Historical Analysis and Map of Vegetation Communities, Land Covers, and Habitats of C and D Canal Wildlife Area New Castle County, Delaware

Back Creek and C and D Canal Watersheds

Submitted to:

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CHAPTER 1: INTRODUCTION AND METHODS

Setting of C and D Canal Wildlife Area

C and D Canal Wildlife Area is located in East Central New Castle County, Delaware (Figure 1.1). The wildlife area does not have any formal tracts, but has been divided into three sections; West Canal, Middle Canal, and East Canal, for description and mapping purposes. The sections comprise a total of 5,090 acres, with the East Canal Section having 1,841 acres, the Middle Canal Section having 1,859 acres, and the West Canal Section having 1,390 acres.

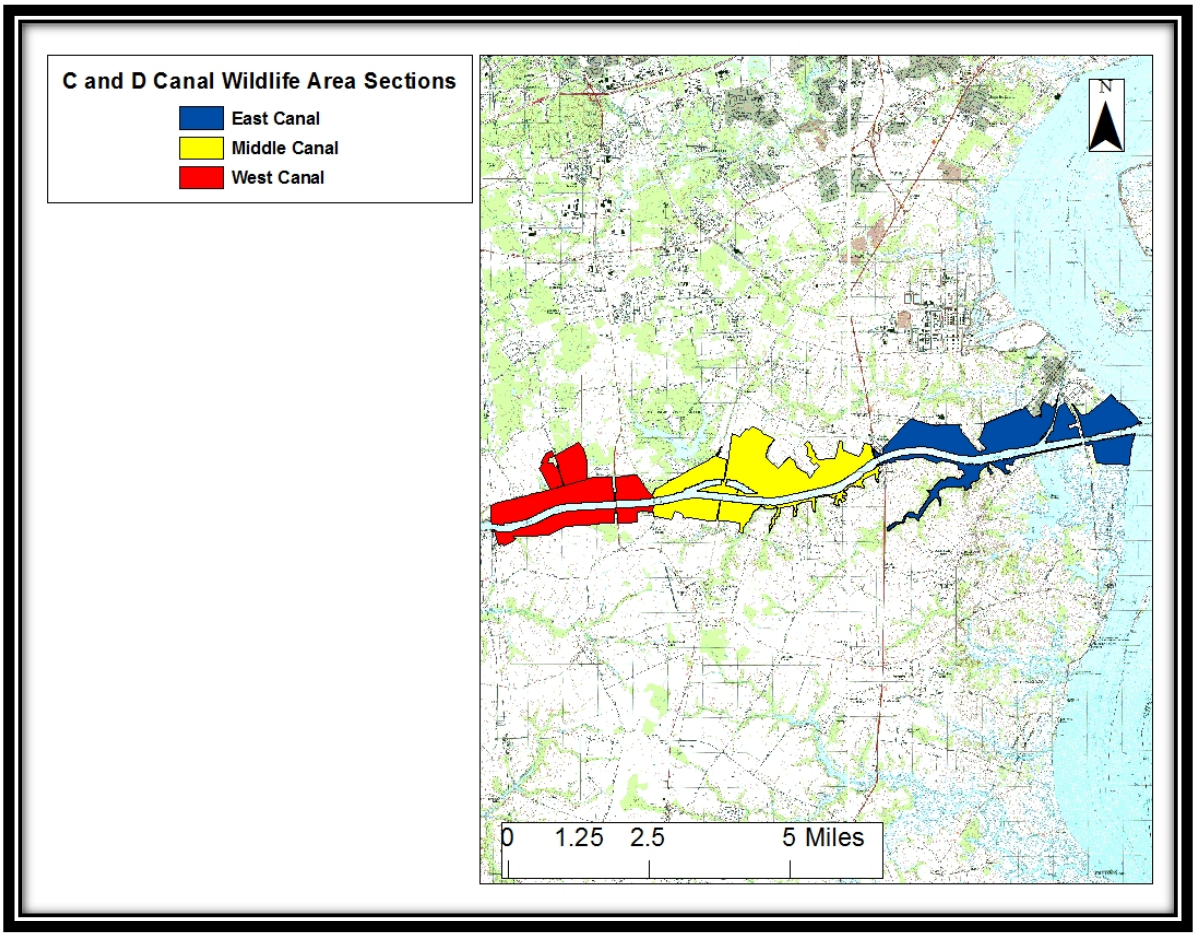

Figure 1.1. Sections at C and D Canal Wildlife Area

History and Formation of C and D Canal Wildlife Area

Early History of the Land

The land that is now C and D Canal Wildlife Area was first surveyed by Augustine Herman in the mid 1600's. Even at this time, Augustine proposed that a waterway be built between the Chesapeake Bay and Delaware Bay, since he realized it was a thin strip of land. Action was not taken however to build the canal until about 1800 and it was not completed until about 1830. A little than 100 years, later in 1919, the canal was purchased by the U.S. Government and responsibility for its operation shifted to the US Army Corps of Engineers.

Formation of C and D Canal Wildlife Area

C and D Canal Wildlife Area is leased to the Division of Fish and Wildlife by the US Army Corps of Engineers for the management of lands associated with the canal.

Soils and Geology of C and D Canal Wildlife Area

Underlying Geology[1]

Most of the C and D Canal Wildlife Area is underlain by the Columbia Formation. The eastern end of the East Canal Section contains a large area of marsh deposits. Smaller amounts of swamp deposits, Mt. Laurel Formation, Dredge Disposal Deposits, fill, and Lynch Heights Formation are present in the wildlife area.

The Columbia Formation is one of the most common in the upper Coastal Plain of Delaware. It is described as "yellowish-to reddish-brown, fine to coarse, feldspathic quartz sand with varying amounts of gravel."

Soil

Udorthents (3,541 acres) are the most common soil in the C and D Canal Wildlife Area. Other prominent soils include Reybold Silt Loam (265 acres), Broadkill Mucky Peat (254 acres), and Endoaquepts and Sulfaquepts (175 acres). Elevations range from sea level to about 120 feet in the West Canal Section at C and D Canal Wildlife Area.

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

East Canal Section Soils

Two soils are prominent in the East Canal Section and include Udorthents (907 acres) and Broadkill Mucky Peat (429 acres). Other minor soils include Nassawango Silt Loam (58 acres), Mattapex Silt Loam (42 acres), and Lenape-Nanticoke Complex (41 acres).

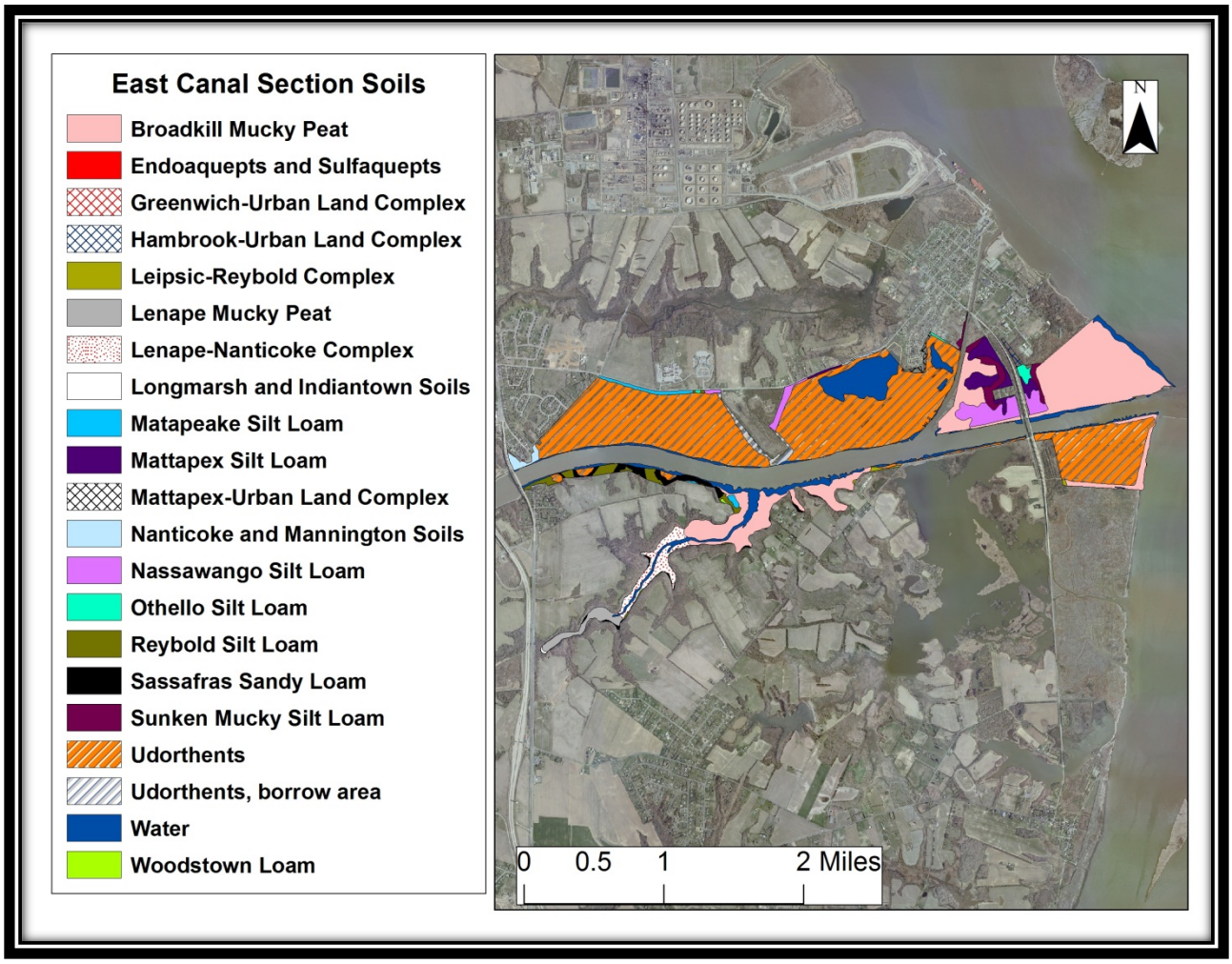

Figure 1.2. East Canal Section Soil Map

Middle Canal Section Soils

Udorthents (1454 acres) are the most common soil in the Middle Canal Section. Other minor soils include Reybold Silt Loam (157 acres) and Sassafras Sandy Loam (61 acres).

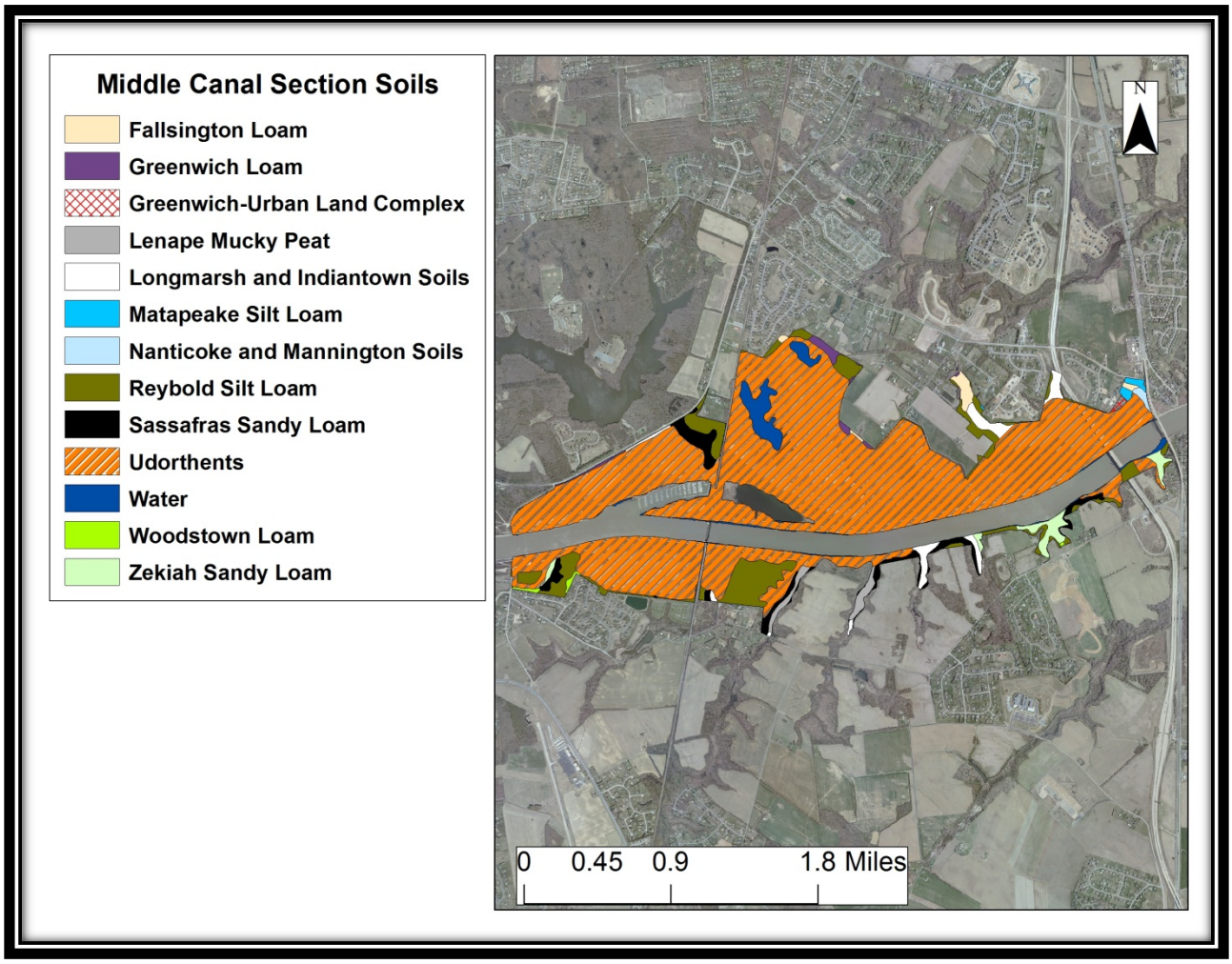

Figure 1.3. Middle Canal Section Soil Map

West Canal Section Soils

Udorthents (1,169 acres) are the most common soil in the West Canal Section. Pineyneck Loam (80 acres) is a minor soil in the section.

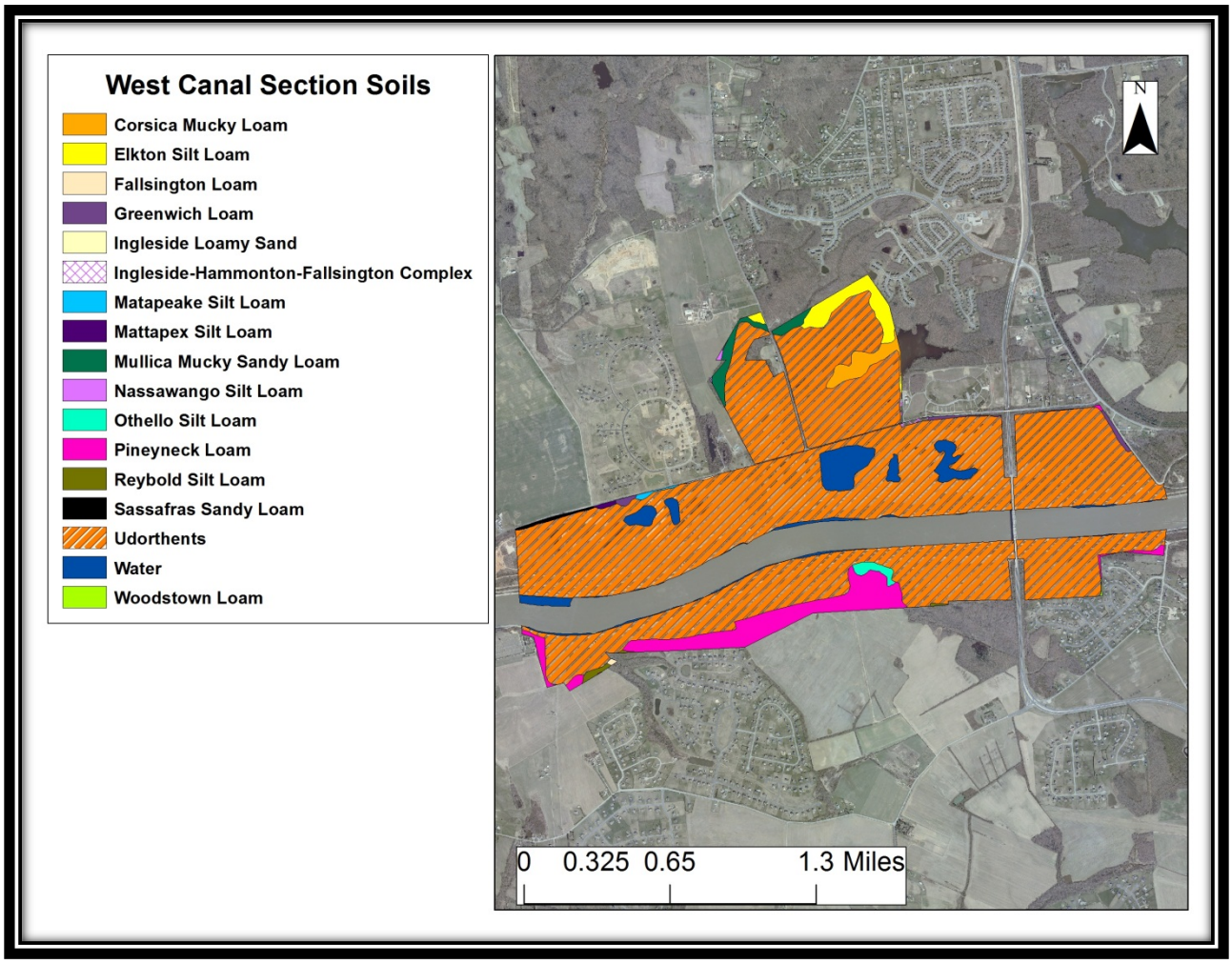

Figure 1.4. West Canal Section Soil Map

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 C and D Canal Wildlife Area

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 was about 3 cm/decade (30 cm/100 years). From 3,000 years to the present time it has been rising 1 cm/decade (10 cm/100 years)[2]. Data from the Reedy Point tidal station (1985-2009) shows the average rate of rise to be 5.4 cm/year and at Lewes (1919-2009), 3.24 mm/year.[3] 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 rise to 3.28 mm/year or 3.3 cm/decade.[4] This is above the fast rate 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 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.

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[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.

[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).

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 of sea-level rise is now 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. The rate 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 be 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 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 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.

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[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] Larson, C.E. and I. Clark. 2006. A search for scale in the 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.

[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.

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)

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].

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[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.
[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.

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.

[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 asses habitat conditions for Species of Greatest Conservation Need (SGCN)[as defined in the Delaware Wildlife Action Plan (DEWAP)] for C and D Canal Wildlife Area 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 wildlife area.
3. Determine the forest blocks located within or partially within the wildlife area.
4. Produce Ecological Integrity Assessments (EIAs) for vegetation communities that ranked S2 or higher.

Surveys were conducted during 2010 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 the land covers in Chapter 6. A crosswalk to the Delaware Wildlife Action Plan (DEWAP) and the Northeast Habitat Classification (NHC) is provided for each individual description.

Analysis of Historical Imagery

Historical imagery of C and D Canal Wildlife Area 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 wildlife area discussion. There is more imagery available but these were not used due to registration problems in the image tiles.

Ecological Integrity Assessment (EIA)

An EIA was conducted for those communities in the wildlife area 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).

Forest Block Analysis

Current forest blocks within or partially within the wildlife area that are greater than 100 acres were mapped. Each current block is described for current total acres and current forest interior habitat, potential acres, potential forest interior habitat, vegetation communities currently present, and major drainage (Table 3). A block is defined as contiguous forest habitat that is contained with 30 feet of non-forested and is the method used by the Maryland's Strategic Forest Lands Assessment.[35] Forest interior is forested area that is 100m from a forest edge. Potential blocks were extended out to areas of noncontiguous habitat (such as roads, powerline right-of-ways, and developed areas) that were considered to be immovable. Most of the area that could be reverted to forest is currently old field

[34] Coxe, Robert. 2010. Guide to Delaware Vegetation Communities-Summer 2010 Edition. Unpublished report.
[35] Maryland Department of Natural Resources. 2003. Strategic Forest Lands Assessment. Co-op Project between Maryland Department of Natural Resources, Watershed Services, and Maryland Forest Service. 40 p.

habitat or in agricultural use. These blocks were determined for future planning in regards to improving and increasing forest interior habitat.

Sea Level Rise Analysis

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

Natural Capital Analysis

The natural capital of each vegetation community was determined using a table in Costanza, et al.[36] The values from the table were calculated per acre of the vegetation community and then adjusted using an inflation calculator (DollarTimes.com) from 1994 values to 2012 values. Using these methods the following values were obtained:

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

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

Wetlands

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

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

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

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

Cropland: $37/acre/year

Grassland/fields: $94/acre/year

Open Ocean: $102/acre/year

Values were rounded off to the nearest whole dollar.

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

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

Summary of Findings from this study

1. **Vegetation Communities:** Sixteen vegetation communities and eleven land covers are currently found at C and D Canal Wildlife Area. Northeastern Modified Successional Forest (1,297 acres) and Northeastern Successional Shrubland (455 acres) are the prominent vegetation communities in the wildlife area. Semi-impervious Surface (178 acres) and Modified Land (171 acres) are the prominent land covers.

2. **Rare Plants:** Six rare plants are known to exist in C and D Canal Wildlife Area and it is unknown whether the wildlife area has been extensively surveyed for rare plants.

Scientific Name	Common Name	Rank	Last Observed
Agastache nepetoides	Yellow Giant Hyssop	G5, S2	1991
Carex mitchelliana	Mitchell's Sedge	G3G4, S2	1994
Dryopteris marginalis	Marginal Wood Fern	G5, CPS1	???
Ophioglossum vulgatum	Southern Adder's Tongue	G5, S3	1992
Sagittaria calycina	Spongy Arrowhead	G5, S3	1994
Schoenoplectus purshianus	Weakstalk Bulrush	G4G5, S2	1994

Table 2.1. Rare Plants located at C and D Canal Wildlife Area

3. **Rare Animals:** Two rare animals are known to occur in the wildlife area

Scientific Name	Common Name	Rank	Last Observed
Atildes halesus	Great Purple Hairstreak	G5, S1	1981
Regina septemvittata	Queen Snake	G5, S1	1972

Table 2.2. Rare Animals located at C and D Canal Wildlife Area

Ecological Integrity Assessment (EIA)

No communities in the C and D Canal Wildlife Area were ranked S2 or higher.

Forest Block Analysis

Importance of Forest Blocks

Forest blocks are important for a number of animals such as bobcat and neo-tropical migratory birds which nest in forest interiors (those places that are 100 meters from the edge of a forest). Many neotropical migratory birds are considered to be breeders in forest interior areas. Due to development, road building, which causes fragmentation, agricultural fields and other non-forest land uses, habitats for these birds are increasingly being eliminated leading to reductions in populations. Predators are better able to get the birds in small woodlands and edge habitats. In Ontario it was found that 80% of the neo-tropical bird nests in small woodlands (<100 ha) were lost to predators[37]. Nests in interior forests are less susceptible to predation and are not taken over by cowbirds, which is another hazard on edge habitats. Examples of birds that may be affected by a lack of large forest tracts include Barred Owl, Black and White Warbler, Worm-Eating Warbler, Acadian Flycatcher, Ovenbird, Kentucky Warbler, Red-Shouldered Hawk and many others.

Management of wildlife areas has traditionally favored forest game species such as wild turkey, ruffed grouse and American woodcock, which require old fields and edges running counter to the habitat needed for forest interior birds. Protecting forest interior birds runs contrary to the idea that artificially created edges creates more diversity. While this technique creates more diversity of some aggressive species it diminishes the populations of other species.

In protecting forest blocks, those blocks which are circular contain the most interior area per unit area. The next best shape is a square and linear configurations produce the least forest interior due to shape.

A study by Robbins et al. (1989) showed that most forest interior species require a forest of at least 150 ha (370 acres) in size. Very few forest tracts in Delaware are at least this size, one of the more notable being the Great Cypress Swamp.

Analysis of Forest Blocks at C and D Canal Wildlife Area

Five forest blocks are present that are more than 100 acres in size and are located in whole or part in the wildlife area (Table 2.3 and Figure 2.1). All forest blocks are bounded by a road, agricultural field, or other non-forested habitat. These areas are considered to be barriers to the passage of forest dwelling wildlife. Descriptions are provided for each forest block.

[37] Ontario Landowner Resource Centre. 2000. Conserving the Forest Interior: A threatened wildlife habitat. Ontario Ministry of Natural Resources.

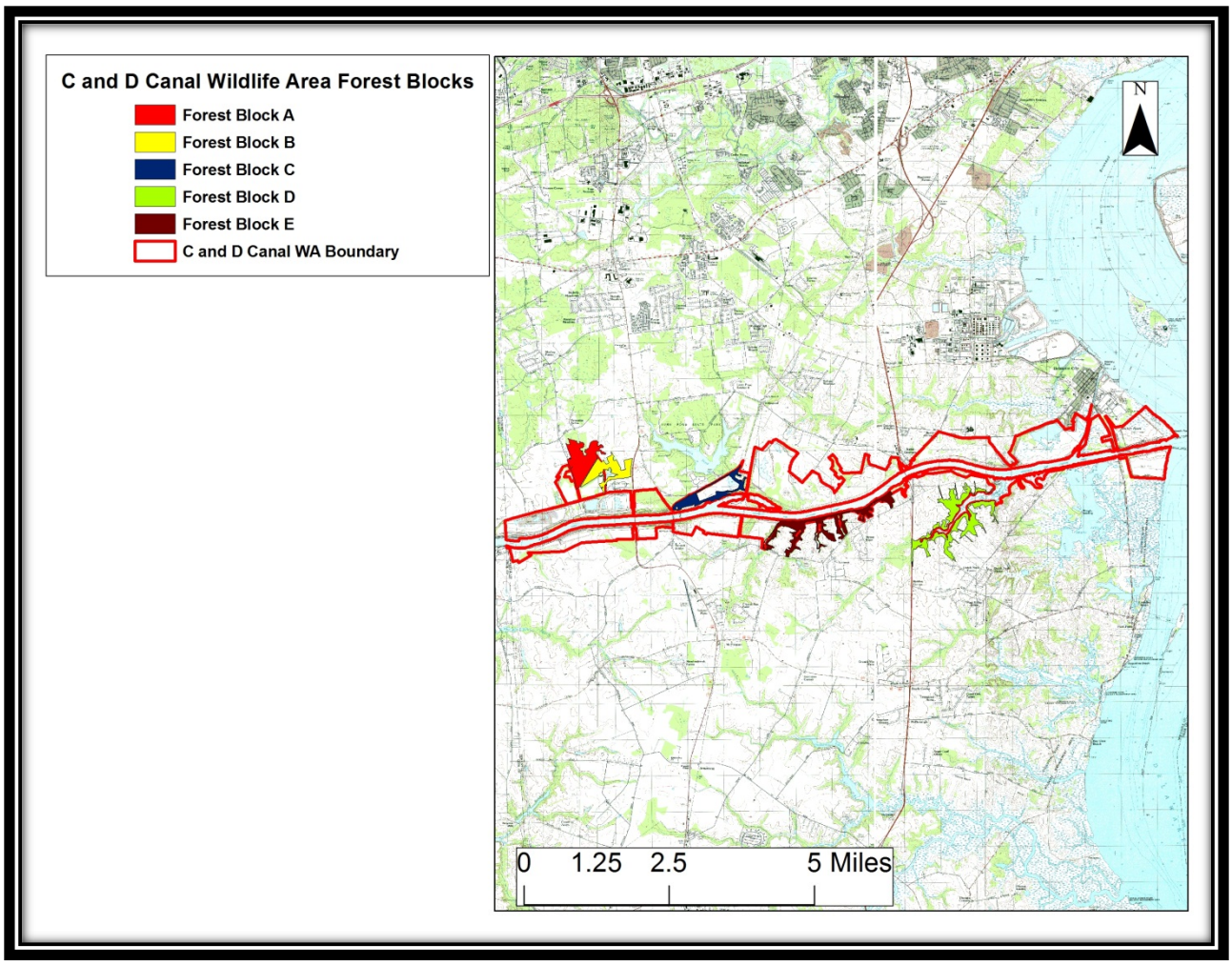
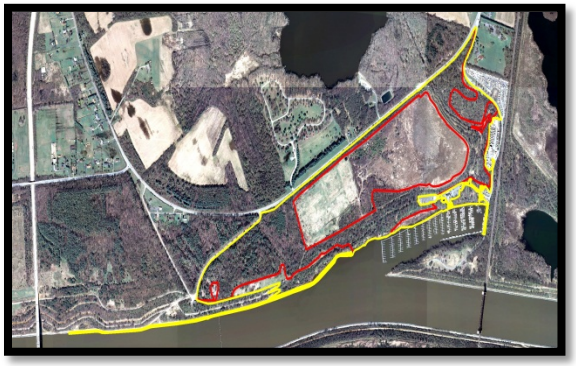


Figure 2.1. Forest Blocks at C and D Canal Wildlife Area

Table 2.3. Forest Blocks located in whole or part in C and D Canal Wildlife Area

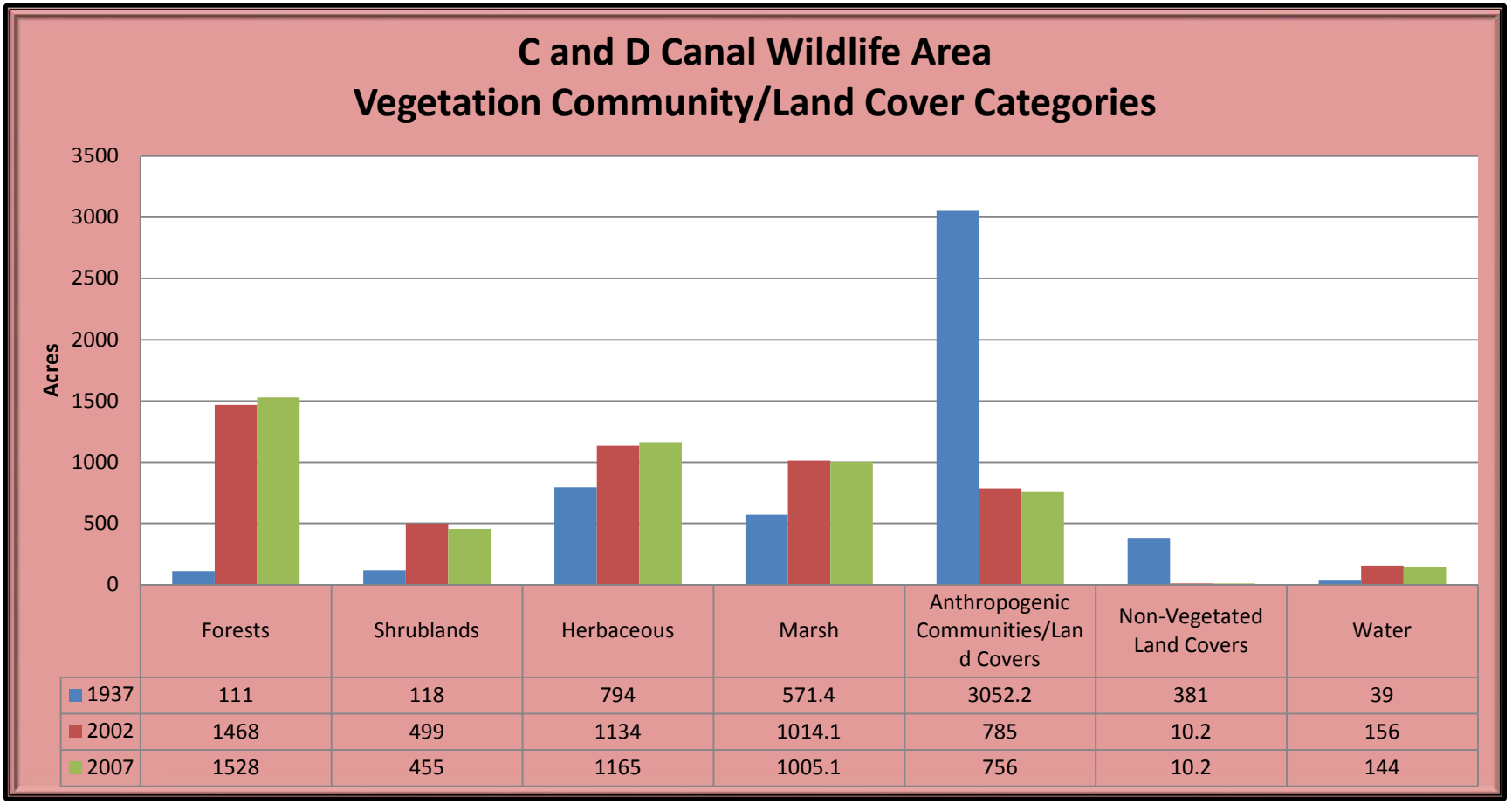
Forest Block Map	Block Name/Acreage	Description
	**C and D Canal A** **Current Block = 178 acres (62 acres interior)** **Potential Block = 538 acres (239 acres interior)**	C and D Canal A encompasses a large wooded area at the northwestern end of the Canal area. The forest block is borders by Frazer Road on the west, a housing development on the north and east and a right-of-way on the south. Three vegetation communities are located within this block and include Early to Mid-Successional Loblolly Pine Forest, Northeastern Pin Oak-Swamp White Oak Forest, and Chesapeake Bay Non-riverine Wet Hardwood Forest. Back Creek drains this block. Currently this block contains 62 acres of forest interior habitat. Potentially this block could be 538 acres in size, and contain 239 acres of forest interior habitat.
	**C and D Canal B** **Current Block = 131 acres (9 acres interior)** **Potential Block = 538 acres (239 acres interior)**	C and D Canal B encompasses a large wooded area at the northwestern end of the Canal area. It is bounded by on the north by a right-of-way, on the east by DE 896, on the south by Chesapeake City Road, and on the west by Frazer Road. Four vegetation communities are located within this block and include Early to Mid-Successional Loblolly Pine Forest, Mid-Atlantic Mesic Mixed Hardwood Forest, Northeastern Modified Successional Forest, and Northeastern Pin Oak-Swamp White Oak Forest. Back Creek drains this block. Currently this block contains 9 acres of forest interior habitat. Potentially this block could be 538 acres in size and contain 239 acres of forest interior habitat.

Forest Block Map	Block Name/Acreage	Description
	**C and D Canal C** **Current Block = 104 acres (4 acres interior)** **Potential Block = 230 acres (99 acres interior)**	C and D Canal C is located in the north-central part of the Canal just north of the marina. It is bounded by the canal on the south, modified land east, Red Lion Road on the north, and DE 896 on the west. Two vegetation communities are located within this block and include Early to Mid-Successional Loblolly Pine Forest and Northeastern Modified Successional Forest. Tributaries to the C and D Canal are main drainages for this block. Currently this block contains 4 acres of forest interior habitat. Potentially this block could be 230 acres in size and contain 99 acres of forest interior habitat.
	**C and D Canal D** **Current Block = 261 acres (3 acres interior)** **Potential Block = 1,849 acres (973 acres interior)**	C and D Canal D is located at the southeastern end of the Canal area. It is bounded on the north by agricultural field, on the east by Dutch Neck Road, on the south by Port Penn Road, and on the west by DE 1. Three vegetation communities are located within this block and include Mid-Atlantic Mesic Mixed Hardwood Forest, Northeastern Modified Successional Forest, and Chesapeake Bay Non-riverine Wet Hardwood Forest. Scott Run, a tributary to the C and D Canal drains this block. Currently this block contains 3 acres of forest interior habitat. Potentially this block could be 1,849 acres in size and contain 973 acres of forest interior habitat.

Forest Block Map	Block Name/Acreage	Description
	**C and D Canal E** **Current Block = 217 acres (2 acres interior)** **Potential Block = 688 acres (434 acres interior)**	C and D Canal E is located in the south-central area of the canal. It is bounded by the canal on the north, DE 1 on the east, Lorewood Grove Road on the south, and an un-named canal access road on the west. Two vegetation communities are located within this block and include Northeastern Modified Successional Forest and Northeastern Successional Shrubland. Tributaries to the C and D Canal drain this block. Currently this block contains 2 acres of forest interior habitat. Potentially this block could be 688 acres in size and contain 434 acres of forest interior habitat.

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

Vegetation communities located adjacent to the shore of Delaware Bay 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.



	Forests	Shrublands	Herbaceous	Marsh	Anthropogenic Communities/Land Covers	Non-Vegetated Land Covers	Water
1937	111	118	794	571.4	3052.2	381	39
2002	1468	499	1134	1014.1	785	10.2	156
2007	1528	455	1165	1005.1	756	10.2	144

Figure 3.1. Vegetation Community/Land Cover Categories at C and D Canal Wildlife Area (1937, 2002, and 2007)

C and D Canal Wildlife Area Vegetation Communities/Land Covers (Figure 3.1): Forest is the most prominent vegetation cover in the C and D Canal Wildlife Area, with herbaceous communities and marsh coming in a close second and third. Anthropogenic communities which were prominent close to the construction of the canal in the 1930's have succeeded into more "natural" vegetation type albeit with a lot of exotic invasive plants present.

DNREC Sea Level Rise Analysis (Table 3.1)

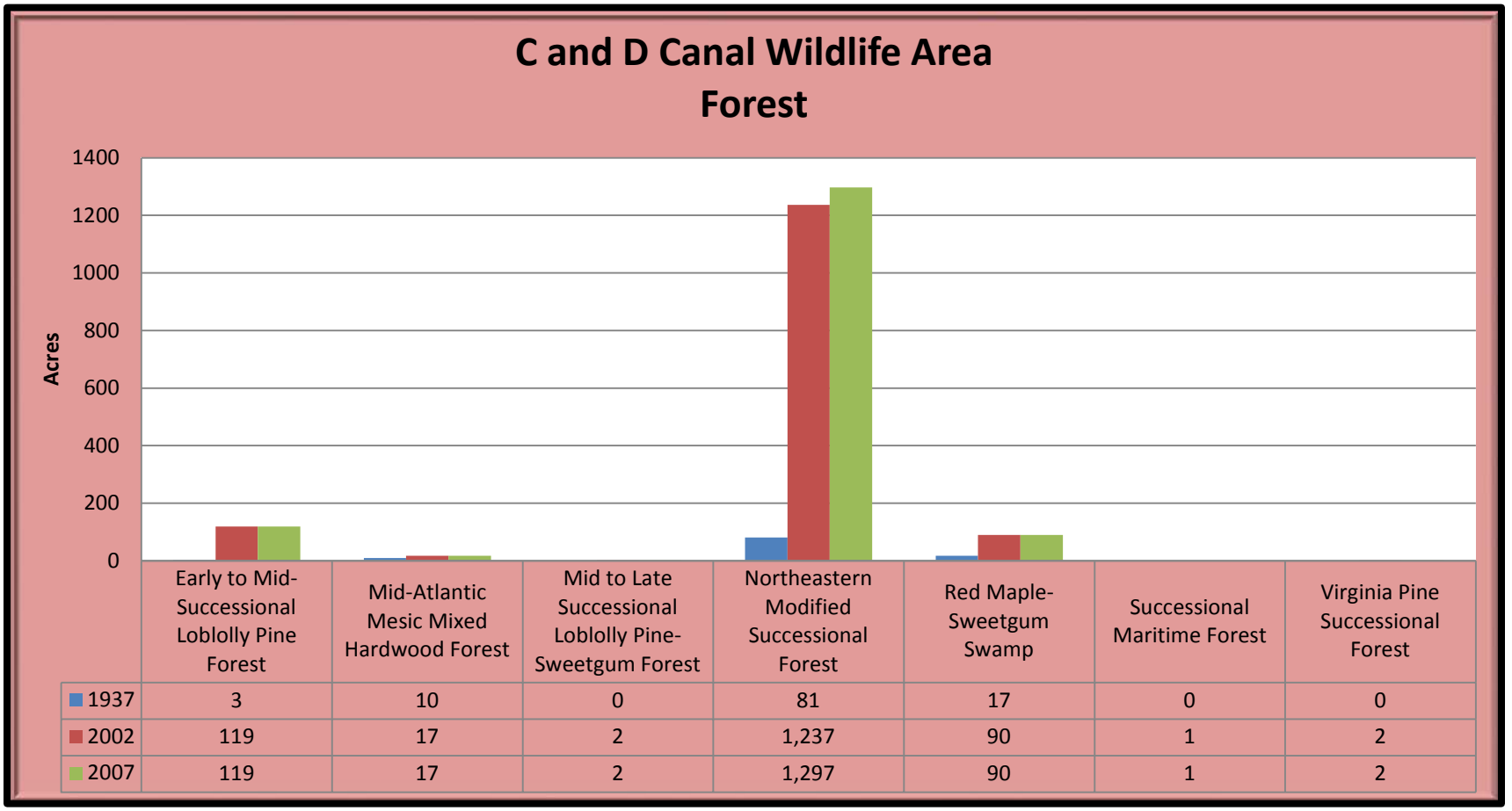
At the highest amount of sea level rise (1.5 m), only about 14% of C and D Canal Wildlife Area will be inundated.

Table 3.1. Projected acres of the C and D Canal Wildlife Area Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	468 acres
1 m	601 acres
1.5 m	717 acres

Natural Capital (Table 3.2)

The capital of C and D Canal Wildlife Area increased up to 2002 and then has dropped due to losses in marsh and water coverage. It is unknown whether the capitalization will continue to go down.

Table 3.2. Natural Capital of the C and D Canal Wildlife Area	
Year	**Natural Capital (in 2012 dollars)**
1937	$5,401,458/year
2002	$13,263,838/year
2007	$12,592,556/year



	Early to Mid-Successional Loblolly Pine Forest	Mid-Atlantic Mesic Mixed Hardwood Forest	Mid to Late Successional Loblolly Pine-Sweetgum Forest	Northeastern Modified Successional Forest	Red Maple-Sweetgum Swamp	Successional Maritime Forest	Virginia Pine Successional Forest
1937	3	10	0	81	17	0	0
2002	119	17	2	1,237	90	1	2
2007	119	17	2	1,297	90	1	2

Figure 3.2. C and D Canal Wildlife Area Forest (1937, 2002, and 2007)

C and D Canal Wildlife Area Forest (Figure 3.2): Northeastern Modified Successional Forest is by far the most common forest type in the wildlife area and has come about in the recent past. Early to Mid-Successional Loblolly Pine Forest is a very distant second in acreage.

DNREC Sea Level Rise Analysis (Table 3.3)

About half of the current herbaceous communities will be inundated with 0.5 m of sea level rise. At 1 m of rise 17 acres will be inundated and at 1.5 m of rise, 20 acres will be inundated.

Table 3.3. Projected acres of C and D Canal Wildlife Area Forest Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	20 acres
1 m	47 acres
1.5 m	67 acres

Natural Capital (Table 3.4)

The natural capital of herbaceous communities has been steadily going downward with the transfer of the capital into more mature communities such as shrubland and forests.

Table 3.4. Natural Capital of C and D Canal Wildlife Area Forest	
Year	**Natural Capital (in 2012 dollars)**
1937	$226,731/year
2002	$1,366,815/year
2007	$1,378,161/year

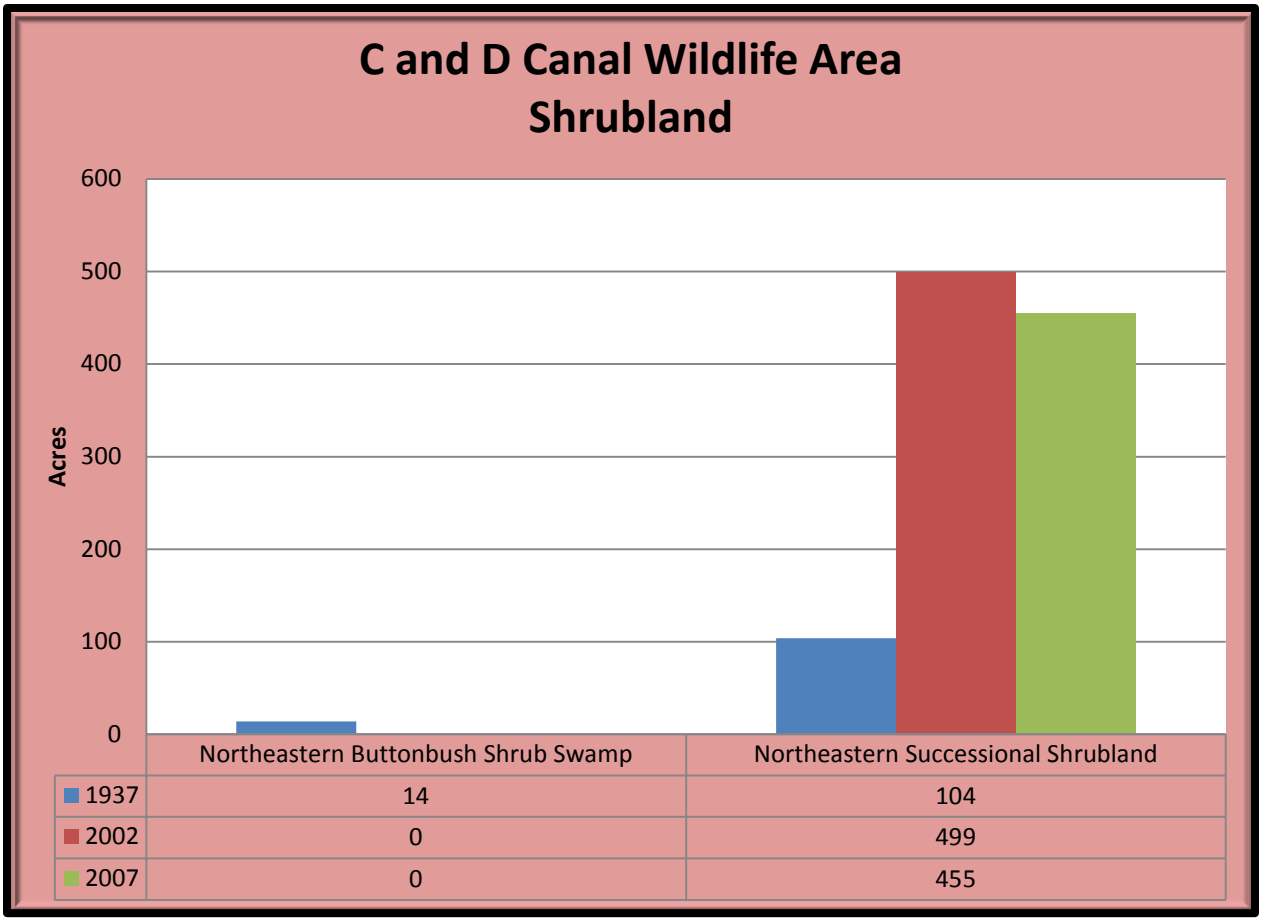


Figure 3.3. Shrubland at C and D Canal Wildlife Area (1937, 2002, and 2007)

C and D Canal Wildlife Area Shrubland (Figure 3.3): Northeastern Successional Shrubland is the most common and only shrubland still present in the wildlife area. In time, these shrubland may eventually succeed into Northeastern Modified Successional Forests.

DNREC Sea Level Rise Analysis (Table 3.5)

As a whole, very little of the shrubland present in the wildlife area will be inundated at the highest amount (1.5 m).

Table 3.5. Projected acres of C and D Canal Wildlife Area Shrubland Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	3 acres
1 m	11 acres
1.5 m	21 acres

Natural Capital (Table 3.6)

Shrubland has been decreasing due to a loss of a wetland shrubland (Northeastern Buttonbush Shrub Swamp) and maturing of Northeastern Successional Shrubland.

Table 3.6. Natural Capital of C and D Canal Wildlife Area Shrubland	
Year	**Natural Capital (in 2012 dollars)**
1937	$145,087/year
2002	$72,704/year
2007	$66,294/year

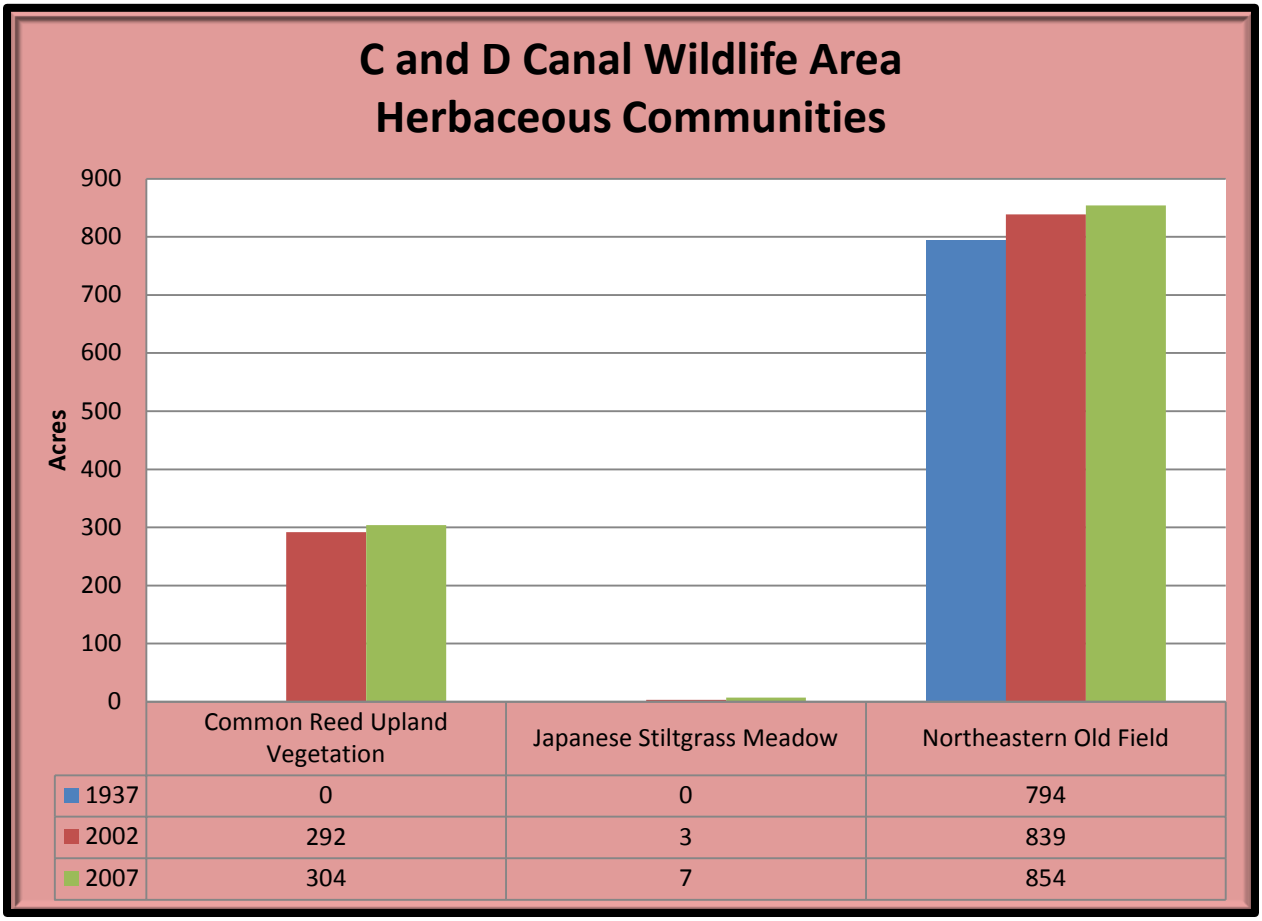


Figure 3.4. Herbaceous Communities at C and D Canal Wildlife Area (1937, 2002, and 2007)

C and D Canal Wildlife Area Herbaceous Communities (Figure 3.4): Northeastern Old Field that is present on a lot the spoil areas in the wildlife area is the most common herbaceous community. Common Reed Upland Vegetation, the second most common is also present on the spoil areas.

DNREC Sea Level Rise Analysis (Table 3.7)

Very little of the herbaceous communities present in the wildlife area will be affected by sea level rise.

Table 3.7. Projected acres of C and D Canal Wildlife Area Herbaceous Communities Inundated by Sea Level Rise

Rise	Acres
0.5 m	14 acres
1 m	22 acres
1.5 m	25 acres

Natural Capital (Table 3.8)

The natural capital of herbaceous communities has been steadily going downward with the transfer of the capital into more mature communities such as shrubland and forests.

Table 3.8. Natural Capital of C and D Canal Wildlife Area Herbaceous Communities	
Year	**Natural Capital (in 2012 dollars)**
1937	$115,686/year
2002	$165,224/year
2007	$169,741/year

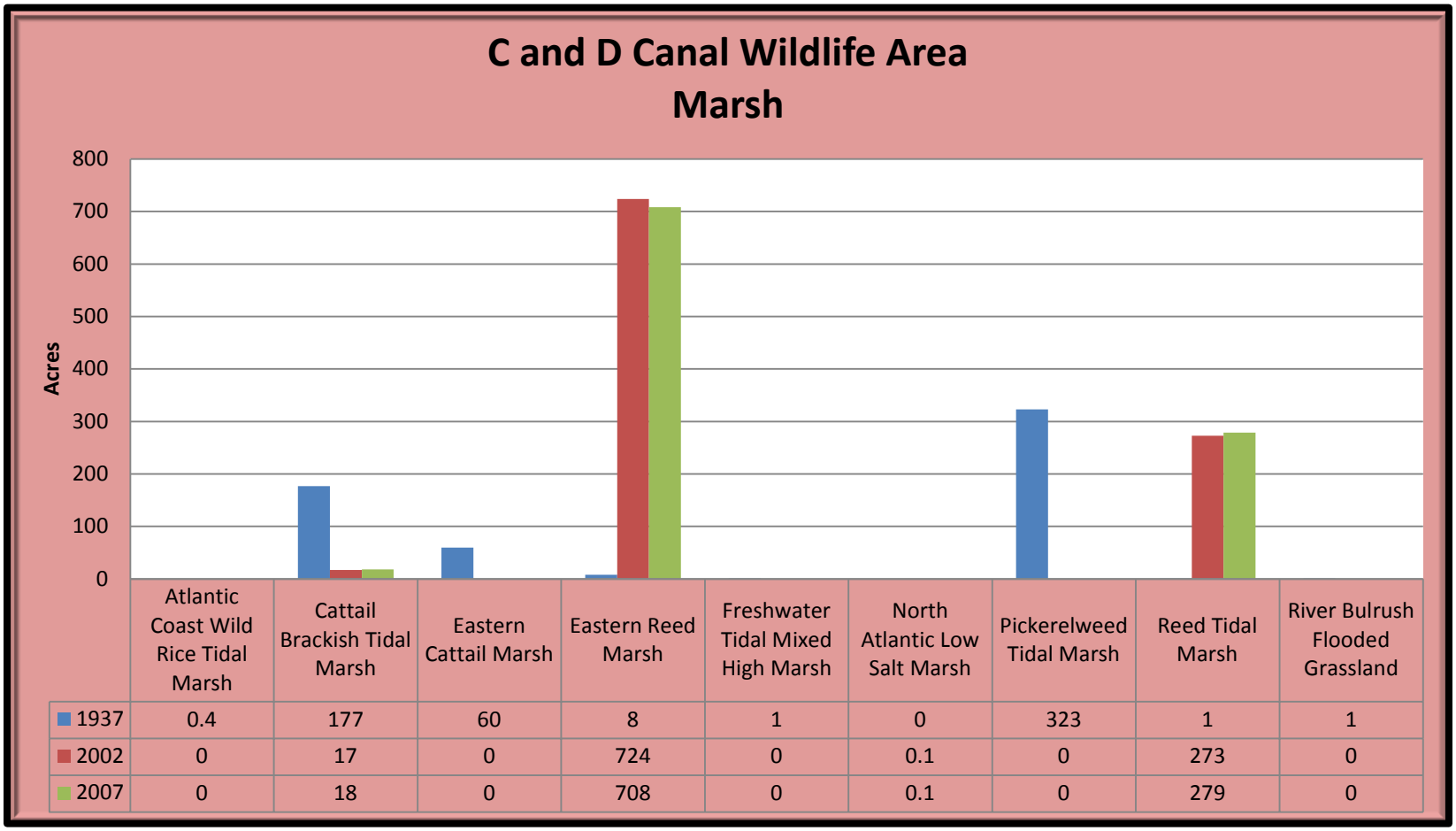


Figure 3.7. Marsh at C and D Canal Wildlife Area (1937, 2002, and 2007)

C and D Canal Wildlife Area Marsh (Figure 3.7): Eastern Reed Marsh is located in low disturbed areas and is the most common marsh type in the wildlife area, seconded by the related Reed Tidal Marsh which is in tidal areas.

DNREC Sea Level Rise Analysis (Table 3.9)

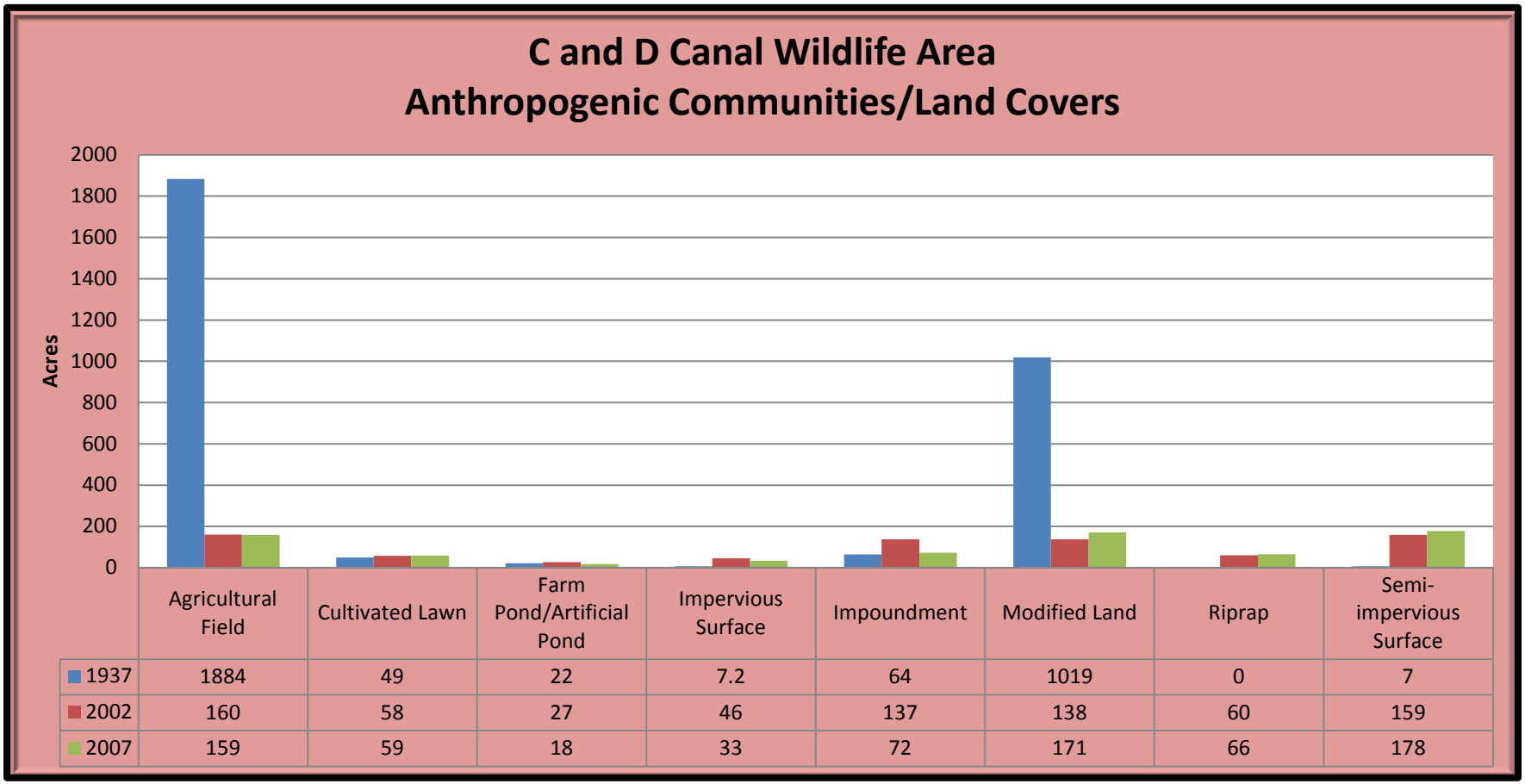
Most of the tidal marsh will be impacted by sea level rise, but the non-tidal marsh (Eastern Reed Marsh) will be largely unaffected.

Table 3.9. Projected acres of C and D Canal Wildlife Area Marsh Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	247 acres
1 m	288 acres
1.5 m	306 acres

Natural Capital (Table 3.10)

Capital has increased greatly based on the spread of Reed Tidal Marsh and Eastern Reed Marsh. A slight decline was seen in the recent period (2002-2007) based on the loss of some of the Eastern Reed Marsh.

Table 3.10. Natural Capital of C and D Canal Wildlife Area Marsh	
Year	**Natural Capital (in 2012 dollars)**
1937	$3,788,108/year
2002	$8,539,038/year
2007	$8,425,153/year



	Agricultural Field	Cultivated Lawn	Farm Pond/Artificial Pond	Impervious Surface	Impoundment	Modified Land	Riprap	Semi-impervious Surface
1937	1884	49	22	7.2	64	1019	0	7
2002	160	58	27	46	137	138	60	159
2007	159	59	18	33	72	171	66	178

Figure 3.8. Anthropogenic Communities at C and D Canal Wildlife Area (1937, 2002, and 2007)

C and D Canal Wildlife Area Anthropogenic Communities/Land Covers (Figure 3.8): Semi-impervious surface from the many roads running through the wildlife area, modified land, and Agricultural Fields are the prominent anthropogenic communities.

DNREC Sea Level Rise Analysis (Table 3.11)

Riprap will be the most impacted anthropogenic land cover in the wildlife area.

Table 3.11. Projected acres of C and D Canal Wildlife Area Anthropogenic Communities/Land Covers Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	53 acres
1 m	101 acres
1.5 m	162 acres

Natural Capital (Table 3.12)

Anthropogenic community/land cover capital has decreased overall with most of the decrease coming from losses in ponds and impoundments.

Table 3.12. Natural Capital of C and D Canal Wildlife Area Anthropogenic Communities/Land Covers	
Year	**Natural Capital (in 2012 dollars)**
1937	$566,866/year
2002	$884,132/year
2007	$489,278/year

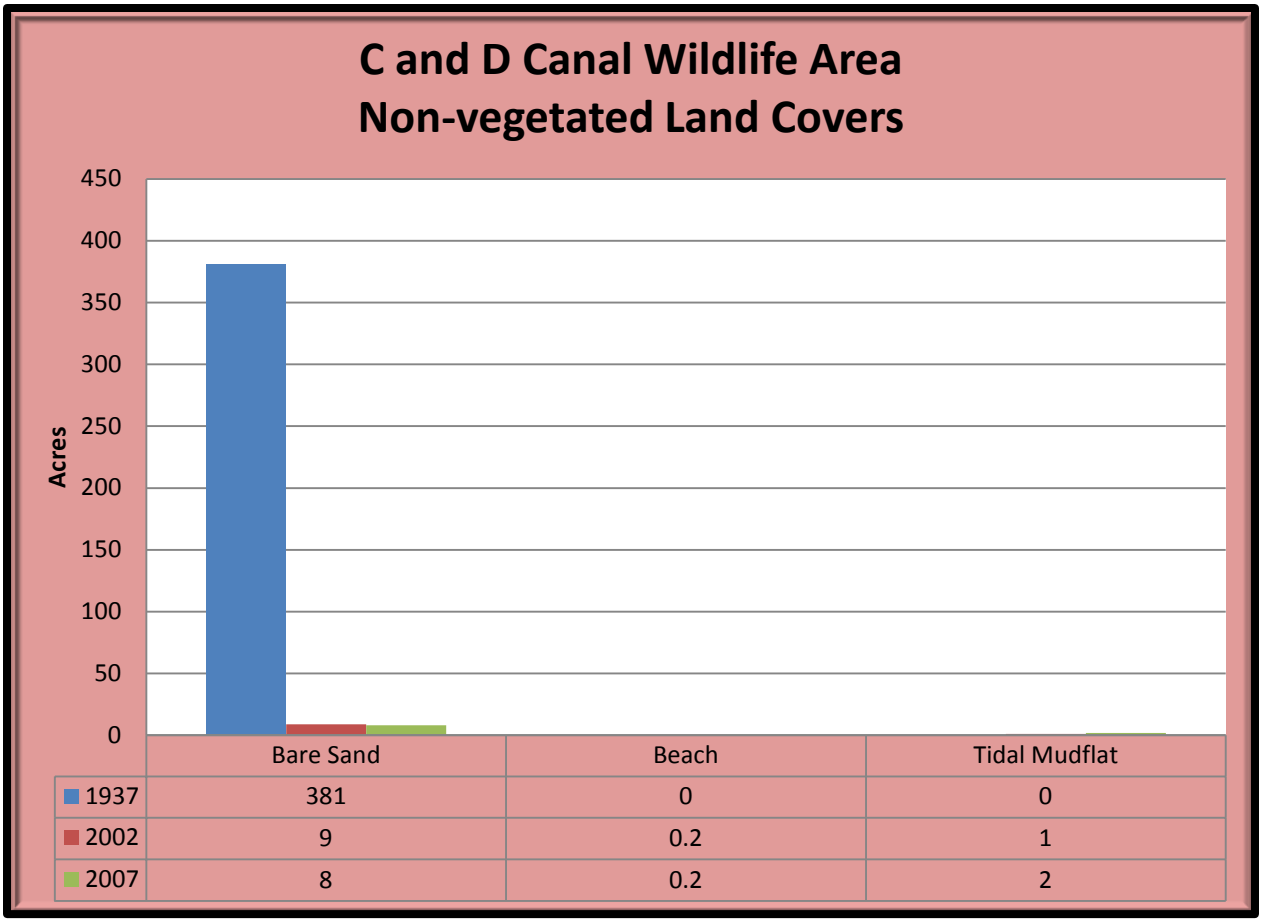


Figure 3.7. Non-vegetated Land Covers at C and D Canal Wildlife Area (1937, 2002, and 2007)

C and D Canal Wildlife Area Non-vegetated Land Covers (Figure 3.7): In 1937, there was still a lot of bare sandy area on old spoil piles. These areas have since vegetated leaving very little bare sand left.

DNREC Sea Level Rise Analysis (Table 3.13)

Tidal mudflat and beach are the most affected non-vegetated community in the wildlife area with sea level rise.

Table 3.13. Projected acres of C and D Canal Wildlife Area Non-vegetated Land Covers Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	2 acres
1 m	2 acres
1.5 m	2 acres

Natural Capital (Table 3.14)

Tidal mudflat is the only land cover with a natural capital value in the wildlife area and has been increasing as the marsh succumbs to sea level rise and erosion.

Table 3.14. Natural Capital of C and D Canal Wildlife Area Non-vegetated Land Covers

Year	Natural Capital (in 2012 dollars)
1937	$0/year
2002	$6,271/year
2007	$12,543/year

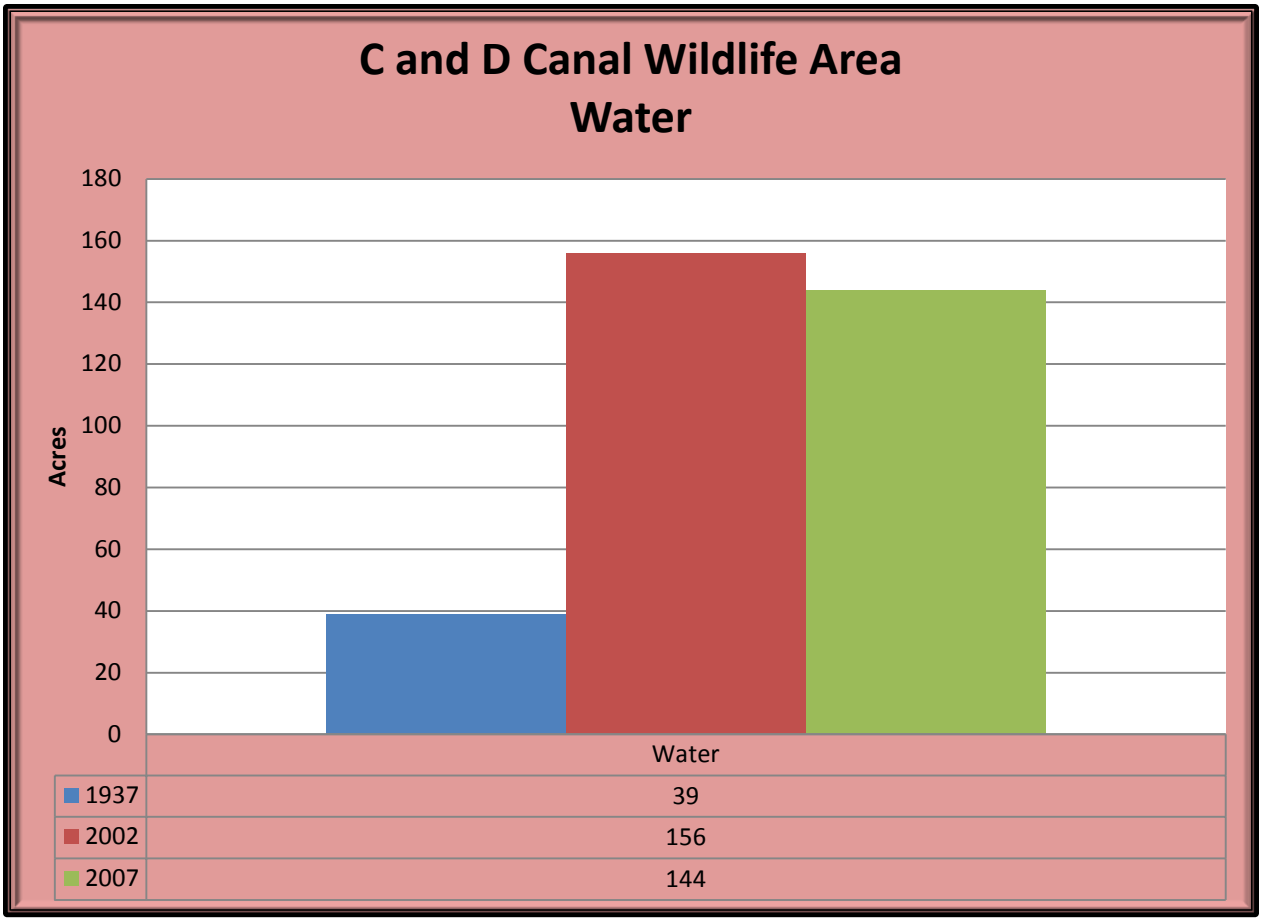


Figure 3.8. Water coverage (non-impoundment) at C and D Canal Wildlife Area (1937, 2002, and 2007)

C and D Canal Wildlife Area Water Coverage (Figure 3.8): The canal area could be considered to be an artificial habitat and as such is built around rises in water levels. Those areas not exposed to riprapping have experienced quite a bit of water incursion, likely due to sea level rise since 1937.

Natural Capital (Table 3.16)

Water capital has increased greatly from gains in the East Canal section, which is most heavily impacted by sea level rise.

Table 3.16. Natural Capital of C and D Canal Wildlife Area Water	
Year	**Natural Capital (in 2012 dollars)**
1937	$358,321/year
2002	$1,820,272/year
2007	$1,605,279/year

CHAPTER 4: VEGETATION COMMUNITIES BY SECTION

1. East Canal Section

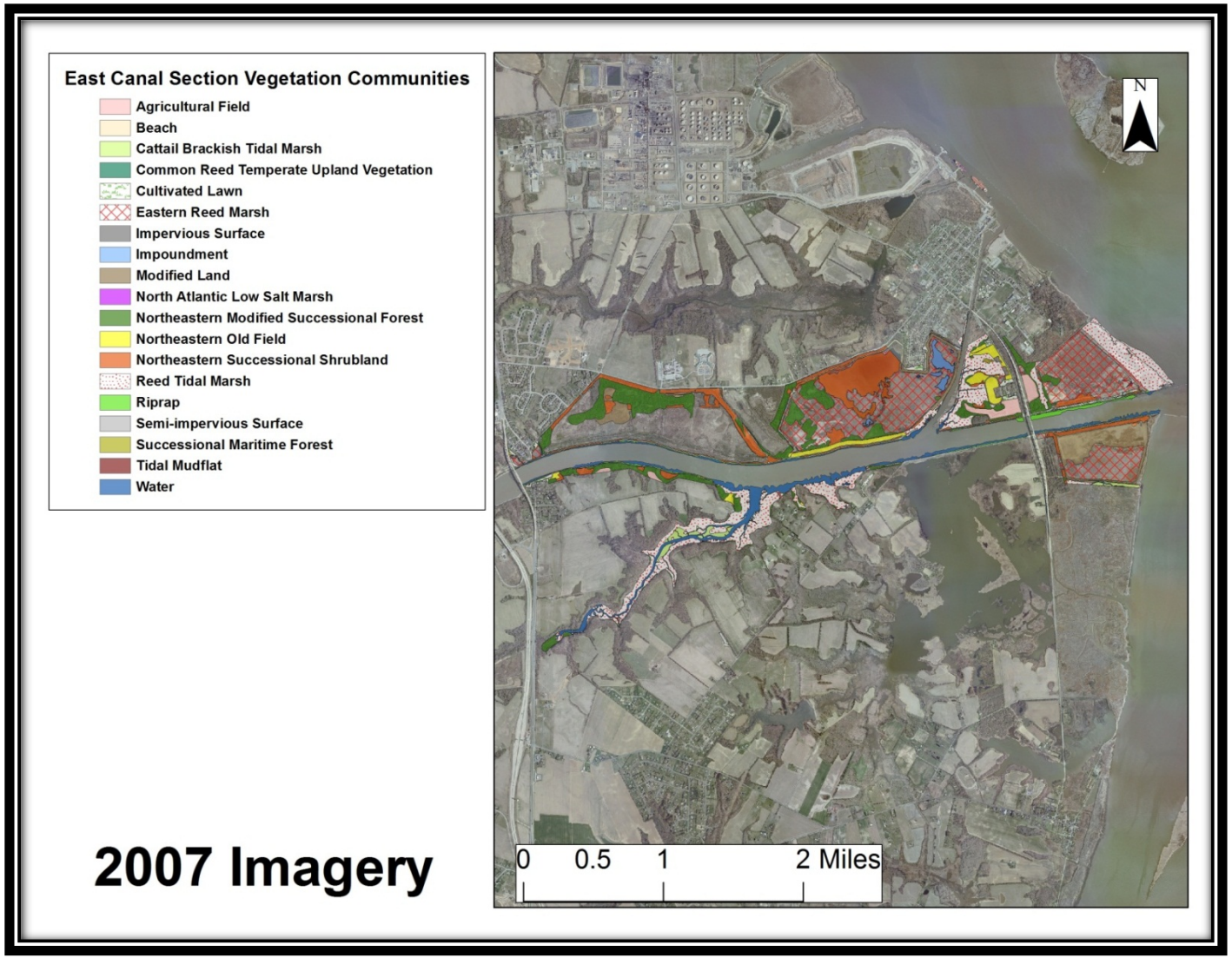


Figure 4-1.1. 2007 Vegetation Community Map of the East Canal Section

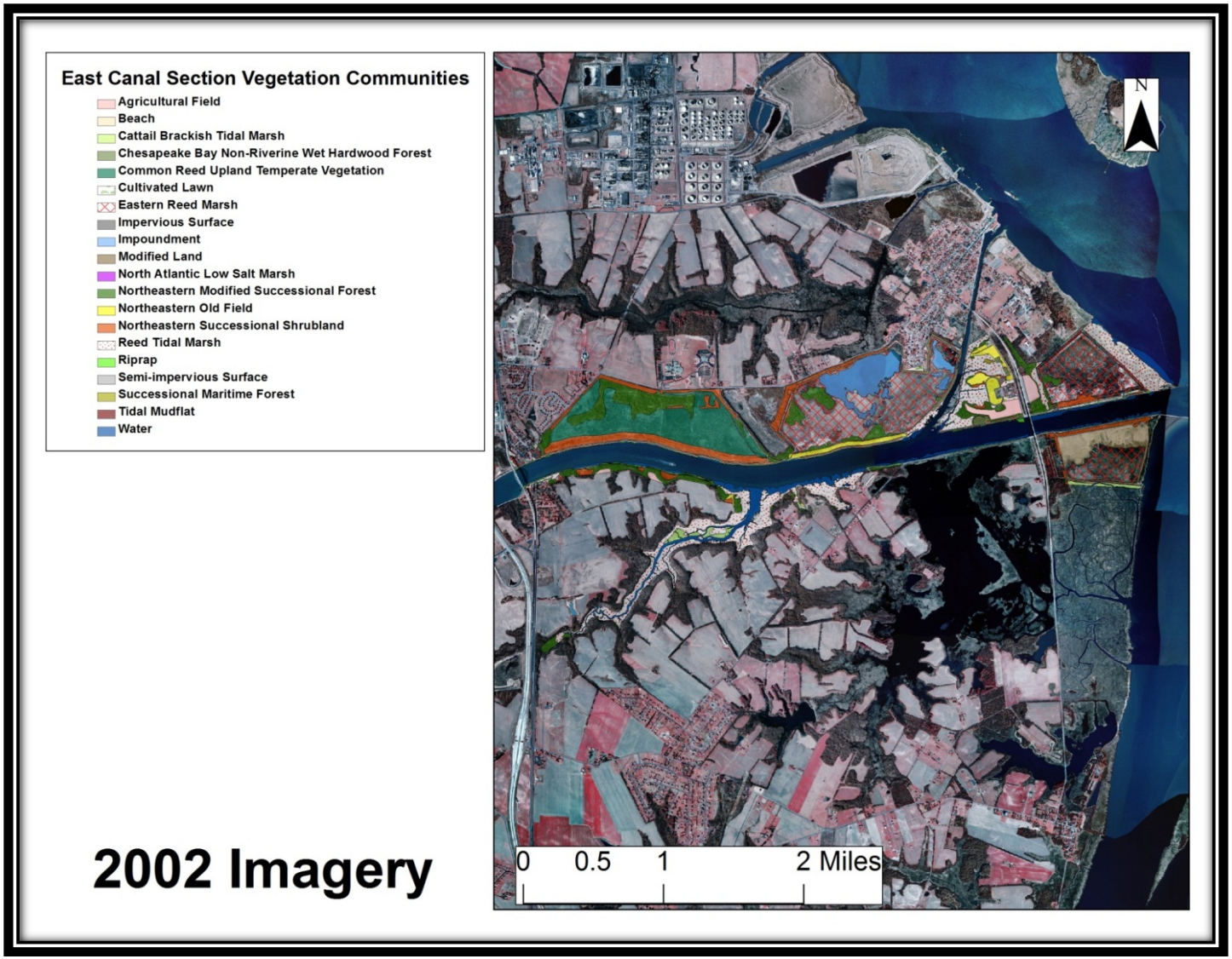


Figure 4-1.2. 2002 Vegetation Community Map of the East Canal Section

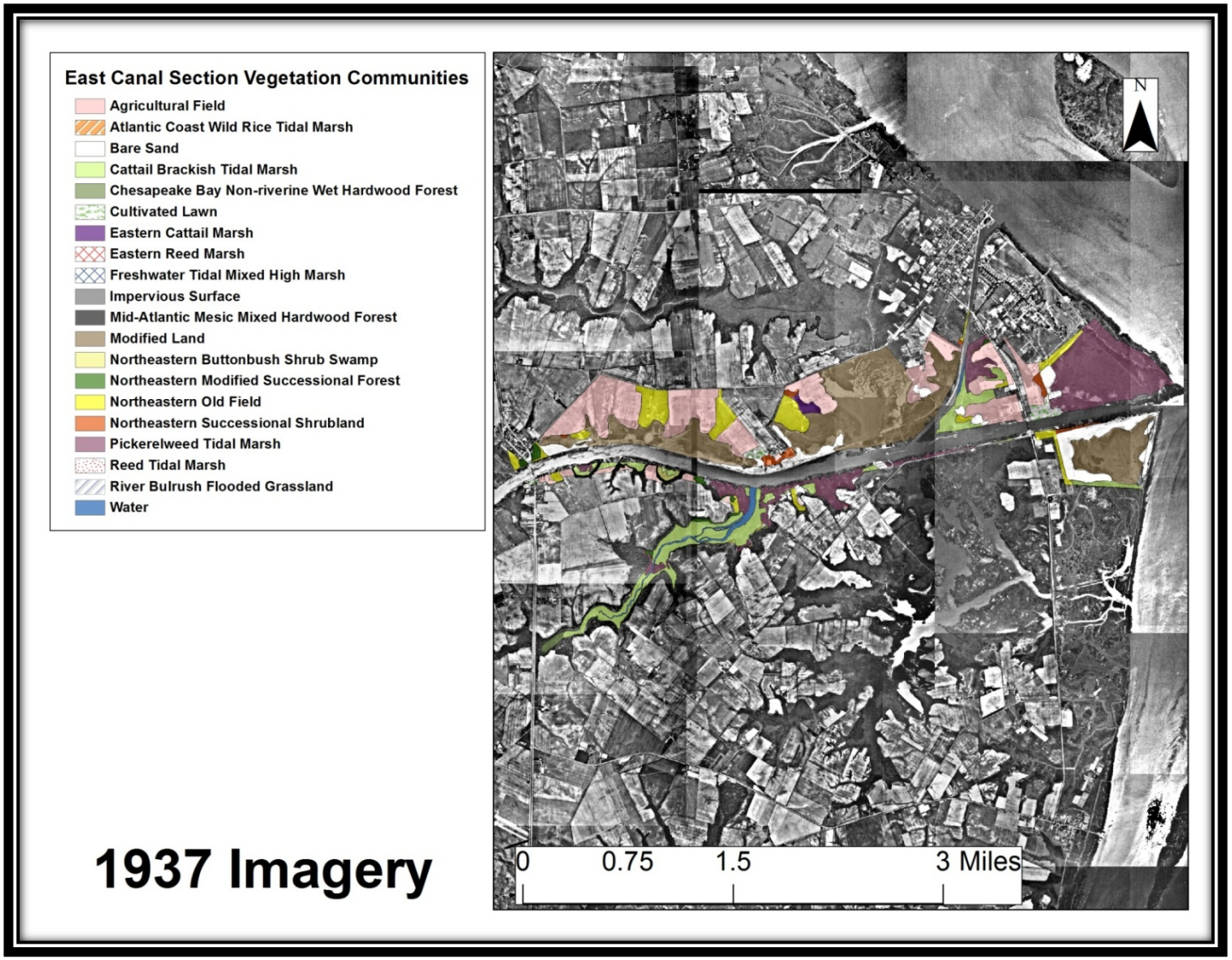


Figure 4-1.3. 1937 Vegetation Community Map of the East Canal Section

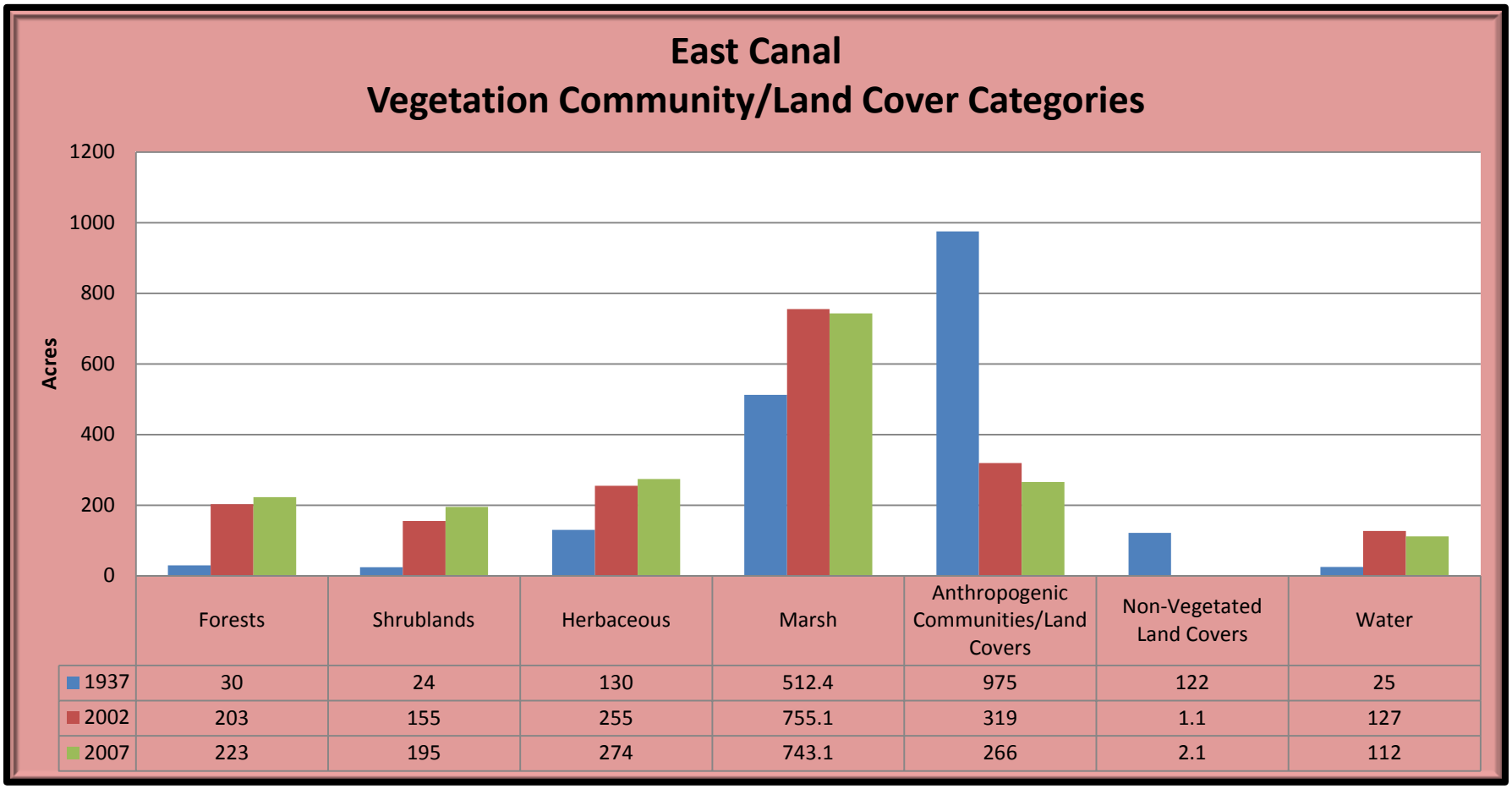


Figure 4-1.4. East Canal Section Vegetation Community/Land Cover Categories (1937, 2002, and 2007)

East Canal Section Categories (Figure 4-1.4): The C and D Canal cuts through the middle spine of the Delmarva Peninsula making the western section the highest overall section and sloping towards the Delaware River. The eastern section is the lowest and closest to the Delaware River

and Bay. Most of the marshland present in the wildlife area is present in this section in an area called Thousand Acre Marsh. Other distantly prominent land covers and vegetation communities are forests and anthropogenic communities.

DNREC Sea Level Rise Analysis (Table 4-1.1)

About 27% of the East Canal Section will be flooded with 0.5 m of sea level rise. An additional 1 m of rise will inundate about 39% of the section.

Table 4-1.1. Projected acres of the East Canal Section Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	427 acres
1 m	537 acres
1.5 m	605 acres

Natural Capital (Table 4-1.2)

Natural capital in the East Canal Section has increased overall since 1937, with a decrease in the recent period (2002-2007) due to losses in water and marsh.

Table 4-1.2. Natural Capital of the East Canal Section	
Year	**Natural Capital (in 2012 dollars)**
1937	$3,758,746/year
2002	$8,629,386/year
2007	$7,872,851/year

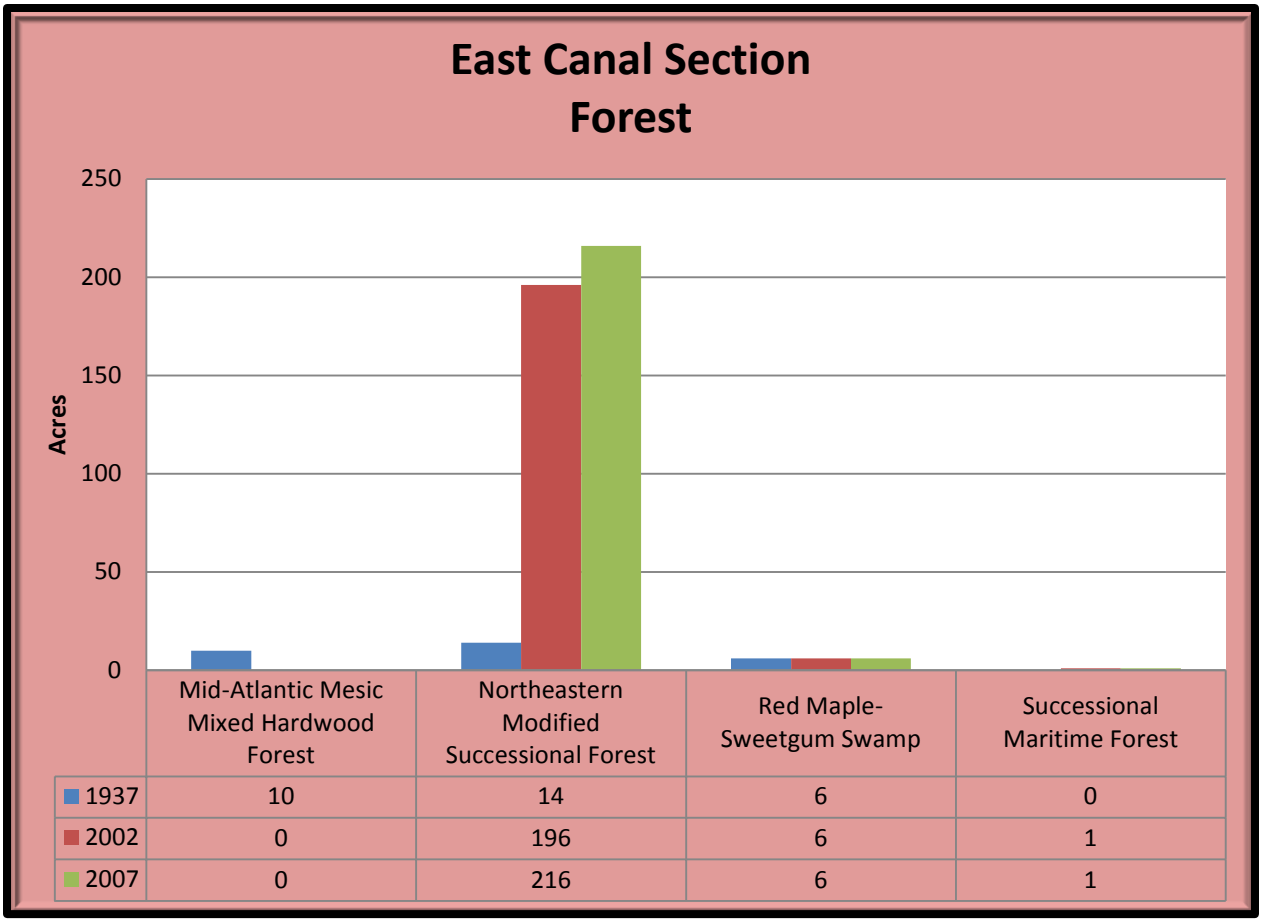


Figure 4-1.5. East Canal Section Forest (1937, 2002, and 2007)

East Canal Section Forest (Figure 4-1.5): Northeastern Modified Successional Forest is essentially the only forest type present in the eastern section. This forest type is characterized by a large infestation of exotic invasive plant species and comes about from disturbance, in this case the canal.

DNREC Sea Level Rise Analysis (Table 4-1.3)

A little less than ¼ of the current forestland in the East Canal Section will be inundated by 1.5 m of sea level rise.

Table 4-1.3. Projected acres of East Canal Section Forest Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	18 acres
1 m	41 acres
1.5 m	53 acres

Natural Capital (Table 4-1.4)

Forestland has steadily increased its capital as more forests grow into the East Section.

Table 4-1.4. Natural Capital of East Canal Section Forest	
Year	**Natural Capital (in 2012 dollars)**
1937	$78,287/year
2002	$111,002/year
2007	$114,784/year

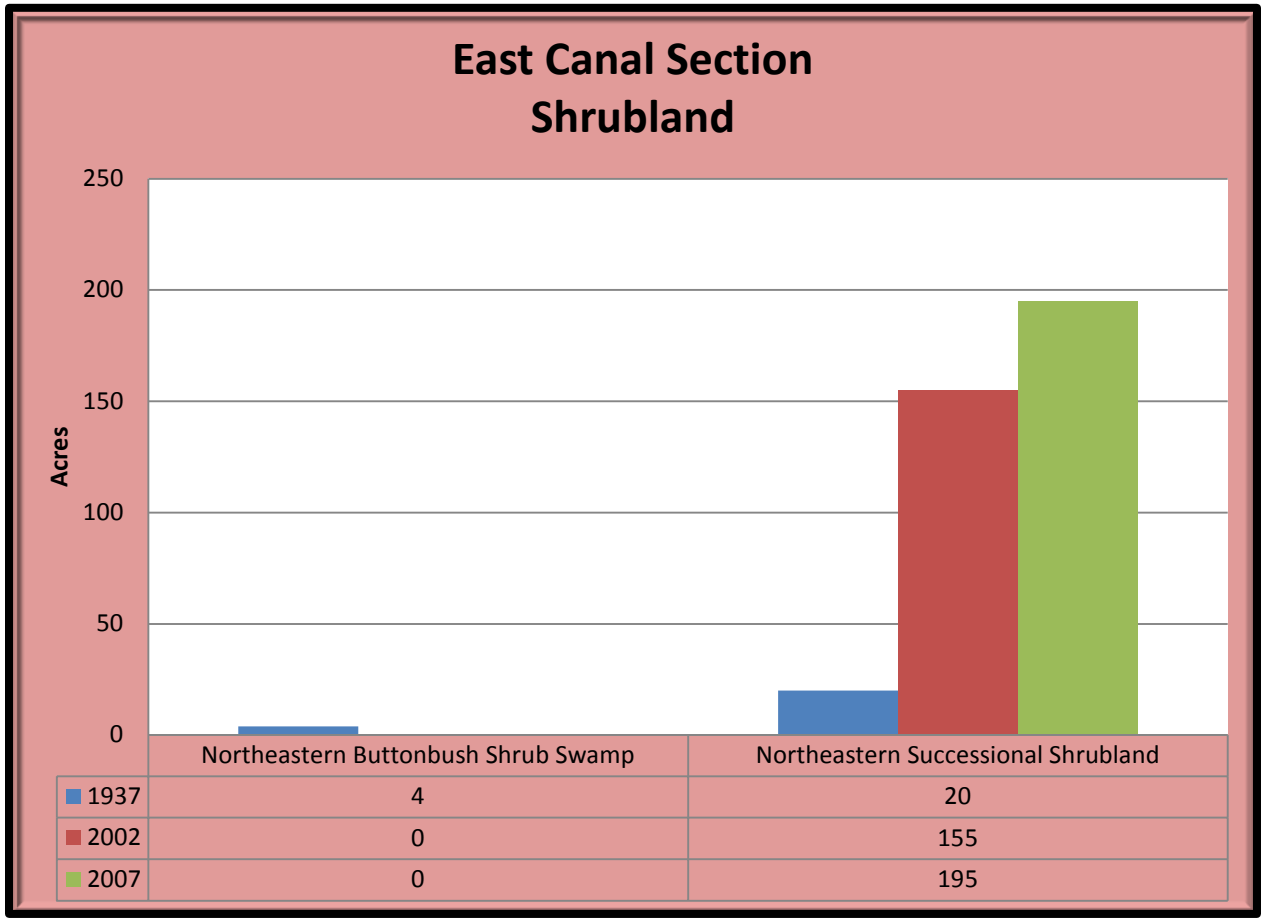


Figure 4-1.6. East Canal Section Shrubland (1937, 2002, and 2007)

East Canal Section Shrubland (Figure 4-1.6): Northeastern Successional Shrubland is the only shrubland in the eastern section and in the wildlife area. Like the Northeastern Modified Successional Forest, it comes about often from disturbance.

DNREC Sea Level Rise Analysis (Table 4-1.5)

Less than 10% of the current shrubland in the East Section will be impacted with 1.5 m of sea level rise. This category is one of the least impacted in the section.

Table 4-1.5. Projected acres of East Canal Section Shrubland Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	3 acres
1 m	10 acres
1.5 m	17 acres

Natural Capital (Table 4-1.6)

Shrubland capital has been increasing with acreage of Northeastern Successional Shrubland covering open field areas.

Table 4-1.6. Natural Capital of East Canal Section Shrubland	
Year	**Natural Capital (in 2012 dollars)**
1937	$40,038/year
2002	$22,584/year
2007	$28,412/year

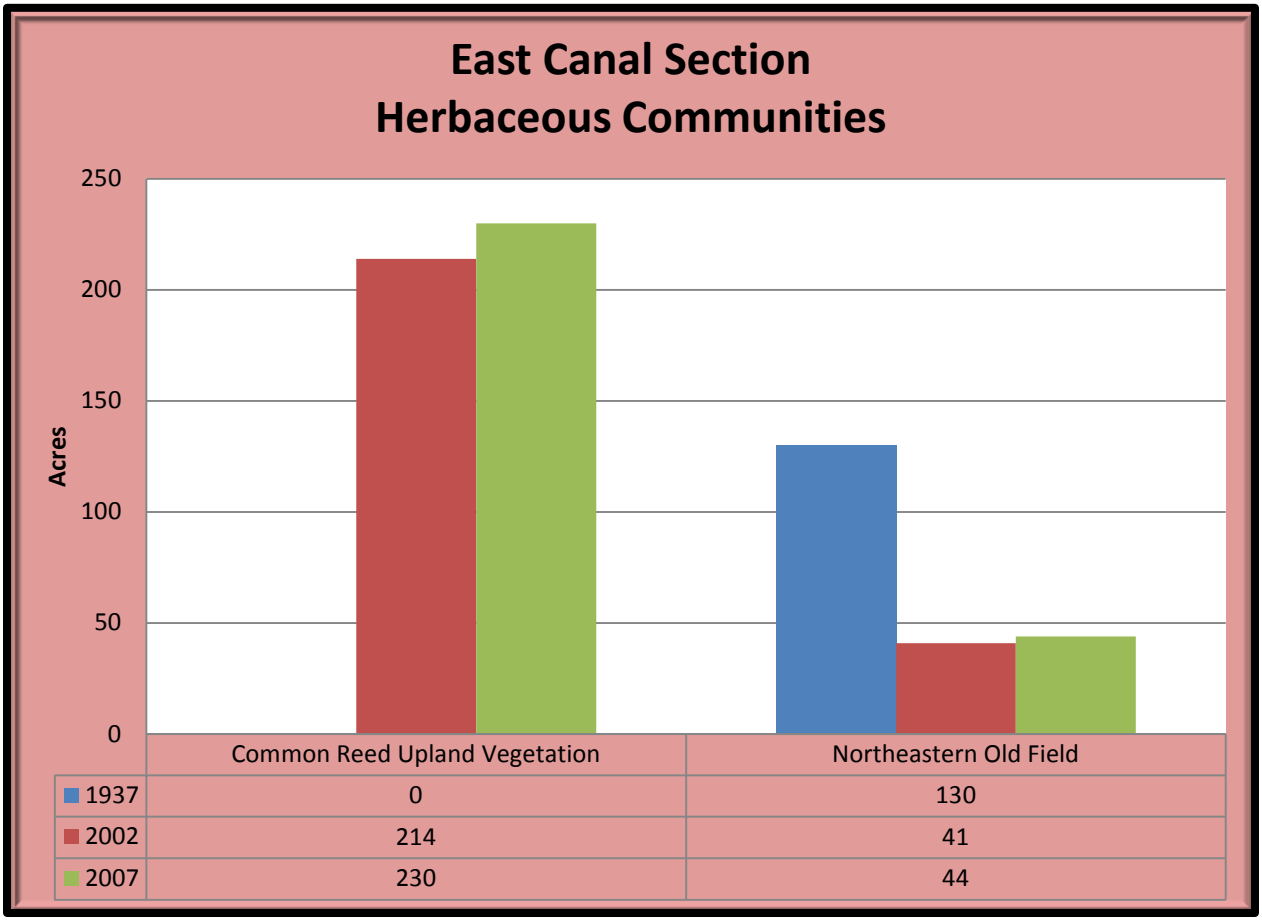


Figure 4-1.7. East Canal Section Herbaceous Communities (1937, 2002, and 2007)

East Canal Section Herbaceous Communities (Figure 4-1.7): Common Reed Upland Vegetation is the most common herbaceous community and is located on upland areas in the wildlife area. It is related to the Eastern Reed Marsh that is present in wetlands. Northeastern Old Field, once prominent has succeeded to other community types.

DNREC Sea Level Rise Analysis (Table 4-1.7)

About half of the current herbaceous communities will be inundated with 0.5 m of sea level rise. At 1 m of rise 17 acres will be inundated and at 1.5 m of rise, 20 acres will be inundated.

Table 4-1.7. Projected acres of East Canal Section Herbaceous Communities Inundated by Sea Level Rise

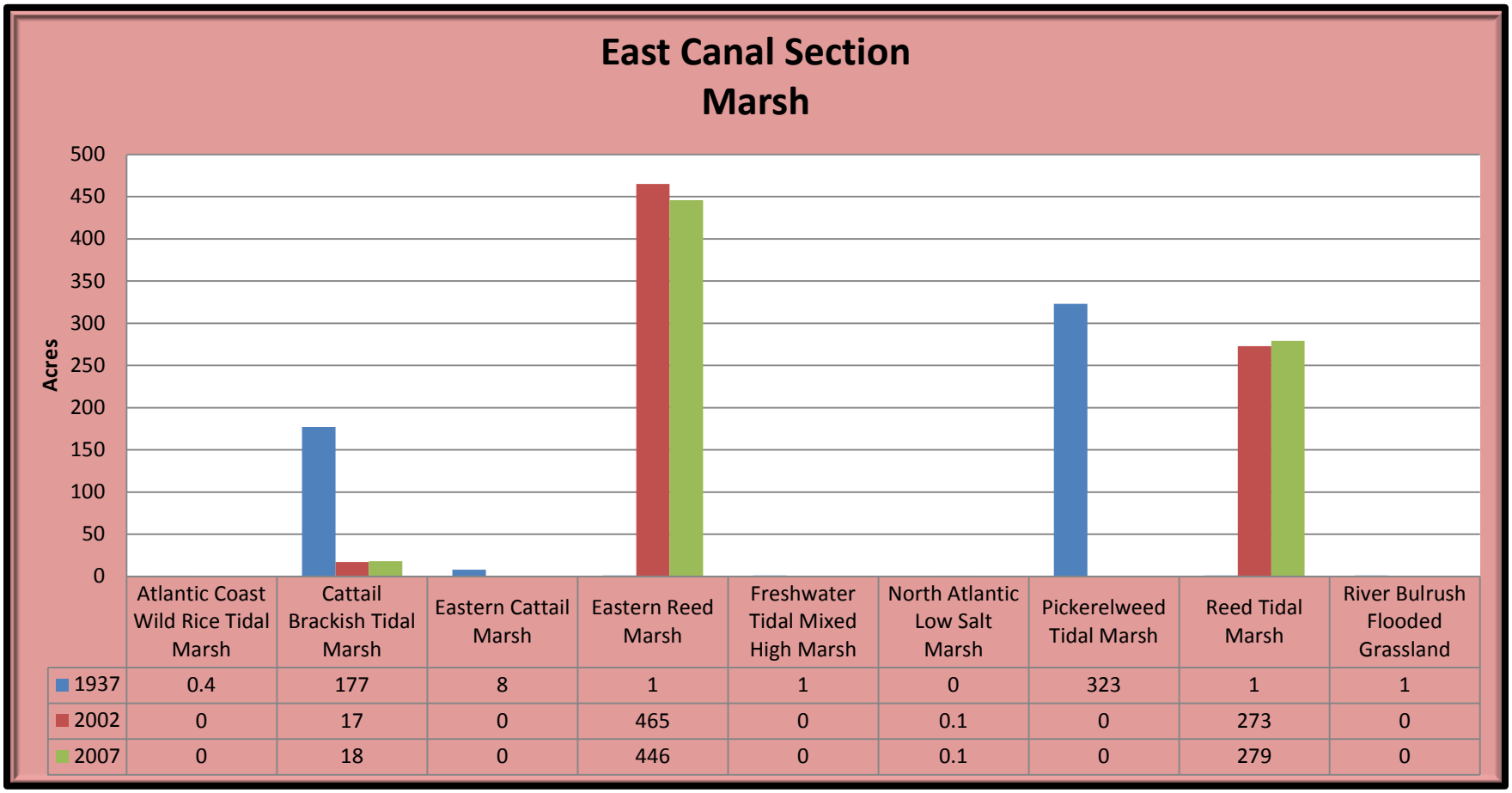
Rise	Acres
0.5 m	12 acres
1 m	19 acres
1.5 m	24 acres

Natural Capital (Table 4-1.8)

Common Reed Upland Vegetation has been increasing in acreage, increasing the overall capital for herbaceous communities.

Table 4-1.8. Natural Capital of East Canal Section Herbaceous Communities

Year	Natural Capital (in 2012 dollars)
1937	$18,941/year
2002	$37,154/year
2007	$39,922/year



	Atlantic Coast Wild Rice Tidal Marsh	Cattail Brackish Tidal Marsh	Eastern Cattail Marsh	Eastern Reed Marsh	Freshwater Tidal Mixed High Marsh	North Atlantic Low Salt Marsh	Pickerelweed Tidal Marsh	Reed Tidal Marsh	River Bulrush Flooded Grassland
1937	0.4	177	8	1	1	0	323	1	1
2002	0	17	0	465	0	0.1	0	273	0
2007	0	18	0	446	0	0.1	0	279	0

Figure 4-1.8. East Canal Section Marsh (1937, 2002, and 2007)

East Canal Section Marsh (Figure 4-1.8): Eastern Reed Marsh is the most common marsh type followed by Reed Tidal Marsh that is found in tidal areas. A remnant population of Cattail Brackish Tidal Marsh is present on a tributary to the canal.

DNREC Sea Level Rise Analysis (Table 4-1.9)

About 41% of the current marshland in the East Section will be flooded with 1.5 m of sea level rise.

Table 4-1.9. Projected acres of East Canal Section Marsh Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	247 acres
1 m	288 acres
1.5 m	304 acres

Natural Capital (Table 4-1.10)

Capital in marshland has increased since 1937 to 2002. Since 2002 marsh has decreased in capital with losses in Eastern Reed Marsh.

Table 4-1.10. Natural Capital of East Canal Section Marsh	
Year	**Natural Capital (in 2012 dollars)**
1937	$3,240,505/year
2002	$6,135,155/year
2007	$6,002,708/year

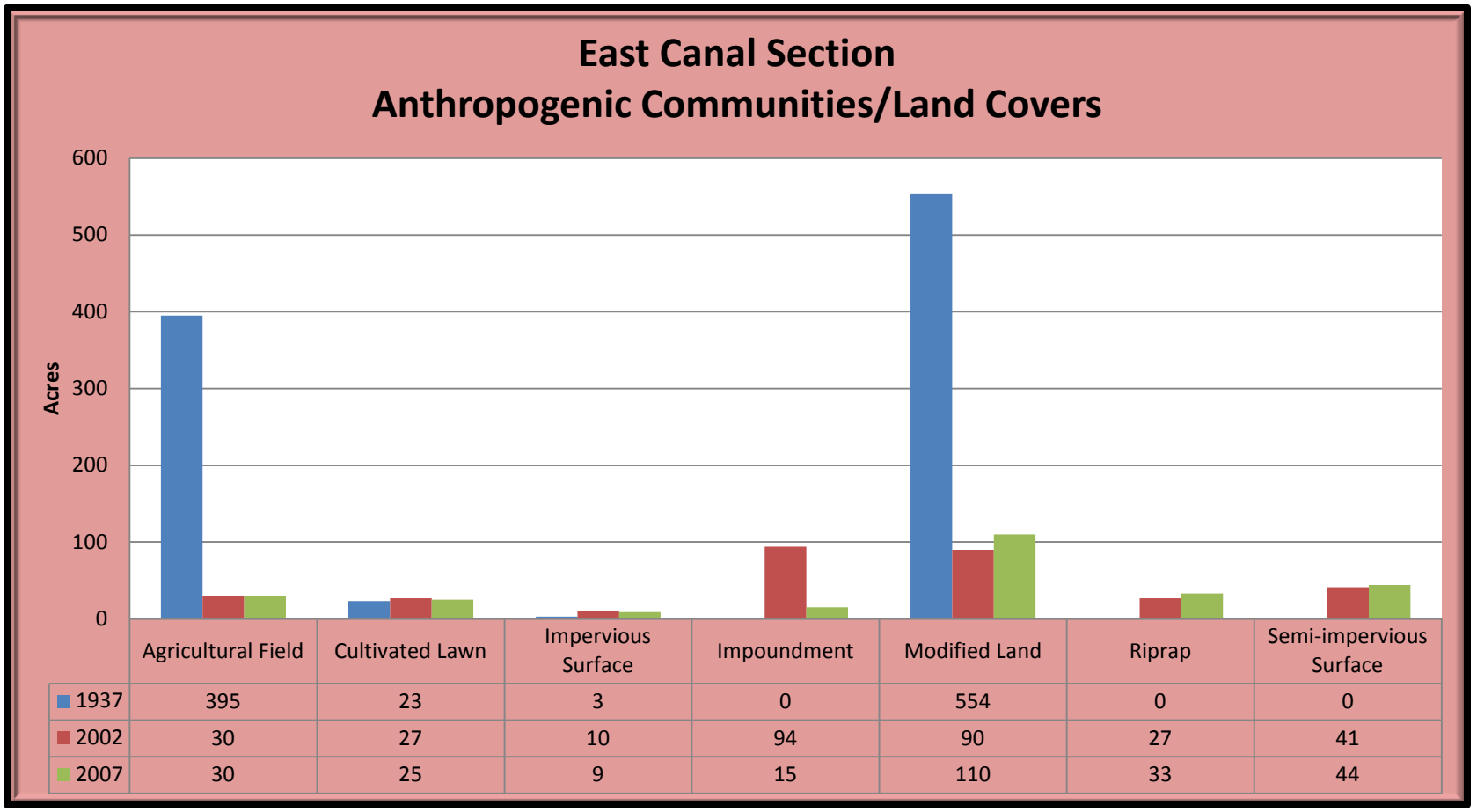


Figure 4-1.9. East Canal Section Anthropogenic Communities/Land Covers (1937, 2002, and 2007)

East Canal Section Anthropogenic Communities/Land Covers (Figure 4-1.9): Modified Land associated with spoil areas is the most common anthropogenic community, followed by Semi-impervious Surface and Riprap.

DNREC Sea Level Rise Analysis (Table 4-1.11)

A little more than 1/3 of the current anthropogenic communities/land covers will be inundated with 1.5 m of sea level rise.

Table 4-1.11. Projected acres of East Canal Section Anthropogenic Communities/Land Covers Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	35 acres
1 m	66 acres
1.5 m	93 acres

Natural Capital (Table 4-1.12)

Capital of anthropogenic communities/land covers has increased overall with a major decline in the recent period (2002-2007) due a drastic loss in impoundment area.

Table 4-1.12. Natural Capital of East Canal Section Anthropogenic Communities/Land Covers	
Year	**Natural Capital (in 2012 dollars)**
1937	$22,653/year
2002	$503,220/year
2007	$81,747/year

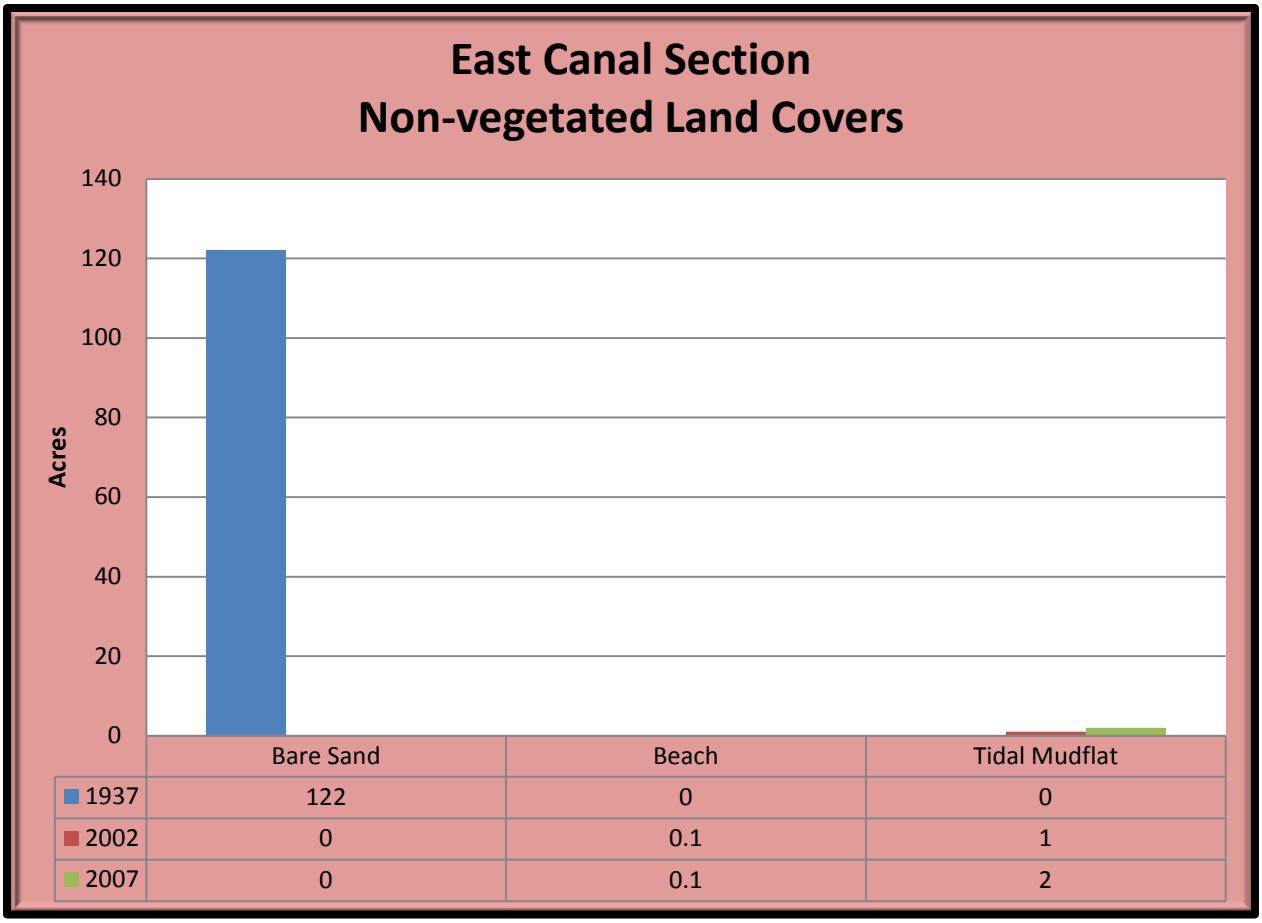


Figure 4-1.10. East Canal Section Non-vegetated Land Covers (1937, 2002, and 2007)

East Canal Section Non-vegetated Land Covers (Figure 4-1.10): Tidal Mudflat is the most common non-vegetated community in the East Canal section, followed by a small amount of beach.

DNREC Sea Level Rise Analysis (Table 4-1.13)

All of the current Non-vegetated Land Covers will be inundated with 0.5 m of sea level rise.

Table 4-1.13. Projected acres of East Canal Section Non-vegetated Land Covers Inundated by Sea Level Rise

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

Natural Capital (Table 4-1.14)

Tidal Mudflat is the only Non-vegetated Land Cover with any capital value. It was not present in 1937 and has since continued to gain capital since 2002.

Table 4-1.14. Natural Capital of East Canal Section Non-vegetated Land Covers	
Year	**Natural Capital (in 2012 dollars)**
1937	$0/year (not present)
2002	$6,271/year
2007	$12,543/year

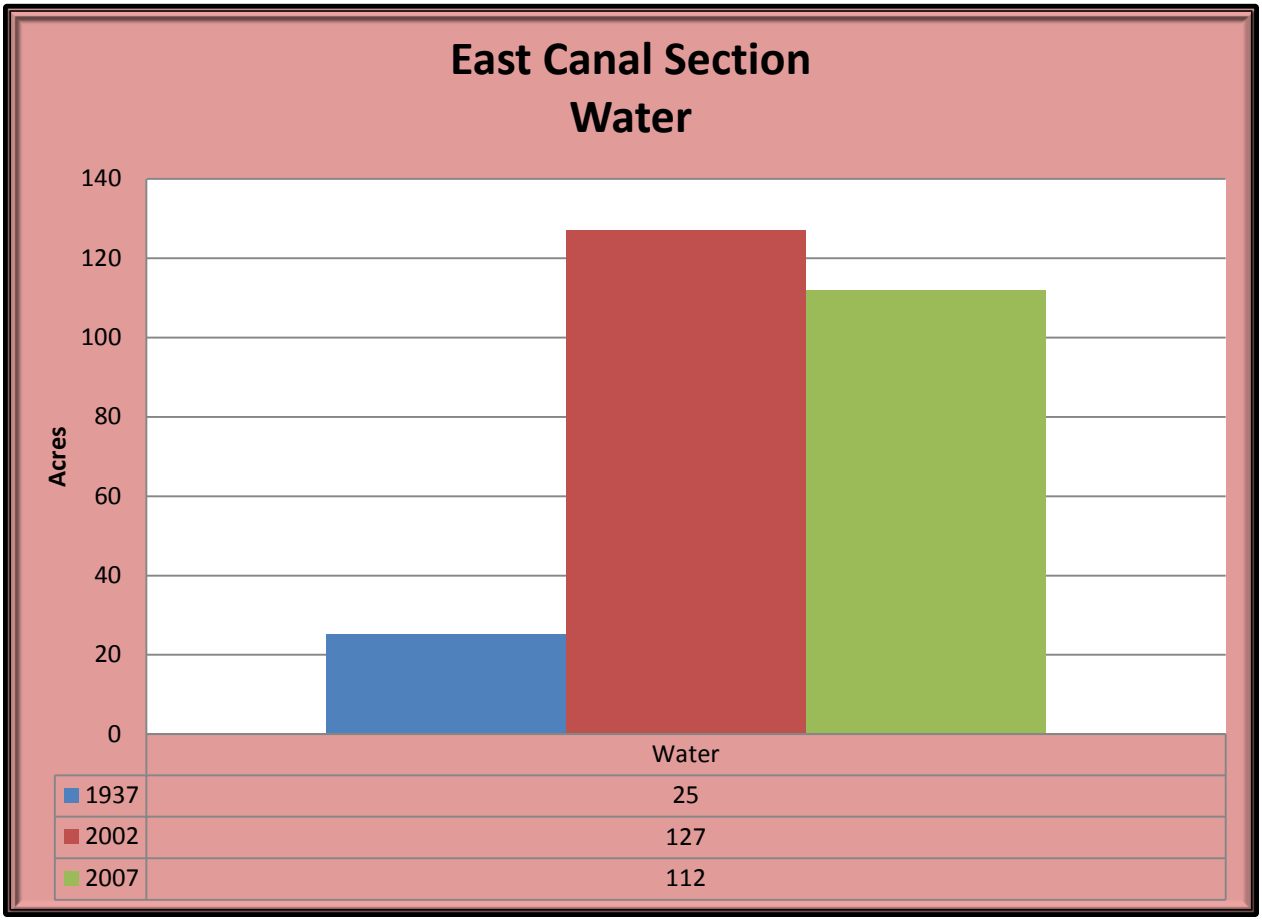


Figure 4-1.11. East Canal Water coverage (1937, 2002, and 2007)

East Canal Section Water Coverage (Figure 4-1.11): Since the eastern section is the lowest section overall, and contains the most marshland, it is most exposed to the effects of sea level rise. Most of the increase of water in the wildlife area comes from this area.

Natural Capital (Table 4-1.15)

Capital of water has increased overall since 1937, but has declined recently with more riprap being added on the sides of the canal.

Table 4-1.15. Natural Capital of East Canal Section Water	
Year	**Natural Capital (in 2012 dollars)**
1937	$358,321/year
2002	$1,820,272/year
2007	$1,605,279/year

2. Middle Canal Section

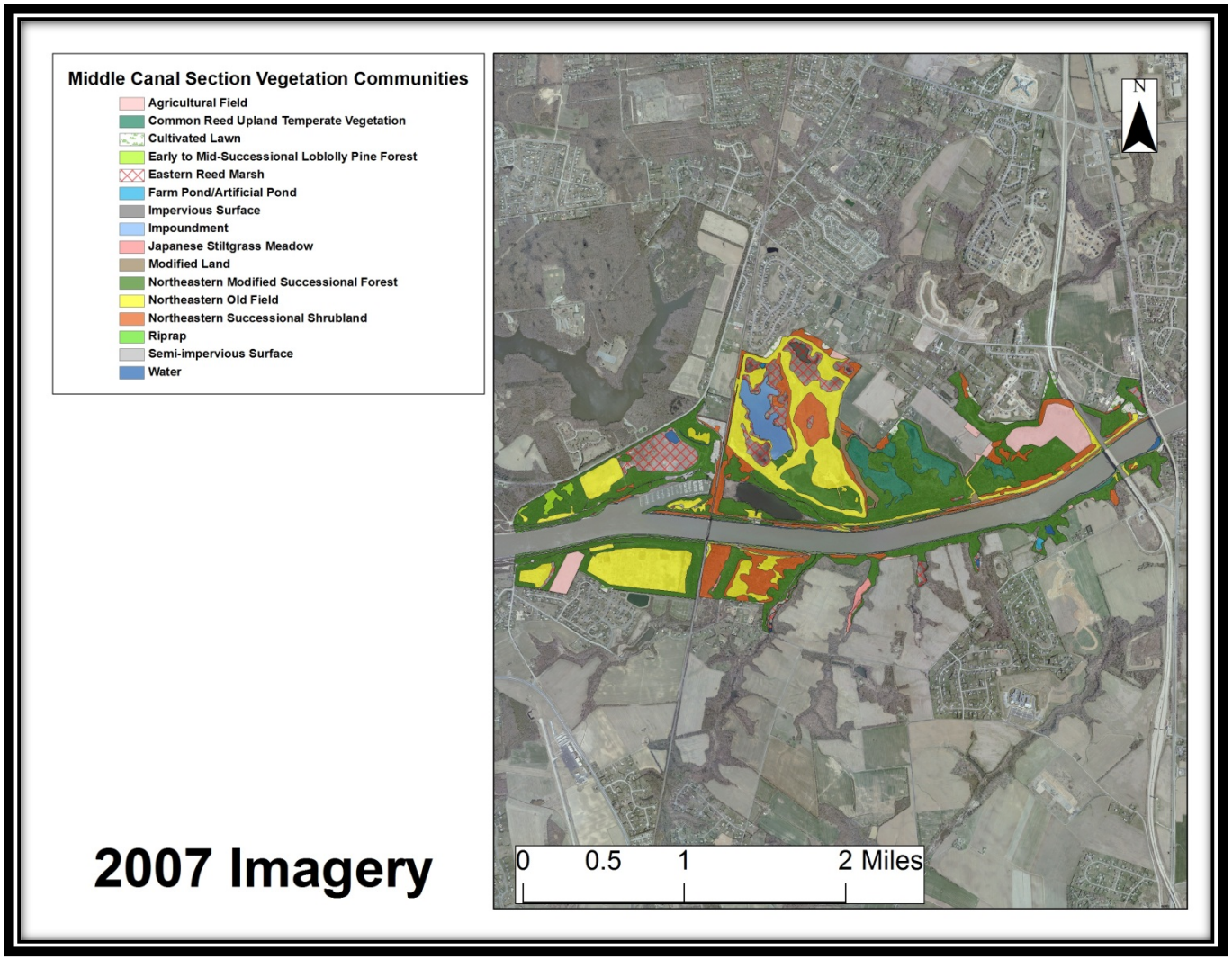


Figure 4-2.1. 2007 Vegetation Community Map of the Middle Canal Section

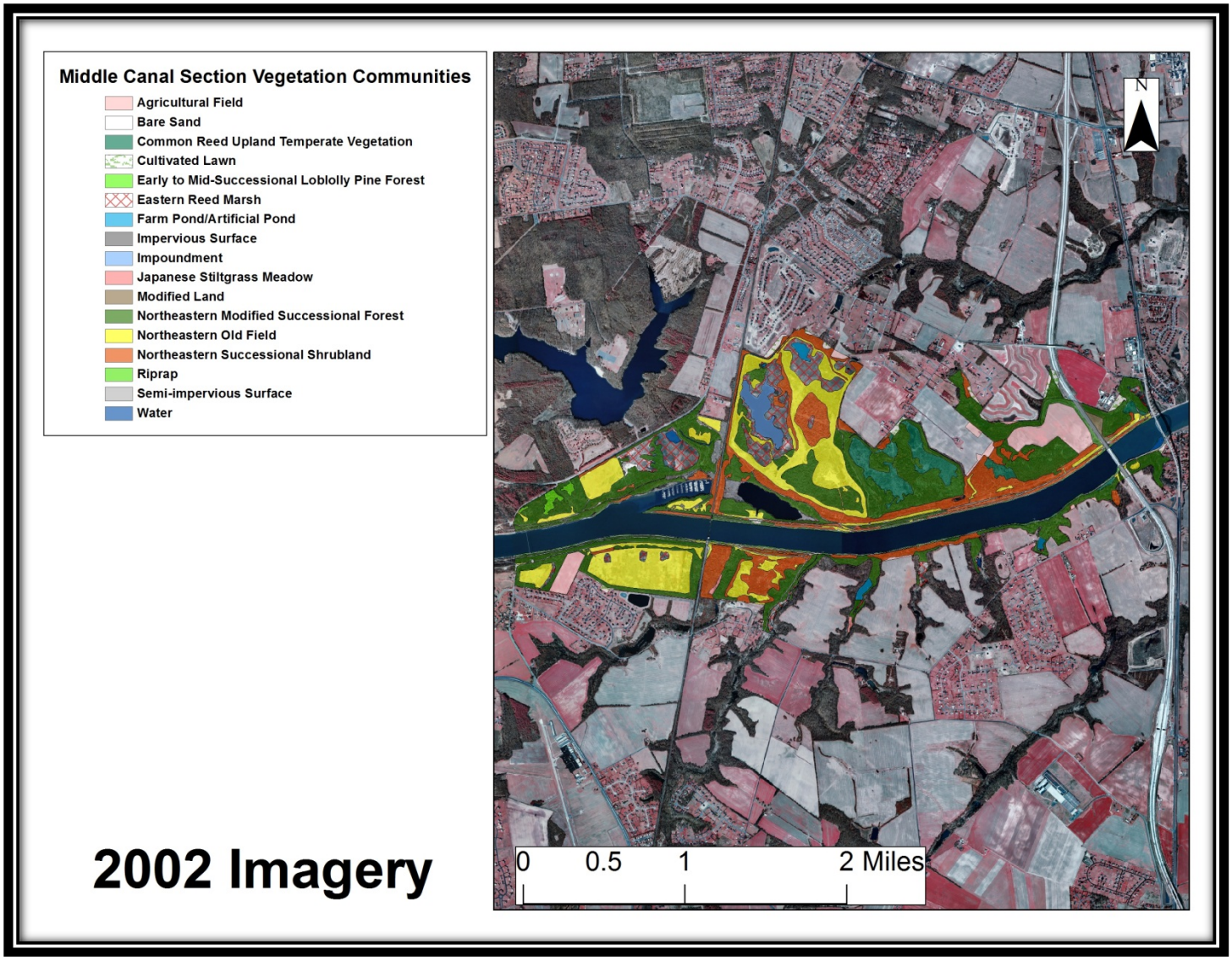


Figure 4-2.2. 2002 Vegetation Community Map of the Middle Canal Section

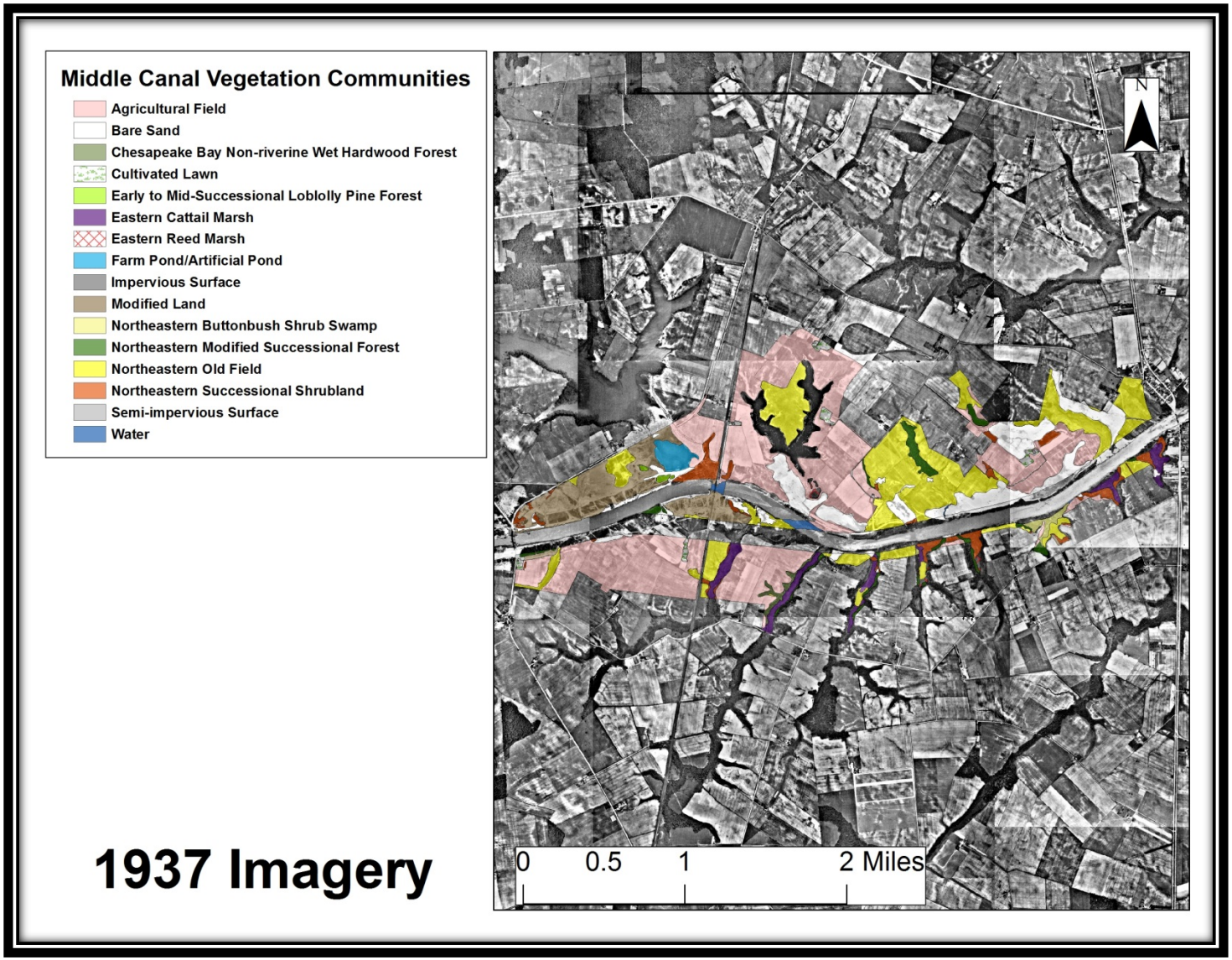


Figure 4-2.3. 1937 Vegetation Community Map of the Middle Canal Section

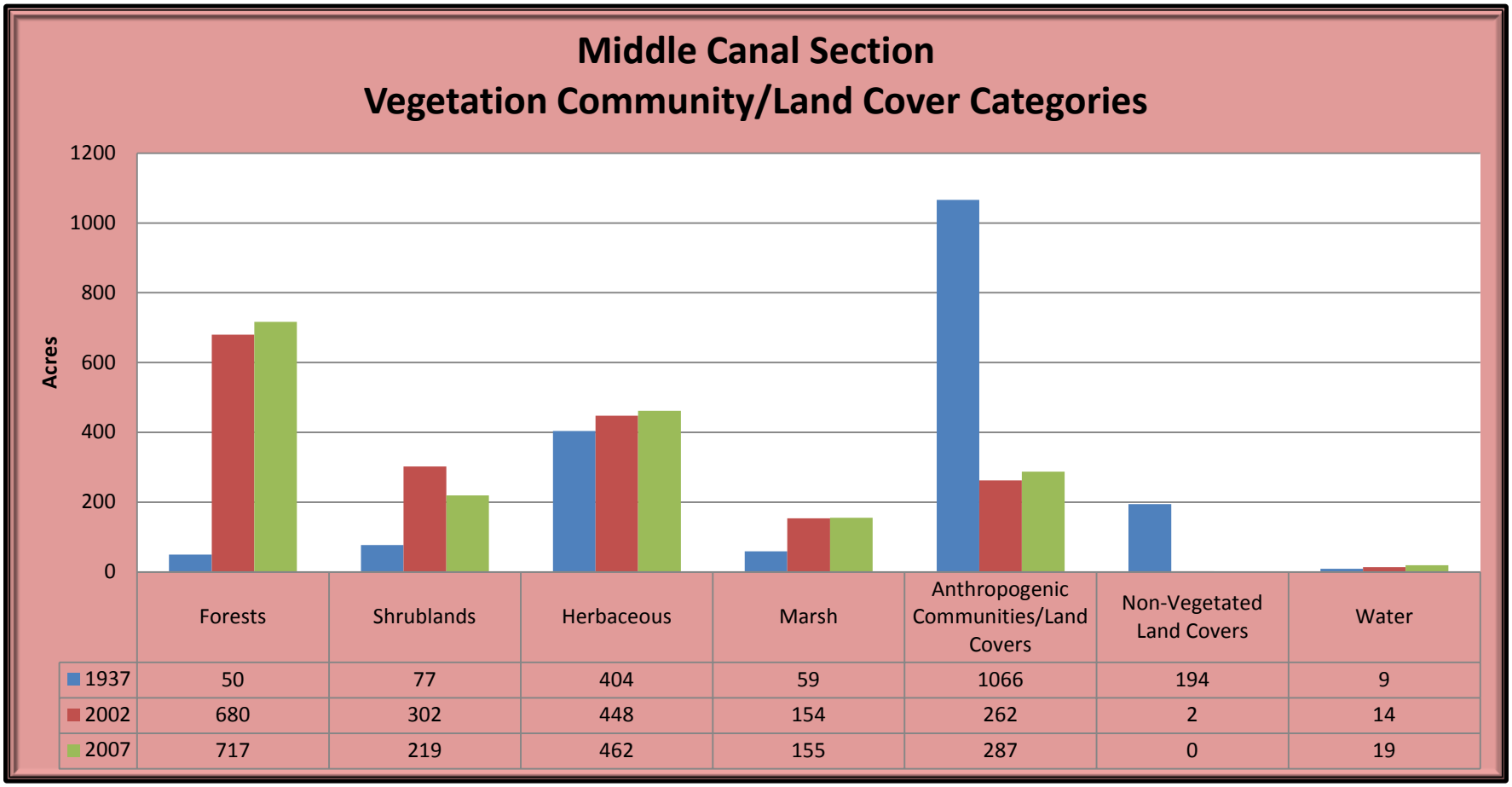


Figure 4-2.4. Middle Canal Section Vegetation Community/Land Cover Categories (1937, 2002, and 2007)

Middle Canal Section Vegetation Community/Land Covers (Figure 4-2.4): The middle canal is located between DE 1 on the east and DE 896 on the west. About half of the area is forested with the rest being open land or shrubland.

DNREC Sea Level Rise Analysis (Table 4-2.1)

About 1.2% of the Middle Section will be flooded with 0.5 m of sea level rise. An additional 1 m of rise will flood 3.6% of the section.

Table 4-2.1. Projected acres of the Middle Canal Section Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	23 acres
1 m	37 acres
1.5 m	67 acres

Natural Capital (Table 4-2.2)

The capital of the Middle Canal section has been increasing with the growth of forestland.

Table 4-2.2. Natural Capital of the Middle Canal Section	
Year	**Natural Capital (in 2012 dollars)**
1937	$1,460,133/year
2002	$2,097,037/year
2007	$2,201,544/year

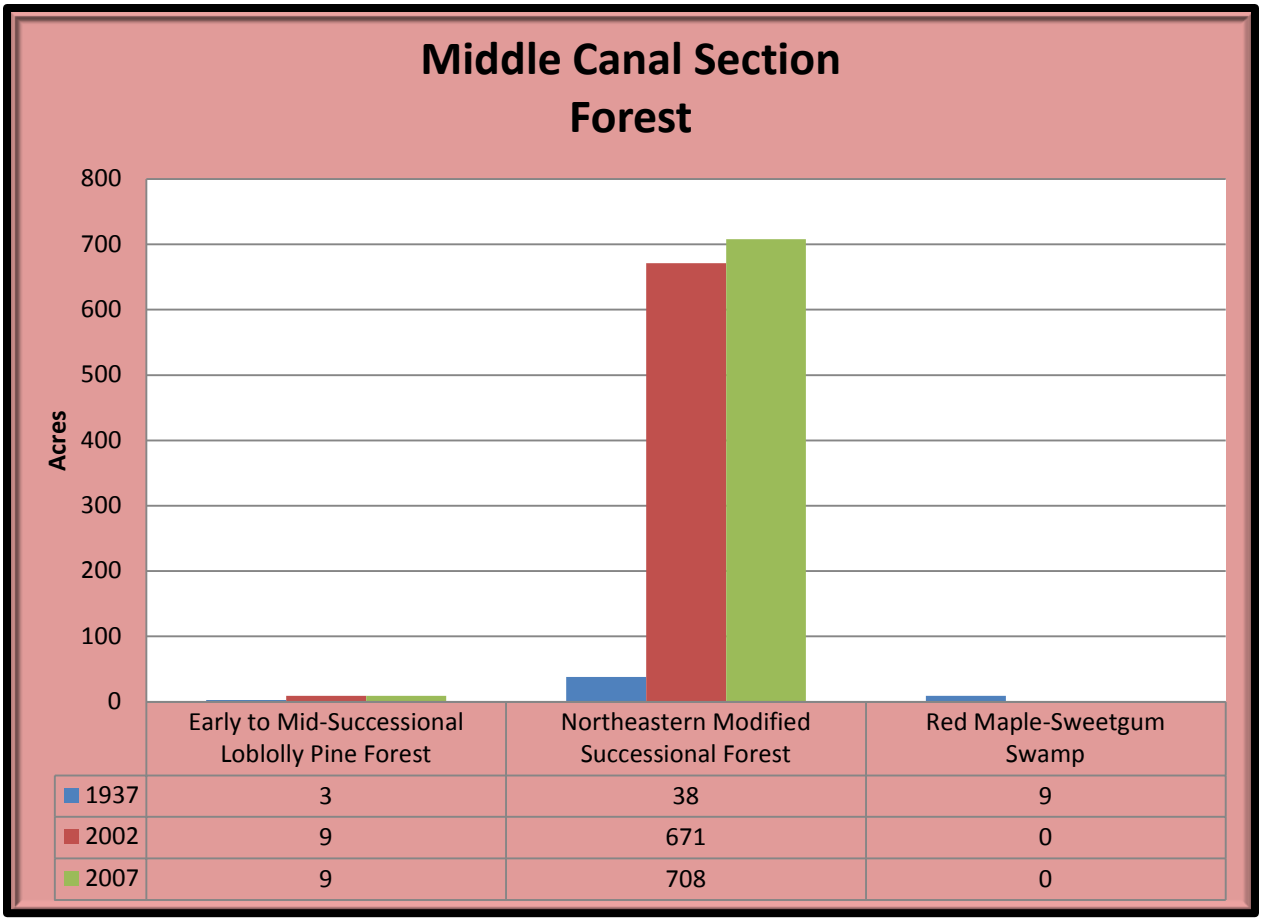


Figure 4-2.5. Middle Canal Section Forest (1937, 2002, and 2007)

Middle Canal Section Forest (Figure 4-2.5): Northeastern Modified Successional Forest is the most common forest type with a token amount of Early to Mid-Successional Loblolly Pine Forest. These forests have come about from the disturbance related to the canal.

DNREC Sea Level Rise Analysis (Table 4-2.3)

Only a very small amount (1.7%) of the forestland in the Middle Canal Section will be inundated with 1.5 m of sea level rise.

Table 4-2.3. Projected acres of Middle Canal Section Forest Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	2 acres
1 m	5 acres
1.5 m	12 acres

Natural Capital (Table 4-2.4)

Forest capital has been increasing as the forest area matures and spreads in the wildlife area.

Table 4-2.4. Natural Capital of Middle Canal Section Forest	
Year	**Natural Capital (in 2012 dollars)**
1937	$118,376/year
2002	$128,588/year
2007	$135,585/year

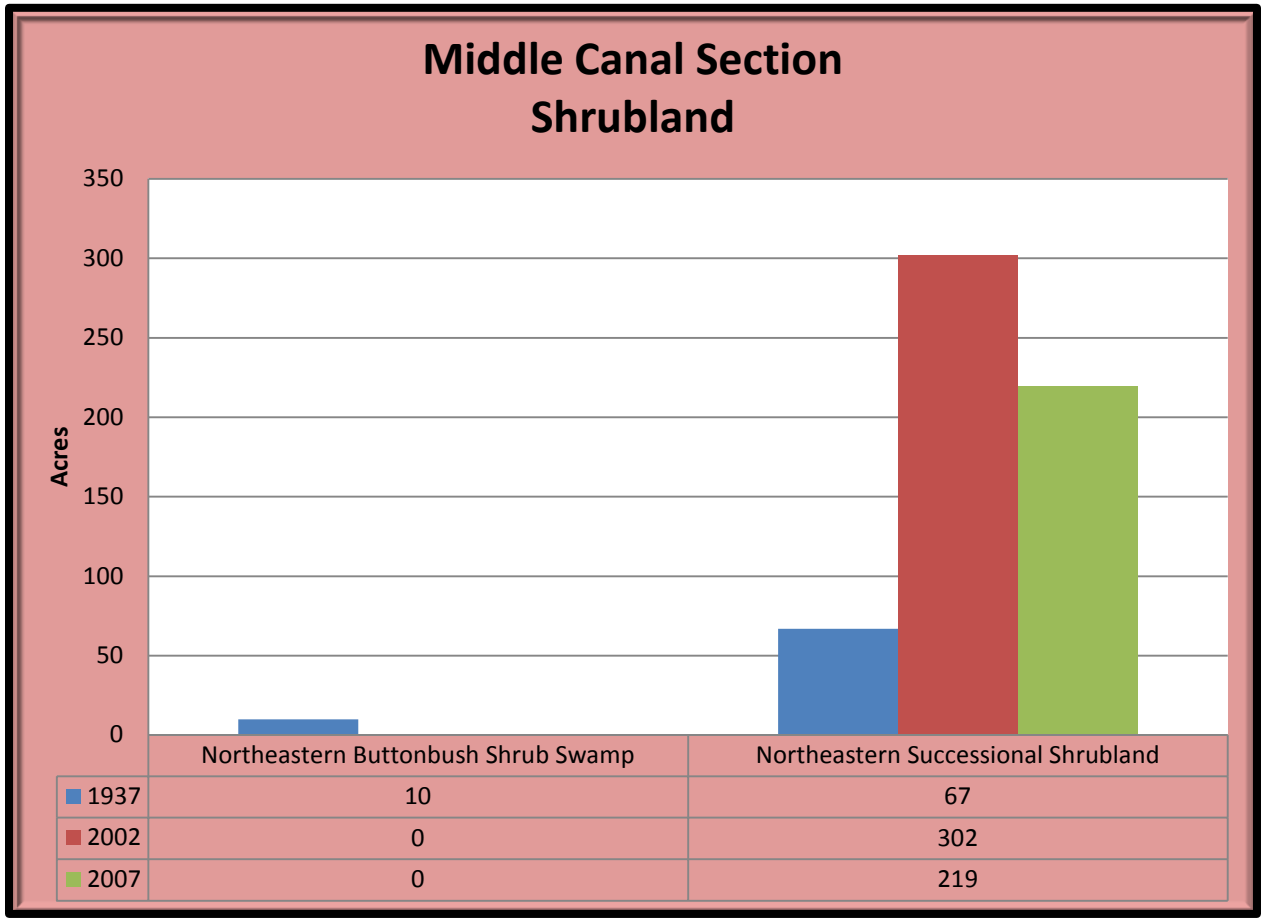


Figure 4-2.6. Middle Canal Section Shrubland (1937, 2002, and 2007)

Middle Canal Section Shrubland (Figure 4-2.6): Northeastern Successional Shrubland is the only shrubland in this section. It also arises from disturbed areas.

DNREC Sea Level Rise Analysis (Table 4-2.5)

Very little of the shrublands in the Middle Section will be affected by sea level rise, even at 1.5 m of rise.

Table 4-2.5. Projected acres of Middle Canal Section Shrubland Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	0.2 acres
1 m	1 acre
1.5 m	2 acres

Natural Capital (Table 4-2.6)

Shrubland capital has declined in the Middle Canal section as Northeastern Buttonbush Shrub Swamp has disappeared and Northeastern Successional Shrubland has matured to forest.

Table 4-2.6. Natural Capital of Middle Canal Section Shrubland	
Year	**Natural Capital (in 2012 dollars)**
1937	$102,572/year
2002	$44,001/year
2007	$31,908/year

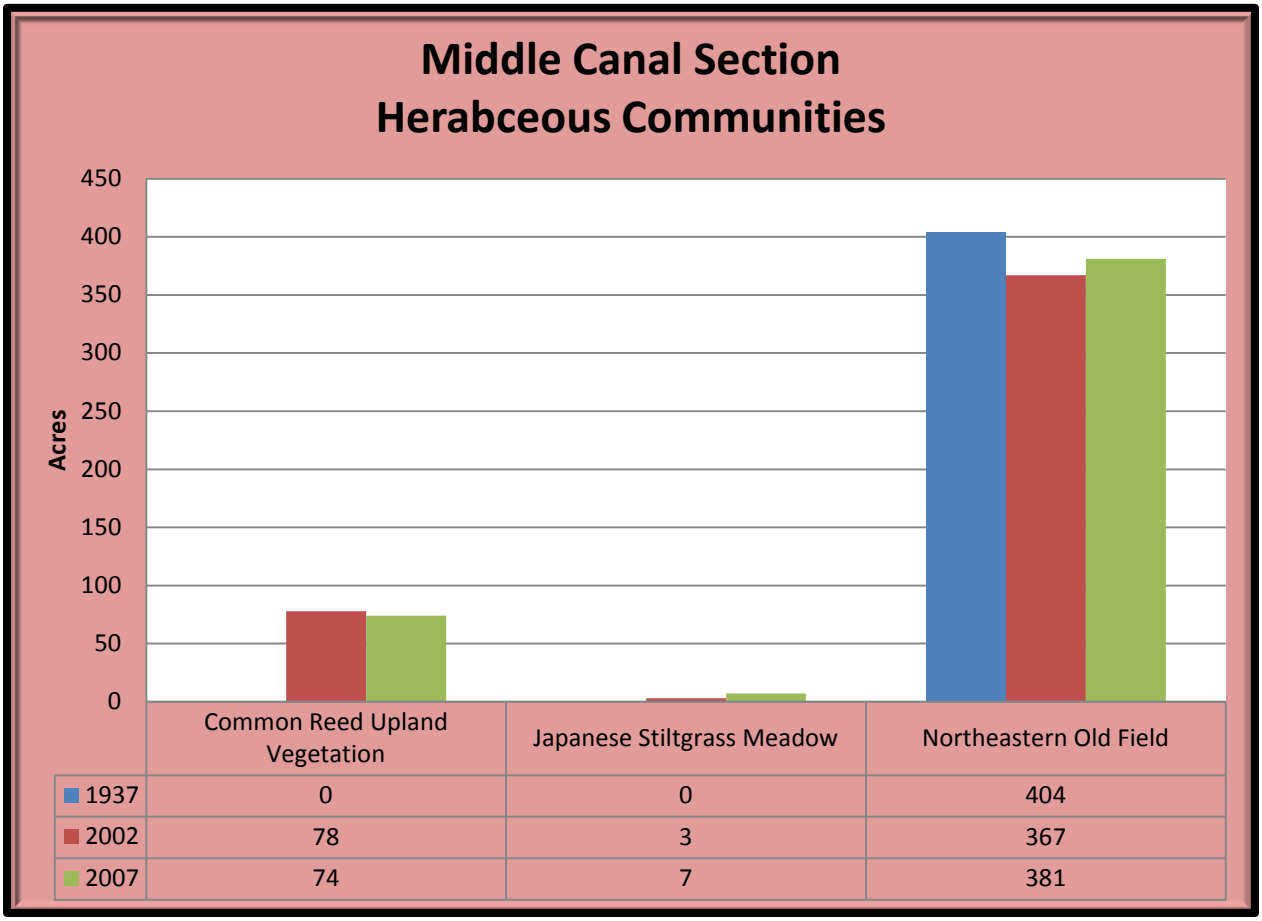


Figure 4-2.7. Middle Canal Section Herbaceous Communities (1937, 2002, and 2007)

Middle Canal Section Herbaceous Communities (Figure 4-2.7): Northeastern Old Field, located on old spoil areas, is the most common herbaceous community.

DNREC Sea Level Rise Analysis (Table 4-2.7)

Like the Shrubland areas, very little of the herbaceous communities will be affected by sea level rise.

Table 4-2.7. Projected acres of Middle Canal Section Herbaceous Communities Inundated by Sea Level Rise

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

Natural Capital (Table 4-2.8)

The amount of herbaceous communities has been increasing leading the capital to increase over time.

Table 4-2.8. Natural Capital of Middle Canal Section Herbaceous Communities	
Year	**Natural Capital (in 2012 dollars)**
1937	$58,863/year
2002	$65,274/year
2007	$67,313/year

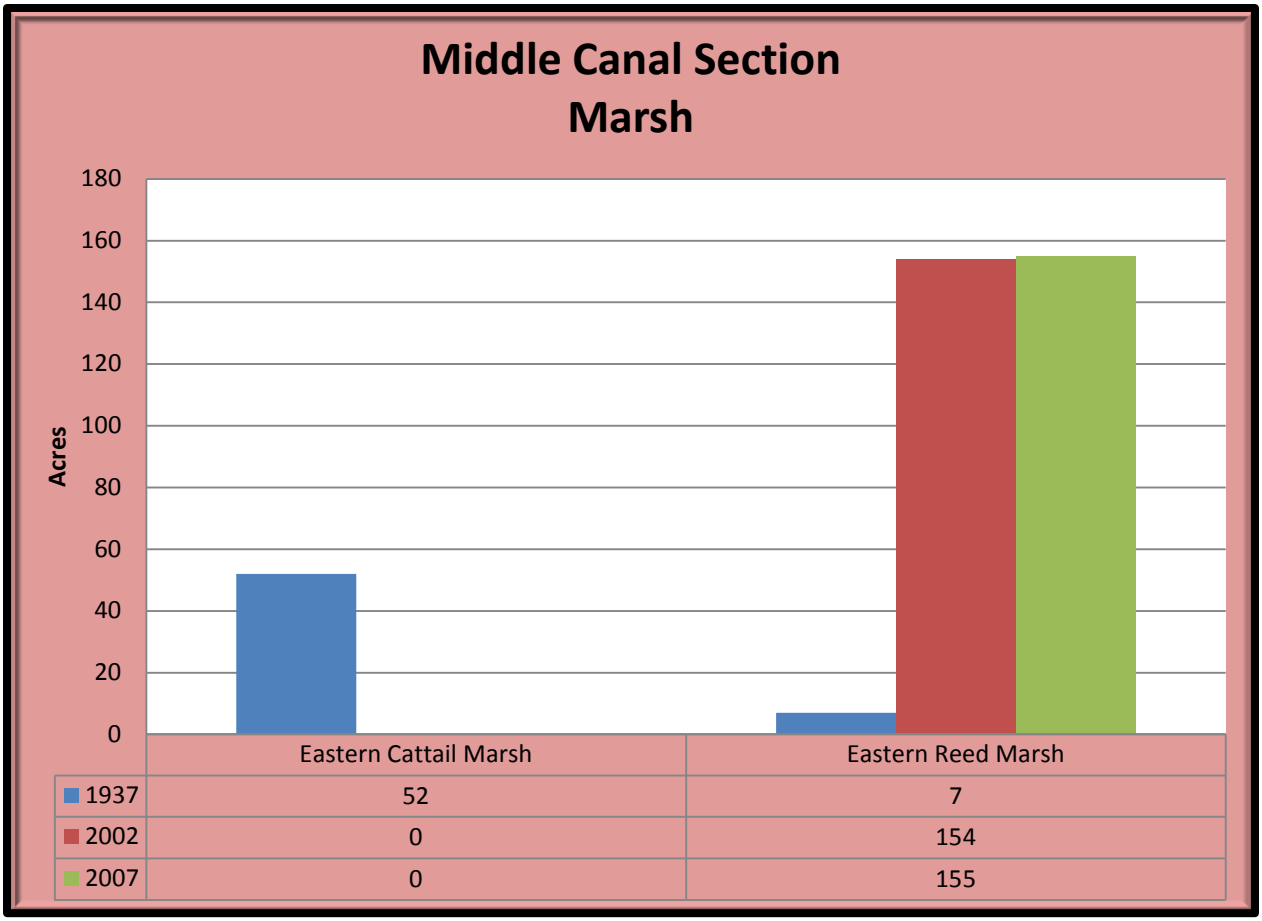


Figure 4-2.8. Middle Canal Section Marsh (1937, 2002, and 2007)

Middle Canal Section Marsh (Figure 4-2.8): Eastern Reed Marsh that is located in wet places in the spoil areas is the most common marsh in this section. Eastern Cattail Marsh used to be in this area, but has been taken over by the Eastern Reed Marsh.

DNREC Sea Level Rise Analysis (Table 4-2.9)

All of the marshland in the Middle Canal section is non-tidal and is mostly located away from tidal areas. Because of this, marsh areas will be little affected by sea level rise in this section.

Table 4-2.9. Projected acres of Middle Canal Section Marsh Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	0.3 acres
1 m	0.3 acres
1.5 m	2 acres

Natural Capital (Table 4-2.10)

Marsh capital been increasing, being driven by gains in Eastern Reed Marsh, which replacing native wetlands.

Table 4-2.10. Natural Capital of Middle Canal Section Marsh	
Year	**Natural Capital (in 2012 dollars)**
1937	$547,603/year
2002	$1,429,336/year
2007	$1,438,617/year

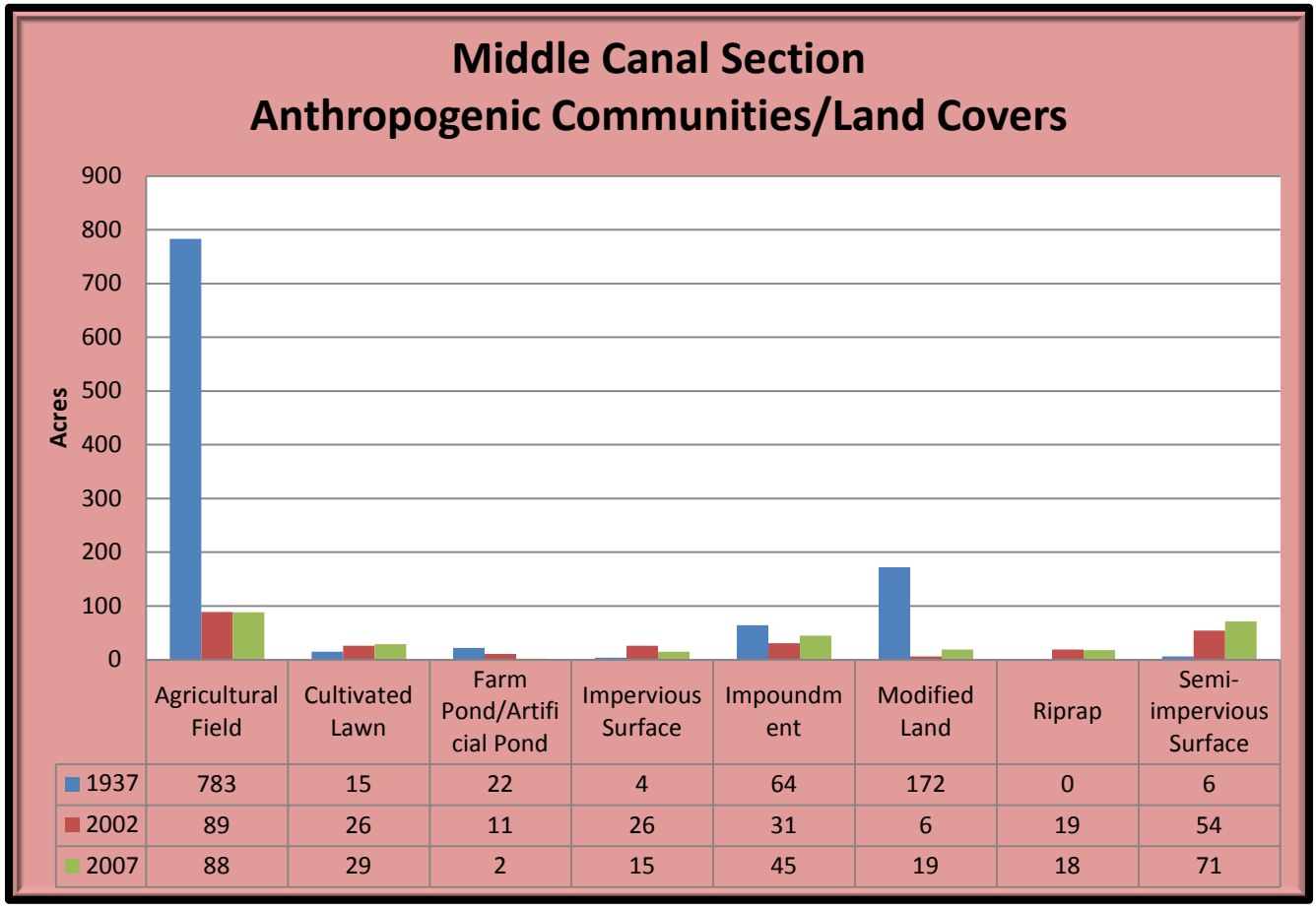


Figure 4-2.9. Middle Canal Section Anthropogenic Communities/Land Covers (1937, 2002, and 2007)

Middle Canal Section Anthropogenic Communities/Land Covers (Figure 4-2.9): Agricultural Fields are the most common anthropogenic communities, followed by Semi-impervious Surface.

DNREC Sea Level Rise Analysis (Table 4-2.11)

Anthropogenic Communities/Land Covers will be affected more than some of the other categories due to the inundation of riprap that lines the banks of the canal. The adjacent canal road will also be inundated mostly at 1.5 m of sea level rise.

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

Rise	Acres
0.5 m	9 acres
1 m	19 acres
1.5 m	38 acres

Natural Capital (Table 4-2.12)

Agricultural fields and impoundments and ponds are the only land covers with natural capital value. Their value has decreased due to abandonment of agricultural fields that once lined the canal. There has been a recent uptick due to an increase in impoundment area.

Table 4-2.12. Natural Capital of Middle Canal Section Anthropogenic Communities/Land Covers

Year	Natural Capital (in 2012 dollars)
1937	$503,724/year
2002	$229,178/year
2007	$255,797/year

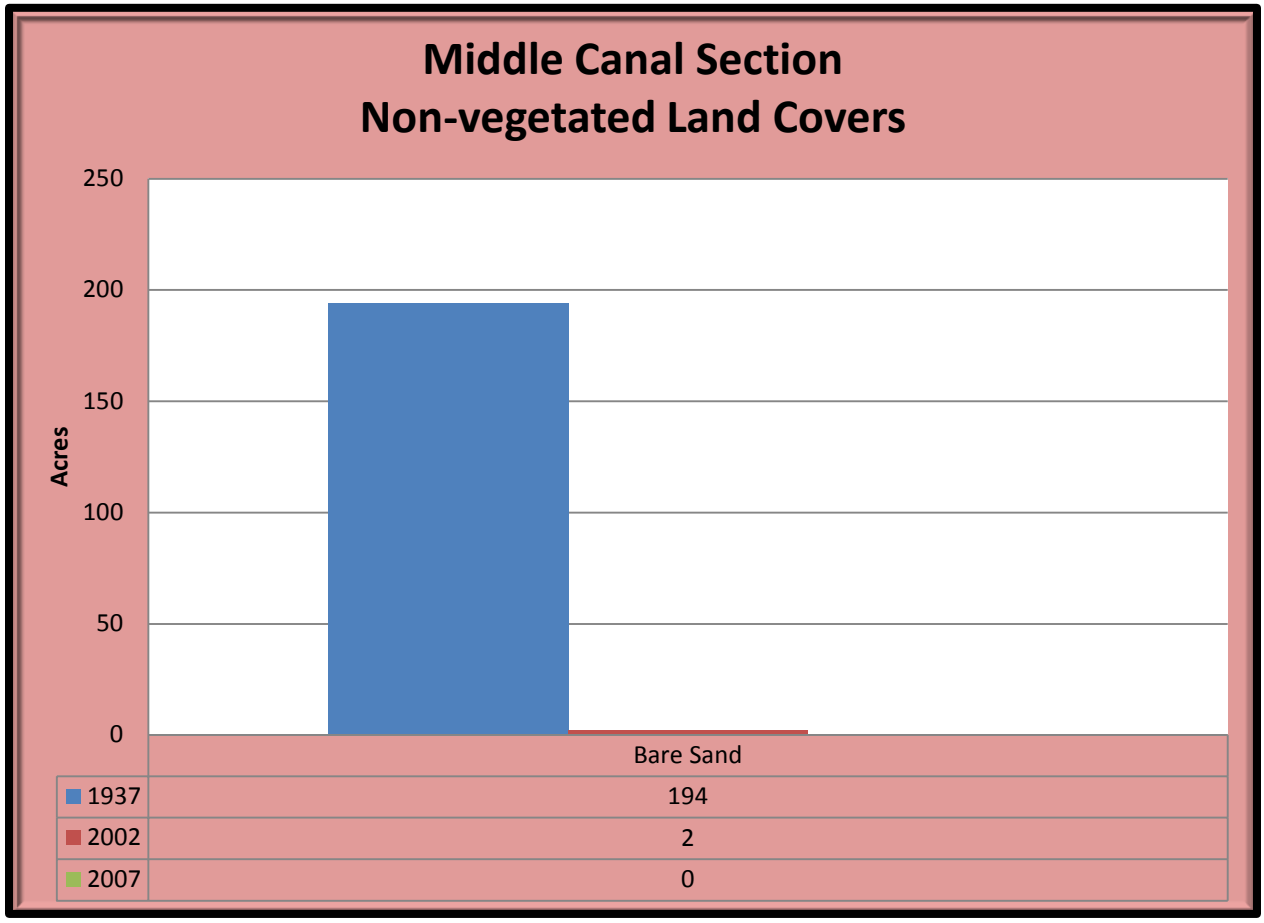


Figure 4-2.10. Middle Canal Section Non-vegetated Land Covers (1937, 2002, and 2007)

Middle Canal Section Non-vegetated Land Covers (Figure 4-2.10): No non-vegetated land covers are currently present in the middle canal area, but there used to be a lot of Bare Sand in the spoil areas.

Natural Capital

Sand does not have any natural capital value.

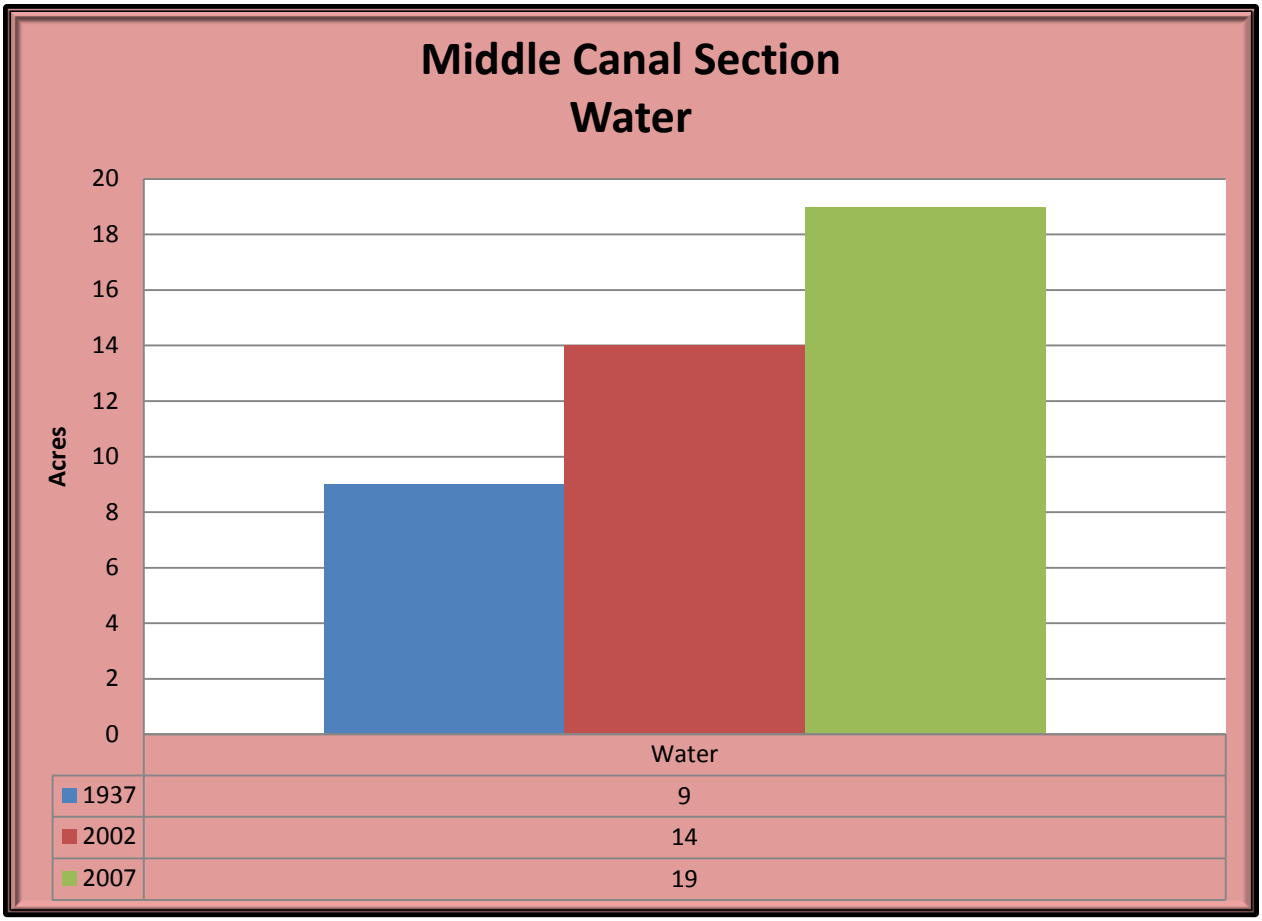


Figure 4-2.11. Middle Canal Section Water Coverage (1937, 2002, and 2007)

Middle Canal Section Water Coverage (Figure 4-2.11): The amount of water in this section is deceiving since this the canal was moved in the 1960's. The canal used to make a curve northward in the 1930's but was straightened in the 1960's.

Natural Capital (Table 4-2.13)

Water coverage has been increasing in the Middle Canal section over time leading to an increase in the capital of water.

Table 4-2.13. Natural Capital of Middle Canal Section Water	
Year	**Natural Capital (in 2012 dollars)**
1937	$128,996/year
2002	$200,660/year
2007	$272,324/year

3. West Canal Section

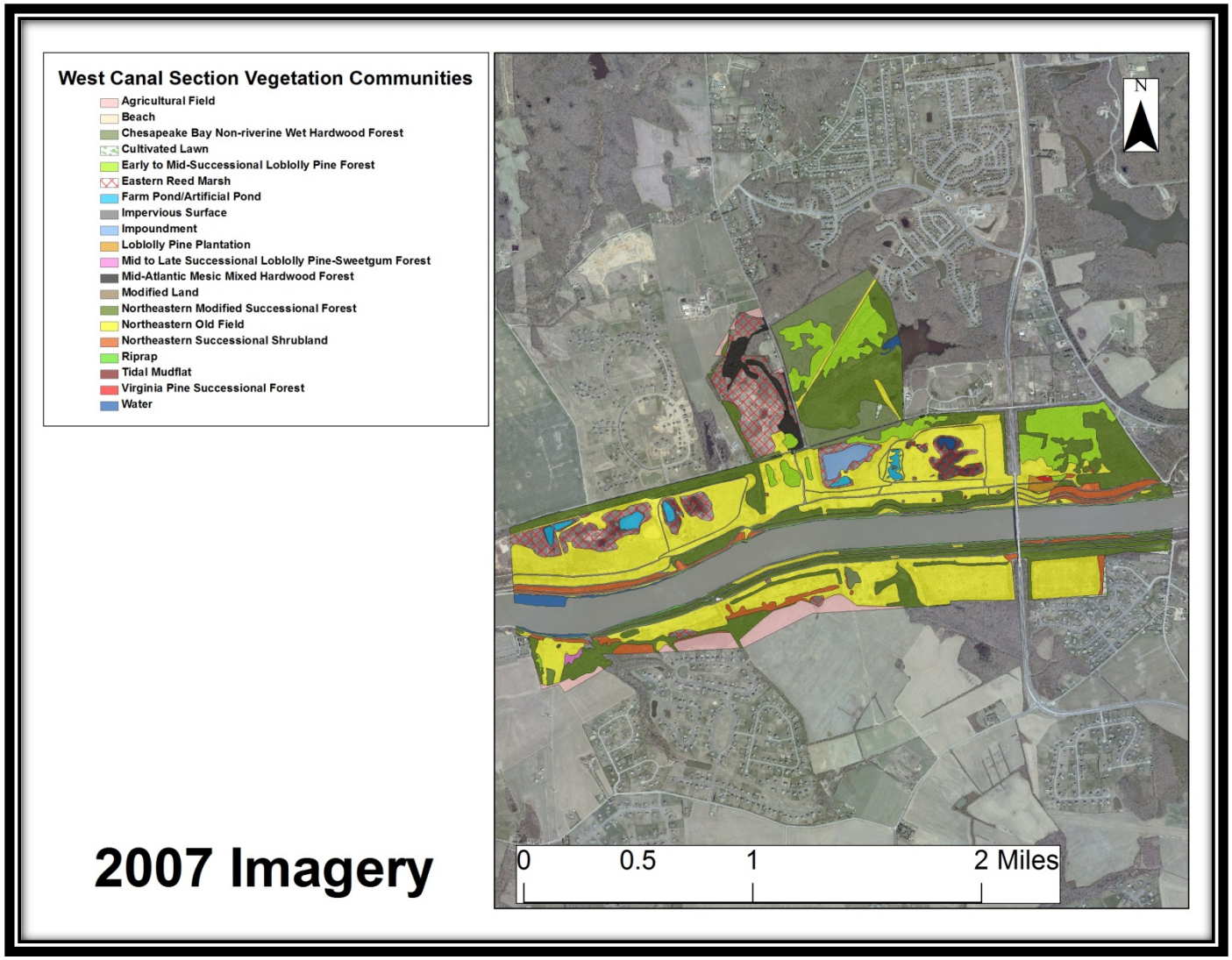


Figure 4-3.1. 2007 Vegetation Community Map of the West Canal Section

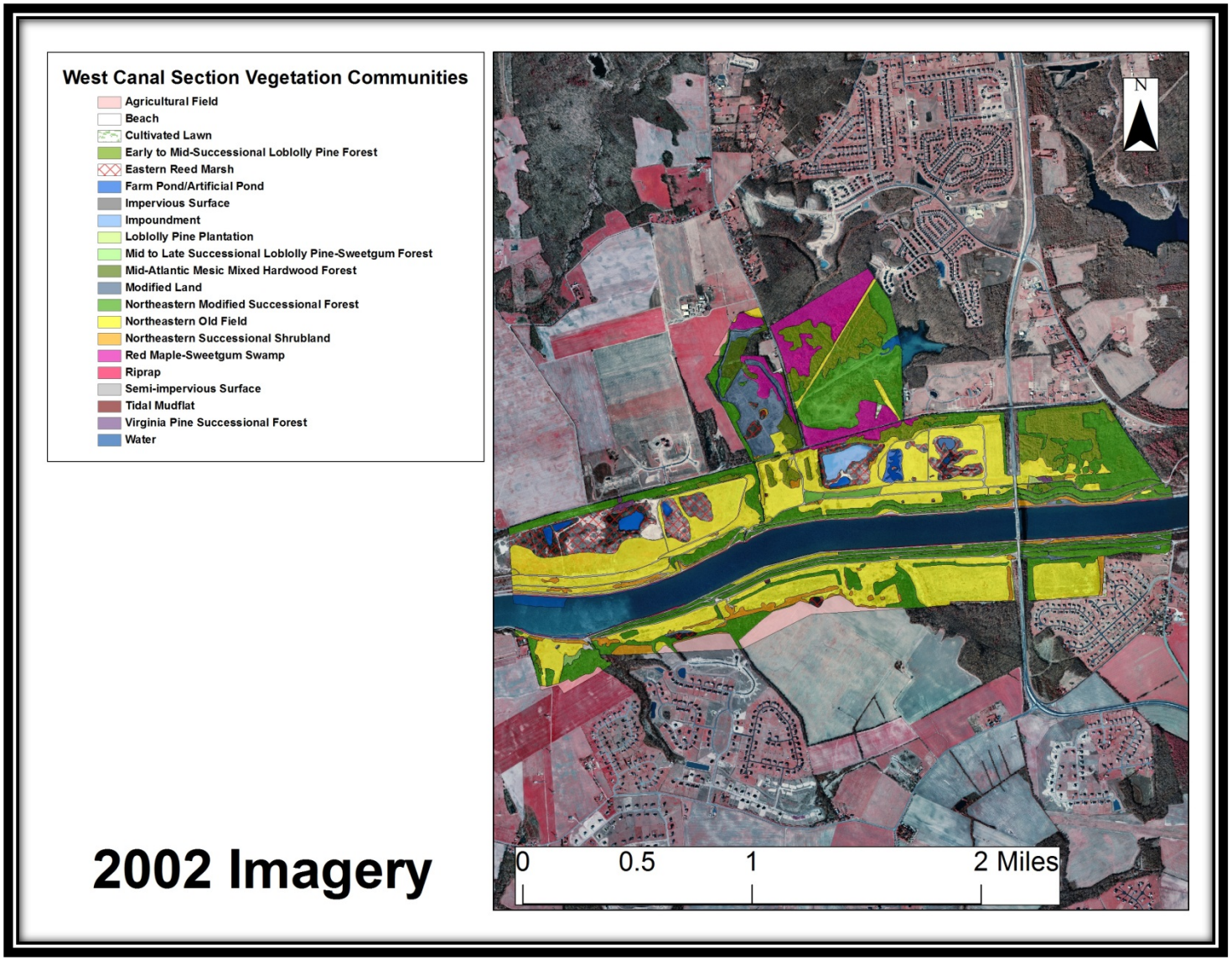


Figure 4-3.2. 2002 Vegetation Community Map of the West Canal Section

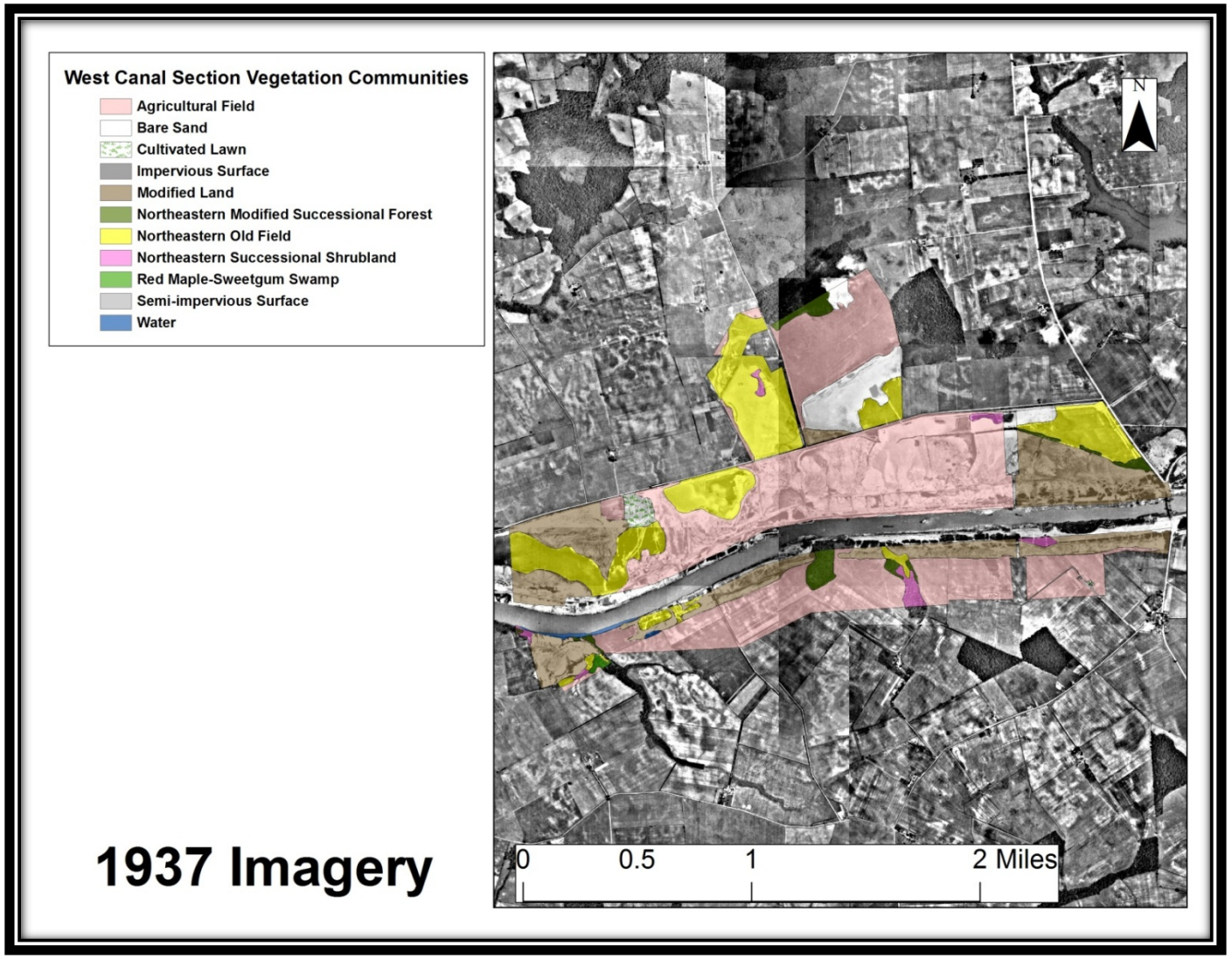


Figure 4-3.3. 1937 Vegetation Community Map of the West Canal Section

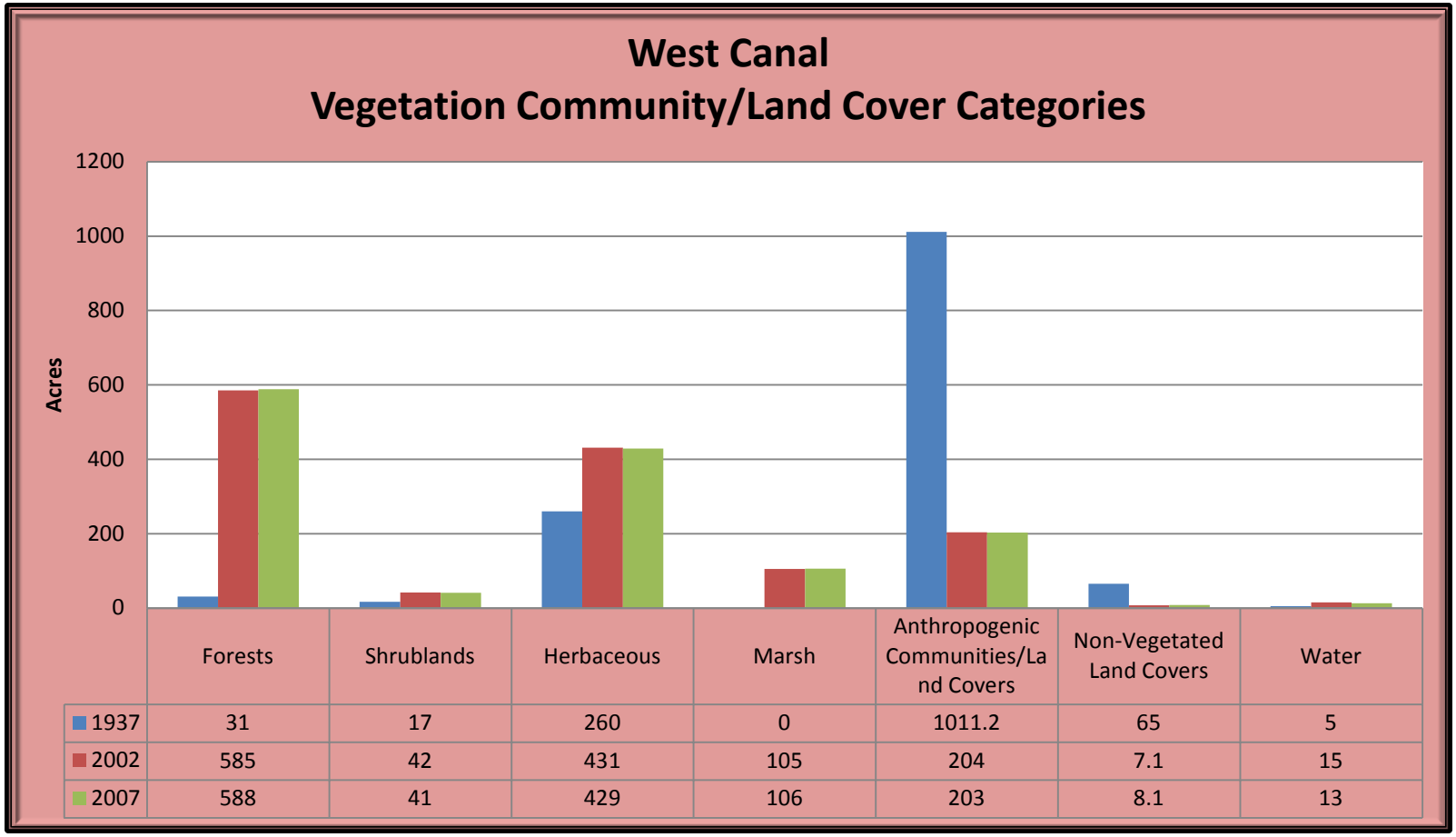


Figure 4-3.4. West Canal Section Vegetation Community/Land Cover Categories (1937, 2002, and 2007)

West Canal Section Vegetation Community/Land Covers (Figure 4-3.4): Forests and Herbaceous communities are the most vegetation communities in the western section of the canal.

DNREC Sea Level Rise Analysis (Table 4-3.1)

The West Canal section is located at the highest point of the wildlife area in the middle of the peninsula at the divide between the Delaware River and the Chesapeake Bay. This makes this section less vulnerable to sea level rise. At 1.5 m of sea level rise about 3.2% of the section will be flooded.

Table 4-3.1. Projected acres of the West Canal Section Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	18 acres
1 m	26 acres
1.5 m	45 acres

Natural Capital (Table 4-3.2)

Natural capital for the West Section has increased markedly since 1937 with a large increase in forestland and herbaceous communities. Recently, however, the capital has decreased with a loss in shrublands and herbaceous communities.

Table 4-3.2. Natural Capital of the West Canal Section	
Year	**Natural Capital (in 2012 dollars)**
1937	$182,579/year
2002	$2,537,415/year
2007	$2,518,161/year

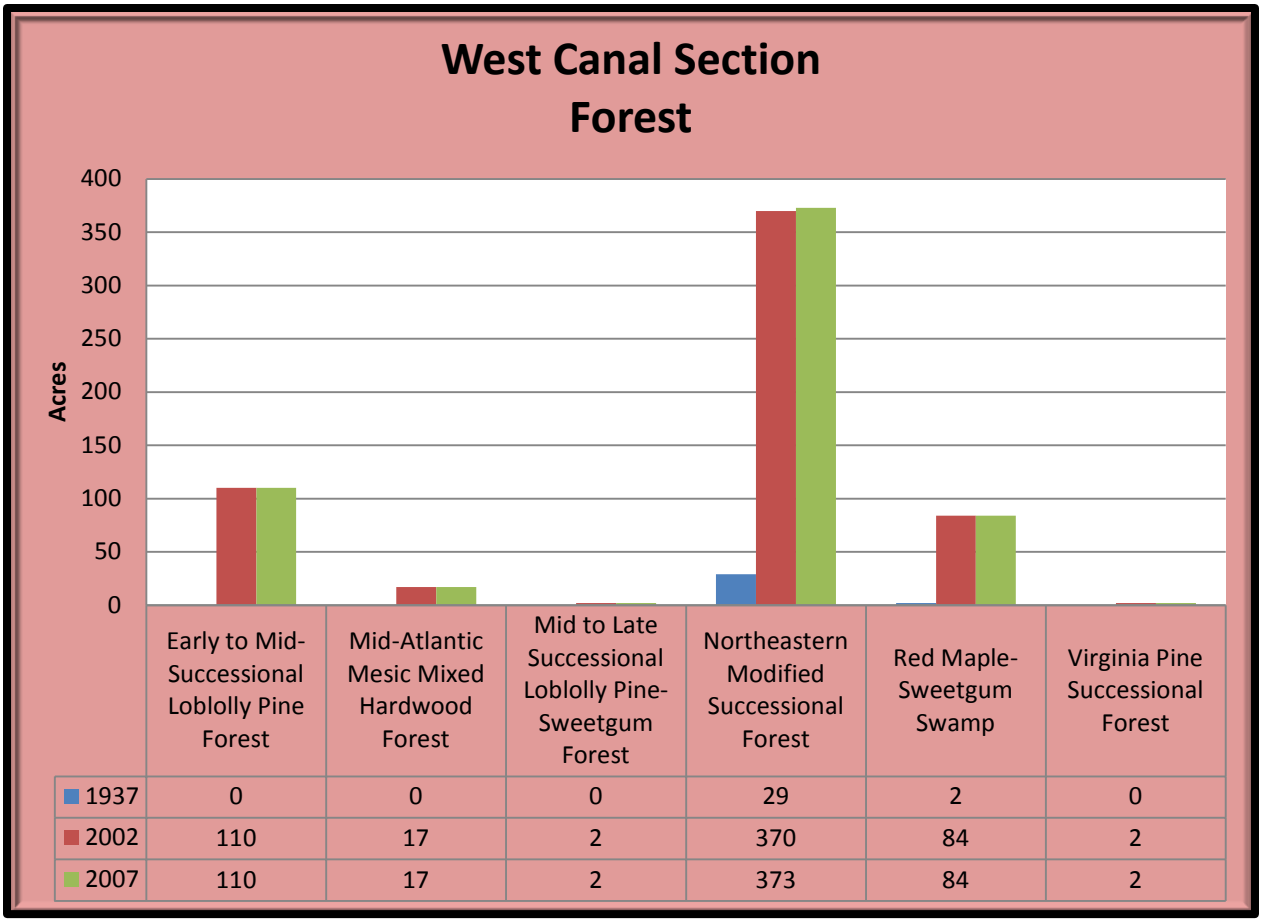


Figure 4-3.5. West Canal Section Forest (1937, 2002, and 2007)

West Canal Section Forest (Figure 4-3.5): Northeastern Modified Successional Forest, like the other sections, is the most common forest community. The western section does have the largest amount of Early to Mid-Successional Loblolly Pine Forest and Red Maple-Sweetgum Swamp-Flatwoods Type.

DNREC Sea Level Rise Analysis (Table 4-3.3)

At 1.5 m of sea level rise only two acres of forest will be affected and Northeastern Modified Successional Forest is the only forest inundated.

Table 4-3.3. Projected acres of West Canal Section Forest Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	0.03 acres
1 m	0.2 acres
1.5 m	2 acres

Natural Capital (Table 4-3.4)

Capital of forest has greatly increased since 1937. In 1937 very little of the West Canal area was forested and most of it was open land or in agricultural field. Most of it has since grown into forest, albeit a forest with a lot of exotic invasive plant species.

Table 4-3.4. Natural Capital of West Canal Section Forest	
Year	**Natural Capital (in 2012 dollars)**
1937	$30,067/year
2002	$1,127,225/year
2007	$1,127,792/year

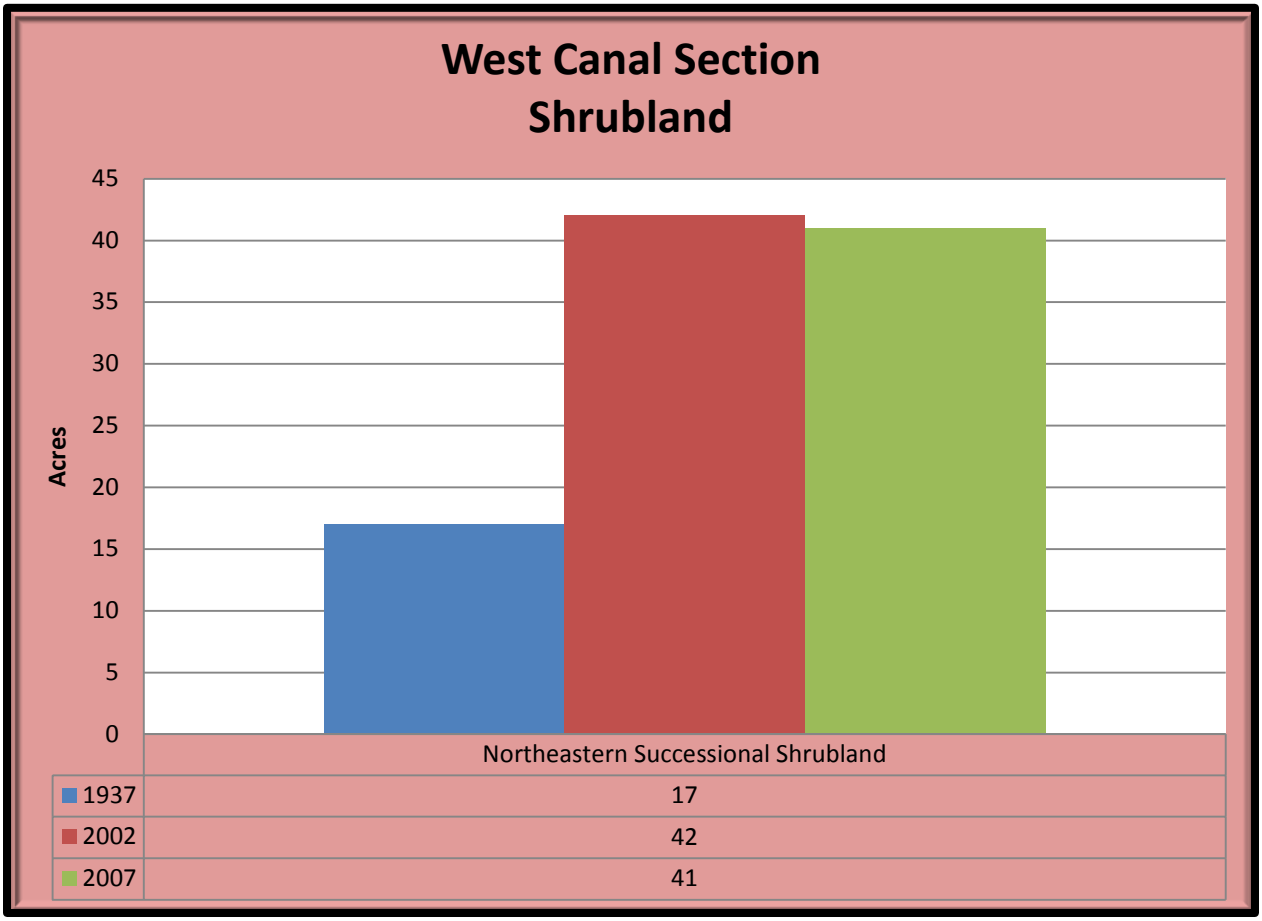


Figure 4-3.7. West Canal Section Shrubland (1937, 2002, and 2007)

West Canal Section Shrubland (Figure 4-3.7): Northeastern Successional Shrubland is the only shrubland located in this section.

DNREC Sea Level Rise Analysis (Table 4-3.5)

Like the forests, most of the shrublands are located in higher areas and will not be much affected by sea level rise.

Table 4-3.5. Projected acres of West Canal Section Shrubland Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	0.1 acres
1 m	0.3 acres
1.5 m	1 acre

Natural Capital (Table 4-3.6)

Shrubland capital has increased overall since 1937 with a slight dip in the recent period (2002-2007) due to shrubland maturing into forest.

Table 4-3.6. Natural Capital of West Canal Section Shrubland	
Year	**Natural Capital (in 2012 dollars)**
1937	$2,477/year
2002	$6,119/year
2007	$5,974/year

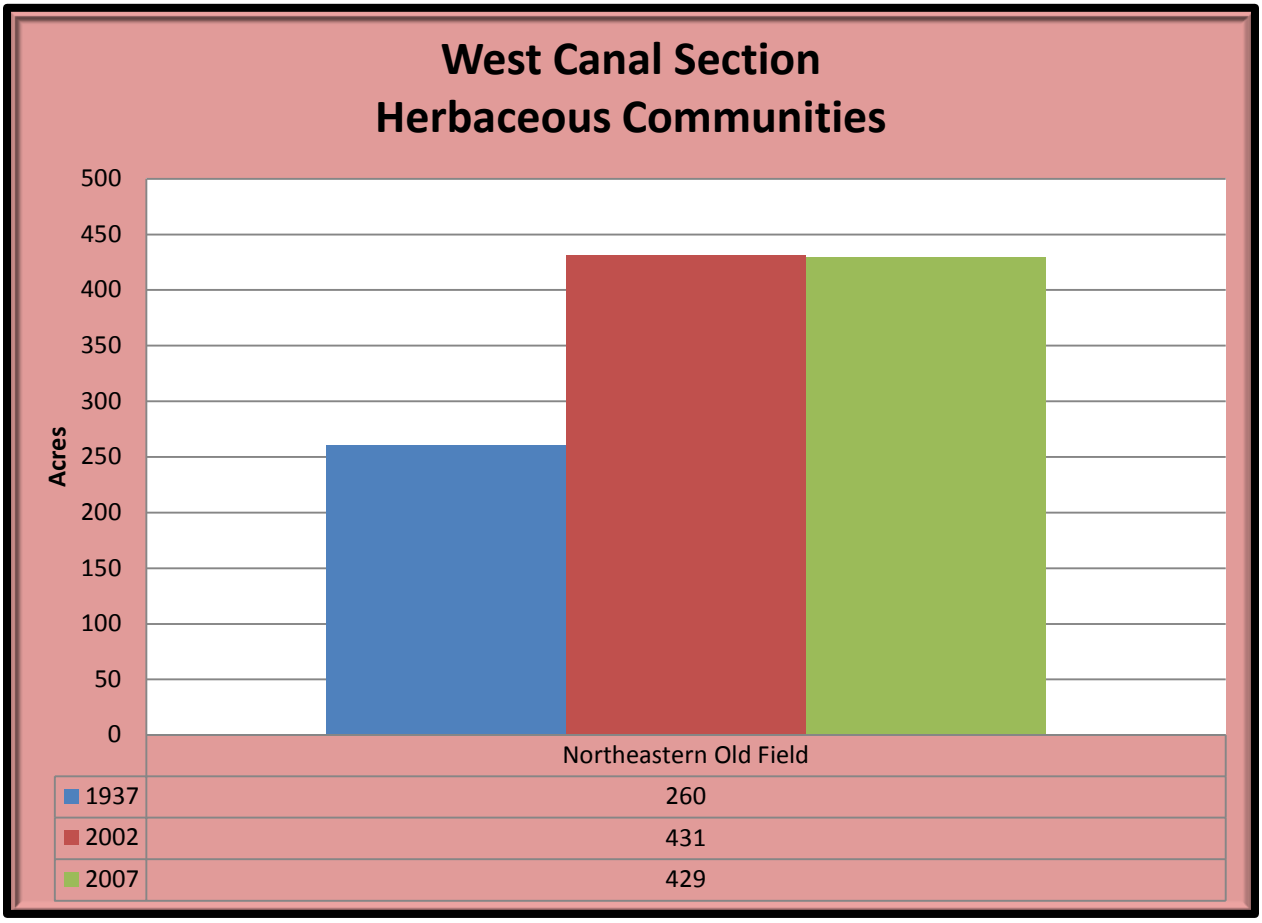


Figure 4-3.8. West Canal Section Herbaceous Communities (1937, 2002, and 2007)

West Canal Section Herbaceous Communities (Figure 4-3.8): Northeastern Old Field is prominent in the western section and is found atop a lot of the spoil areas.

DNREC Sea Level Rise Analysis (Table 4-3.7)

Herbaceous communities will be barely nicked relative to the amount of acreage at 1.5 m of sea level rise. Most of the large fields are located on the higher shelf away from the canal zone and are not affected by sea level rise water.

Table 4-3.7. Projected acres of West Canal Section Herbaceous Communities Inundated by Sea Level Rise

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

Natural Capital (Table 4-3.8)

Herbaceous community capital has increased overall since 1937, with a slight dip in the recent period as some of the fields have matured to other more mature communities.

Table 4-3.8. Natural Capital of West Canal Section Herbaceous Communities	
Year	**Natural Capital (in 2012 dollars)**
1937	$37,882/year
2002	$62,797/year
2007	$62,505/year

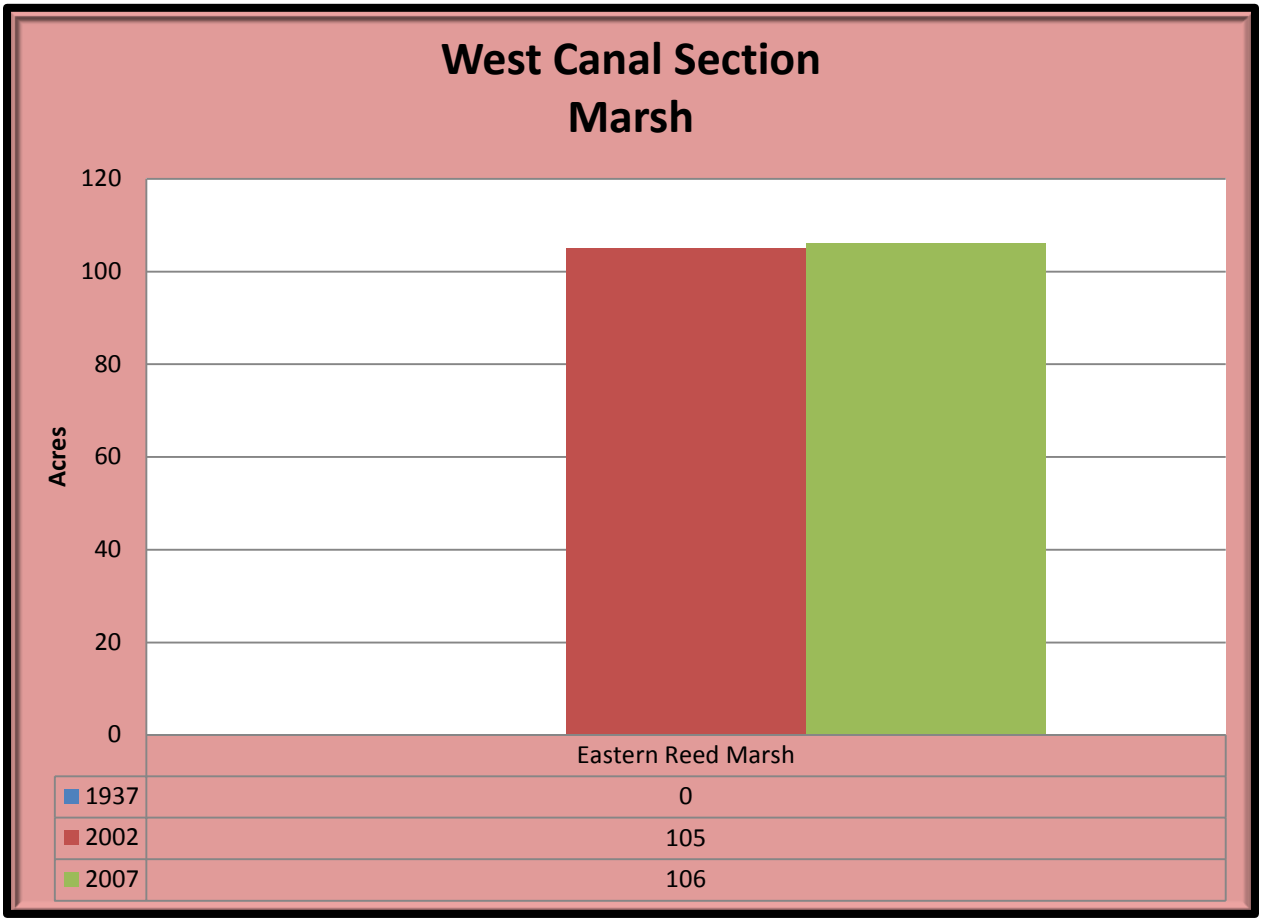


Figure 4-3.9. West Canal Section Marsh (1937, 2002, and 2007)

West Canal Section Marsh (Figure 4-3.9): Eastern Reed Marsh is the only marsh in this area and is associated with the spoil areas.

DNREC Sea Level Rise Analysis (Table 4-3.9)

None of the current marshland will be impacted by sea level rise in the West Canal section under any of the scenarios.

Table 4-3.9. Projected acres of West Canal Section Marsh Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	0 acres
1 m	0 acres
1.5 m	0 acres

Natural Capital (Table 4-3.10)

Marsh was not present in the West Canal section in 1937 and came into some of impoundments before 2002. In the recent period they have increased in acreage leading to an increase in capital.

Table 4-3.10. Natural Capital of West Canal Section Marsh	
Year	**Natural Capital (in 2012 dollars)**
1937	$0/year (not present)
2002	$974,547/year
2007	$983,828/year

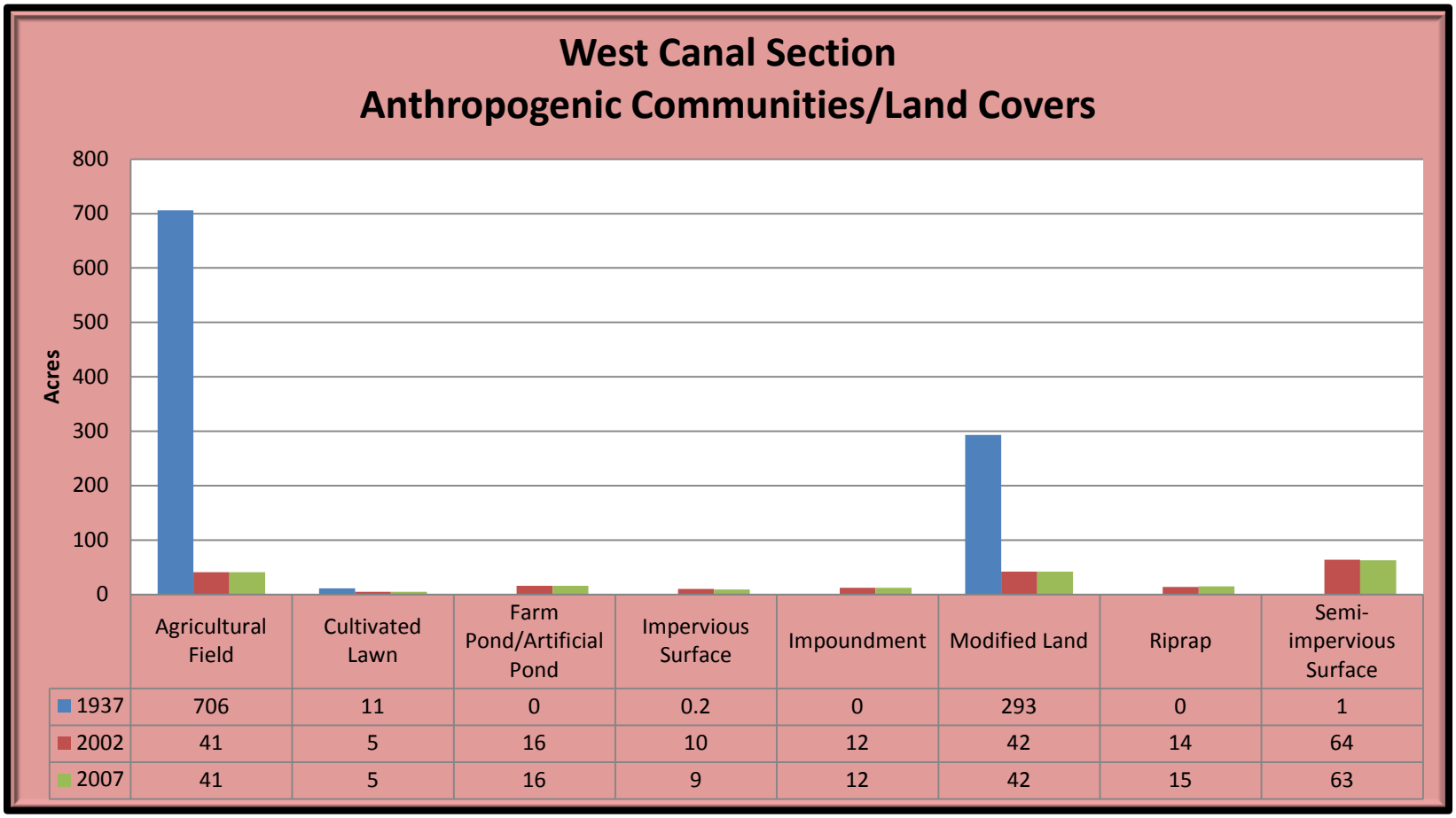


Figure 4-3.10. West Canal Section Anthropogenic Communities/Land Covers (1937, 2002, and 2007)

West Canal Section Anthropogenic Communities/Land Covers (Figure 4-3.10): Semi-impervious Surface from the many roads bisecting the canal area is the most prominent anthropogenic land cover. Modified Land and Agricultural Fields are also prominent in this area.

DNREC Sea Level Rise Analysis (Table 4-3.11)

Riprap is the main anthropogenic community/land cover affected by sea level rise. At 1.5 m of rise 31 acres of all of the anthropogenic communities will be flooded.

Table 4-3.11. Projected acres of West Canal Section Herbaceous Communities Inundated by Sea Level Rise	
Rise	**Acres**
0.5 m	9 acres
1 m	16 acres
1.5 m	31 acres

Natural Capital (Table 4-3.12)

Agricultural field and impoundments and ponds are the only land covers with natural value. The overall capital has increased in spite of agricultural field being abandoned, due to the increase in impounded area.

Table 4-3.12. Natural Capital of West Canal Section Anthropogenic Communities/Land Covers	
Year	**Natural Capital (in 2012 dollars)**
1937	$40,489/year
2002	$151,734/year
2007	$151,734/year

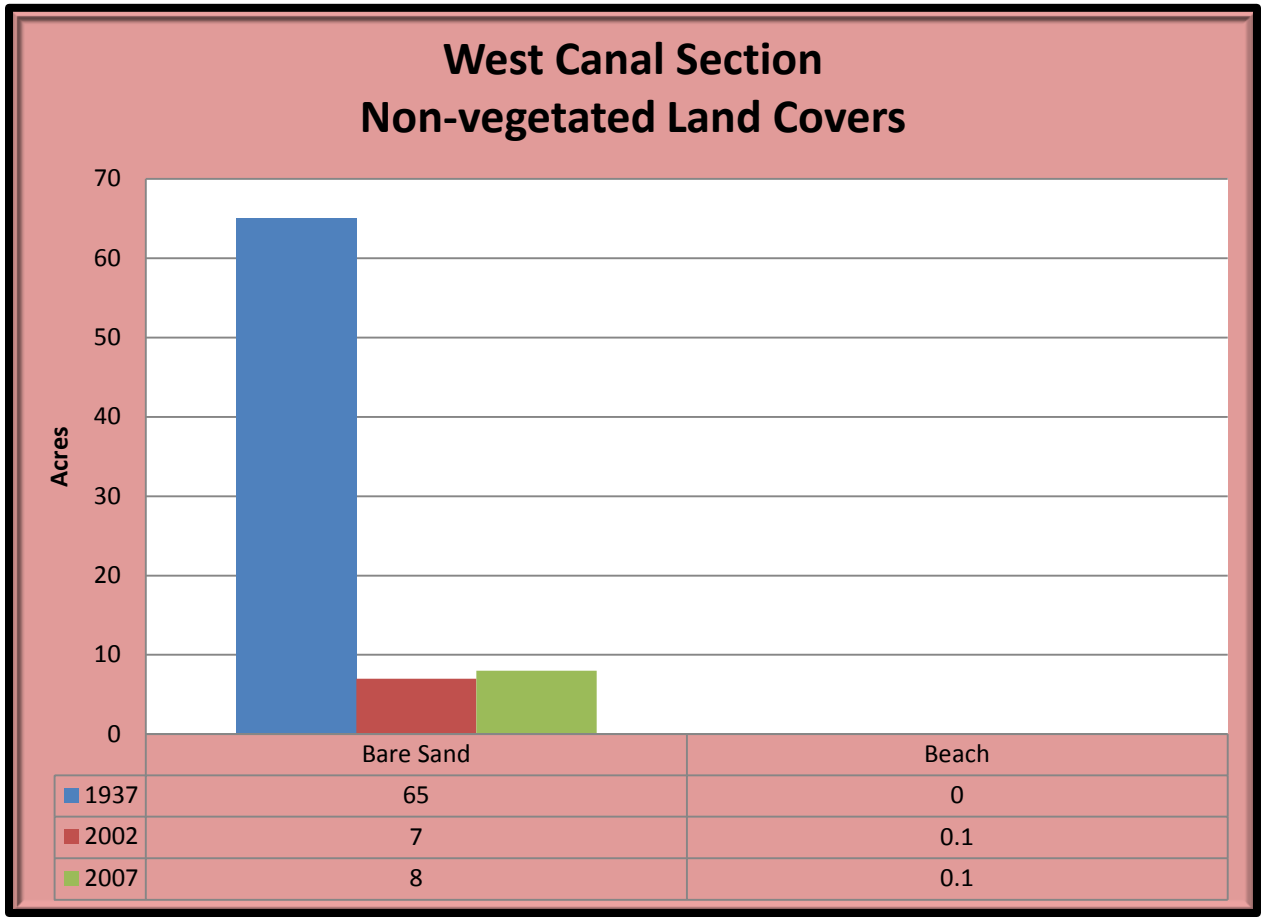


Figure 4-3.11. West Canal Section Non-vegetated Covers (1937, 2002, and 2007)

West Canal Section Non-vegetated Land Covers (Figure 4-3.11): Bare Sand and Beach are the only Non-vegetated land covers present in the West Canal Section. The acreage of these land covers has been markedly falling over time.

DNREC Sea Level Rise Analysis (Table 4-3.13)

All of the beach area will be inundated with 0.5 m of sea level rise. None of the sand area will be affected under any scenario.

Table 4-3.13. Projected acres of West Canal Section Non-vegetated Land Covers Inundated by Sea Level Rise

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

Natural Capital

None of the Non-vegetated communities have any natural capital value.

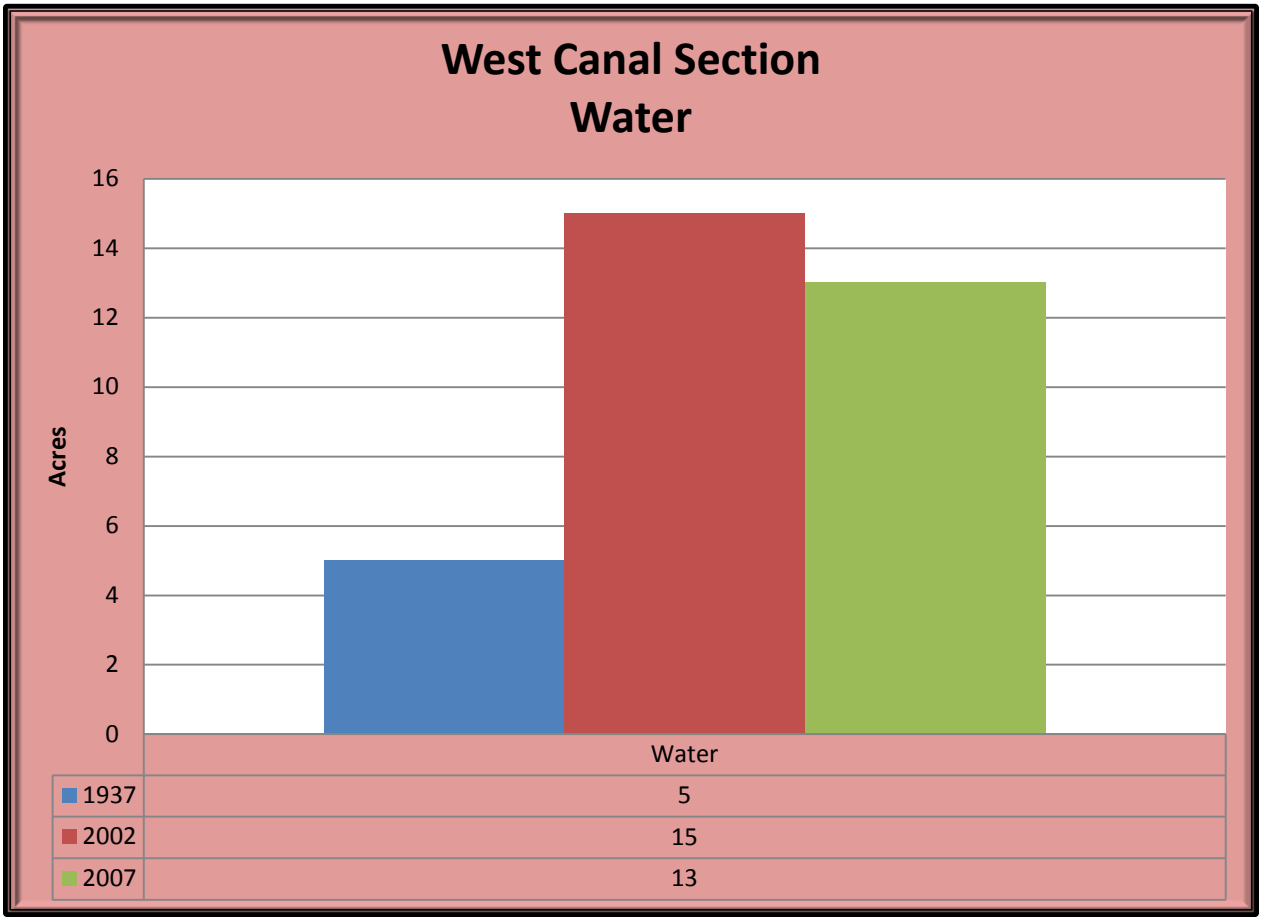


Figure 4-3.12. West Canal Section Water Coverage (1937, 2002, and 2007)

West Canal Section Water Coverage (Figure 4-3.12): Water has increased overall, with the slight decrease in the recent period (2002-2007). This decrease may be due to the filling in of the sides of the canal with riprap.

Natural Capital (Table 4-3.8)

Water coverage has increased overall since 1937, mainly due to a change in the canal. In the recent period (2002-2007) the amount of water has decreased from more riprap being laid.

Table 4-3.14. Natural Capital of West Canal Section Water	
Year	**Natural Capital (in 2012 dollars)**
1937	$71,664/year
2002	$214,993/year
2007	$186,327/year

CHAPTER 5: DESCRIPTIONS OF THE VEGETATION COMMUNITIES

Sixteen vegetation communities were noted in the survey (Figures 4-1.1-1.3, 4-2.1-2.3, and 4-3.1-3.3) and six historical vegetation communities were noted in the aerial imagery. 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.

Current Vegetation Communities (2007):

1. Cattail Brackish Tidal Marsh (CEGL004201)—18 acres
2. Common Reed Upland Vegetation (CEGL004019)—304 acres
3. Cultivated Lawn (CEGL008462)—59 acres
4. Early to Mid-Successional Loblolly Pine Forest (CEGL006011)—119 acres
5. Eastern Reed Marsh (CEGL004141)—707 acres
6. Japanese Stiltgrass Meadow (No NVCS Classification)—7 acres
7. Mid-Atlantic Mesic Mixed Hardwood Forest (CEGL006075)—17 acres
8. Mid to Late Successional Loblolly Pine-Sweetgum Forest (CEGL008462)—2 acres
9. North Atlantic Low Salt Marsh (CEGL004192)—0.1 acres
10. Northeastern Modified Successional Forest (CEGL006599)—1,297 acres
11. Northeastern Old Field (CEGL006107)—854 acres
12. Northeastern Successional Shrubland (CEGL006451)—455 acres
13. Red Maple-Sweetgum Swamp (CEGL006110)—90 acres
14. Reed Tidal Marsh (CEGL004187)—279 acres
15. Successional Maritime Forest (CEGL006154)—1 acre
16. Virginia Pine Successional Forest (CEGL002591)—2 acres

Historical Vegetation Communities (1937 or 2002):

1. Atlantic Coast Wild Rice Tidal Marsh (CEGL004202)—0.4 acres (1937)
2. Eastern Cattail Marsh (CEGL006153)—60 acres (1937)
3. Freshwater Tidal Mixed High Marsh (CEGL006325)—1 acre (1937)
4. Northeastern Buttonbush Shrub Swamp (CEGL006069)—14 acres (1937)
5. Pickerelweed Tidal Marsh (CEGL004706)—323 acres (1937)
6. River Bulrush Flooded Grassland (CEGL006366)—1 acre (1937)

***Atlantic Coast Wild Rice Tidal Marsh* [0 acres (Figure 5.1, Table 5.1)] G4? S3**

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

Description

This marsh community is no longer present in the wildlife area and was likely a victim of increased salinity in the marsh. This marsh is dominated by wild rice (*Zizania aquatica*), and associated by smooth bur-marigold (*Bidens laevis*), arrow-arum (*Peltandra virginica*), and halbeard-leaf tearthumb (*Polygonum arifolium*).

Analysis of Condition at C and D Canal Wildlife Area

This community is likely a victim of increased salinity in the canal area and the invasion of common reed (*Phragmites australis*). The main species wild rice (*Zizania aquatica*) cannot handle salinity conditions higher than 1.0 ppt. All of the former Atlantic Coast Wild Rice Tidal Marsh is now Reed Tidal Marsh.

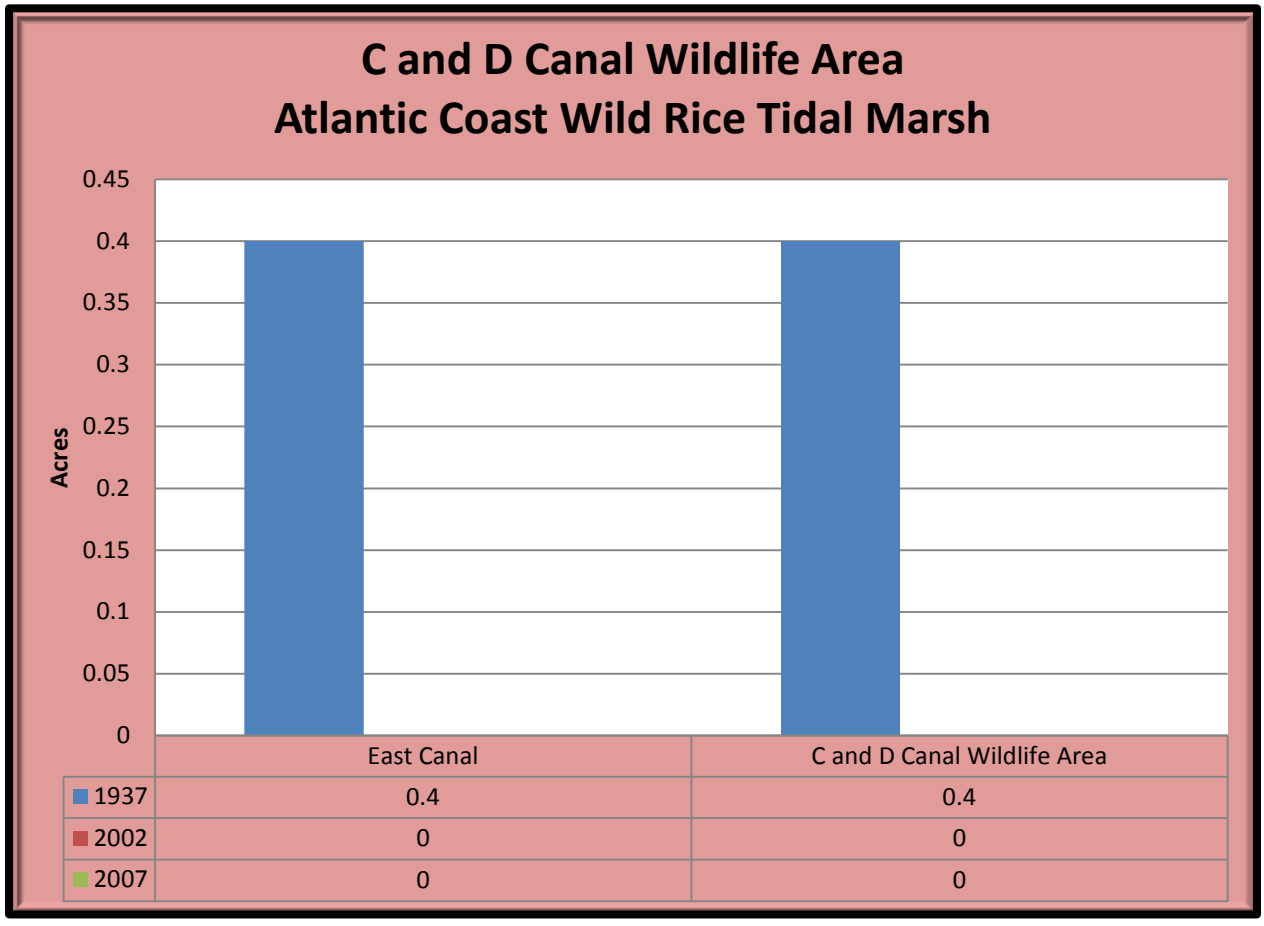


Figure 5.1. Atlantic Coast Wild Rice Tidal Marsh at C and D Canal Wildlife Area (1937, 2002, and 2007)

Natural Capital (Table 5.1)

All of the capital for Atlantic Coast Wild Rice Tidal Marsh has been transferred to Reed Tidal Marsh since 1937.

Table 5.1. Natural Capital of Atlantic Coast Wild Rice Tidal Marsh	
Year	**Natural Capital (in 2012 dollars)**
1937	$2,509/year
2002	$0/year (not present)
2007	$0/year (not present)

Cattail Brackish Tidal Marsh **[18 acres (Figure 5.2, Tables 5.2-5.5)] G4G5 S3**

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

Description

This marsh community is currently found in a small area in the East Canal area. This marsh is composed of narrow-leaf cattail (*Typha angustifolia*) and wide-leaved cattail (*Typha latifolia*) in a tidal marsh. This community ranges from oligohaline to mesohaline.

Analysis of Condition at C and D Canal Wildlife Area

Cattail Brackish Tidal Marsh appears to be maintaining on the east side of the canal. It is expected that this marsh will continue in the short-term but it is unknown how sea level will affect it.

In 2007, 16 acres of the original 177 acres from 1937 still existed. The rest of the acreage has converted to 104 acres of Reed Tidal Marsh, 30 acres of water, 7 acres of Northeastern Modified Successional Forest (most likely through fill), and 4 acres of Northeastern Successional Shrubland, also from fill (Table 5.2).

This community has migrated hardly at all since 1937, likely leading to its decline. Only 1 acre of water has been converted to this community (Table 5.3).

Table 5.2. What was once Cattail Brackish Tidal Marsh in 1937 has become X or remained in 2007

X	Acreage
Reed Tidal Marsh	104 acres
Water	30 acres
Cattail Brackish Tidal Marsh	16 acres
Northeastern Modified Successional Forest	7 acres
Northeastern Successional Shrubland	4 acres
Other communities/land covers	15 acres

Table 5.3. Cattail Brackish Tidal Marsh has migrated into X or remained since 1937

X	Acreage
Cattail Brackish Tidal Marsh	16 acres
Water	1 acre

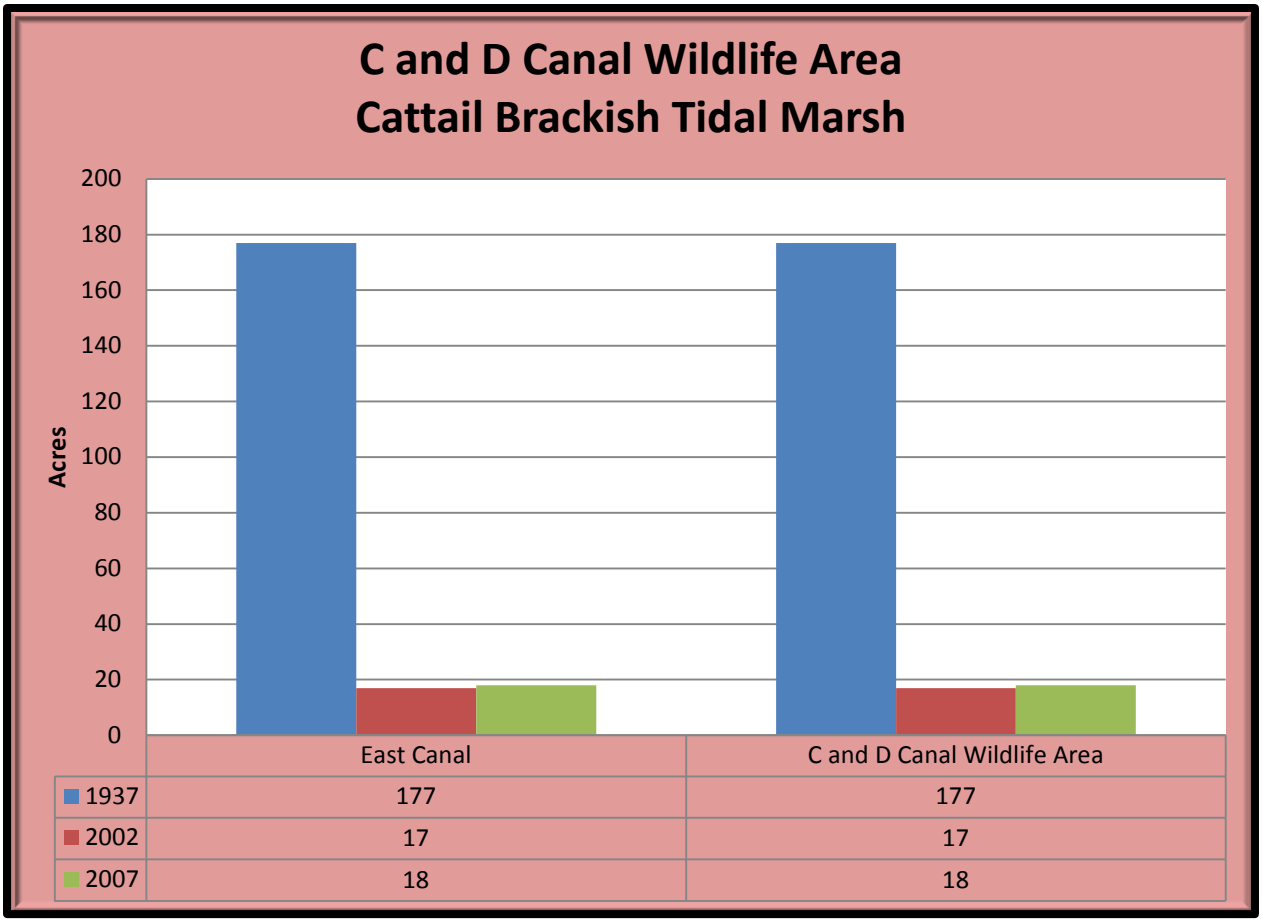


Figure 5.2. Cattail Brackish Tidal Marsh at C and D Canal Wildlife Area (1937, 2002, and 2007)

DNREC Sea Level Rise Analysis (Table 5.4)

All of the current acreage of Cattail Brackish Tidal Marsh would be lost at 1 m of sea level rise and practically all would be lost with 0.5 m of rise.

Table 5.4. Projected acres of Cattail Brackish Tidal Marsh Impacted by Sea Level Rise	
Rise	**Acres**
0.5 m	17 acres
1 m	18 acres
1.5 m	18 acres

Natural Capital (Table 5.5)

A lot of capital has been lost from this community and transferred to Reed Tidal Marsh and water. In the recent period (2002-2007) there has been a slight increase leading to an increase in capital.

Table 5.5. Natural Capital of Cattail Brackish Tidal Marsh	
Year	**Natural Capital (in 2012 dollars)**
1937	$1,110,020/year
2002	$106,612/year
2007	$112,883/year

Chesapeake Bay Non-riverine Wet Hardwood Forest **[90 acres (Figures 5.3-5.4, Tables 5.6-5.9)] G2? S4**

DEWAP: Isolated Forested Wetlands
NHC: Northern Atlantic Coastal Basin Swamp and Wet Hardwood Forest

Description

This forest community is present in a lot of the low flat areas of the wildlife area and does contain as many of the exotic invasive plant species found in the Northeastern Modified Successional Forest. Red maple (*Acer rubrum*), pin oak (*Quercus palustris*), wild black cherry (*Prunus serotina*), and black locust (*Robinia pseudoacacia*) are common canopy associates with red maple being dominant. The understory is composed of osage-orange (*Maclura pomifera*), sassafras (*Sassafras albidum*), blackgum (*Nyssa sylvatica*), willow oak (*Quercus phellos*), and serviceberry (*Amelanchier canadensis*). The shrub and vine layer includes poison ivy (*Toxicodendron radicans*), Japanese honeysuckle (*Lonicera japonica*), multiflora rose (*Rosa multiflora*), blackberry (*Rubus* sp.), arrow-wood (*Viburnum dentatum*), and highbush blueberry (*Vaccinium corymbosum*).

Figure 5.3. Chesapeake Bay Non-riverine Wet Hardwood Forest

The examples of this community could best described as being in a late successional state. Most, if not all, of the examples are invaded by exotic invasive plants and do not exhibit natural layering.

Analysis of Condition at C and D Canal Wildlife Area

This forest type has come into prominence in low flat areas of the west section of the canal. The long-term outlook for this community is uncertain since most of the examples are being invaded by exotic species and will likely convert to Northeastern Modified Successional Forest.

None of the original acreage of this forest from 1937 was still present in 2007. The acreage since this time has become 14 acres of Northeastern Modified Successional Forest, and 1 acre each of Northeastern Successional Shrubland, Reed Tidal Marsh, Water, and Semi-impervious Surface (Table 5.6).

Since 1937, this community has greatly increased, growing into 40 acres of agricultural field, 22 acres of Northeastern Old Field, 12 acres of bare sand, and 6 acres of modified land and converting 8 acres of Northeastern Modified Successional Forest (Table 5.7).

Table 5.6. What was once Chesapeake Bay Non-riverine Wet Hardwood Forest in 1937 has become X or remained in 2007	
X	**Acreage**
Northeastern Modified Successional Forest	14 acres
Northeastern Successional Shrubland	1 acre
Reed Tidal Marsh	1 acre
Water	1 acre
Semi-impervious Surface	1 acre
Other communities/land covers	1 acre

Table 5.7. Chesapeake Bay Non-riverine Wet Hardwood Forest has migrated into X or remained since 1937	
X	**Acreage**
Agricultural Field	40 acres
Northeastern Old Field	22 acres
Bare Sand	12 acres
Northeastern Modified Successional Forest	8 acres
Modified Land	6 acres
Other communities/land covers	2 acres

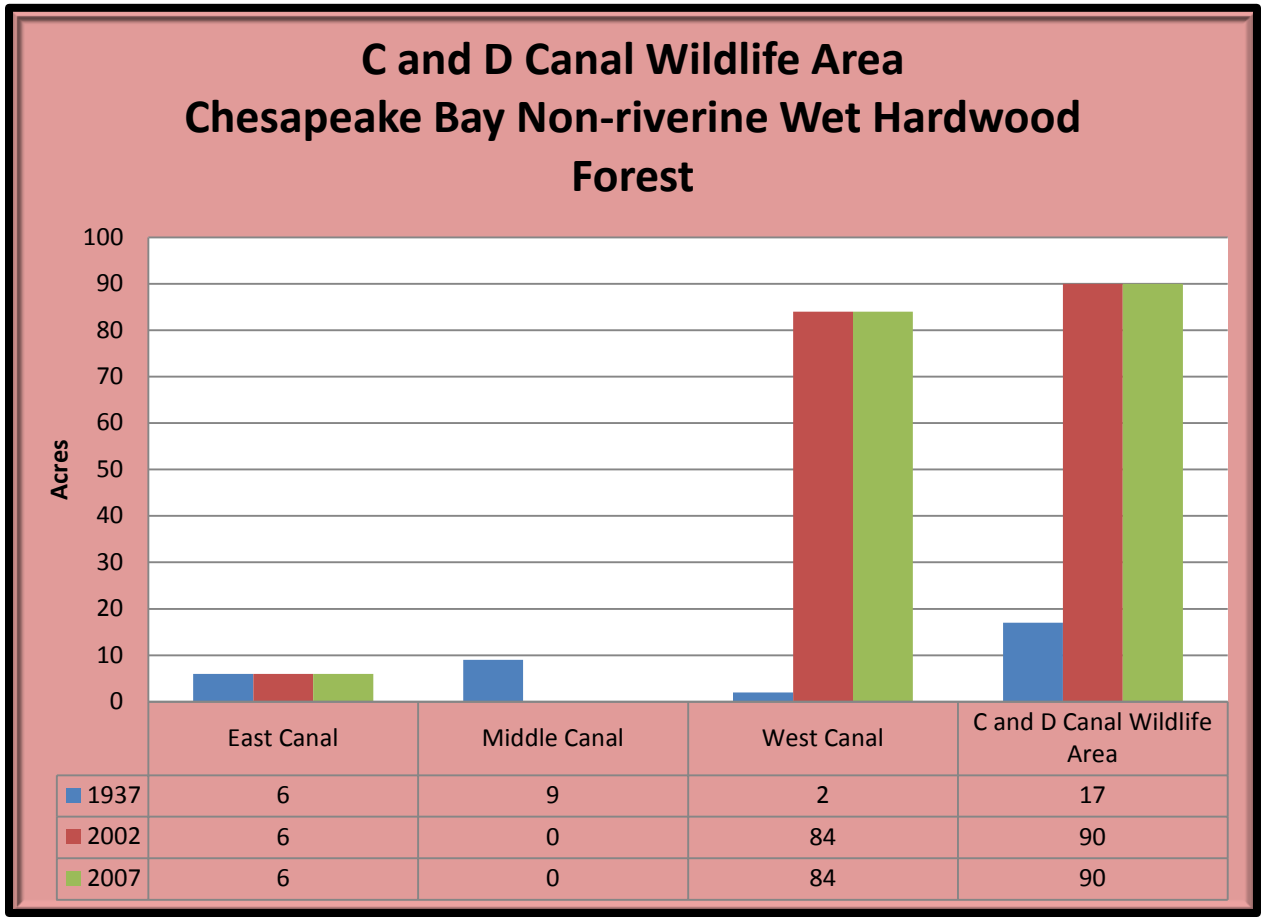


Figure 5.4. Chesapeake Bay Non-riverine Wet Hardwood Forest at C and D Canal Wildlife Area (1937, 2002, and 2007)

DNREC Sea Level Rise Analysis (Table 5.8)

Very little of Chesapeake Bay Non-riverine Wet Hardwood Forest will be impacted by sea level rise under any scenario.

Table 5.8. Projected acres of Chesapeake Bay Non-riverine Wet Hardwood Forest Impacted by Sea Level Rise

Rise	Acres
0.5 m	2 acres
1 m	6 acres
1.5 m	6 acres

Natural Capital (Table 5.9)

This community has gained acreage in former agricultural fields and Northeastern Old Field and has been stable in the recent period (2002-2007).

Table 5.9. Natural Capital of Chesapeake Bay Non-riverine Wet Hardwood Forest	
Year	**Natural Capital (in 2012 dollars)**
1937	$208,956/year
2002	$1,106,235/year
2007	$1,106,235/year

Common Reed Upland Temperate Vegetation **[304 acres (Figures 5.5-5.6, Tables 5.10-5.12)]** **GNA SNA**

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

Description

Figure 5.5. Common Reed Upland Temperate Vegetation

This herbaceous community is similar in habit and composition to the Eastern Reed Marsh but is located in an upland situation and without tidal influence. It is composed entirely of common reed (*Phragmites australis*).

Analysis of Condition at C and D Canal Wildlife Area

This community is composed of an exotic invasive plant species. It is hoped that this community will be eradicated in the wildlife area at some point. It was not present in 1937 and has since taken over 114 acres of agricultural field, 92 acres of modified land, 73 acres of Northeastern Old Field, 10 acres of sand, and 9 acres of Northeastern Modified Successional Forest (Table 5.10).

Table 5.10. Common Reed Upland Temperate Vegetation has migrated into X or remained since 1937	
X	**Acreage**
Agricultural Field	114 acres
Modified Land	92 acres
Northeastern Old Field	73 acres
Bare Sand	10 acres
Northeastern Modified Successional Forest	9 acres
Other vegetation communities/land covers	6 acres

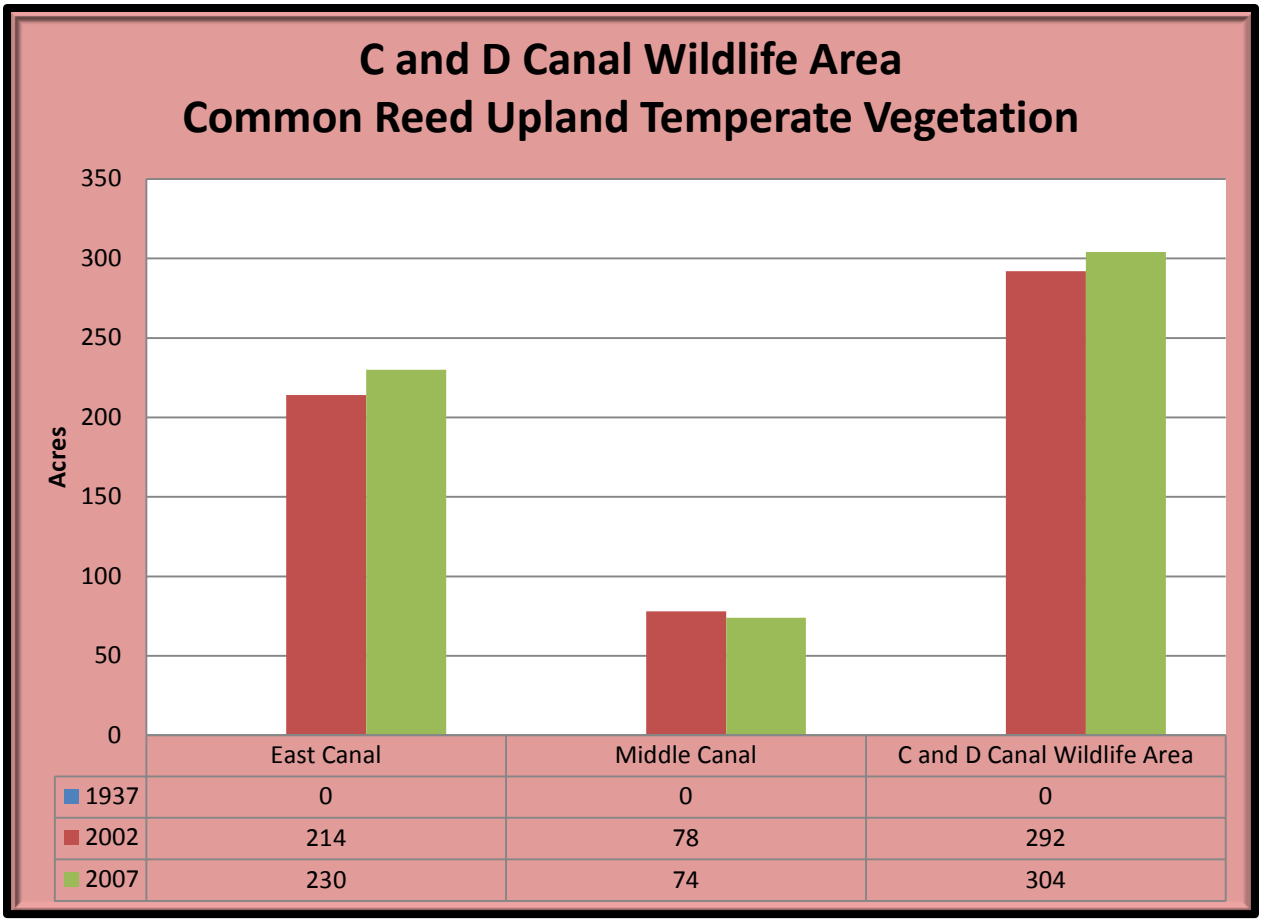


Figure 5.6. Common Reed Upland Temperate Vegetation at C and D Canal Wildlife Area (1937, 2002, and 2007)

DNREC Sea Level Rise Analysis (Table 5.11)

Very little of the Common Reed Upland Temperate Vegetation will be impacted by sea level rise.

Table 5.11. Projected acres of Common Reed Upland Temperate Vegetation Impacted by Sea Level Rise	
Rise	**Acres**
0.5 m	1 acre
1 m	2 acres
1.5 m	2 acres

Natural Capital (Table 5.12)

This community has been increasing in the uplands of the wildlife area and has a capital that is gaining with it.

Table 5.12. Natural Capital of Common Reed Upland Temperate Vegetation	
Year	**Natural Capital (in 2012 dollars)**
1937	$0/year (not present)
2002	$42,544/year
2007	$44,293/year

Cultivated Lawn **[59 acres (Figure 5.7, Tables 5.13-5.15)]** **GNA SNA**

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

Description

This community is located adjacent to some of the historic houses and roadsides in the wildlife area. It is dominated by tall fescue (*Festuca arundinacea*) with other ornamental grasses and plants. It is mowed more than once a year.

Analysis of Condition at C and D Canal Wildlife Area

This anthropogenic community has gradually gained acreage with new roads and development in the wildlife area. Given the acreage of the wildlife area, there is still very little cultivated lawn present compared to other areas. In 2007, only 3 acres of the cultivated lawn present in 1937 still existed. The rest of the lawns had become 12 acres of Northeastern Modified Successional Forest, 8 acres of Northeastern Successional Shrubland, 6 acres of riprap, 5 acres of Eastern Reed Marsh, and 4 acres of Northeastern Old Field (Table 5.13).

Since 1937, Cultivated Lawn has been developed in 23 acres of agricultural field, 17 acres of Northeastern Old Field, 6 acres of Pickerelweed Tidal Marsh, and 5 acres of bare sand (Table 5.14).

Table 5.13. What was once Cultivated Lawn in 1937 has become X or remained in 2007

X	Acreage
Northeastern Modified Successional Forest	12 acres
Northeastern Successional Shrubland	8 acres
Riprap	6 acres
Eastern Reed Marsh	5 acres
Northeastern Old Field	4 acres
Other communities/land covers	15 acres

Table 5.14. Cultivated Lawn has migrated into X or remained since 1937

X	Acreage
Agricultural Field	23 acres
Northeastern Old Field	17 acres
Pickerelweed Tidal Marsh	6 acres
Bare Sand	5 acres
Cultivated Lawn	3 acres
Other communities/land covers	5 acres

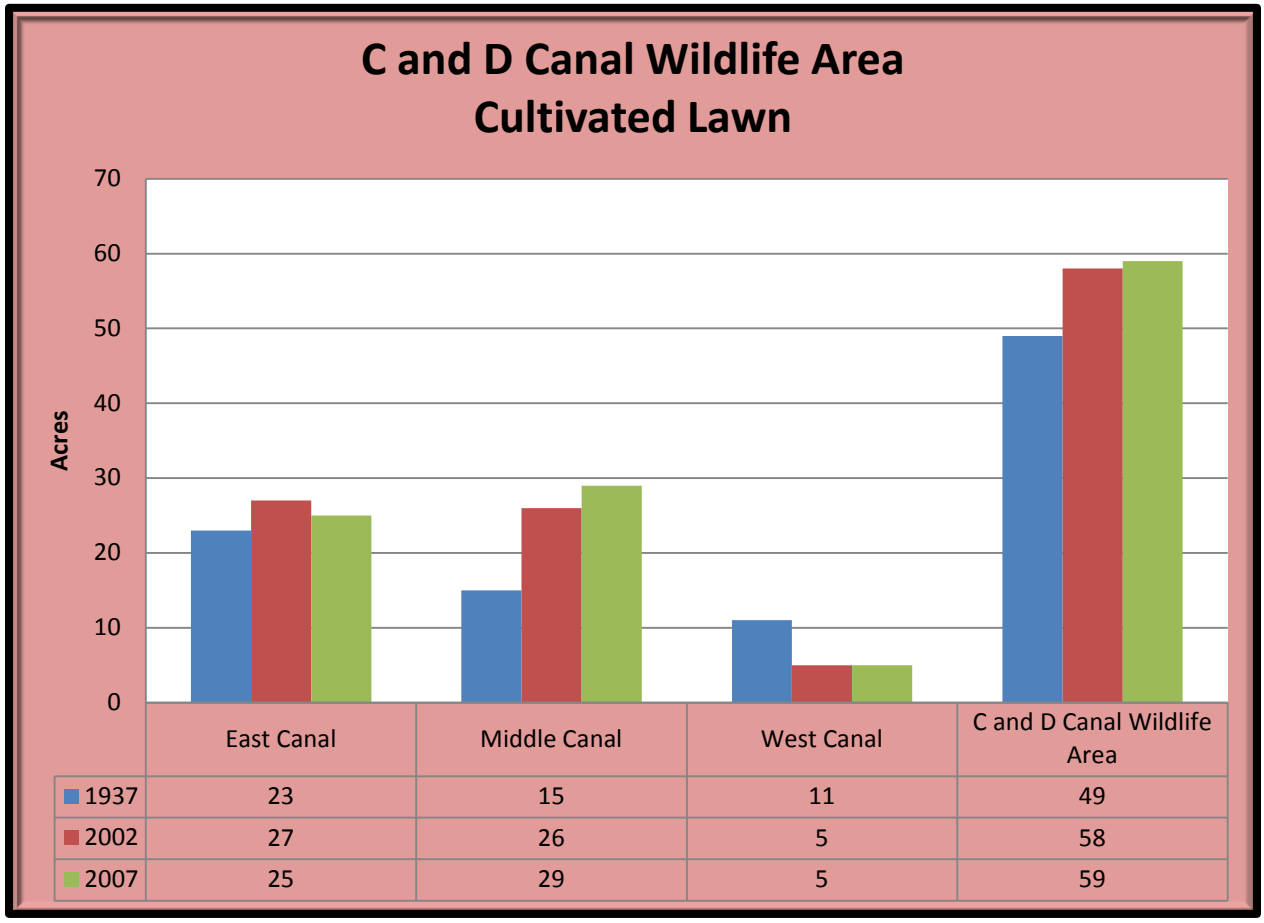


Figure 5.7. Cultivated Lawn at C and D Canal Wildlife Area (1937, 2002, and 2007)

DNREC Sea Level Rise Analysis (Table 5.15)

A little less than ¼ of the current cultivated lawn will be impacted by 1.5 m of sea level rise.

Table 5.15. Projected acres of Cultivated Lawn Impacted by Sea Level Rise	
Rise	**Acres**
0.5 m	2 acres
1 m	7 acres
1.5 m	13 acres

Natural Capital

Cultivated Lawn does not have any natural capital value.

Early to Mid-Successional Loblolly Pine Forest **[119 acres (Figures 5.8-5.9, Tables 5.16-5.18)] GNA SNA**

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

Description

This community is most common in the west canal section with some present in the middle canal section. Loblolly pine (*Pinus taeda*) is the only species present in the canopy overtopping an understory of red maple (*Acer rubrum*), wild black cherry (*Prunus serotina*), eastern red cedar (*Juniperus virginiana*), tree-of-heaven (*Ailanthus altissima*), white mulberry (*Morus alba*), and willow oak (*Quercus phellos*). Shrubs and vines include poison ivy (*Toxicodendron radicans*), summer grape (*Vitis aestivalis*), Japanese honeysuckle (*Lonicera japonica*), autumn olive (*Elaeagnus umbellata*), and blackberry (*Rubus* sp.). Blue-eyed grass (*Sisyrinchium angustifolium*) was the only herb noted.

Figure 5.8. Early to Mid-Successional Loblolly Pine Forest

Analysis of Condition at C and D Canal Wildlife Area

None of the Early to Mid-Successional Loblolly Pine Forest from 1937 still exists in 2007. It has become 1 acre each of Northeastern Modified Successional Forest, Eastern Reed Marsh, and Semi-impervious Surface (Table 5.16). Since 1937, this forest community has become much more common by growing into 62 acres of agricultural field, 26 acres of modified land, 25 acres of Northeastern Old Field, 5 acres of bare sand, and 1 acre of Northeastern Modified Successional Forest (Table 5.17). This forest type may gradually decline with succession since a lot of the other younger successional communities are infested with exotic invasive species.

Table 5.16. What was once Early to Mid-Successional Loblolly Pine Forest in 1937 has become X or remained in 2007	
X	**Acreage**
Northeastern Modified Successional Forest	1 acre
Eastern Reed Marsh	1 acre
Semi-impervious Surface	1 acre

Table 5.17. Early to Mid-Successional Loblolly Pine Forest has migrated into X or remained since 1937	
X	**Acreage**
Agricultural Field	62 acres
Modified Land	26 acres
Northeastern Old Field	25 acres
Bare Sand	5 acres
Northeastern Modified Successional Forest	1 acre
Other communities/land covers	1 acre

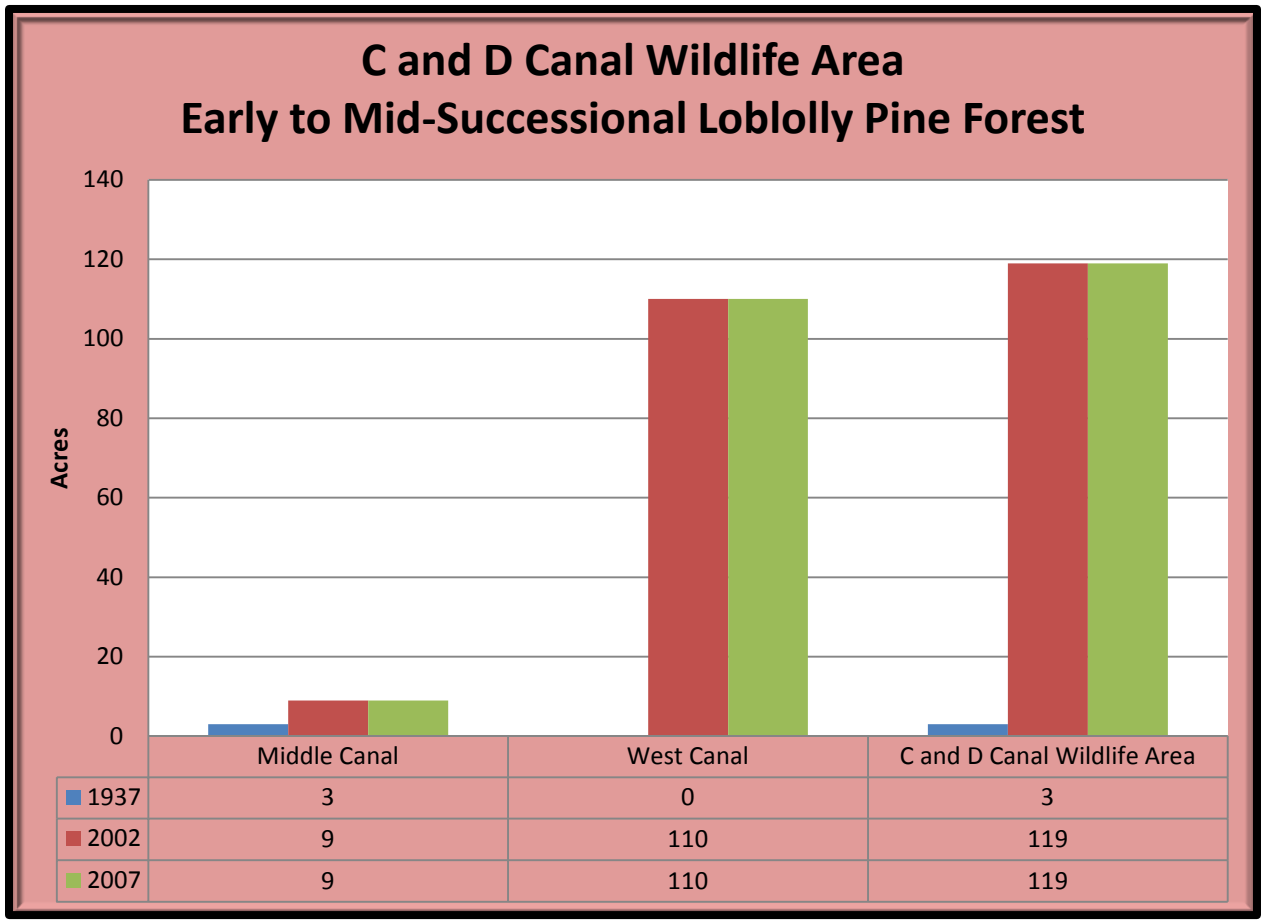


Figure 5.9. Early to Mid-Successional Loblolly Pine Forest at C and D Canal Wildlife Area (1937, 2002, and 2007)

DNREC Sea Level Rise Analysis

None of the current acreage of Early to Mid-Successional Loblolly Pine Forest will be impacted up to 1.5 m of sea level rise.

Natural Capital (Table 5.18)

Early to Mid-Successional Loblolly Pine Forest has increased in capital with increasing acreage.

Table 5.18. Natural Capital of Early to Mid-Successional Loblolly Pine Forest	
Year	**Natural Capital (in 2012 dollars)**
1937	$567/year
2002	$22,503/year
2007	$22,503/year

Eastern Cattail Marsh **[0 acres (Figure 5.10, Tables 5.19-5.20)] G5 S4**

DEWAP: Streamside Herbaceous Wetlands
NHC: Laurentian-Acadian Freshwater Marsh

Description

Eastern Cattail Marsh is a former community present in the wildlife area and was likely taken over by Eastern Reed Marsh.

Analysis of Condition at C and D Canal Wildlife Area

This community is no longer present in the wildlife area and will not likely re-establish with competition from eastern reed (*Phragmites australis*). The acreage that was once this community has become 26 acres of Northeastern Modified Successional Forest, likely through fill, 13 acres of Eastern Reed Marsh, 7 acres of Northeastern Successional Shrubland, 5 acres of Japanese Stiltgrass Meadow, and 3 acres of Semi-impervious Surface (Table 5.15).

Table 5.19. What was once Eastern Cattail Marsh in 1937 has become X or remained in 2007

X	**Acreage**
Northeastern Modified Successional Forest	26 acres
Eastern Reed Marsh	13 acres
Northeastern Successional Shrubland	7 acres
Japanese Stiltgrass Meadow	5 acres
Semi-impervious Surface	3 acres
Other vegetation communities/land covers	6 acres

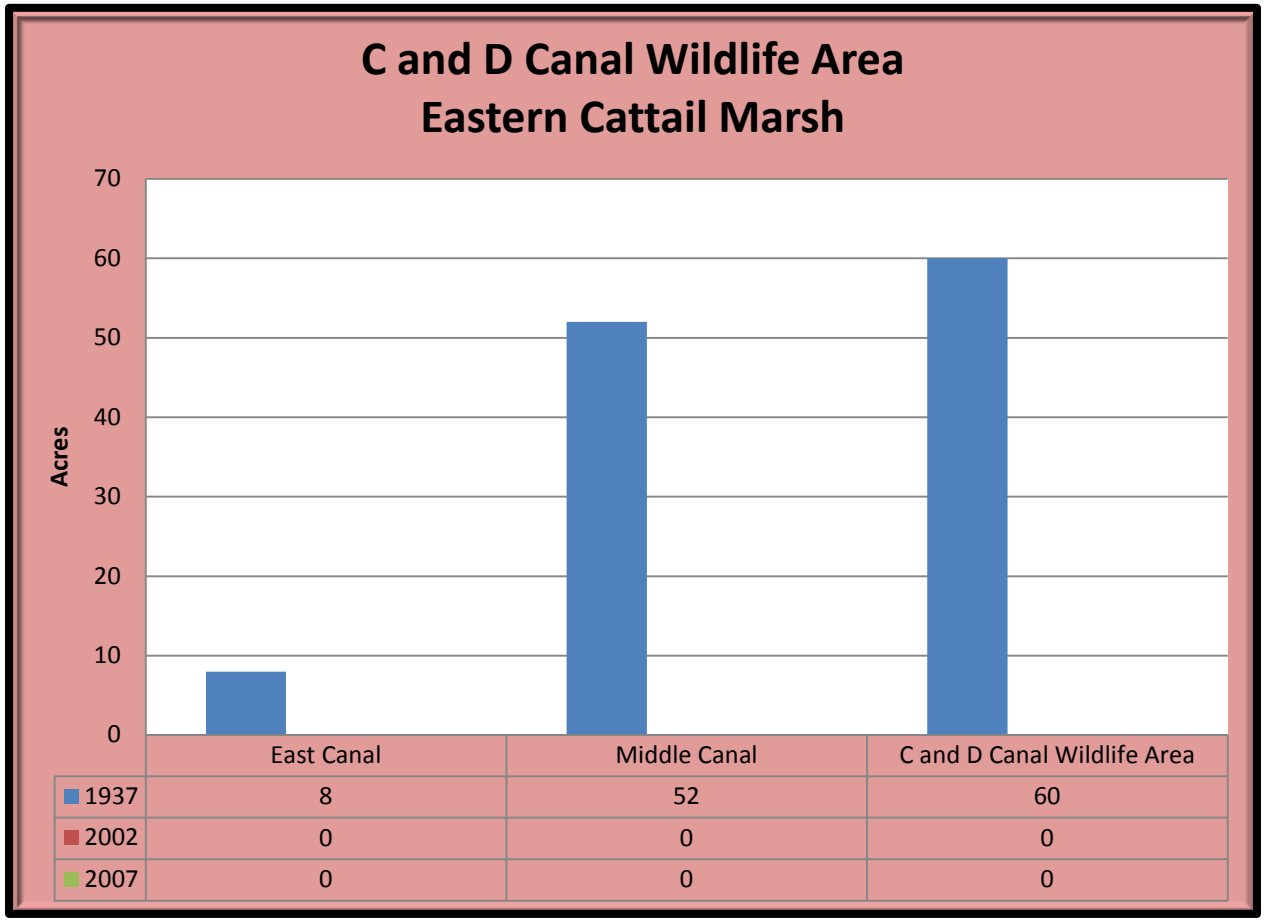


Figure 5.10. Eastern Cattail Marsh at C and D Canal Wildlife Area (1937, 2002, and 2007)

Natural Capital (Table 5.20)

Capital of Eastern Cattail Marsh was transferred to forest and other marsh types.

Table 5.20. Natural Capital of Eastern Cattail Marsh	
Year	**Natural Capital (in 2012 dollars)**
1937	$556,884/year
2002	$0/year (not present)
2007	$0/year (not present)

***Eastern Reed Marsh* [708 acres (Figure 5.11, Tables 5.21-5.24)] GNA SNA**

DEWAP: Streamside Herbaceous Wetlands
NHC: Semi-natural/Altered vegetation and Conifer Plantations

Description

This community is composed of a monoculture of eastern reed (*Phragmites australis*) in a non-tidal wetland situation.

Analysis of Condition at C and D Canal Wildlife Area

This community is artificially created and maintained and is not judged by condition. Three acres of the 8 acres present in 1937 still existed in 2007. The rest of the acreage had become 3 acres of Northeastern Modified Successional Forest, 1 acre of water, and 1 acre of Northeastern Old Field (Table 5.21).

Since 1937, this community has greatly increased its acreage. The acreage has come from 267 acres of modified land, 151 acres of agricultural field, 121 acres of Pickerelweed Tidal Marsh, 73 acres of Northeastern Old Field, and 33 acres of bare sand (Table 5.22).

Table 5.21. What was once Eastern Reed Marsh in 1937 has become X or remained in 2007	
X	**Acreage**
Eastern Reed Marsh	3 acres
Northeastern Modified Successional Forest	3 acres
Water	1 acre
Northeastern Old Field	1 acre
Reed Tidal Marsh	0.5 acres

Table 5.22. Eastern Reed Marsh has migrated into X or remained since 1937	
X	**Acreage**
Modified Land	267 acres
Agricultural Field	151 acres
Pickerelweed Tidal Marsh	121 acres
Northeastern Old Field	73 acres
Bare Sand	33 acres
Other communities/land covers	62 acres

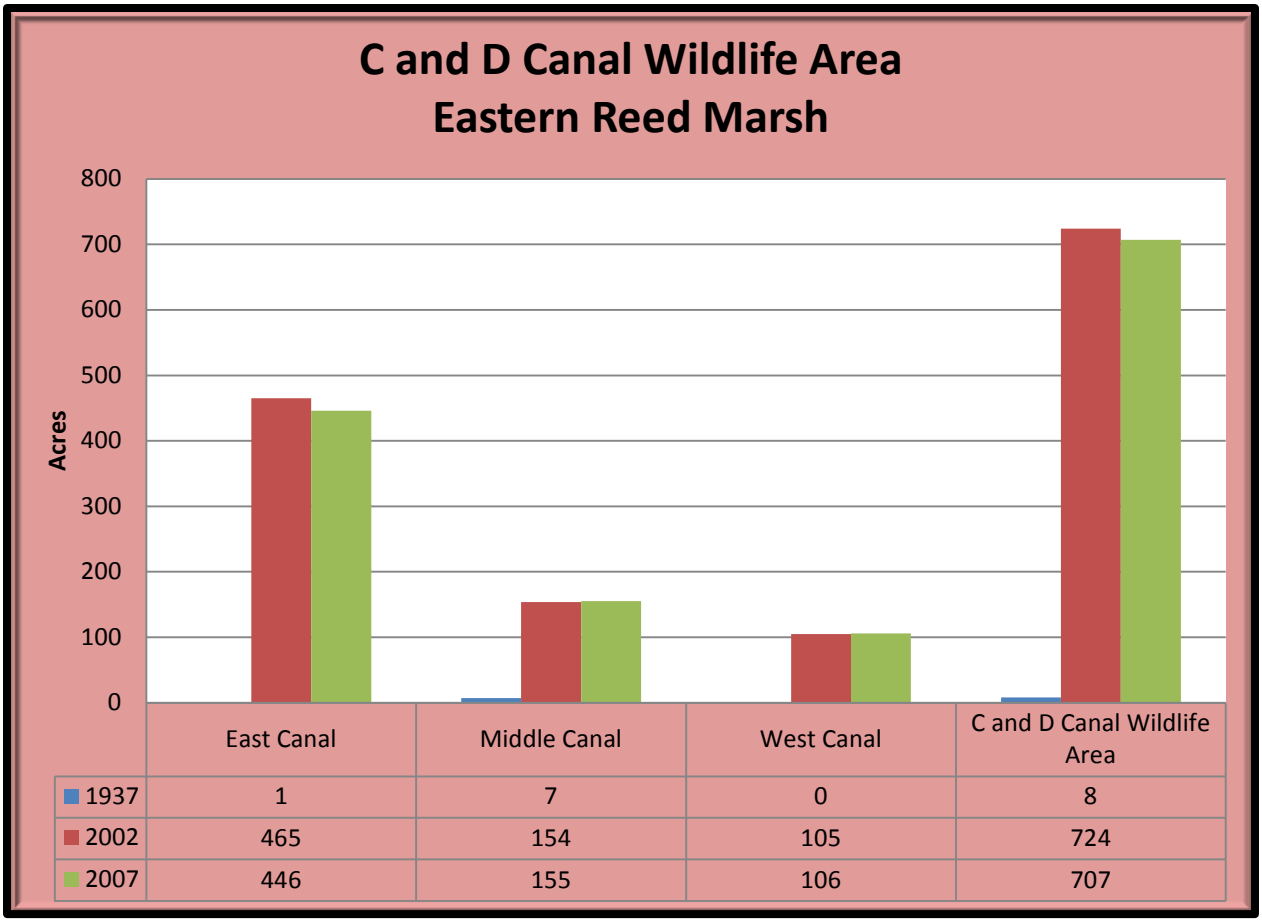


Figure 5.11. Eastern Reed Marsh at C and D Canal Wildlife Area (1937, 2002, and 2007)

DNREC Sea Level Rise Analysis (Table 5.23)

Only small amount of the current acreage will be impacted by the highest amount of sea level rise (1.5 m). Most of the occurrences are located in raised impoundments above the level of tidal water.

Table 5.23. Projected acres of Eastern Reed Marsh Impacted by Sea Level Rise	
Rise	**Acres**
0.5 m	3 acres
1 m	8 acres
1.5 m	13 acres

Natural Capital (Table 5.24)

Capital of Eastern Reed Marsh has greatly increased with increasing acreage. Recently a slight decrease in the acreage has led to the capital decreasing as well.

Table 5.24. Natural Capital of Eastern Reed Marsh	
Year	**Natural Capital (in 2012 dollars)**
1937	$74,251/year
2002	$6,719,734/year
2007	$6,561,950/year

Freshwater Tidal Mixed High Marsh **[0 acres (Figure 5.12, Tables 5.25-5.26)] GNR S1**

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

Description

A small amount of Freshwater Tidal Mixed High Marsh was present in 1937 but has since disappeared with rising water and competition with reed grass (*Phragmites australis*). Since this community is no longer present in the wildlife area a direct observation cannot be made. However, common dominants or co-dominants in this community include arrow-arum (*Peltandra virginica*), orange-spotted jewelweed (*Impatiens capensis*), broad-leaf arrow-head (*Sagittaria latifolia*), and narrow-leaf cattail (*Typha angustifolia*). Other associates may include pickerelweed (*Pontederia cordata*), halbeard-leaf tearthumb (*Polygonum arifolium*), arrow-leaved tearthumb (*Polygonum sagittatum*), river bulrush (*Schoenoplectus fluviatilis*), and mild water-pepper (*Polygonum hydropiperoides*).

Analysis of Condition at C and D Canal Wildlife Area

This community is no longer present in the wildlife having been taken over by 1 acre of Reed Tidal Marsh and 0.1 acres of Northeastern Modified Successional Forest through filling (Table 5.25). It is also likely that its demise was assisted by an increase in salinity.

Table 5.25. What was once Freshwater Tidal Mixed High Marsh in 1937 has become X or remained in 2007

X	**Acreage**
Reed Tidal Marsh	1 acre
Northeastern Modified Successional Forest	0.1 acres

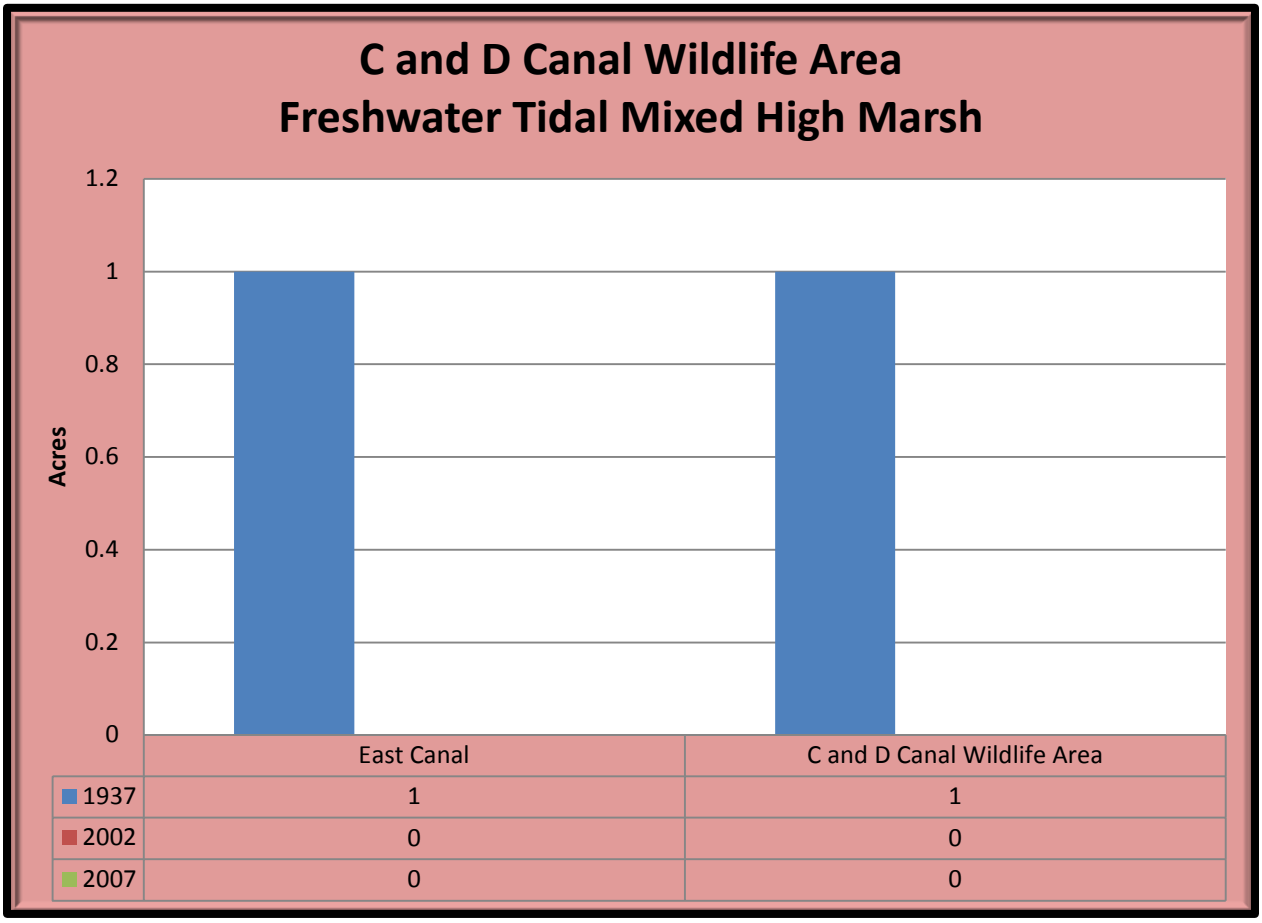


Figure 5.12. Freshwater Tidal Mixed High Marsh at C and D Canal Wildlife Area (1937, 2002, and 2007)

Natural Capital (Table 5.26)

The capital of this community was mostly transferred to Reed Tidal Marsh with a small amount going to Northeastern Modified Successional Forest.

Table 5.26. Natural Capital of Freshwater Tidal Mixed High Marsh	
Year	**Natural Capital (in 2012 dollars)**
1937	$9,281/year
2002	$0/year (not present)
2007	$0/year (not present)

Japanese Stiltgrass Meadow **[7 acres (Figure 5.13, Tables 5.27-5.29)] GNA SNA**

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

Description

This community is often found in places where there is a beaver impoundment that has been dewatered. Japanese stiltgrass (*Microstegium vimineum*) will often take over completely and form thick green mats over the impoundment area.

Analysis of Condition at C and D Canal Wildlife Area

This community is found on a small tributary in the middle canal area and since this community is dominated by an exotic invasive plant species it is hoped that it will be eradicated. It was not present in 1937 and has since colonized 5 acres of Eastern Cattail Marsh, 2 acres of Northeastern Old Field, 0.1 acres of Northeastern Modified Successional Forest, and 0.1 acres of Northeastern Successional Shrubland (Table 5.27).

Table 5.27. Eastern Reed Marsh has migrated into X or remained since 1937

X	**Acreage**
Eastern Cattail Marsh	5 acres
Northeastern Old Field	2 acres
Northeastern Modified Successional Forest	0.1 acres
Northeastern Successional Shrubland	0.1 acres

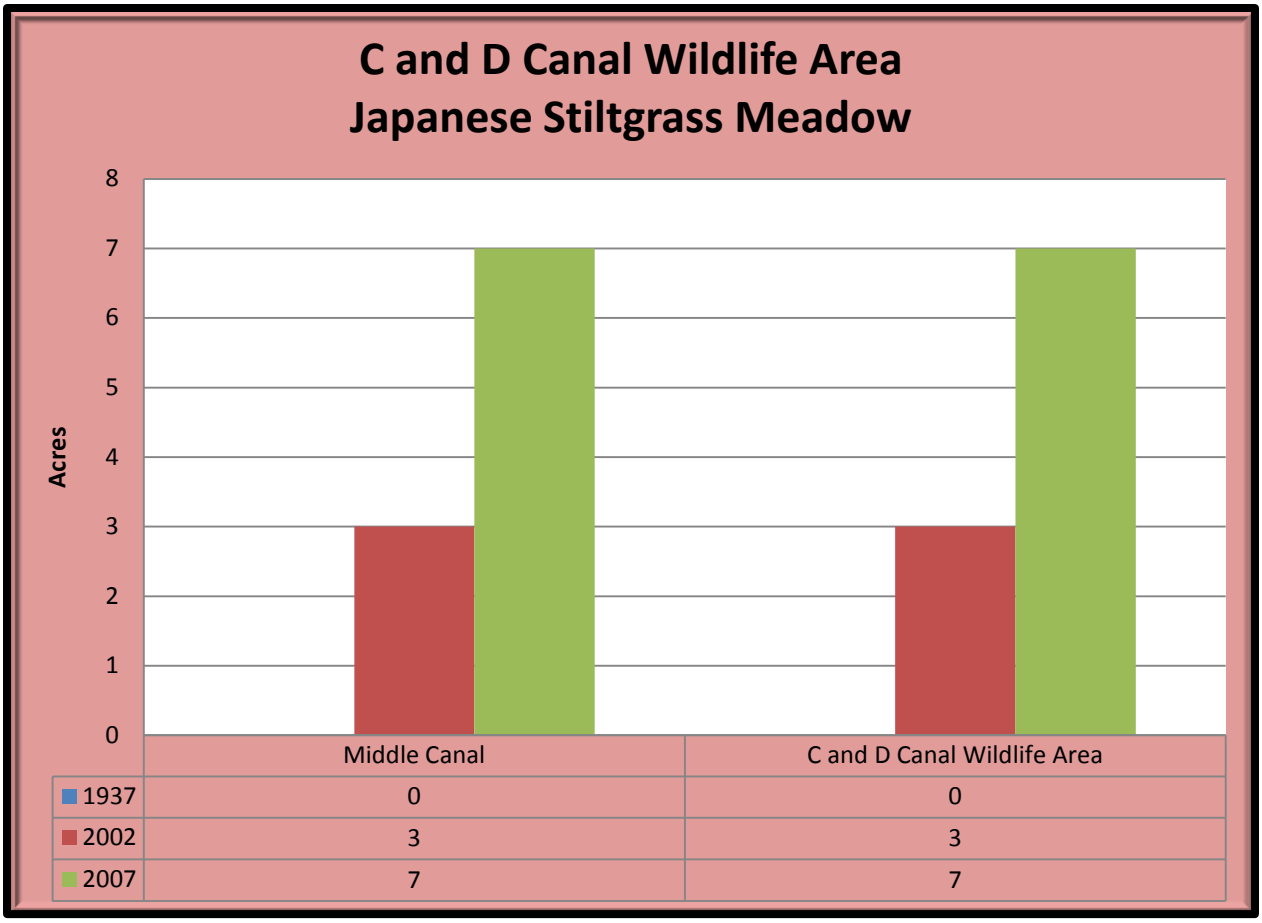


Figure 5.13. Japanese Stiltgrass Meadow at C and D Canal Wildlife Area (1937, 2002, and 2007)

DNREC Sea Level Rise Analysis (Table 5.28)

Japanese Stiltgrass Meadow is not affected by any of the sea level rise scenarios.

Table 5.28. Projected acres of Japanese Stiltgrass Meadow Impacted by Sea Level Rise

Rise	Acres
0.5 m	0 acres
1 m	0 acres
1.5 m	0 acres

Natural Capital (Table 5.29)

Japanese Stiltgrass Meadow has been spreading since it came into the wildlife area increasing its capital.

Table 5.29. Natural Capital of Japanese Stiltgrass Meadow	
Year	**Natural Capital (in 2012 dollars)**
1937	$0/year (not present)
2002	$437/year
2007	$1,020/year

Mid-Atlantic Mesic Mixed Hardwood Forest **[17 acres (Figure 5.14, Tables 5.30-5.33)] G5 S5**

DEWAP: Coastal Plain Upland Forests
NHC: Northern Atlantic Coastal Plain Hardwood Forest

Description

This is one of the only truly natural forest types present in the wildlife area. The occurrences of this community were determine from aerial imagery interpretation and were observed directly. From the imagery, these forests appeared to be mature. Typically these communities are dominated by American beech (*Fagus grandifolia*), northern red oak (*Quercus rubra*), white oak (*Q. alba*), and red maple (*Acer rubrum*) in the canopy. The understory contains sassafras (*Sassafras albidum*), flowering dogwood (*Cornus florida*), and smaller members of the canopy. The shrub and vine layer contains common greenbrier (*Smilax rotundifolia*), highbush blueberry (*Vaccinium corymbosum*), and low-bush blueberry (*Vaccinium pallidum*). Herbs in this community are typically few and include partridge-berry (*Mitchella repens*) and wintergreen (*Chimaphila maculata*).

Analysis of Condition at C and D Canal Wildlife Area

None of the original 10 acres from 1937 still exists in 2007. The rest of the acreage has become 8 acres of Northeastern Modified Successional Forest, 1 acre each of Water and Northeastern Successional Shrubland, 0.4 acres of riprap, and 0.3 acres of Semi-impervious Surface (Table 5.30).

Since 1937, Mid-Atlantic Mesic Mixed Hardwood Forest has developed from 16 acres of Northeastern Old Field, 0.4 acres of agricultural field, and 0.3 acres of Northeastern Successional Shrubland (Table 5.31).

Table 5.30. What was once Mid-Atlantic Mesic Mixed Hardwood Forest in 1937 has become X or remained in 2007

X	Acreage
Northeastern Modified Successional Forest	8 acres
Water	1 acre
Northeastern Successional Shrubland	1 acre
Riprap	0.4 acres
Semi-impervious Surface	0.3 acres

Table 5.31. Mid-Atlantic Mesic Mixed Hardwood Forest has migrated into X or remained since 1937

X	Acreage
Northeastern Old Field	16 acres
Agricultural Field	0.4 acres
Northeastern Successional Shrubland	0.3 acres

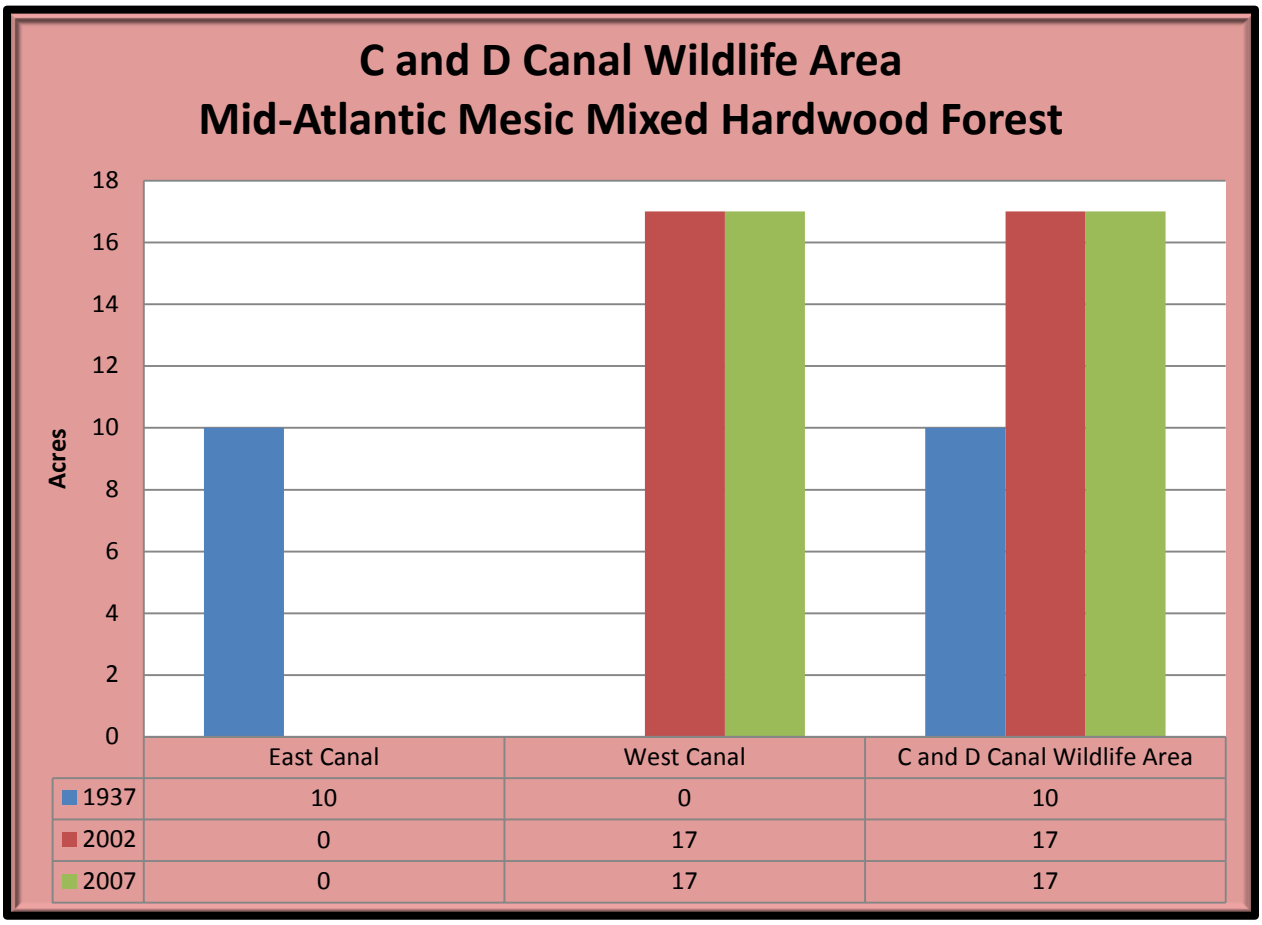


Figure 5.14. Mid-Atlantic Mesic Mixed Hardwood Forest at C and D Canal Wildlife Area (1937, 2002, and 2007)

DNREC Sea Level Rise Analysis (Table 5.32)

Mid-Atlantic Mesic Mixed Hardwood Forest is not affected by any of the sea level rise scenarios.

Table 5.32. Projected acres of Mid-Atlantic Mesic Mixed Hardwood Forest Impacted by Sea Level Rise	
Rise	**Acres**
0.5 m	0 acres
1 m	0 acres
1.5 m	0 acres

Natural Capital (Table 5.33)

Capital in Mid-Atlantic Mesic Mixed Hardwood has increased with increasing acreage.

Table 5.33. Natural Capital of Mid-Atlantic Mesic Mixed Hardwood Forest	
Year	**Natural Capital (in 2012 dollars)**
1937	$1,891/year
2002	$3,215/year
2007	$3,215/year

Mid to Late Successional Loblolly Pine-Sweetgum Forest **[2 acres (Figure 5.15, Tables 5.34-5.35)]**
GNA SNA

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

Description

This is an older form the Early to Mid-Successional Loblolly Pine Forest and is characterized by the canopy being joined by species other than loblolly pine (*Pinus taeda*). Otherwise the species list is essentially the same.

Analysis of Condition at C and D Canal Wildlife Area

All of the current acreage of Mid to Late Successional Forest developed from modified land in 1937.

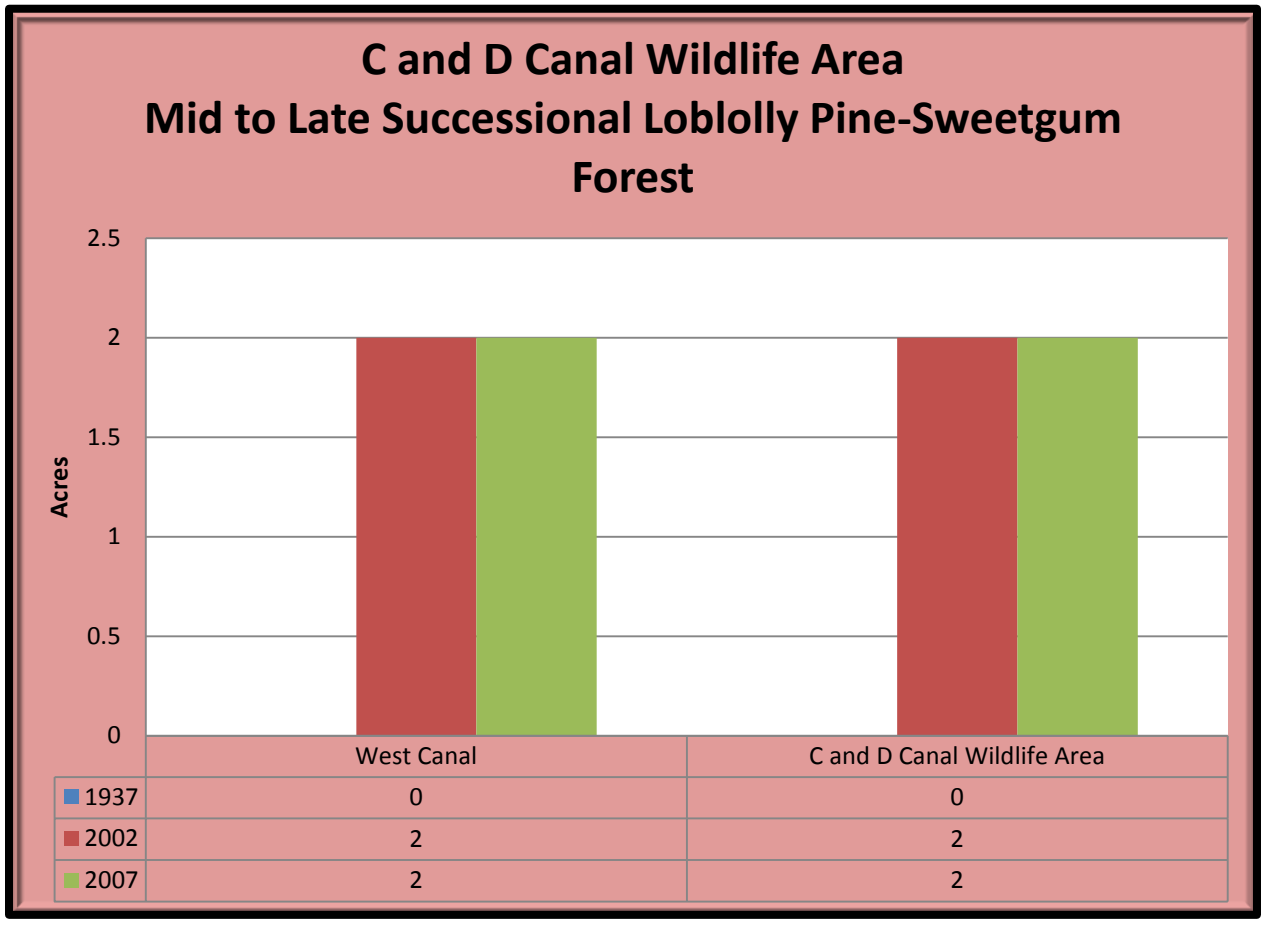


Figure 5.15. Mid to Late Successional Loblolly Pine-Sweetgum Forest at C and D Canal Wildlife Area (1937, 2002, and 2007)

DNREC Sea Level Rise Analysis (Table 5.34)

Mid to Late Successional Loblolly Pine-Sweetgum Forest is not affected by any of the sea level rise scenarios.

Table 5.34. Projected acres of Mid to Late Successional Loblolly Pine-Sweetgum Forest Impacted by Sea Level Rise

Rise	Acres
0.5 m	0 acres
1 m	0 acres
1.5 m	0 acres

Natural Capital (Table 5.35)

Capital in Mid to Late Successional Loblolly Pine-Sweetgum Forest has remained stable in the recent period (2002-2007).

Table 5.35. Natural Capital of Mid to Late Successional Loblolly Pine-Sweetgum Forest

Year	Natural Capital (in 2012 dollars)
1937	$0/year (not present)
2002	$378/year
2007	$378/year

North Atlantic Low Salt Marsh **[0.1 acres (Figure 5.16, Tables 5.36-5.37)] G5 S5**

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

Description

A very small amount of this community is located on the edge of Delaware Bay in the east canal section of the wildlife area. This community is dominated by salt meadow cordgrass (*Spartina alternifolia*), and associated by sea lavender (*Limonium carolinianum*), glasswort (*Salicornia* sp.), hastate orache (*Atriplex prostrata*), tidal marsh amaranth (*Amaranthus cannabinus*), and sweetscent (*Pluchea odorata*).

Analysis of Condition at C and D Canal Wildlife Area

This community has likely only recently come into the wildlife area with sea level rise and dredging on the Delaware River allowing more salinity to enter the bay. All of the current acreage came from the conversion of Cattail Brackish Tidal Marsh, which shows an increase of salinity in the area. As conditions become saltier there will likely be more of this community entering the marshlands.

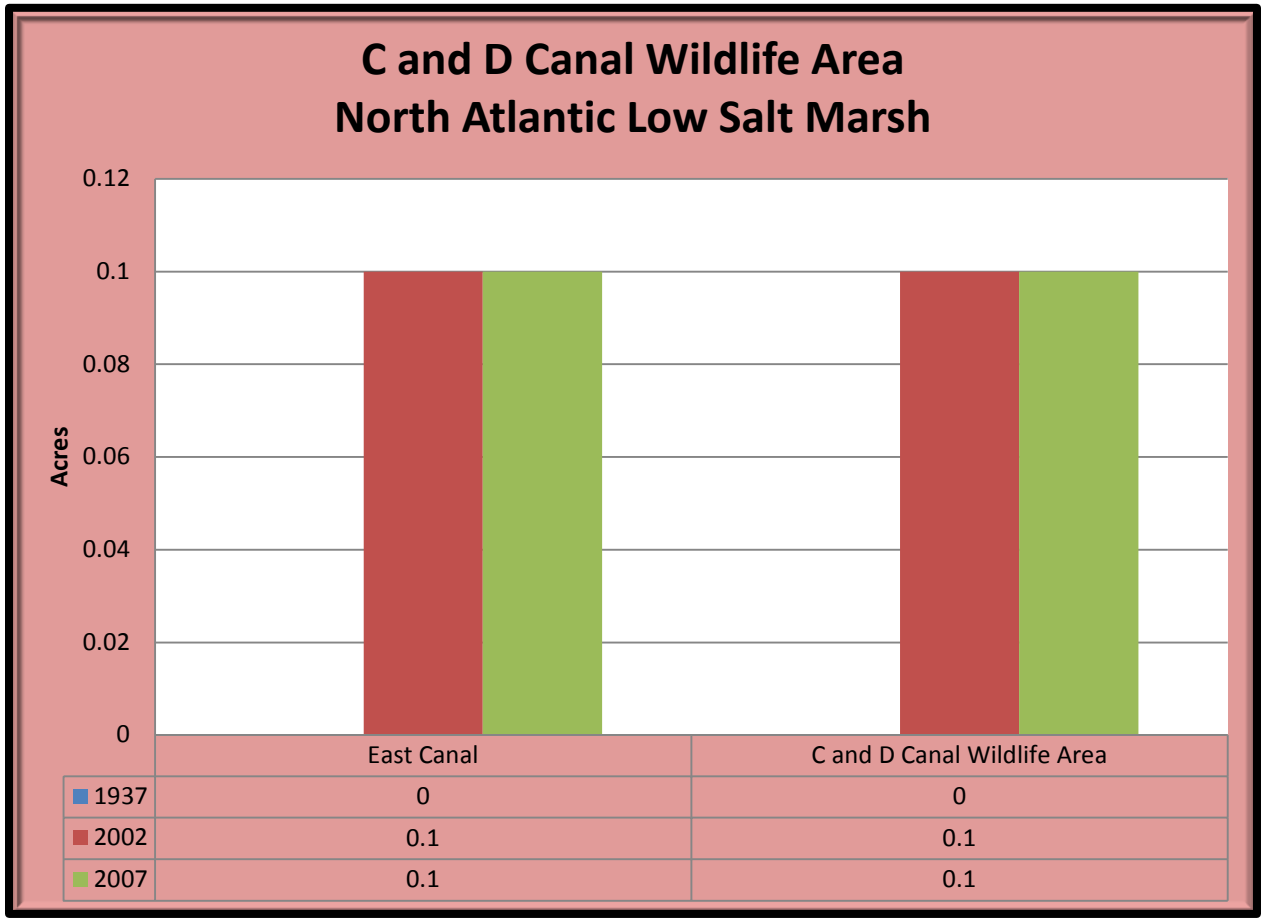


Figure 5.16. North Atlantic Low Salt Marsh at C and D Canal Wildlife Area (1937, 2002, and 2007)

DNREC Sea Level Rise Analysis (Table 5.36)

All of the current acreage will be inundated with 0.5 m of sea level rise.

Table 5.36. Projected acres of North Atlantic Low Salt Marsh Impacted by Sea Level Rise	
Rise	**Acres**
0.5 m	0.1 acres
1 m	0.1 acres
1.5 m	0.1 acres

Natural Capital (Table 5.37)

Capital in North Atlantic Low Salt Marsh has remained stable in the recent period (2002-2007).

Table 5.37. Natural Capital of North Atlantic Low Salt Marsh	
Year	**Natural Capital (in 2012 dollars)**
1937	$0/year (not present)
2002	$627/year
2007	$627/year

Northeastern Buttonbush Shrub Swamp **[0 acres (Figure 5.17, Tables 5.38-5.39)] G4G5 S1**

DEWAP: Shrub Swamps
NHC: Laurentian-Acadian Floodplain Forest

Description

This community was likely present in the Thousand Acre marsh area and tributaries in the middle canal section of the wildlife area in 1937 and has since disappeared. These shrublands are dominated by buttonbush (*Cephalanthus occidentalis*).

Analysis of Condition at C and D Canal Wildlife Area

This community is no longer present and has become 8 acres of Northeastern Modified Successional Forest and 2 acres of Northeastern Successional Shrubland through filling, and 1 acre each of water, Semi-impervious Surface, and riprap (Table 5.38).

Table 5.38. What was once Northeastern Buttonbush Shrub Swamp in 1937 has become X or remained in 2007

X	Acreage
Northeastern Modified Successional Forest	8 acres
Northeastern Successional Shrubland	2 acres
Water	1 acre
Semi-impervious Surface	1 acre
Riprap	1 acre
Other vegetation communities/land covers	1 acre

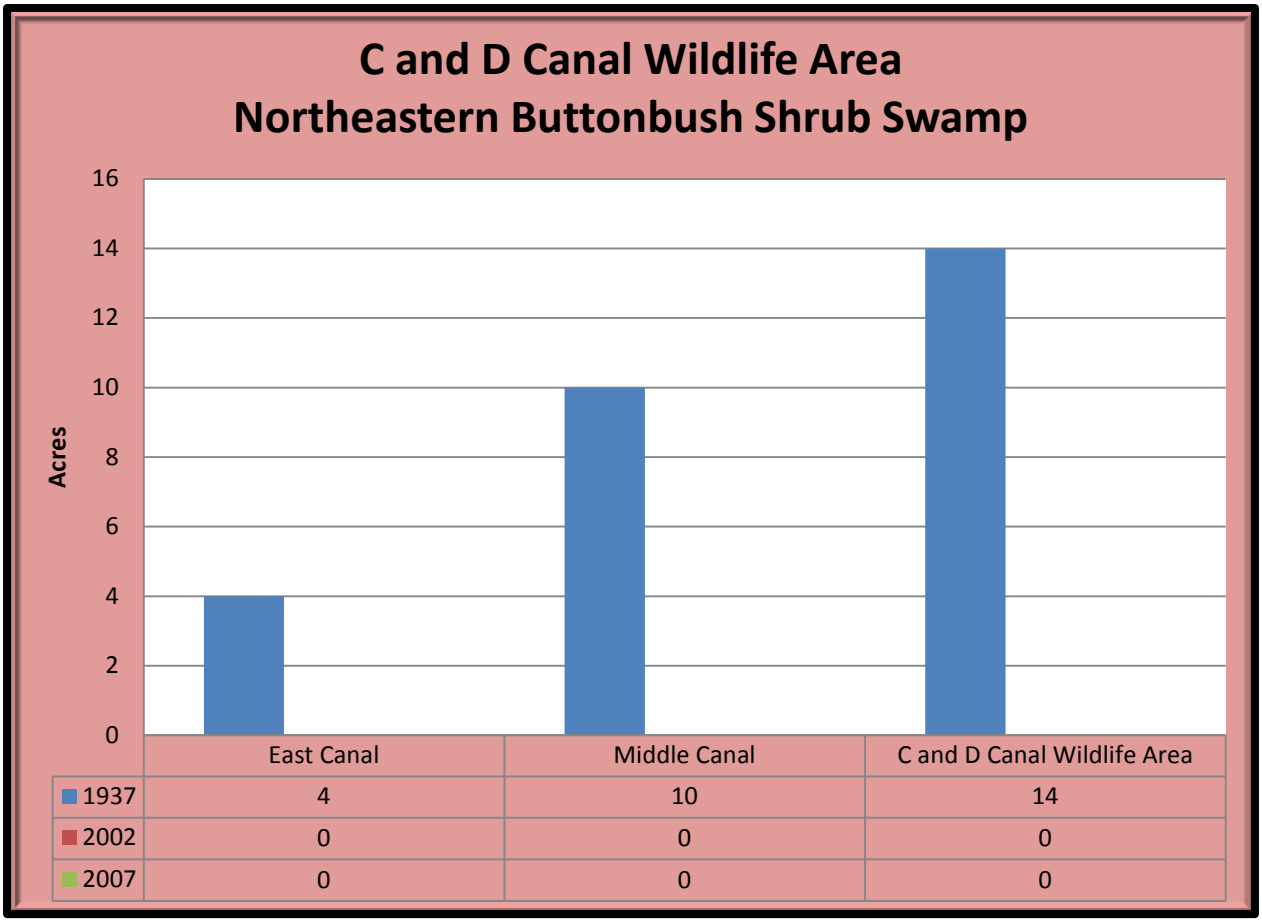


Figure 5.17. Northeastern Buttonbush Shrub Swamp at C and D Canal Wildlife Area (1937, 2002, and 2007)

Natural Capital (Table 5.39)

Northeastern Buttonbush Shrub Swamp does contain any more capital since it is no longer present in the wildlife area.

Table 5.39. Natural Capital of Northeastern Buttonbush Shrub Swamp	
Year	**Natural Capital (in 2012 dollars)**
1937	$129,940/year
2002	$0/year (not present)
2007	$0/year (not present)

Northeastern Modified Successional Forest **[1,297 acres (Figures 5.18-5.19, Tables 5.40-5.43)] GNA SNA**

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

Description

This is the most common forest community in the wildlife area and is typified by the presence of disturbance and infestations of exotic invasive plant species. Common canopy species include red maple (*Acer rubrum*), sweetgum (*Liquidambar styraciflua*), northern red oak (*Quercus rubra*), tuliptree (*Liriodendron tulipifera*), wild black cherry (*Prunus serotina*), willow oak (*Quercus phellos*), loblolly pine (*Pinus taeda*), and black locust (*Robinia pseudoacacia*). The understories are dense in most examples and include smaller members of the species above plus eastern red cedar (*Juniperus virginiana*), sassafras (*Sassafras albidum*), flowering dogwood (*Cornus florida*), and blackgum (*Nyssa sylvatica*). The shrub and vine layer is often composed of sweet pepperbush (*Clethra alnifolia*), common greenbrier (*Smilax rotundifolia*), Japanese honeysuckle (*Lonicera japonica*), poison ivy (*Toxicodendron radicans*), arrow-wood (*Viburnum dentatum*), winged euonymus (*Euonymus alata*), multiflora rose (*Rosa multiflora*), highbush blueberry (*Vaccinium corymbosum*), Oriental bittersweet (*Celastrus orbiculatus*), white-leaf greenbrier (*Smilax glauca*), and Ligustrum (*Ligustum sinense*). Common herbs include Japanese stiltgrass (*Microstegium vimineum*), pokeweed (*Phytolacca americana*), swan's sedge (*Carex swanii*), Virginia creeper (*Parthenocissus quinquefolia*), ground pine (*Dendrolycopodium obscurum*), cinnamon fern (*Osmunda cinnamomea*), and netted chainfern (*Woodwardia areolata*).

Figure 5.18. Northeastern Modified Successional Forest

Nearly all of the occurrences of this community in the wildlife area range from early to mid-successional. These communities are heavily invaded by exotic invasive plants and do not contain the natural layering you expect from a forest.

Analysis of Condition at C and D Canal Wildlife Area

This forest community has been gaining acreage in all sections as exotic invasive species become more prevalent. Until the invasive species are controlled, this forest type will at some point be the only one present in the wildlife area.

Thirty-four of the original 81 acres from 1937 were present in 2007. The rest of the acreage has become 10 acres of Northeastern Old Field, 9 acres of Common Reed Upland Temperate Vegetation, 8

acres of Chesapeake Bay Non-riverine Wet Hardwood Forest, and 4 acres of Reed Tidal Marsh (Table 5.40).

Since 1937, this community has expanded into a number of other communities, becoming the largest community in the wildlife area. This community has matured from a number of communities or land covers including 473 acres of agricultural field, 269 acres of Northeastern Old Field, 218 acres of Modified Land, 149 acres of bare sand, and 57 acres of Northeastern Successional Shrubland (Table 5.41).

Table 5.40. What was once Northeastern Modified Successional Forest in 1937 has become X or remained in 2007

X	Acreage
Northeastern Modified Successional Forest	34 acres
Northeastern Old Field	10 acres
Common Reed Upland Temperate Vegetation	9 acres
Chesapeake Bay Non-riverine Wet Hardwood Forest	8 acres
Reed Tidal Marsh	4 acres
Other vegetation communities/land covers	11 acres

Table 5.41. Northeastern Modified Successional Forest has migrated into X or remained since 1937

X	Acreage
Agricultural Field	473 acres
Northeastern Old Field	269 acres
Modified Land	218 acres
Bare Sand	149 acres
Northeastern Successional Shrubland	57 acres
Other communities/land covers	97 acres

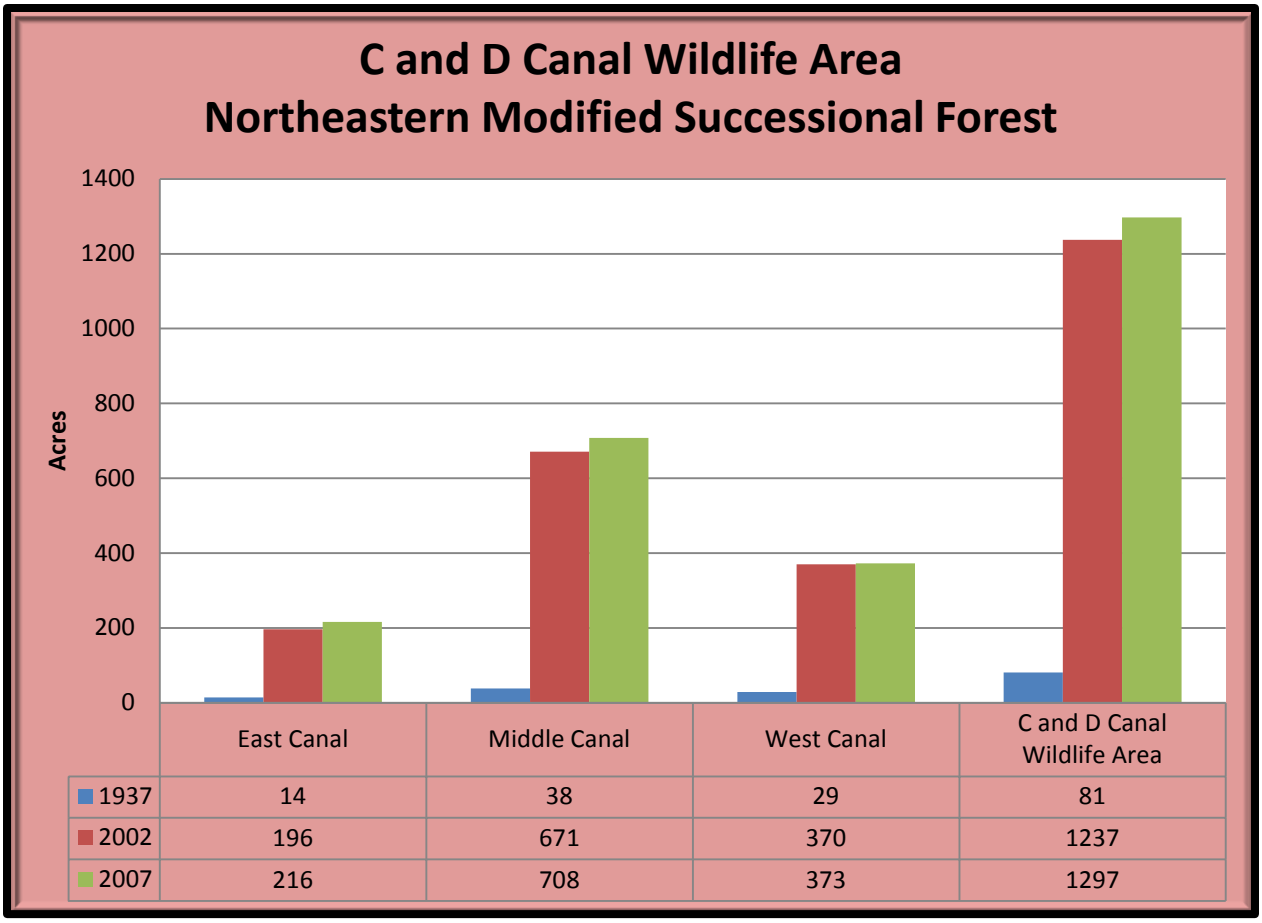


Figure 5.19. Northeastern Modified Successional Forest at C and D Canal Wildlife Area (1937, 2002, and 2007)

DNREC Sea Level Rise Analysis (Table 5.42)

Most of the occurrences of Northeastern Modified Successional Forest are located in places of higher elevation and on slopes overlooking the canal. As such very little of the current extent of this community will be impacted by sea level rise.

Table 5.42. Projected acres of Northeastern Modified Successional Forest Impacted by Sea Level Rise	
Rise	**Acres**
0.5 m	17 acres
1 m	40 acres
1.5 m	60 acres

Natural Capital (Table 5.43)

Capital of Northeastern Modified Successional Forest has been going up with the spread of exotic invasive plant species.

Table 5.43. Natural Capital of Northeastern Modified Successional Forest	
Year	**Natural Capital (in 2012 dollars)**
1937	$15,317/year
2002	$233,917/year
2007	$245,263/year

Northeastern Old Field **[854 acres (Figures 5.20-5.21, Tables 5.44-5.47)]GNA SNA**

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

Description

Figure 5.20. Northeastern Old Field

Many fields are present in the C and D Canal wildlife area. Most of the fields are composed of goldenrod (*Solidago* sp.), sweet clover (*Melilotus officinalis*), Amaranth (*Amaranthus* sp.), tall fescue (*Festuca rubra*), morning glory (*Ipomoea* sp.), and red clover (*Trifolium pratense*).

Analysis of Condition at C and D Canal Wildlife Area

The amount of Northeastern Old Field present in wildlife area has remained roughly stable with some areas losing field and others gaining it. This cycle will likely continue into the foreseeable future since this is a working landscape. Since Northeastern Old Fields tend to be ephemeral, a lot of the original acreage from 1937 has matured into other communities leaving only 106 acres of the 1937 acreage present in 2007. The rest of the acres have become 269 acres of Northeastern Modified Successional Forest, 73 acres Eastern Reed Marsh, 73 acres of Common Reed Upland Temperate Vegetation, and 63 acres of Northeastern Successional Shrubland (Table 5.44).

Since 1937, Northeastern Old Fields have appeared in 565 acres of former agricultural field, 105 acres of modified land, 30 acres of bare sand, and 17 acres of impoundment (Table 5.45).

Table 5.44. What was once Northeastern Old Field in 1937 has become X or remained in 2007	
X	**Acreage**
Northeastern Modified Successional Forest	269 acres
Northeastern Old Field	106 acres
Eastern Reed Marsh	73 acres
Common Reed Upland Temperate Vegetation	73 acres
Northeastern Successional Shrubland	63 acres
Other vegetation communities/land covers	209 acres

Table 5.45. Northeastern Old Field has migrated into X or remained since 1937	
X	**Acreage**
Agricultural Field	565 acres
Northeastern Old Field	106 acres
Modified Land	105 acres
Bare Sand	30 acres
Impoundment	17 acres
Other communities/land covers	31 acres

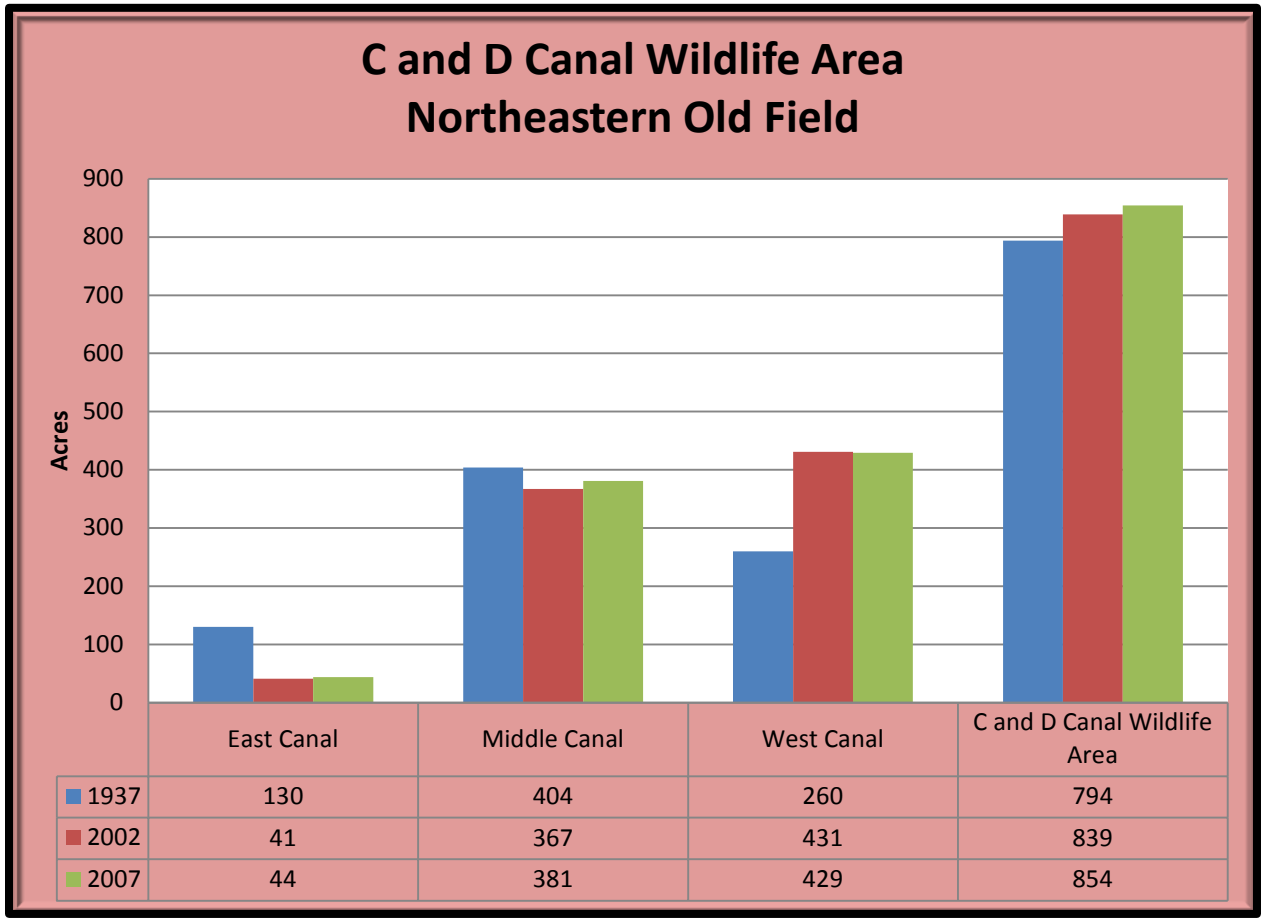


Figure 5.21. Northeastern Old Field at C and D Canal Wildlife Area (1937, 2002, and 2007)

DNREC Sea Level Rise Analysis (Table 5.46)

Like the Northeastern Modified Successional Forest, most of the occurrences of this community are located in places of higher elevation. A small amount of this community will be impacted by sea level rise.

Table 5.46. Projected acres of Northeastern Old Field Impacted by Sea Level Rise	
Rise	**Acres**
0.5 m	13 acres
1 m	20 acres
1.5 m	26 acres

Natural Capital (Table 5.47)

Capital in Northeastern Old Field has been going up as more agricultural fields and modified land grows into this community.

Table 5.47. Natural Capital of Northeastern Old Field	
Year	**Natural Capital (in 2012 dollars)**
1937	$115,686/year
2002	$122,242/year
2007	$124,428/year

Northeastern Successional Shrubland **[455 acres (Figure 5.22, Tables 5.48-5.51)] GNA SNA**

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

Description

This shrub community is composed of shrubs present in the Northeastern Modified Successional Forest such as multiflora rose (*Rosa multiflora*), Japanese honeysuckle (*Lonicera japonica*), Oriential bittersweet (*Celastrus orbiculatus*), blackberry (*Rubus* sp.), and ligustrum (*Ligustrum sinense*).

Analysis of Condition at C and D Canal Wildlife Area

This community has gained in amount since the 1930's, with only recent losses. A lot of the gains have likely come as the result of the planting of borders for wildlife in fields. This community will likely persist in some amount well into the future.

Showing the tendency of this community to mature to forest; only 8 acres of the original 104 acres from 1937 were present in 2007. The remainder of the acreage has matured to 57 acres of Northeastern Modified Successional Forest, 8 acres of Semi-impervious surface have been developed, 6 acres have become Northeastern Old Field, and 5 acres have been inundated by water (Table 5.48).

Since 1937, Northeastern Successional Shrubland has matured from 171 acres of agricultural field, 123 acres of modified land, 63 acres of Northeastern Old Field and 39 acres of bare sand. Eleven acres have been developed into impoundment (Table 5.49).

Table 5.48. What was once Northeastern Successional Shrubland in 1937 has become X or remained in 2007

X	**Acreage**
Northeastern Modified Successional Forest	57 acres
Semi-impervious Surface	8 acres
Northeastern Successional Shrubland	8 acres
Northeastern Old Field	6 acres
Water	5 acres
Other vegetation communities/land covers	20 acres

Table 5.49. Northeastern Successional Shrubland has migrated into X or remained since 1937	
X	**Acreage**
Agricultural Field	171 acres
Modified Land	123 acres
Northeastern Old Field	63 acres
Bare Sand	39 acres
Impoundment	11 acres
Other communities/land covers	49 acres

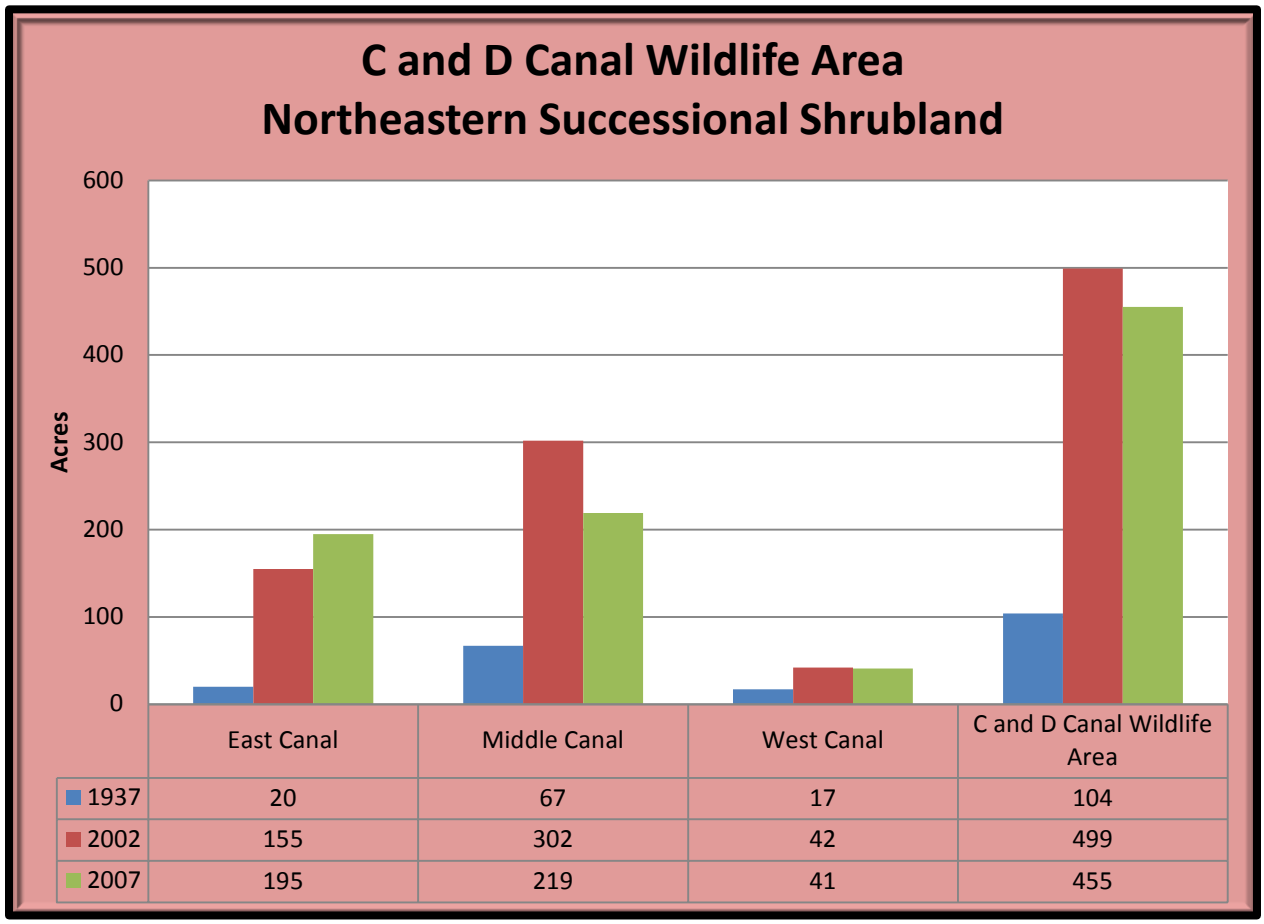


Figure 5.22. Northeastern Successional Shrubland at C and D Canal Wildlife Area (1937, 2002, and 2007)

DNREC Sea Level Rise Analysis (Table 5.50)

Little of the current Northeastern Successional Shrubland will be impacted by sea level rise, even at 1.5 m of rise.

Table 5.50. Projected acres of Northeastern Successional Shrubland Impacted by Sea Level Rise	
Rise	**Acres**
0.5 m	3 acres
1 m	11 acres
1.5 m	20 acres

Natural Capital (Table 5.51)

Capital in Northeastern Successional Shrubland has largely increased from 1937, with slight dip with a loss in acreage in the recent period (2002-2007).

Table 5.51. Natural Capital of Northeastern Successional Shrubland	
Year	**Natural Capital (in 2012 dollars)**
1937	$15,153/year
2002	$72,704/year
2007	$66,294/year

Pickerelweed Tidal Marsh **[0 acres (Figure 5.23, Tables 5.52-5.53)]** **G5 S5**

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

Description

This community was once the most common marsh type in the wildlife area and was found in the Thousand Acre Marsh area of the east section. Changes in salinity and sea level have likely resulted in the demise of this community. This community today is now prevalent in the upper reaches of the Appoquinimink River and Drawyers Creek. This community is co-dominated by arrow-arum (*Peltandra virginica*) and pickerelweed (*Pontederia cordata*) and associated by wild rice (*Zizania aquatica*), broadleaf arrowhead (*Sagittaria latifolia*), halbeard-leaf tearthumb (*Polygonum arifolium*), mild water pepper (*Polygonum hydropiperoides*), and arrow-leaved tearthumb (*Polygonum sagittatum*).

Analysis of Condition at C and D Canal Wildlife Area

This community is no longer known to be present in the wildlife area. It could still reside in some limited areas in the upper reaches of Thousand Acre Marsh or could reform if the tidal structures are removed and slightly more salinity is allowed into the current freshwater marshes. The area that once was this community has become 126 acres of Reed Tidal Marsh, 121 acres of Eastern Reed Marsh, 32 acres of water, 9 acres of Northeastern Successional Shrubland, and 9 acres of Northeastern Modified Successional Forest (Table 5.52).

Table 5.52. What was once Pickerelweed Tidal Marsh in 1937 has become X or remained in 2007

X	**Acreage**
Reed Tidal Marsh	126 acres
Eastern Reed Marsh	121 acres
Water	32 acres
Northeastern Successional Shrubland	9 acres
Northeastern Modified Successional Forest	9 acres
Other vegetation communities/land covers	25 acres

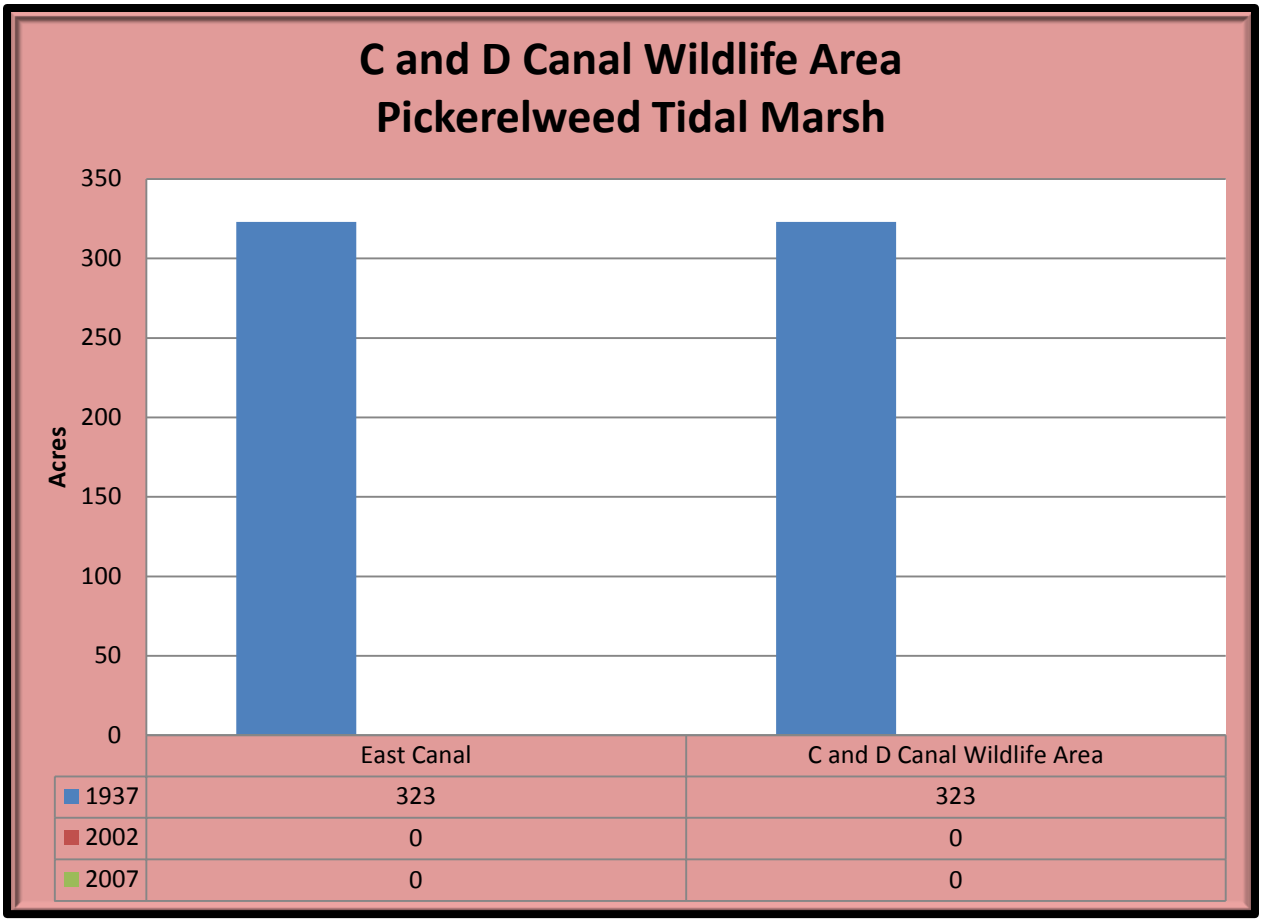


Figure 5.23. Pickerelweed Tidal Marsh at C and D Canal Wildlife Area (1937, 2002, and 2007)

Natural Capital (Table 5.53)

This community is no longer present in the wildlife and all of the capital has been transferred mostly to other marsh communities.

Table 5.53. Natural Capital of Pickerelweed Tidal Marsh	
Year	**Natural Capital (in 2012 dollars)**
1937	$2,025,630/year
2002	$0/year (not present)
2007	$0/year (not present)

Reed Tidal Marsh **[279 acres (Figure 5.24, Tables 5.54-5.57)] GNR S1.1**

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

Description

This tidal marsh is nearly completely dominated by common reed (*Phragmites australis*).

Analysis of Condition at C and D Canal Wildlife Area

All of the acreage from 1937 was still present in 2007 (Table 5.54). Since 1937, this marsh has greatly expanded taking over 126 acres of Pickerelweed Tidal Marsh, 104 acres of Cattail Brackish Tidal Marsh, 16 acres of agricultural field, and 7 acres each of Northeastern Old Field and Modified Land (Table 5.55).

Table 5.54. What was once Reed Tidal Marsh in 1937 has become X or remained in 2007	
X	**Acreage**
Reed Tidal Marsh	1 acres

Table 5.55. Reed Tidal Marsh has migrated into X or remained since 1937	
X	**Acreage**
Pickerelweed Tidal Marsh	126 acres
Cattail Brackish Tidal Marsh	104 acres
Agricultural Field	16 acres
Northeastern Old Field	7 acres
Modified Land	7 acres
Other communities/land covers	20 acres

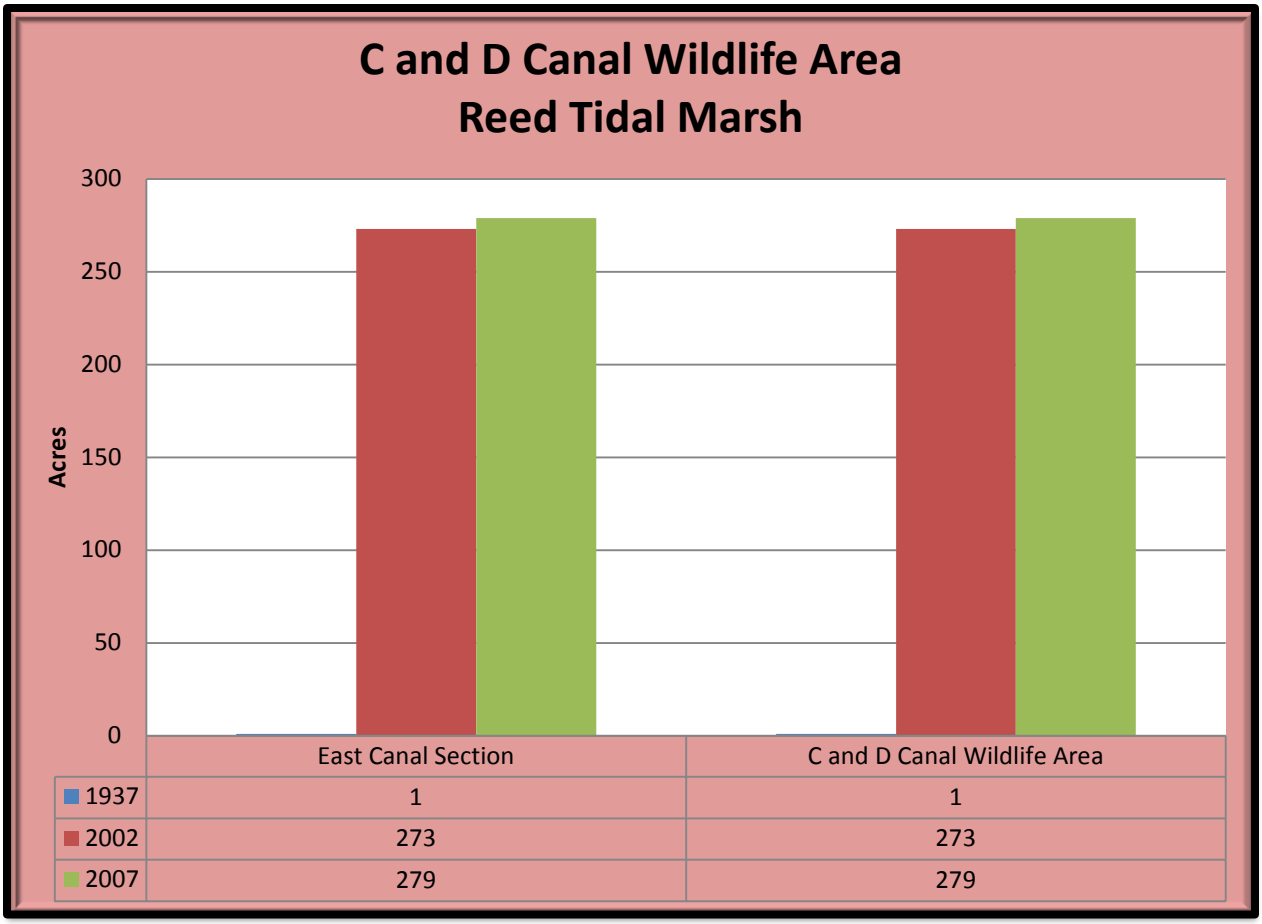


Figure 5.24. Reed Tidal Marsh at C and D Canal Wildlife Area (1937, 2002, and 2007)

DNREC Sea Level Rise Analysis (Table 5.56)

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

Table 5.56. Projected acres of Reed Tidal Marsh Impacted by Sea Level Rise	
Rise	**Acres**
0.5 m	226 acres
1 m	262 acres
1.5 m	275 acres

Natural Capital (Table 5.57)

Capital of Reed Tidal Marsh has been increasing with the spread of common reed (*Phragmites australis*) through the marshes.

Table 5.57. Natural Capital of Reed Tidal Marsh	
Year	**Natural Capital (in 2012 dollars)**
1937	$6,271/year
2002	$1,712,065/year
2007	$1,749,693/year

River Bulrush Flooded Grassland **[0 acres (Figure 5.25, Tables 5.58-5.59)] GNR S1.1**

DEWAP: Freshwater Tidal Marshes
NHC: Laurentian-Acadian Freshwater Marsh

Description

A likely signature of this community is present in a small area of Thousand Acre Marsh in 1937. Like all of the other strictly freshwater marshes it has disappeared from the wildlife area. This marsh if present in 1937 was a marsh dominated nearly completely by river bulrush (*Scirpus fluviatilis*). This marsh, which was once prevalent throughout the tributaries to the Delaware Bay, now only exists in one location on the upper part of the Christina River above Wilmington.

Analysis of Condition at C and D Canal Wildlife Area

This marsh is no longer present in the wildlife area. What was once this community has been filled in and has become 0.5 acres of Northeastern Modified Successional Forest, 0.1 acres of riprap, 0.1 acres of Semi-impervious Surface, and 0.1 acres of water (Table 5.58).

Table 5.58. What was once River Bulrush Flooded Grassland in 1937 has become X or remained in 2007

X	**Acreage**
Northeastern Modified Successional Forest	0.5 acres
Riprap	0.1 acres
Semi-impervious Surface	0.1 acres
Water	0.1 acres

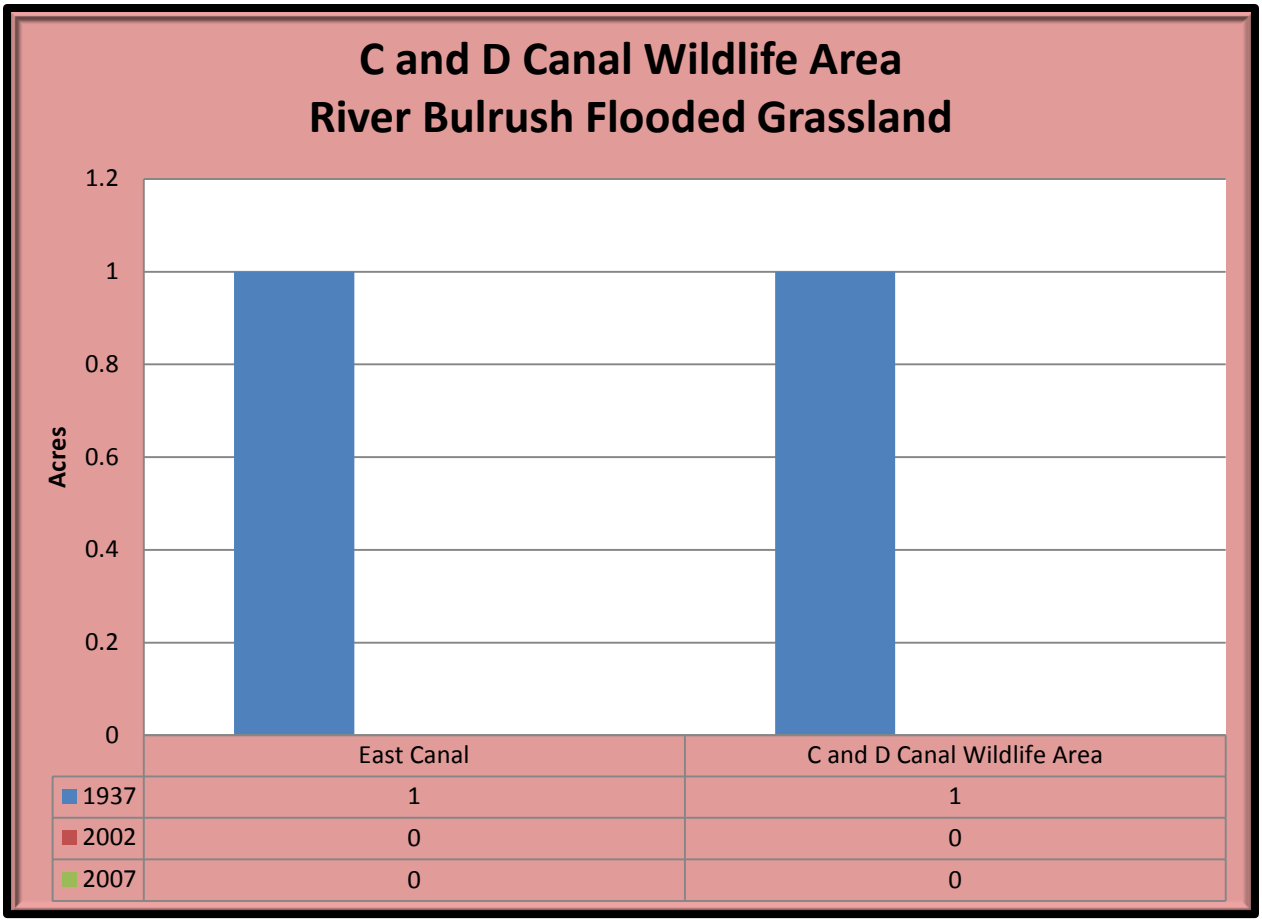


Figure 5.25. River Bulrush Flooded Grassland at C and D Canal Wildlife Area (1937, 2002, and 2007)

Natural Capital (Table 5.59)

This community is no longer present in the wildlife and all of the capital has been transferred to forest communities, resulting in a capital loss to the wildlife area as a whole.

Table 5.59. Natural Capital of River Bulrush Flooded Grassland	
Year	**Natural Capital (in 2012 dollars)**
1937	$6,271/year
2002	$0/year (not present)
2007	$0/year (not present)

Successional Maritime Forest **[1 acre (Figure 5.26, Tables 5.60-5.62)] G2G3 S3**

DEWAP: Dune Forests and Woodlands
NHC: Northern Atlantic Coastal Plain Maritime Forest

Description

These stunted forest communities are found in maritime areas where there is exposure to salt spray and occasional flooding by brackish water. A small area of this community is located adjacent to Delaware Bay in the East Canal section of the wildlife area. Since this area was determined aerially a direct species list was not obtained. Typically these communities contain a stunted canopy of persimmon (*Diospyros virginiana*), sassafras (*Sassafras albidum*), wild black cherry (*Prunus serotina*), and white oak (*Quercus alba*). Understory species may include smaller members of the canopy plus northern bayberry (*Morella pennsylvanica*). Often there are dense areas of common greenbrier (*Smilax rotundifolia*). Few herbs are in this community and generally include speargrass (*Chasmanthium laxum*).

Analysis of Condition at C and D Canal Wildlife Area

Successional Maritime Forest has populated a former Pickerelweed Tidal Marsh since 1937 (Table 5.60). This was likely through fill of the marsh.

Table 5.60. Successional Maritime Forest has migrated into X or remained since 1937

X	Acreage
Pickerelweed Tidal Marsh	1 acre

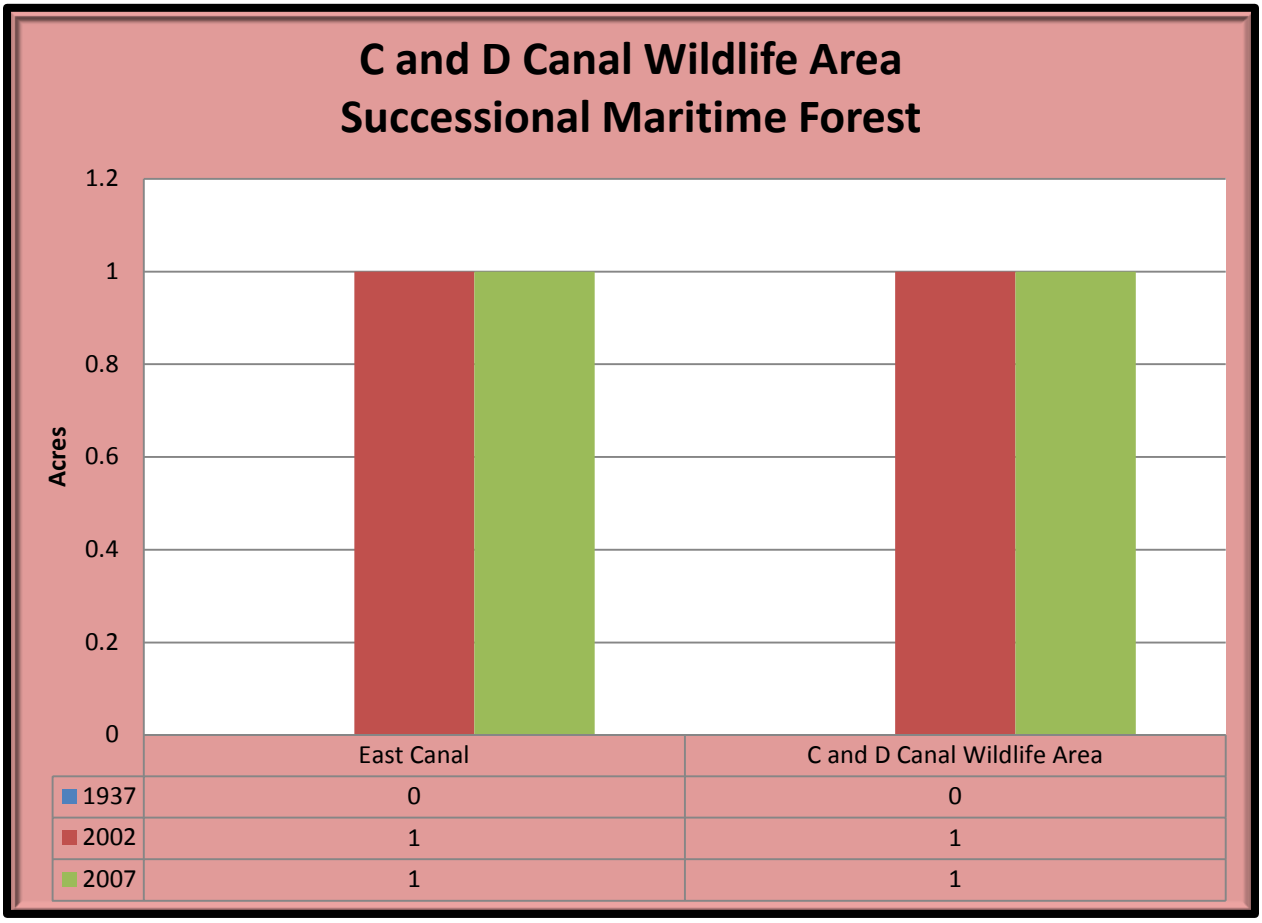


Figure 5.26. Successional Maritime Forest at C and D Canal Wildlife Area (1937, 2002, and 2007)

DNREC Sea Level Rise Analysis (Table 5.61)

All of the current extent of Successional Maritime Forest will be inundated with 0.5 m of sea level rise.

Table 5.61. Projected acres of Successional Maritime Forest Impacted by Sea Level Rise	
Rise	**Acres**
0.5 m	1 acre
1 m	1 acre
1.5 m	1 acre

Natural Capital (Table 5.62)

Successional Maritime Forest was not present in 1937, but has come about since. Its capital has remained stable in the recent period (2002-2007).

Table 5.62. Natural Capital of Successional Maritime Forest	
Year	**Natural Capital (in 2012 dollars)**
1937	$0/year (not present)
2002	$189/year
2007	$189/year

Virginia Pine Successional Forest **[2 acres (Figures 5.27-5.28, Tables 5.63-5.65)] GNA SNA**

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

Description

This successional forest is composed of a dense thicket of young age Virginia pine (*Pinus virginiana*). Very little understory is present and common shrubs and vines include common greenbrier (*Smilax rotundifolia*), and low-bush blueberry (*Vaccinium pallidum*). No herbs are present.

Figure 5.27. Virginia Pine Successional Forest

Analysis of Condition at C and D Canal Wildlife Area

Virginia Pine Successional Forest has grown into the wildlife area from 1 acre or less each of agricultural field, modified land, and cultivated lawn (Table 5.63).

Table 5.63. Virginia Pine Successional Forest has migrated into X or remained since 1937	
X	**Acreage**
Agricultural Field	1 acre
Modified Land	1 acre
Cultivated Lawn	1 acre

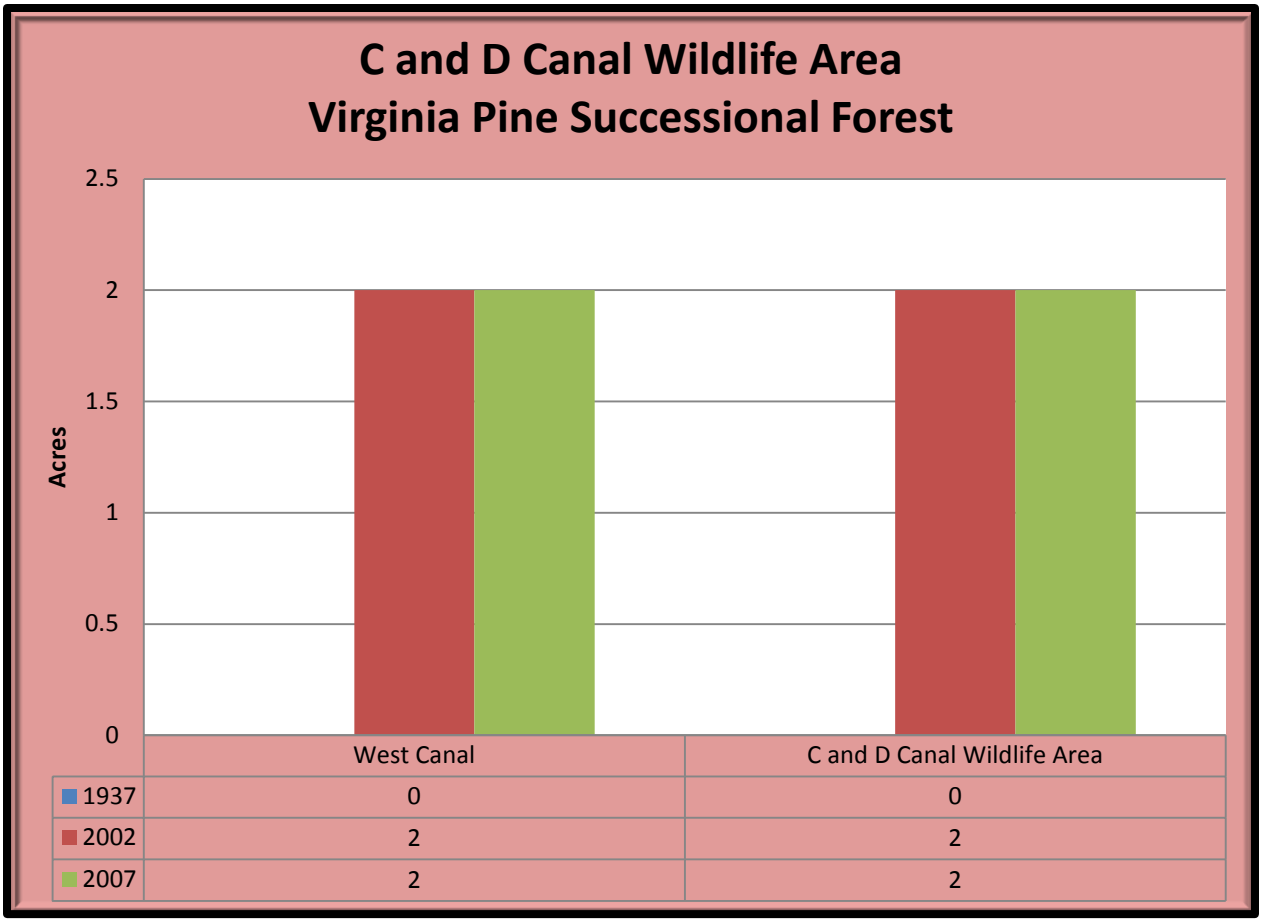


Figure 5.27. Virginia Pine Successional Forest at C and D Canal Wildlife Area (1937, 2002, and 2007)

DNREC Sea Level Rise Analysis

Virginia Pine Successional Forest will not be impacted in any of the sea level rise scenarios.

Natural Capital (Table 5.64)

Capital of Virginia Pine Successional Forest has been stable since 2002.

Table 5.64. Natural Capital of Virginia Pine Successional Forest	
Year	**Natural Capital (in 2012 dollars)**
1937	$0/year (not present)
2002	$378/year
2007	$378/year

CHAPTER 6: DESCRIPTIONS AND ANALYSIS OF THE LAND COVERS

Land covers are those areas that are not 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. Agricultural Field—159 acres
2. Bare Sand—8 acres
3. Beach—0.2 acres
4. Farm Pond/Artificial Pond—18 acres
5. Impervious Surface—33 acres
6. Impoundment—72 acres
7. Modified Land—171 acres
8. Riprap—66 acres
9. Semi-impervious Surface—178 acres
10. Tidal Mudflat—2 acres
11. Water—144 acres

Agricultural Field **[159 acres (Figure 6.1, Tables 6.1-6.4)]**

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

Description

This land covers includes those places that are planted in row crops or other commodity crops.

Analysis of Condition at C and D Canal Wildlife Area

Agricultural fields were once more common in the wildlife area and have since been reduced to less than 10% of what they were in 1937. Only 112 acres of the original 1937 acreage was still present in 2007. The rest of the fields have become 565 acres of Northeastern Old Field, 473 acres of Northeastern Modified Successional Forest, 171 acres of Northeastern Successional Shrubland, 151 acres of Eastern Reed Marsh, and 114 acres of Common Reed Temperate Vegetation (Table 6.1).

Since 1937, agricultural fields have been places in 22 acres of bare sand, 19 of Northeastern Old Field, 5 acres of Northeastern Successional Shrubland, and 1 acre of modified land (Table 6.2).

Table 6.1. What was once Agricultural Field in 1937 has become X or remained in 2007

X	Acreage
Northeastern Old Field	565 acres
Northeastern Modified Successional Forest	473 acres
Northeastern Successional Shrubland	171 acres
Eastern Reed Marsh	151 acres
Common Reed Upland Temperate Vegetation	114 acres
Other vegetation communities/land covers	410 acres

Table 6.2. Agricultural Field has migrated into X or remained since 1937

X	Acreage
Agricultural Field	112 acres
Bare Sand	22 acres
Northeastern Old Field	19 acres
Northeastern Successional Shrubland	5 acres
Modified Land	1 acre
Other communities/land covers	1 acre

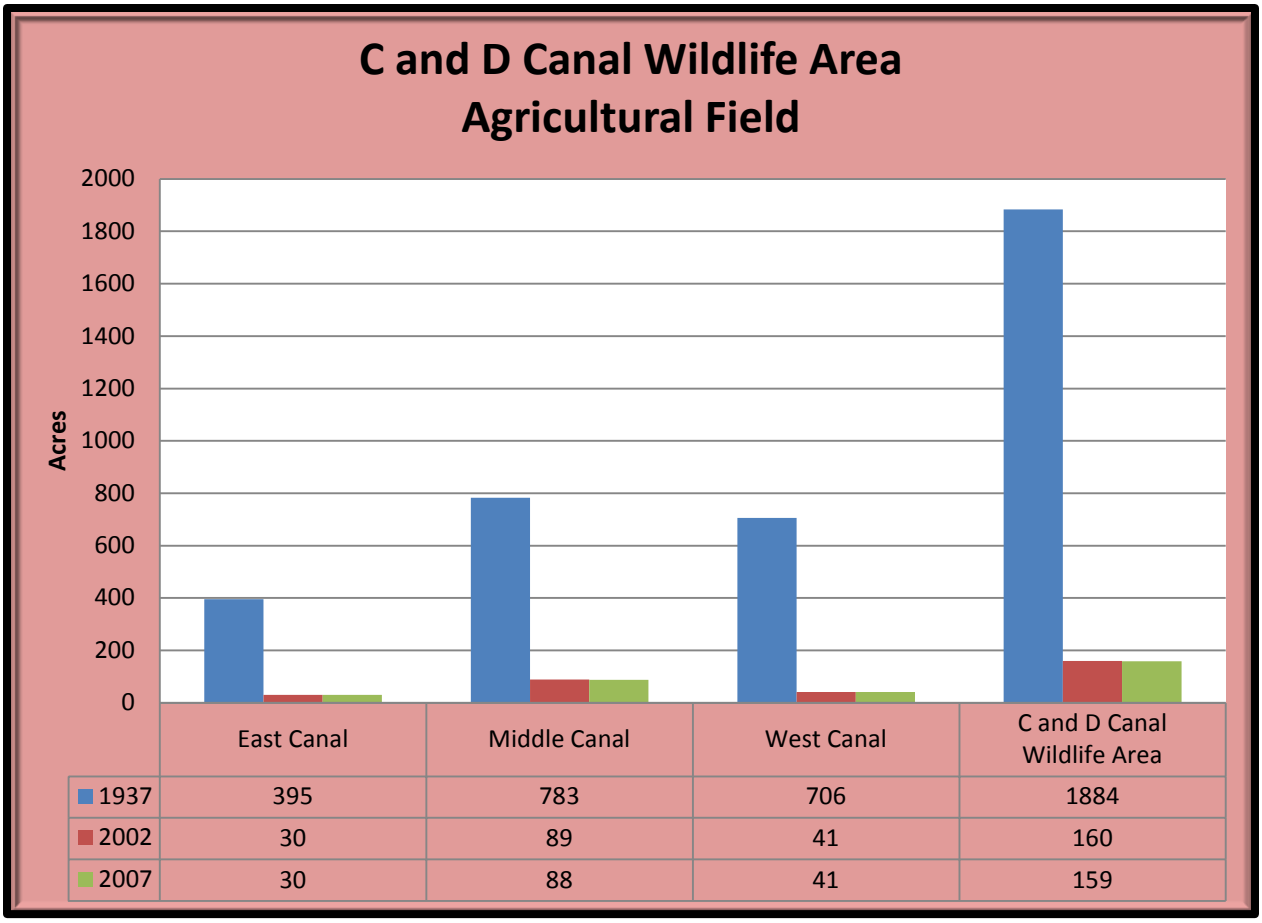


Table 6.1. Agricultural Field at C and D Canal Wildlife Area (1937, 2002, and 2007)

DNREC Sea Level Rise Anlaysis (Table 6.3)

A little more than 10% of the current agricultural land will be impacted by 1.5 m of sea level rise.

Table 6.3. Projected acres of Agricultural Field Impacted by Sea Level Rise	
Rise	**Acres**
0.5 m	0.5 acres
1 m	15 acres
1.5 m	22 acres

Natural Capital (Table 6.4)

Capital of agricultural field has gone down sharply with the abandonment of agricultural land.

Table 6.4. Natural Capital of Agricultural Field	
Year	**Natural Capital (in 2012 dollars)**
1937	$108,047/year
2002	$9,176/year
2007	$9,119/year

Bare Sand **[8 acres (Figure 6.2, Tables 6.5-6.6)]**

DEWAP: No Equivalent Classification
NHC: No Equivalent Classification

Description

Bare sand includes those areas that are bare of vegetation such as fill areas or borrow pits.

Analysis of Condition at C and D Canal Wildlife Area

None of the bare sand from 1937 still existed in 2007. What was bare sand has become 149 acres of Northeastern Modified Successional Forest, 29 acres of Northeastern Successional Shrubland, 33 acres of Eastern Reed Marsh, 30 acres of Northeastern Old Field, and 26 acres of Modified Land (Table 6.5).

Since 1937, bare sand has come into 4 acres of Northeastern Old Field, 2 acres of agricultural field, 1 acre of cultivated lawn, and 1 acre of modified land (Table 6.6).

Table 6.5. What was once Bare Sand in 1937 has become X or remained in 2007	
X	**Acreage**
Northeastern Modified Successional Forest	149 acres
Northeastern Successional Shrubland	39 acres
Eastern Reed Marsh	33 acres
Northeastern Old Field	30 acres
Modified Land	26 acres
Other vegetation communities/land covers	103 acres

Table 6.6. Bare Sand has migrated into X or remained since 1937	
X	**Acreage**
Northeastern Old Field	4 acres
Agricultural Field	2 acres
Cultivated Lawn	1 acre
Northeastern Successional Shrubland	1 acre
Modified Land	1 acre

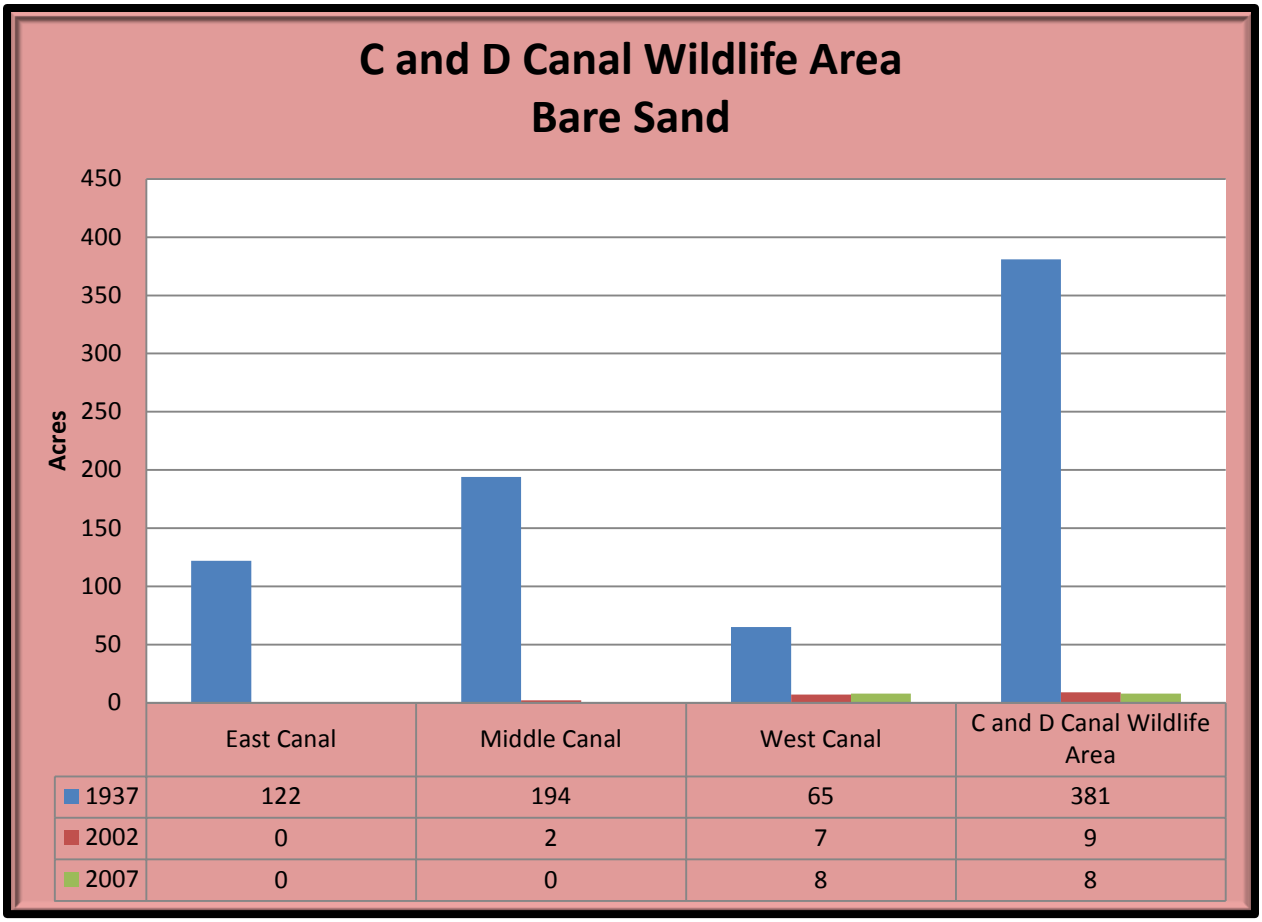


Figure 6.2. Bare Sand at C and D Canal Wildlife Area (1937, 2002, and 2007)

DNREC Sea Level Rise Analysis

None of the current bare sand areas will be impacted by 1.5 m of sea level rise.

Natural Capital

Bare sand does not have any natural capital value.

Beach **[0.2 acres, (Figure 6.3, Tables 6.7-6.8)]**

DEWAP: Un-vegetated Sandy Beach
NHC: No Equivalent Classification

Description

This land covers includes open sandy places that front a water body.

Analysis of Condition at C and D Canal Wildlife Area

Beach has developed since 1937 in the wildlife area by taking 0.1 acres each of water and Cattail Brackish Tidal Marsh (Table 6.7).

Table 6.7. Beach has migrated into X or remained since 1937	
X	**Acreage**
Water	0.1 acres
Cattail Brackish Tidal Marsh	0.1 acres

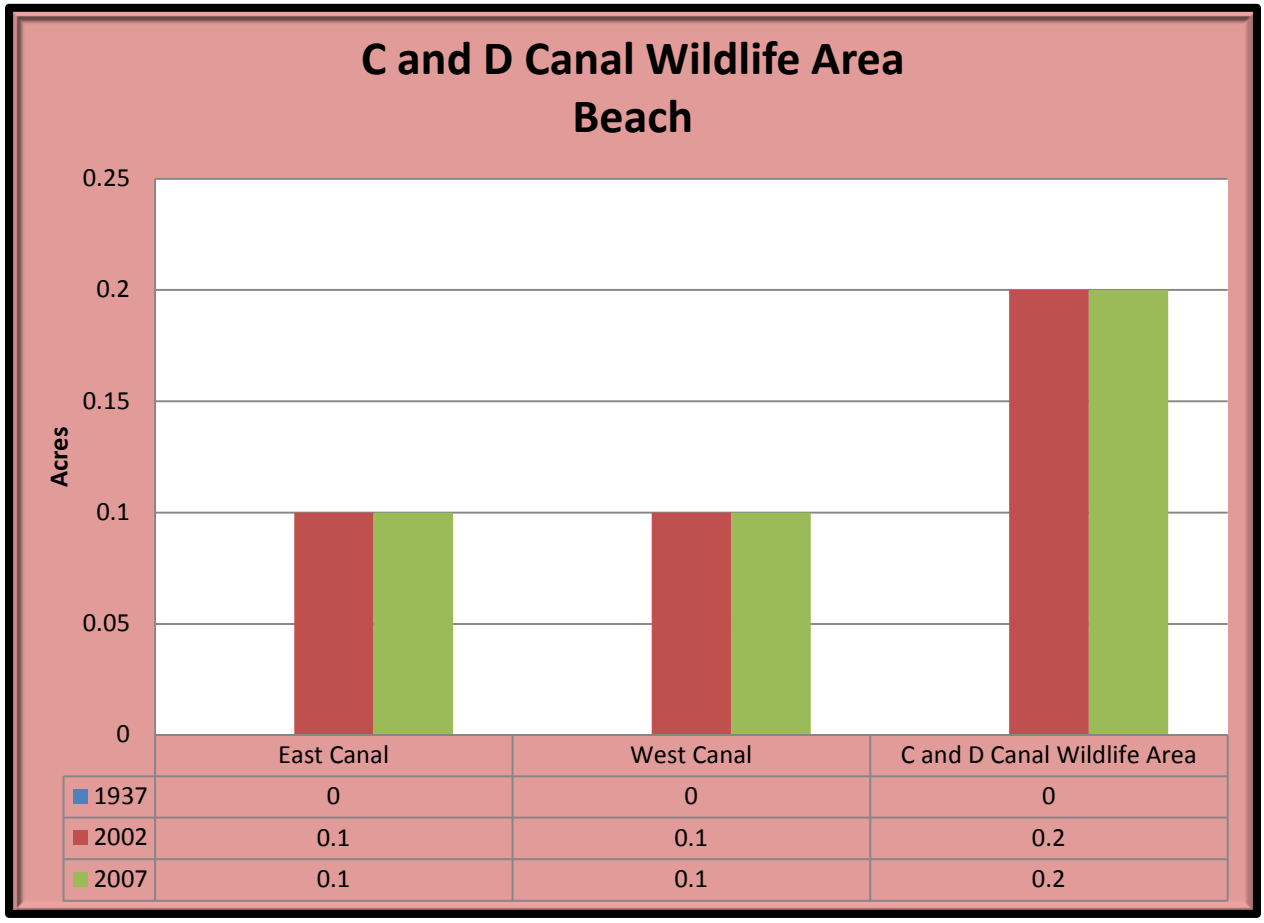


Figure 6.3. Beach at C and D Canal Wildlife Area (1937, 2002, and 2007)

DNREC Sea Level Rise Analysis (Table 6.8)

All of the current acreage of beach will be inundated with 0.5 m of sea level rise.

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

Natural Capital

Beach does not have any natural capital value.

Farm Pond/Artificial Pond **[18 acres, (Table 5.4)]**

DEWAP: Impoundment
NHC: No Equivalent Classification

Description

Farm ponds/artificial ponds include water bodies that are 5 acres or less in size.

Analysis of Condition at C and D Canal Wildlife Area

All of the acreage from 1937 has become an Eastern Reed Marsh (Table 6.9). Since 1937, farm ponds have been developed in 9 acres of agricultural field, 4 acres of modified land, 3 acres of cultivated lawn, 1 acre of Northeastern Modified Successional Forest, and 1 acre of Northeastern Old Field (Table 6.10).

Table 6.9. What was once Farm Pond/Artificial Pond in 1937 has become X or remained in 2007	
X	**Acreage**
Eastern Reed Marsh	22 acres

Table 6.10. Farm Pond/Artificial Pond has migrated into X or remained since 1937	
X	**Acreage**
Agricultural Field	9 acres
Modified Land	4 acres
Cultivated Lawn	3 acres
Northeastern Modified Successional Forest	1 acre
Northeastern Old Field	1 acre
Other vegetation communities/land covers	0.4 acres

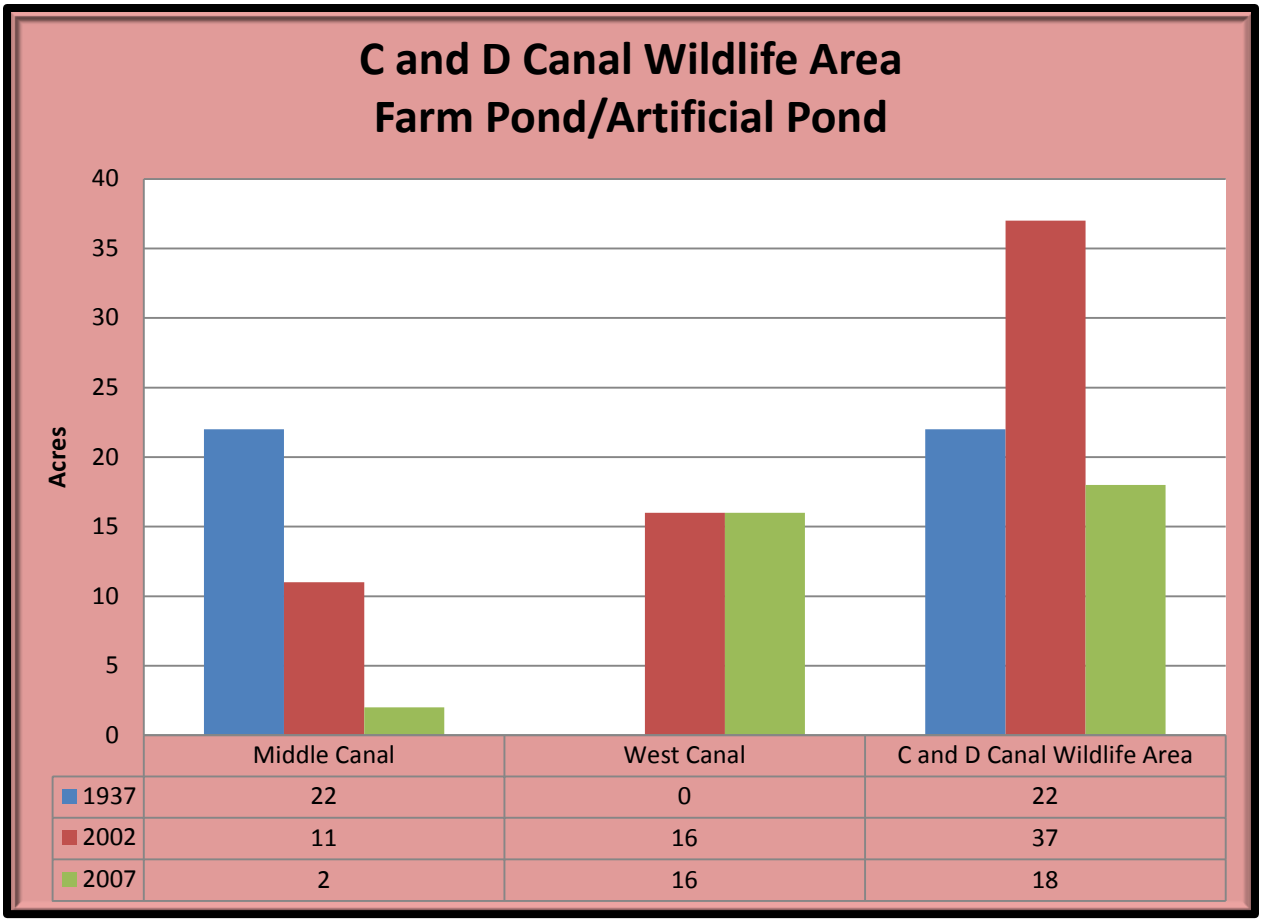


Figure 6.4. Farm Pond/Artificial Pond at C and Canal Wildlife Area (1937, 2002, and 2007)

DNREC Sea Level Rise Analysis

None of the current Farm Ponds/Artificial Ponds will be impacted under any of the current sea level rise scenarios.

Natural Capital (Table 6.11)

The amount of capital and acreage of farm ponds has fluctuated because of the amount of Eastern Reed Marsh.

Table 6.11. Natural Capital of Farm Pond/Artificial Pond	
Year	**Natural Capital (in 2012 dollars)**
1937	$117,372/year
2002	$197,399/year
2007	$96,032/year

Impervious Surface **[33 acres (Figure 6.5, Tables 6.12-6.14)]**

DEWAP: Structures
NHC: No Equivalent Classification

Description

Impervious surface includes those places that are impermeable to water such as roads and human built structures.

Analysis of Condition at C and D Canal Wildlife Area

About 0.03 acres of the 1937 acreage was still present in 2007 out of 7.2 acres. The rest of the acreage had become 3 acres of riprap, 2 acres of semi-impervious surface, 1 acre of Northeastern Successional Shrubland, and 0.3 acres each of Northeastern Modified Successional Forest and water (Table 6.12).

Since 1937, impervious surface acreage has increased and has been developed in 10 acres each of Northeastern Old Field and Modified Land, 9 acres of bare sand, 3 acres of agricultural field and 0.5 acres of Northeastern Successional Shrubland (Table 6.13).

Table 6.12. What was once Impervious Surface in 1937 has become X or remained in 2007	
X	**Acreage**
Riprap	3 acres
Semi-impervious Surface	2 acres
Northeastern Successional Shrubland	1 acre
Northeastern Modified Successional Forest	0.3 acres
Water	0.3 acres
Other vegetation communities/land covers	0.6 acres

Table 6.13. Impervious Surface has migrated into X or remained since 1937	
X	**Acreage**
Northeastern Old Field	10 acres
Modified Land	10 acres
Bare Sand	9 acres
Agricultural Field	3 acres
Northeastern Successional Shrubland	0.5 acres
Other vegetation communities/land covers	1 acre

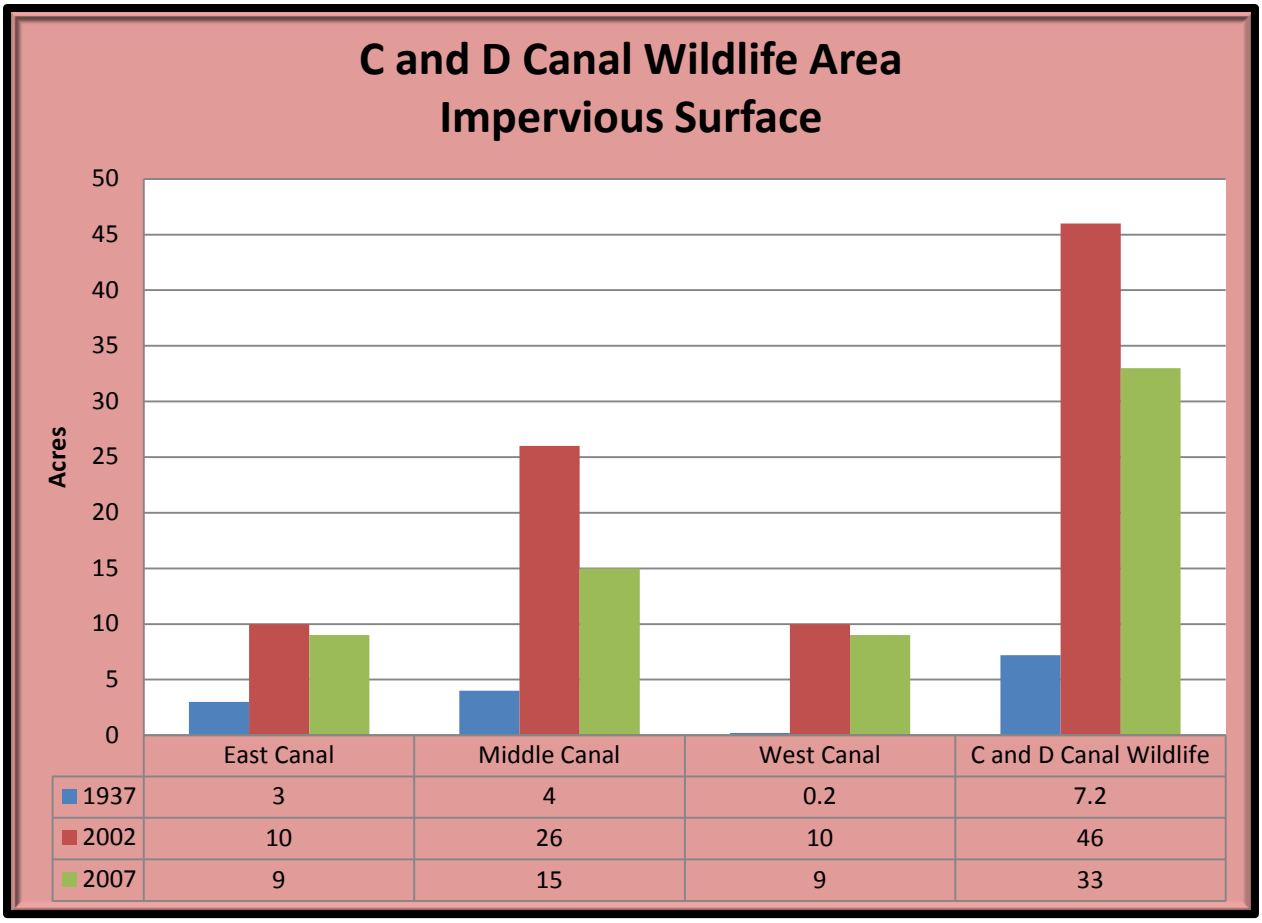


Figure 6.5. Impervious Surface at C and D Canal Wildlife Area (1937, 2002, and 2007)

DNREC Sea Level Rise Analysis (Table 6.14)

About 1/5 of the impervious surfaces in the C and D Wildlife Area will be inundated with 1.5 m of sea level rise.

Table 6.14. Projected acres of Impervious Surface Impacted by Sea Level Rise	
Rise	**Acres**
0.5 m	2 acres
1 m	4 acres
1.5 m	7 acres

Natural Capital

Impervious Surface does not have any natural capital value.

***Impoundment* [72 acres (Figure 6.6, Tables 6.15-6.17)]**

DEWAP: Impoundment
NHC: No Equivalent Classification

Description

Impoundments include water bodies that are larger than 5 acres in size.

Analysis of Condition at C and D Canal Wildlife Area

About 25 acres of the 1937 acreage was still present in 2007 out of 64 acres. The rest of the acreage had become 17 acres of Northeastern Old Field, 11 acres of Northeastern Successional Shrubland, 8 acres of Eastern Reed Marsh, and 4 acres of Northeastern Modified Successional Forest (Table 6.15).

Since 1937, Impoundment acreage has increased and has been developed in 22 acres of agricultural field, 13 acres of Modified Land, 11 acres of Northeastern Old Field and 1 acre of bare sand (Table 6.16).

Table 6.15. What was once Impoundment in 1937 has become X or remained in 2007

X	Acreage
Impoundment	25 acres
Northeastern Old Field	17 acres
Northeastern Successional Shrubland	11 acres
Eastern Reed Marsh	8 acres
Northeastern Modified Successional Forest	4 acres

Table 6.16. Impoundment has migrated into X or remained since 1937

X	Acreage
Impoundment	25 acres
Agricultural Field	22 acres
Modified Land	13 acres
Northeastern Old Field	11 acres
Bare Sand	1 acre

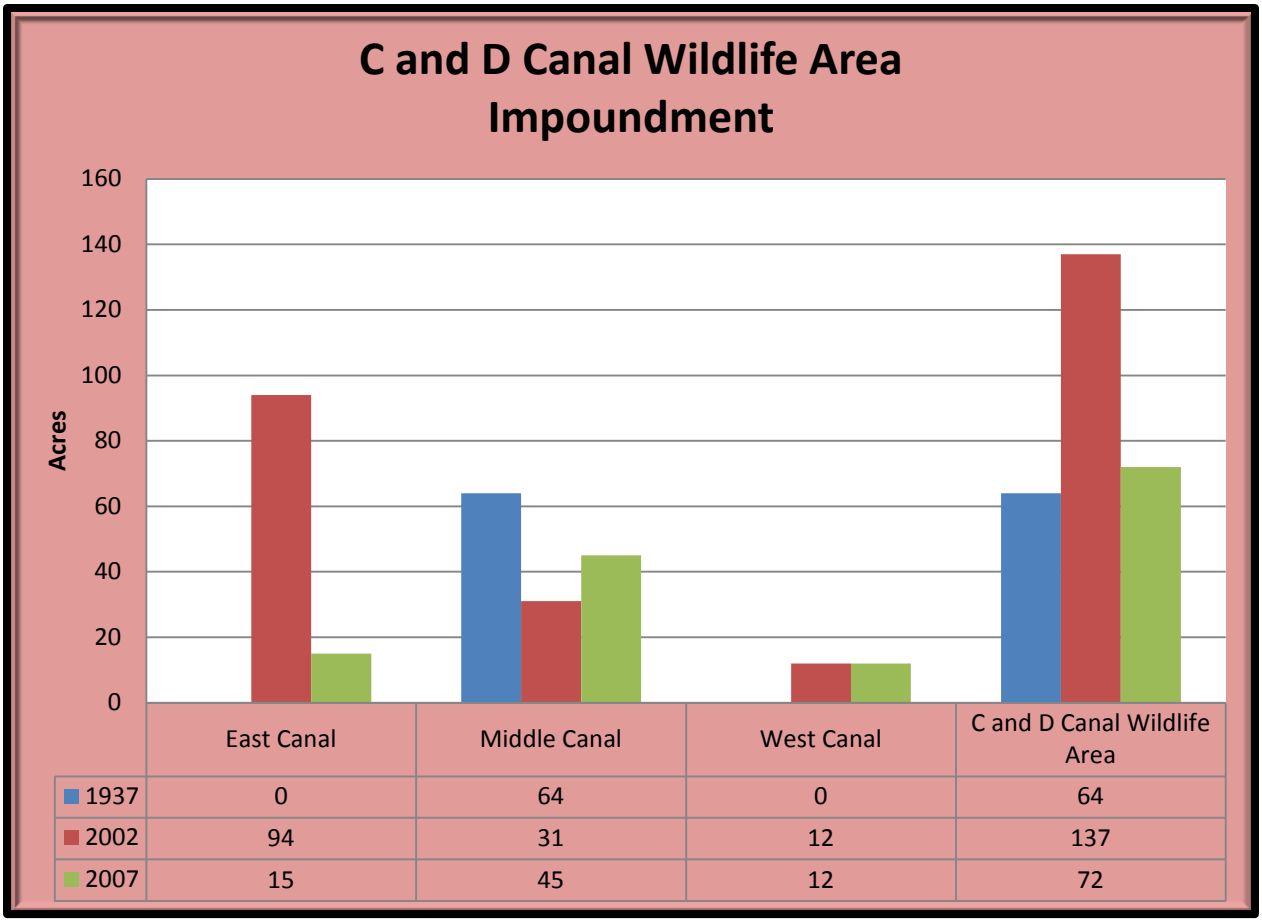


Figure 6.6. Impoundment at C and D Canal Wildlife Area (1937, 2002, and 2007)

DNREC Sea Level Rise Analysis

None of the impoundment acreage will be impacted under the highest sea level rise scenario.

Natural Capital (Table 6.17)

Capital of impoundment has largely increased with a major decreased in the recent period (2002-2007).

Table 6.17. Natural Capital of Impoundment	
Year	**Natural Capital (in 2012 dollars)**
1937	$341,446/year
2002	$730,909/year
2007	$384,127/year

Modified Land **[171 acres (Figure 6.7, Tables 6.18-6.20)]**

DEWAP: Sand and Gravel Pits
NHC: No Equivalent Classification

Description

Modified Land is an area of ground that has been cleared of vegetation and is often a precursor of development.

Analysis of Condition at C and D Canal Wildlife Area

Only 59 acres of the original 1,019 acres of modified land still existed in 2007. The remainder of the acreage had become 267 acres of Eastern Reed Marsh, 218 acres of Northeastern Modified Successional Forest, 123 acres of Northeastern Successional Shrubland, 105 acres of Northeastern Old Field, and 92 acres of Common Reed Upland Temperate Vegetation (Table 6.18).

Since 1937, modified land has come into 41 acres of agricultural field, 41 acres of Northeastern Old Field, 26 acres of bare sand, and 2 acres of Cattail Brackish Tidal Marsh (Table 6.19).

Table 6.18. What was once Modified Land in 1937 has become X or remained in 2007	
X	**Acreage**
Eastern Reed Marsh	267 acres
Northeastern Modified Successional Forest	218 acres
Northeastern Successional Shrubland	123 acres
Northeastern Old Field	105 acres
Common Reed Upland Temperate Vegetation	92 acres
Other vegetation communities/land covers	215 acres

Table 6.19. Modified Land has migrated into X or remained since 1937	
X	**Acreage**
Modified Land	59 acres
Agricultural Field	41 acres
Northeastern Old Field	41 acres
Bare Sand	26 acres
Cattail Brackish Tidal Marsh	2 acres
Other vegetation communities/land covers	1 acre

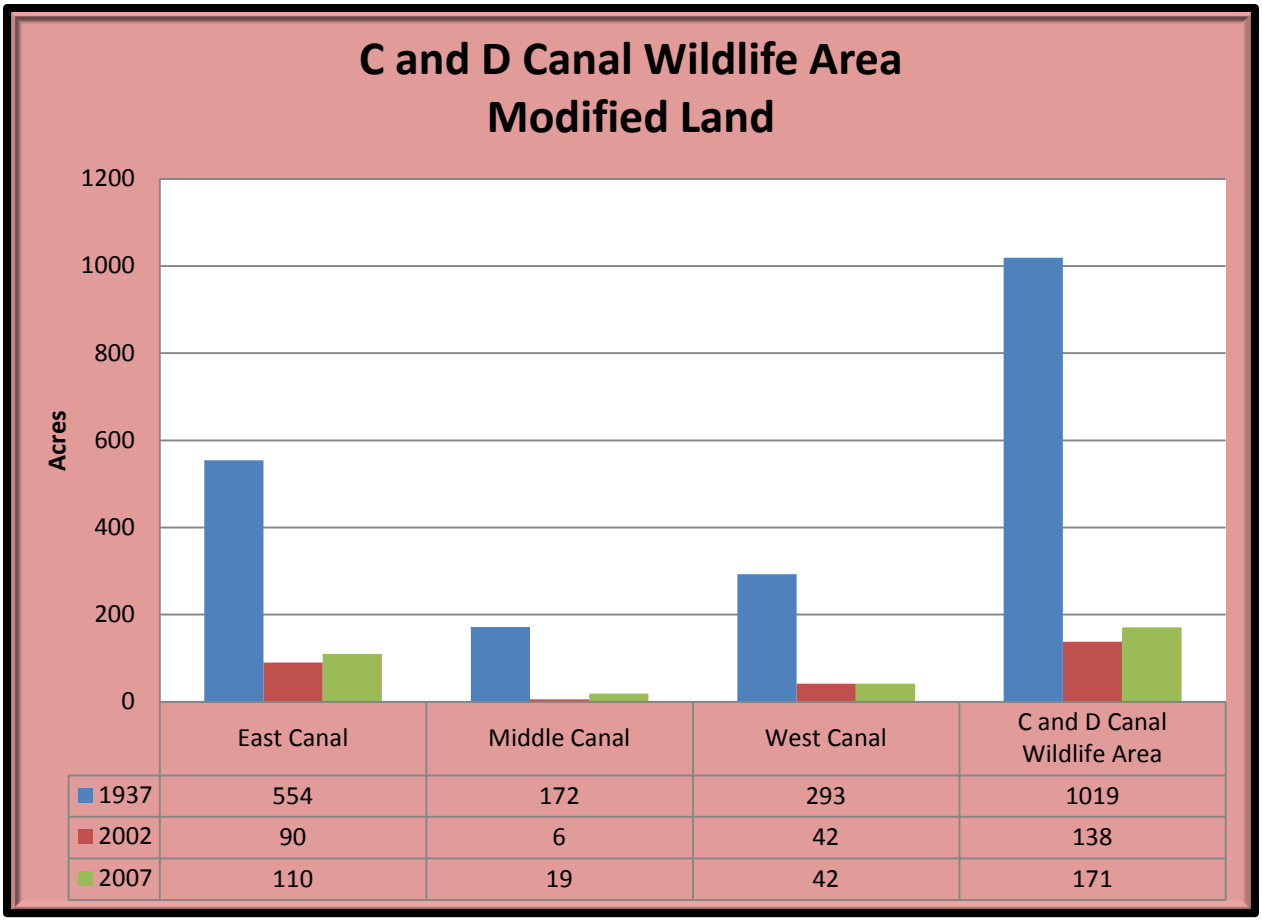


Figure 6.7. Modified Land at C and D Canal Wildlife Area (1937, 2002, and 2007)

DNREC Sea Level Rise Analysis (Table 6.20)

About 4% of the modified land in the wildlife area will be impacted with 1.5 m of sea level rise.

Table 6.20. Projected acres of Modified Land Impacted by Sea Level Rise

Rise	Acres
0.5 m	2 acres
1 m	3 acres
1.5 m	7 acres

Natural Capital

Modified Land does not have any natural capital value.

***Riprap* [66 acres (Figure 6.8, Tables 6.21-6.22)]**

DEWAP: No Equivalent Classification
NHC: No Equivalent Classification

Description

Riprap is laid on the shores of eroding banks to stabilize them. It is often composed of boulder sized granite chunks. The riprap in the wildlife area is likely the largest expanse of riprap in Delaware.

Analysis of Condition at C and D Canal Wildlife Area

Riprap was not present in 1937 and has since come been laid in the wildlife area covering 13 acres of modified land, 10 acres of agricultural field, 8 acre of Pickerelweed Tidal Marsh, 7 acres of bare sand, and 6 acres of Northeastern Old Field (Table 6.21).

Table 6.21. Riprap has been laid into X or remained since 1937

X	Acreage
Modified Land	13 acres
Agricultural Field	10 acres
Pickerelweed Tidal Marsh	8 acres
Bare Sand	7 acres
Northeastern Old Field	6 acres
Other vegetation communities/land covers	22 acres

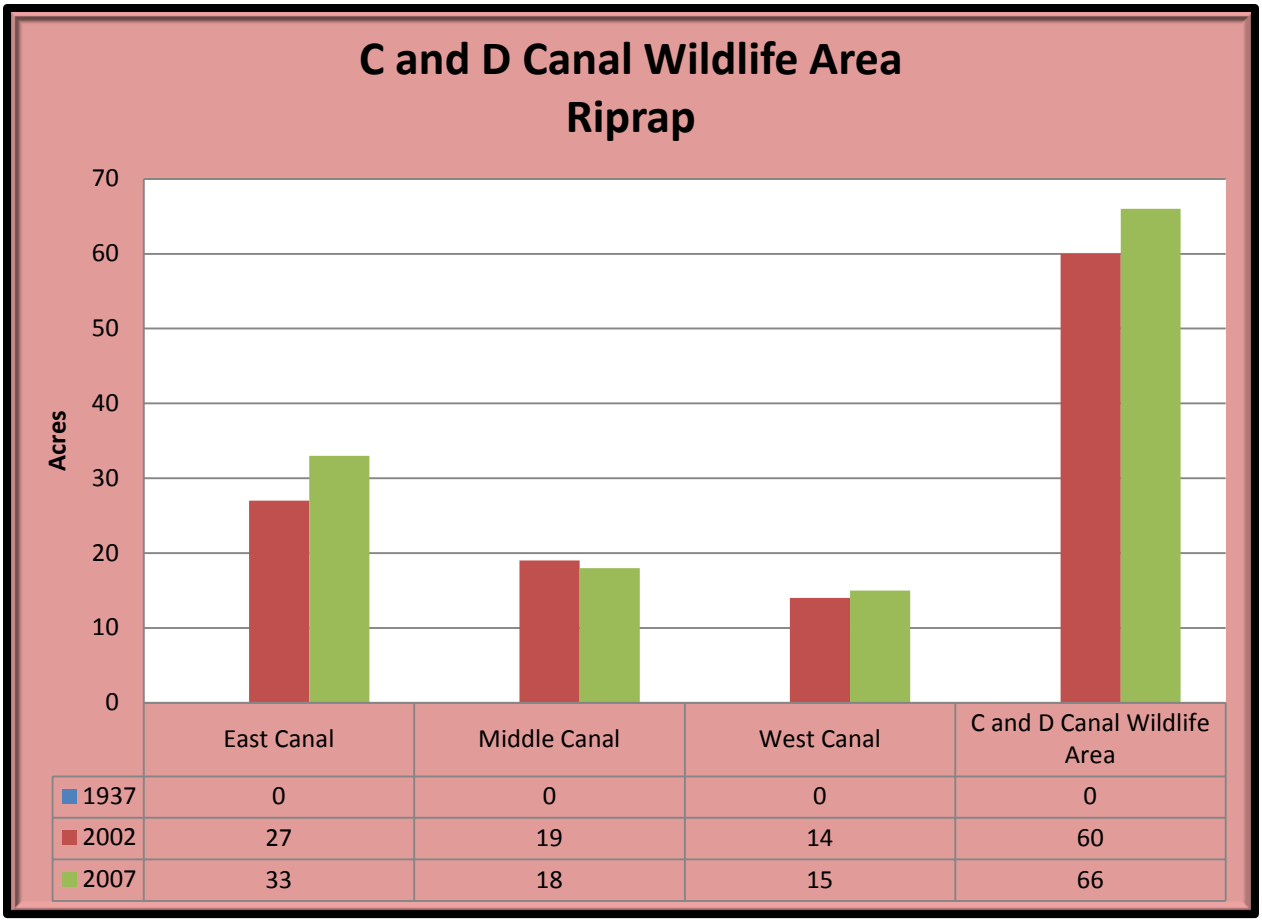


Figure 6.8. Riprap at C and D Canal Wildlife Area (1937, 2002, and 2007)

DNREC Sea Level Rise Analysis (Table 6.22)

Almost all of the riprap in the wildlife area will be inundated with 1.5 m of sea level rise.

Table 6.22. Projected acres of Riprap Impacted by Sea Level Rise

Rise	Acres
0.5 m	43 acres
1 m	56 acres
1.5 m	65 acres

Natural Capital

Riprap does not have any natural capital value.

Semi-impervious Surface **[178 acres (Figure 6.9, Tables 6.23-6.24)]**

DEWAP: No Equivalent Classification
NHC: No Equivalent Classification

Description

This land cover includes the numerous dirt roads that go through the wildlife area. All of the roads are underlain by the sandy substrate that is common in the wildlife area. Most of the additional roads in the wildlife area have been dirt roads.

Analysis of Condition at C and D Canal Wildlife Area

Only 0.4 acres of the original 7 acres of semi-impervious from 1937 still existed in 2007. The remainder of the acreage had become 2 acres of Northeastern Modified Successional Forest, 1 acre of Northeastern Old Field, 1 acre of Northeastern Successional Shrubland, 1 acre of Modified Land, and 0.5 acres of Common Reed Upland Temperate Vegetation (Table 6.23).

Since 1937, Semi-impervious surface has been developed in 58 acres of agricultural field, 51 acres of Modified Land, 19 acres of Northeastern Old Field, 18 acres of bare sand, and 8 acres of Northeastern Successional Shrubland (Table 6.24).

Table 6.23. What was once Semi-impervious Surface in 1937 has become X or remained in 2007	
X	**Acreage**
Northeastern Modified Successional Forest	2 acres
Northeastern Old Field	1 acre
Northeastern Successional Shrubland	1 acre
Modified Land	1 acre
Common Reed Upland Temperate Vegetation	0.5 acres
Other vegetation communities/land covers	1 acre

Table 6.19. Semi-impervious Surface has migrated into X or remained since 1937	
X	**Acreage**
Agricultural Field	58 acres
Modified Land	51 acres
Northeastern Old Field	19 acres
Bare Sand	18 acres
Northeastern Successional Shrubland	8 acres
Other vegetation communities/land covers	24 acres

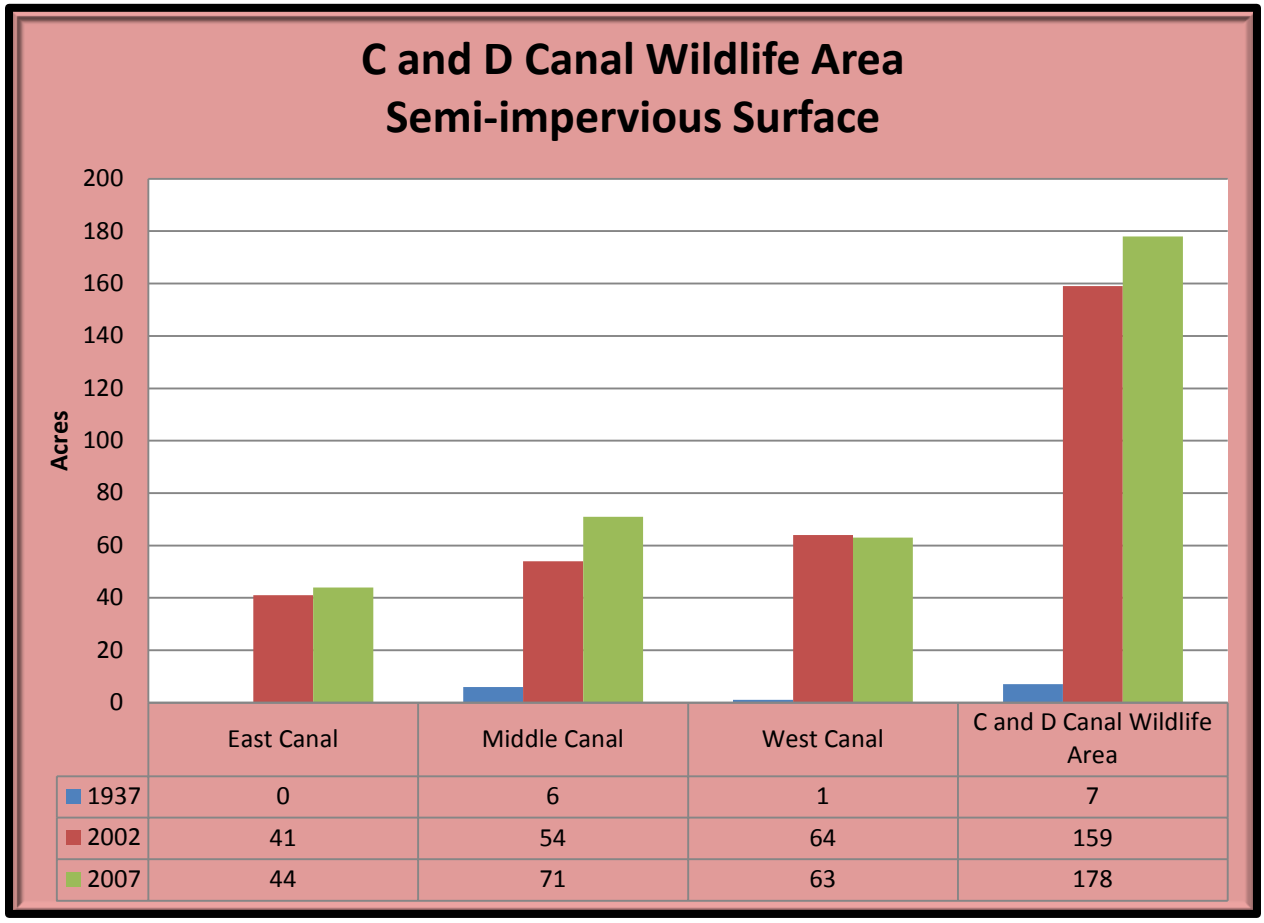


Figure 6.9. Semi-impervious Surface at C and D Canal Wildlife Area (1937, 2002, and 2007)

DNREC Sea Level Rise Analysis (Table 6.24)

At its highest sea level rise will inundate about ¼ of the total semi-impervious surface.

Table 6.24. Projected acres of Semi-impervious Surface Impacted by Sea Level Rise	
Rise	**Acres**
0.5 m	3 acres
1 m	17 acres
1.5 m	49 acres

Natural Capital

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

Tidal Mudflat **[2 acres (Figure 6.10, Tables 6.25-6.26)]**

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

Description

This land cover includes the numerous dirt roads that go through the wildlife area. All of the roads are underlain by the sandy substrate that is common in the wildlife area. Most of the additional roads in the wildlife area have been dirt roads.

Analysis of Condition at C and D Canal Wildlife Area

Since 1937, tidal mudflats have developed in 1 acre each of Cattail Brackish Tidal Marsh and Pickerelweed Tidal Marsh, 0.1 acres of bare sand, and 0.1 acres of water (Table 6.25). Both the Cattail Brackish Tidal Marsh and the Pickerelweed Tidal Marsh no longer exist in the wildlife area.

Table 6.25. Tidal Mudflat has migrated into X or remained since 1937

X	Acreage
Cattail Brackish Tidal Marsh	1 acre
Pickerelweed Tidal Marsh	1 acre
Bare Sand	0.1 acres
Water	0.1 acres

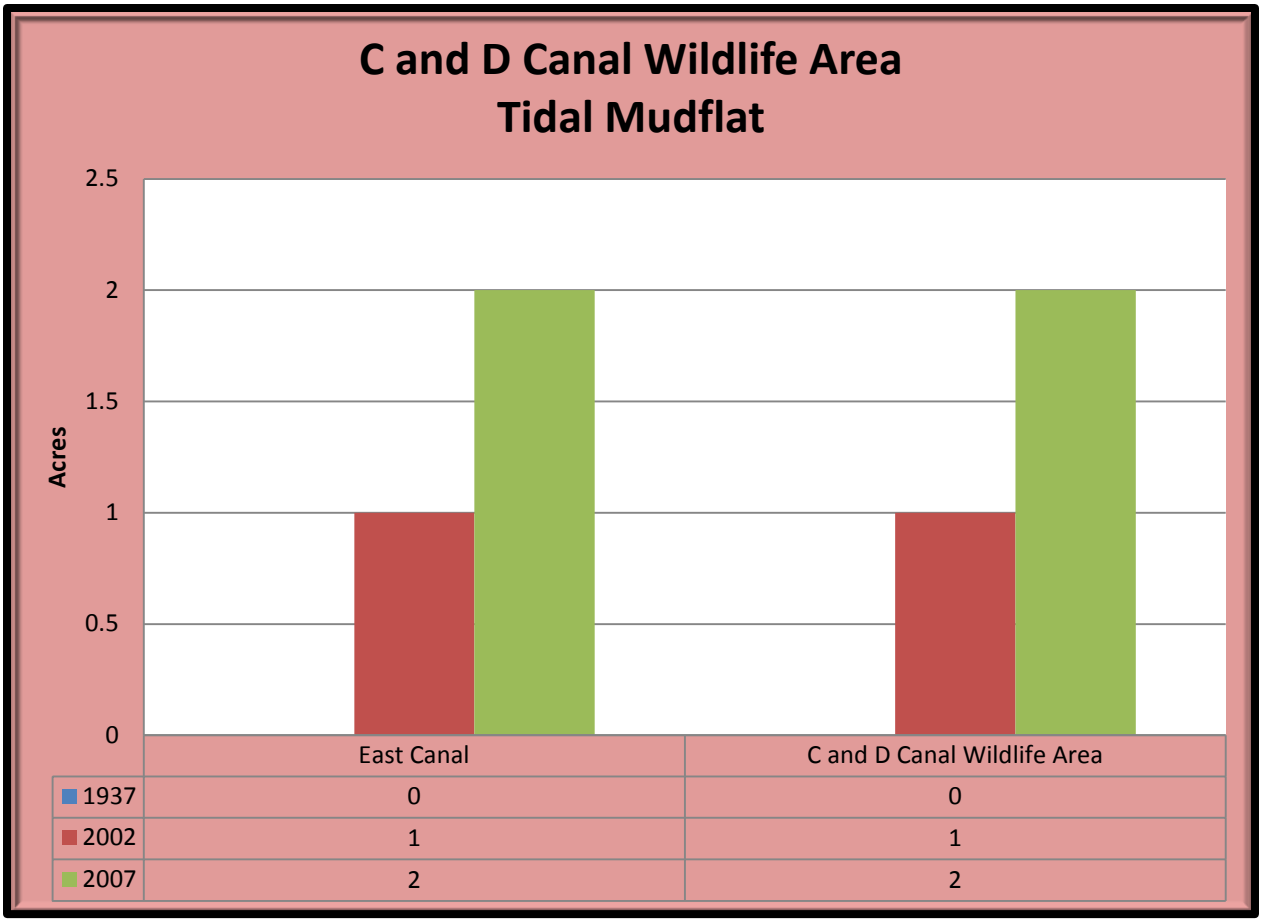


Figure 6.10. Tidal Mudflat at C and D Canal Wildlife Area (1937, 2002, and 2007)

DNREC Sea Level Rise Analysis (Table 6.26)

All of the current acreage of tidal mudflat will be inundated with 0.5 m of sea level rise.

Table 6.26. 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 6.27)

Capital of tidal mudflat has been increasing and could be due to sea level rise flooding the marsh.

Table 6.27. Natural Capital of Tidal Mudflat	
Year	**Natural Capital (in 2012 dollars)**
1937	$0/year (not present)
2002	$6,271/year
2007	$12,543/year

***Water* [144 acres (Figures 6.11-6.12, Tables 6.28-6.30)]**

DEWAP: Nearshore Habitats
NHC: No Equivalent Classification

Description

This land cover includes all of the non-impounded water in the wildlife area.

Analysis of Condition at C and D Canal Wildlife Area

A lot of the water area has changed since 1937 because of a re-route of the canal. Only 18 original acres remained from 1937 in 2007. The other acres became 6 acres of Reed Tidal Marsh, 5 acres of Northeastern Successional Shrubland, 3 acres of riprap, and 2 acres of semi-impervious surface (Table 6.28).

Since 1937, water has increased quite a bit, presumably due to sea level rise in the East Canal Section. During this time water has inundated 32 acres of Pickerelweed Tidal Marsh, 30 acres of Cattail Brackish Tidal Marsh, 21 acres of modified land, and 12 acres of bare sand (Table 6.29).

Table 6.28. What was once Water in 1937 has become X or remained in 2007

X	Acreage
Water	18 acres
Reed Tidal Marsh	6 acres
Northeastern Successional Shrubland	5 acres
Riprap	3 acres
Semi-impervious Surface	2 acres
Other vegetation communities/land covers	5 acres

Table 6.29. Water has migrated into X or remained since 1937

X	Acreage
Pickerelweed Tidal Marsh	32 acres
Cattail Brackish Tidal Marsh	30 acres
Modified Land	21 acres
Water	18 acres
Bare Sand	12 acres
Other vegetation communities/land covers	31 acres

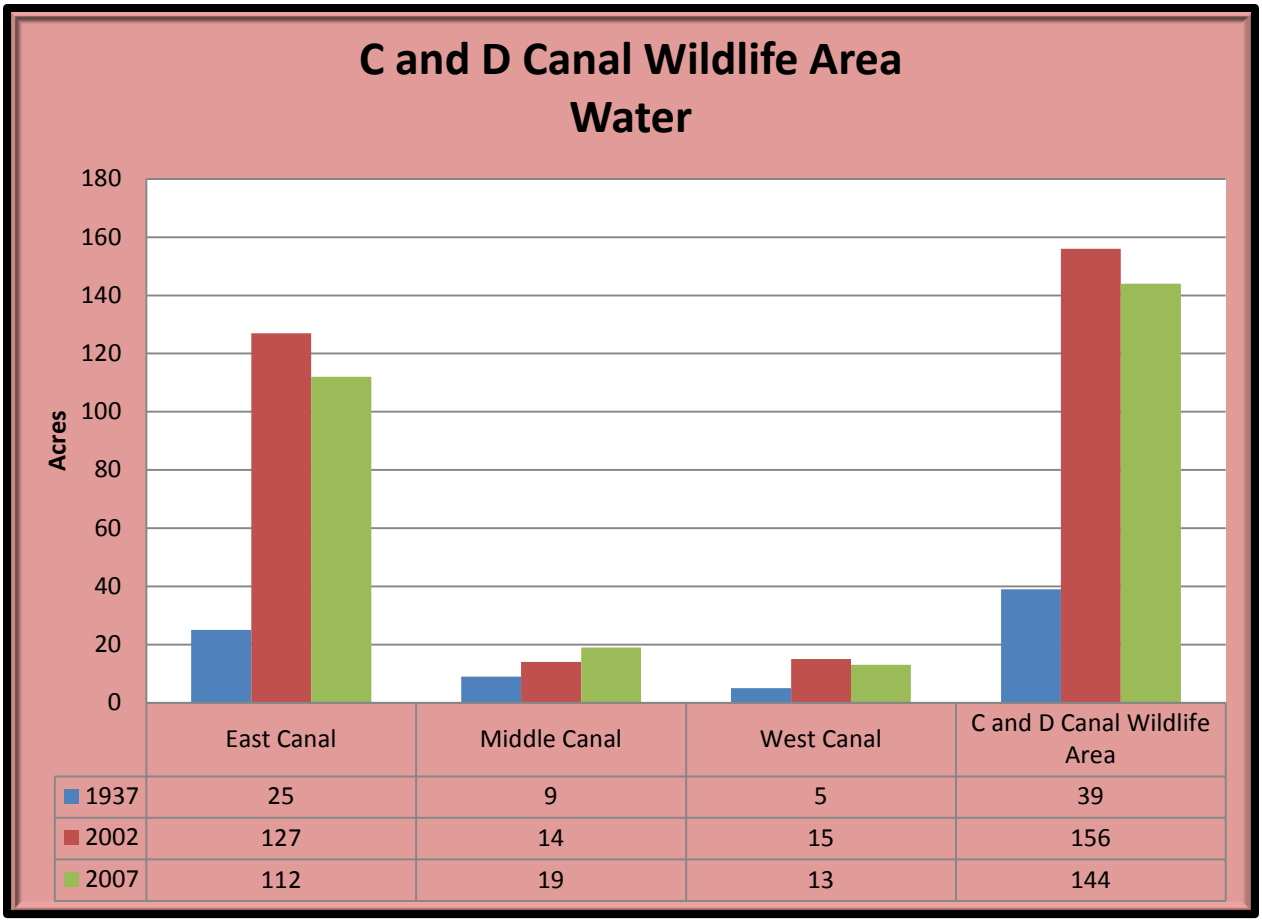
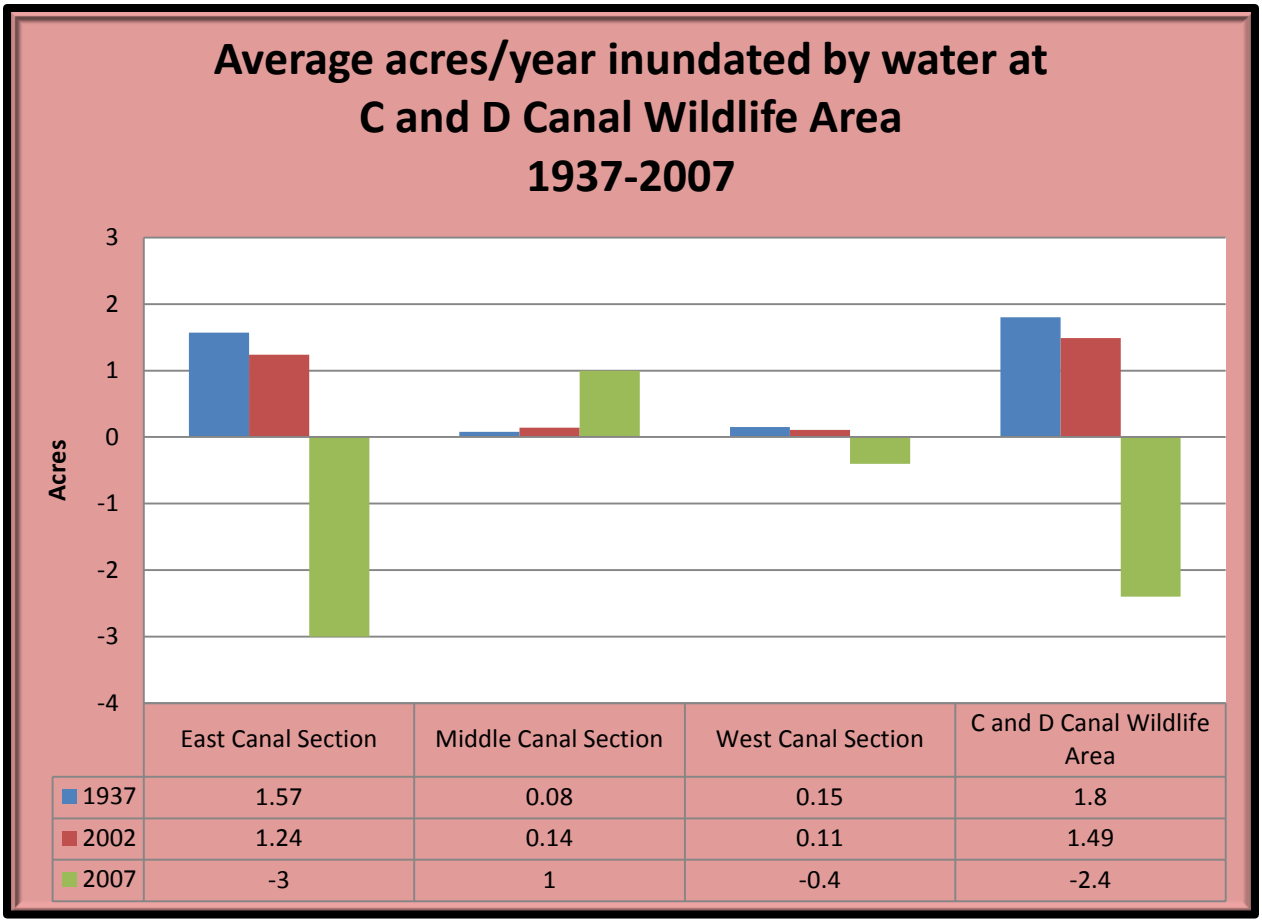


Figure 6.11. Water at C and D Canal Wildlife Area (1937, 2002, and 2007)

Natural Capital (Table 6.30)

Capital of Water increased until 2002, at which point it went down in capital. This is likely caused by fill and riprap on the sides of the canal.

Table 6.30. Natural Capital of Water	
Year	**Natural Capital (in 2012 dollars)**
1937	$558,981/year
2002	$2,235,925/year
2007	$2,063,930/year



	East Canal Section	Middle Canal Section	West Canal Section	C and D Canal Wildlife Area
1937	1.57	0.08	0.15	1.8
2002	1.24	0.14	0.11	1.49
2007	-3	1	-0.4	-2.4

Figure 6.12. Acres of land per year inundated by water at C and D Canal Wildlife Area (1937-2007)

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 Freshwater Tidal Marshes			
Species	**Common Name**	**Class**	**Tier**
Atildes halesus	Great purple hairstreak	Insect	2
Manduca jasminearum	Ash sphinx	Insect	2
Acronicta connecta	A noctuid moth	Insect	2
Papaipema stenocelis	Chain fern borer moth	Insect	2
Terrapene carolina	Eastern box turtle	Reptile	1
Eumeces laticeps	broadhead skink	Reptile	1
Cemophora coccinea	scarlet snake	Reptile	1
Elaphe guttata	corn snake	Reptile	1
Lampropeltis triangulum	milk snake	Reptile	1
Haliaeetus leucocephalus	Bald eagle	Bird	1

Accipiter cooperii	Cooper's Hawk	Bird	1
Buteo platypterus	broad-winged hawk	Bird	1
Asio otus	long-eared owl	Bird	1
Melanerpes erythrocephalus	red-headed woodpecker	Bird	1
Certhia americana	brown creeper	Bird	1
SGCN Species expected in Coastal Plain Upland Forest			
Hylocichla mustelina	wood thrush	Bird	1
Wilsonia citrina	hooded warbler	Bird	1
Sciurus niger cinereus	Delmarva fox squirrel	Mammal	1
Discus catskillensis	angular disc	Gastropod	2
Cicindela patruela	Northern barrens tiger beetle	Insect	2
Cicindela unipunctata	one-spotted tiger beetle	Insect	2
Photuris frontalis	a firefly	Insect	2
Erynnis martialis	mottled duskywing	Insect	2
Erynnis baptisiae	wild indigo duskywing	Insect	2
Battus philenor	pipevine swallowtail	Insect	2
Polygonia progone	gray comma	Insect	2
Caripeta aretaria	a geometer moth	Insect	2
Tolype notialis	a lasiocampid moth	Insect	2
Hemileuca maia maia	the buckmoth	Insect	2
Cisthene kentuckiensis	Kentucky lichen moth	Insect	2
Cisthene tenuifascia	a lichen moth	Insect	2
Grammia phyllira	phyllira tiger moth	Insect	2
Zale metata	a noctuid moth	Insect	2
Catocala flebilis	mournful underwing	Insect	2
Catocala residua	residua underwing	Insect	2
Catocala cerogama	Yellow banded underwing	Insect	2
Acronicta exilis	Exiled dagger moth	Insect	2
Acronicta lithospila	Streaked dagger moth	Insect	2
Papaipema araliae	Aralia shoot borer moth	Insect	2
Papaipema baptisiae	Wild indigo borer moth	Insect	2
Lepipolys perscripta	A noctuid moth	Insect	2
Scincella lateralis	Ground skink	Reptile	2
Heterodon platirhinos	Eastern hognose snake	Reptile	2
Lampropeltis getula	Common kingsnake	Reptile	2
Storeria occipitomaculata	Redbelly snake	Reptile	2
Virginia valeriae	Smooth earth snake	Reptile	2
Agkistrodon contortix	Copperhead	Reptile	2
Coragyps atratus	Black vulture	Bird	2
Strix varia	Barred owl	Bird	2
Caprimulgus vociferus	whip-poor-will	Bird	2
Colaptes auratus	Northern flicker	Bird	2
Myiarchus crinitus	Great crested flycatcher	Bird	2
Sitta pusilla	Brown-headed nuthatch	Bird	2
Vireo flavifrons	Yellow-throated vireo	Bird	2
Dendroica dominca	Yellow-throated warbler	Bird	2
Mniotilta varia	Black-and-white warbler	Bird	2

Seiurus motacilla	Louisiana waterthrush	Bird	2
Oporornis formosus	Kentucky warbler	Bird	2
Piranga olivacea	Scarlet tanager	Bird	2
Piplio erythrophthalmus	Eastern towhee	Bird	2
Icterus galbula	Baltimora oriole	Bird	2
Lasionycteris noctivagans	Silver-haired bat	Mammal	2
Lasiurus borealis	Eastern red bat	Mammal	2
Lasiurus cinereus	Hoary bat	Mammal	2
Canis latrans	coyote	Mammal	2

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

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

SGCN Species expected in Tidal High Marsh Habitats			
Species	**Common Name**	**Class**	**Tier**
Problema bulenta	rare skipper	Insect	1
Pero zalissaria	a geometer moth	Insect	2
Acontia delecta	a noctuid moth	Insect	2
Papaipema birdi	umbellifer borer moth	Insect	2
Brachymesia gravida	four-spotted pennant	Insect	2
Nycticorax nycticorax	black-crowned night-heron	Bird	1
Nyctanassa violacea	yellow-crowned night-heron	Bird	1
Anas rubripes	American black duck	Bird	1
Circus cyaneus	northern harrier	Bird	1
Laterallus jamaicensis	black rail	Bird	1
Asio flammeus	short-eared owl	Bird	1
Cistothorus platensis	sedge wren	Bird	1
Ammodramus caudacutus	saltmarsh sharp-tailed sparrow	Bird	1

Ammodramus maritimus	seaside sparrow	Bird	1
Botaurus lentiginosus	American bittern	Bird	2
Ixobrychus exilis	least bittern	Bird	2
Ardea herodias	great blue heron	Bird	2
Casmerodius albus	great egret	Bird	2
Egretta thula	snowy egret	Bird	2
Egretta caerulea	little blue heron	Bird	2
Egretta tricolor	tricolored heron	Bird	2
Bubulcus ibis	Cattle egret	Bird	2
Porzana carolina	sora	Bird	2
Fulica americana	American coot	Bird	2
Tyto alba	barn owl	Bird	2
Cistothorus palustris	marsh wren	Bird	2

SGCN Species expected in Tidal Low Marsh Habitats			
Species	**Common Name**	**Class**	**Tier**
Problema bulenta	rare skipper	Insect	1
Malaclemys terrapin terrapin	Northern diamondback terrapin	Reptile	1
Podilymbus podiceps	Pied-billed grebe	Bird	1
Nycticorax nycticorax	Black-crowned night-heron	Bird	1
Branta canadensis	Canada goose (migratory)	Bird	1
Anas rubripes	American black duck	Bird	1
Nyctanassa violacea	yellow-crowned night-heron	Bird	1
Circus cyaneus	northern harrier	Bird	1
Arenaria interpres	Ruddy turnstone	Bird	1
Asio flammeus	short-eared owl	Bird	1
Calidris canutus	Red knot	Bird	1
Sterna hirundo	Common tern	Bird	1
Sterna forsteri	Forster's tern	Bird	1
Rhnchops niger	Black skimmer	Bird	1
Ammodramus caudacutus	Saltmarsh sharp-tailed sparrow	Bird	1
Ammodramus maritimus	Seaside sparrow	Bird	1
Cicindela marginata	Margined tiger beetle	Insect	2
Pero zalissaria	A geometer moth	Insect	2
Acontia delecta	A noctuid moth	Insect	2
Brachymesia gravida	Four-spotted pennant	Insect	2
Pelecanus occidentalis	Brown pelican	Bird	2
Phalacrocorax carbo	Great cormorant	Bird	2
Phalacrocorax auritus	Double-crested cormorant	Bird	2
Ardea herodias	Great blue heron	Bird	2
Casmerodius albus	Great egret	Bird	2
Egretta thula	Snowy egret	Bird	2
Egretta caerulea	Little blue heron	Bird	2
Egretta tricolor	Tricolored heron	Bird	2
Bubulcus ibis	Cattle egret	Bird	2
Plegadis falcinellus	Glossy ibis	Bird	2
Anas platyrhynchos	mallard	Bird	2
Falco peregrinus	Peregrine falcon	Bird	2
Rallus elegans	King rail	Bird	2
Fulica americana	American coot	Bird	2
Pluvialis squatarola	Black-bellied plover	Bird	2
Himantopus mexicanus	Black-necked stilt	Bird	2
Catoptrophorus semipalmatus	Willet	Bird	2
Calidris pusilla	Semipalmated sandpiper	Bird	2
Calidris alpina	dunlin	Bird	2
Sterna nilotica	Gull-billed tern	Bird	2
Tyto alba	Barn owl	Bird	2
Cistothorus palustris	Marsh wren	Bird	2

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