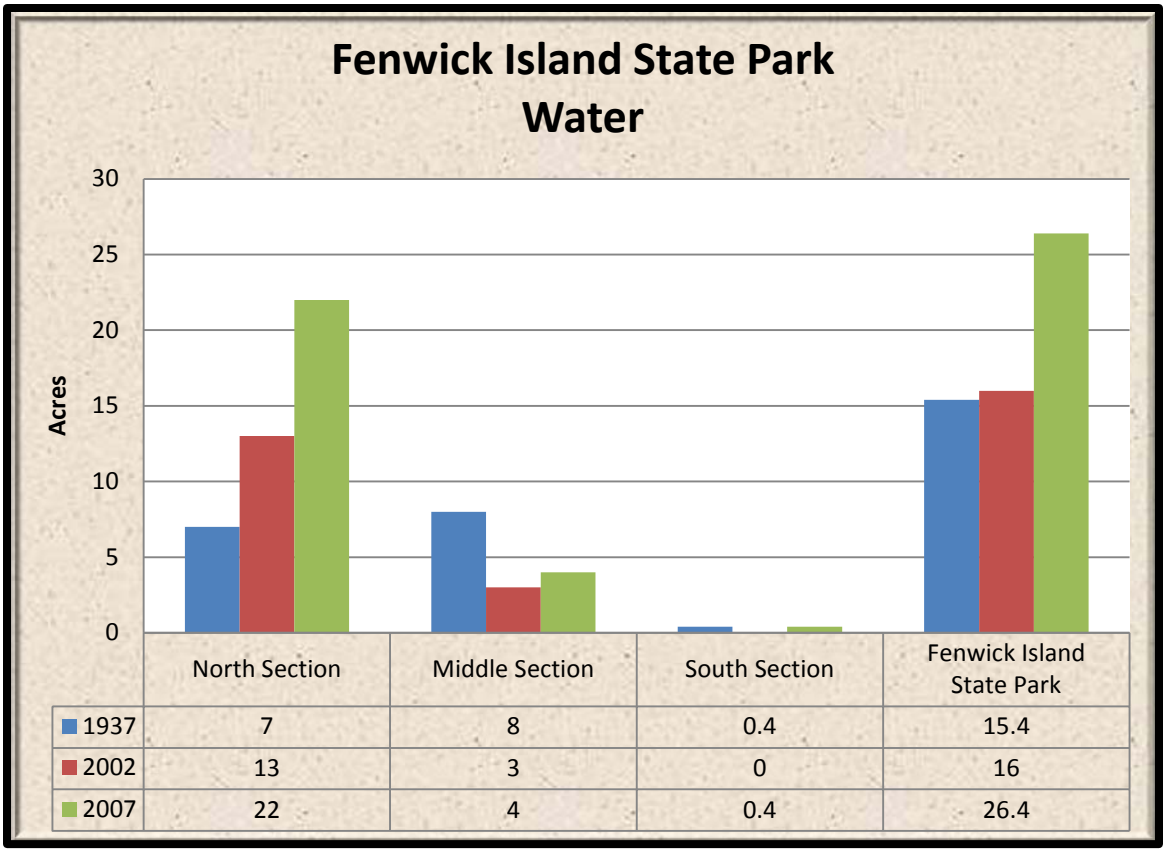


Figure 6.6. Water at Fenwick Island State Park (1937, 2002, and 2007)

Natural Capital

Capitalization of Irregularly Flooded Eastern Tidal Salt Shrub has markedly fallen with decreases in acreage.

Table 6.19. Natural Capital of Water	
Year	**Natural Capital (in 2012 dollars)**
1937	$169,325/year
2002	$12,543/year
2007	$12,543/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 Beach and Dune Habitats			
Species	**Common Name**	**Class**	**Tier**
Cincindela dorsalis media	white tiger beetle	Insect	1
Cincindela lepida	little white tiger beetle	Insect	1
Malaclemys terrapin terrapin	Northern diamondback terrapin	Reptile	1
Charadrius melodus	Piping plover	Bird	1
Haematopus palliatus	American Oystercatcher	Bird	1
Arenaria interpres	ruddy turnstone	Bird	1
Calidris canutus	Red knot	Bird	1
Calidrius alba	sanderling	Bird	1
Sterna hirundo	common tern	Bird	1
Sterna antillarum	least tern	Bird	1
Rynchops niger	black skimmer	Bird	1
Chordeiles minor	common nighthawk	Bird	1
Cincindela dorsalis	Eastern beach tiger beetle	Bird	2
Cincindela hirticolis	beach-dune tiger beetle	Bird	2
Melitara prodenialis	a snout-moth	Bird	2
Drasteria graphica atlantica	Atlantic graphic moth	Bird	2
Schinia spinosae	a noctuid moth	Bird	2
Falco peregrinus	peregrine falcon	Bird	2
Pluvialis squatarola	black-bellied plover	Bird	2
Catoptrophorus semipalmatus	willet	Bird	2
Calidris pusilla	semi-palmated sandpiper	Bird	2
Calidris maritima	purple sandpiper	Bird	2
Calidris alpina	dunlin	Bird	2
Larus marinus	great black-backed gull	Bird	2
Piplio erythrophthalmus	Eastern towhee	Bird	2
Passerculus sandwichensis	savannah sparrow	Bird	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 Interdunal Wetlands			
Species	**Common Name**	**Class**	**Tier**
Photuris bethaniensis	Bethany Beach firefly	Insect	1
Cicindela hirticolis	Beach-dune tiger beetle	Insect	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
Rhynchops 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