INLAND AND COASTAL WETLANDS OF MASSACHUSETTS

STATUS AND TRENDS

WETLANDS—OUR COMMON WEALTH

March 2019

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MassDEP acknowledges the hard work and dedication of the local Conservation Commissions across Massachusetts. Their tireless efforts ensure the protection of our unique and valuable resources.

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Executive Summary

MassDEP is a regulatory agency whose core mission is to ensure the protection of Massachusetts' wetlands by administering and enforcing the Wetlands Protection Act (WPA), and the 401 Water Quality Certification (WQC) Program. To effectively implement this mission, the agency has invested considerable resources to develop accurate data on wetlands that is used extensively across the state by thousands of individuals, organizations and agencies. This data has also been used by MassDEP to inform the development of regulations, policies and outreach programs designed to protect wetlands and the important public interests that they provide such as flood control, storm damage prevention, and prevention of pollution.

This report utilizes five major data sources developed by MassDEP (or that MassDEP contributed significant effort to), and covers the period of time between 1990 and 2017. The "Study Objectives and Methods" section of this report provides a detailed explanation of how the data used for this report was developed and the timeframes relevant to each. By publication of this report it is MassDEP's goal to inform our partners, stakeholders, and the public about the importance of wetlands resources in Massachusetts, the losses, gains and other trends that have occurred in recent years, and the causes of those trends so that we can better protect these valuable resources.

The primary assessment presented in this report is based on MassDEP's first-ever and newly released Updated Statewide Wetlands Maps. These updated maps are based on aerial photos taken in 2005. The Original Statewide Wetlands Maps that have been widely used until now were based on aerial photos taken between 1990 and 2000. The development of the Original and Updated Statewide Wetlands Maps has been a time-consuming process but has resulted in Massachusetts having a level of mapped wetland accuracy that exceeds most – if not all - wetlands mapping available nationally. This first-time update has allowed us to comprehensively evaluate changes in wetlands across the state occurring since the original statewide wetlands maps were completed.

The Updated Statewide Wetlands Map shows that while there were numerous individual areas of gains and losses across Massachusetts, freshwater wetlands have had an estimated net gain of 4,188 acres overall, while coastal wetland resources have had an estimated net gain of 737 acres. The greatest overall change to wetland resources was not due to human activity but from a natural cause - beaver (*Castor canadensis*) activity. Beavers were particularly active in Central Massachusetts, creating 2,403 acres of new freshwater wetlands and changing 12,871 acres of existing freshwater wetlands to other types (e.g. forested to shrub or emergent) between 1990 and 2005.The second largest change to wetland resources from natural causes was due to coastal storms, erosion, and accretion processes, particularly on Cape Cod and the Islands. Over 2,900 acres of coastal wetland resources changed to other types, for example, a salt marsh

buried by sand became a coastal dune. While natural causes resulted in the greatest overall change in wetland resources, human activities also caused significant changes. Approximately 1,548 acres of wetland resource loss and 2,733 acres of wetland resource gain due to human activities were identified. To better understand the human activities that caused wetland resource loss, MassDEP developed more sophisticated evaluation techniques.

In 2002, MassDEP initiated a new project to evaluate wetland resource losses caused by human activities in greater detail using innovative technology that was unavailable in earlier years. This evaluation is referred to as 'The Wetland Change Project' and the results are also presented in this report. One finding of the Wetland Change Project is that the greatest cause of wetland resource loss due to human activity has been residential and commercial development. The Wetlands Change data has become an extremely important tool for MassDEP in identifying unpermitted wetland resource loss. To date, the agency has taken enforcement action in 77 wetland resource loss cases, issued $3,311,337 in combined penalties and ordered 68.2 acres of wetland resources to be restored for violations occurring between 1995 and 2012. MassDEP is currently researching new software to continue this program.

Two other important projects undertaken by MassDEP in recent years are the development of the 'Wetland Information Resource' ("WIRe") data management system and the 'Wetland Monitoring and Assessment Project,' both funded by Wetland Program Development Grants from EPA. Data developed through these projects are also presented in this report. Findings show that single family home construction accounts for 55% of all permit applications, more than any other type. The study also revealed that the wetland resource type with the largest area of impact is land under waterbodies, a third of which is due to aquatic plant management projects. An assessment of wetland resource condition showed that wetland resources impacted as a result of human activity are typically those with low to medium ecological condition.

While this study covers a lengthy timeframe, MassDEP expects that updates in technology will allow the analyses provided in this report to be completed in shorter timeframes in the future. As a result, the Wetlands Program is actively researching technologies available to meet our needs and to assist with carrying out our mission of continued strong wetlands protection in Massachusetts.

This report fulfills the Massachusetts Department of Environmental Protection (MassDEP)-U.S. Environmental Protection Agency (EPA) 2016-2019 Performance Partnership Agreement Two-Year Work Plan commitment (Task 72) which requires reporting on the status, trends, and patterns of change in wetlands statewide.

Massachusetts Wetlands

Wetlands exist in every community across Massachusetts, from Cape Cod to the Berkshires. The benefits they provide are important to everyone. Wetlands cover 14% of the state, and are protected because they perform crucial functions including:

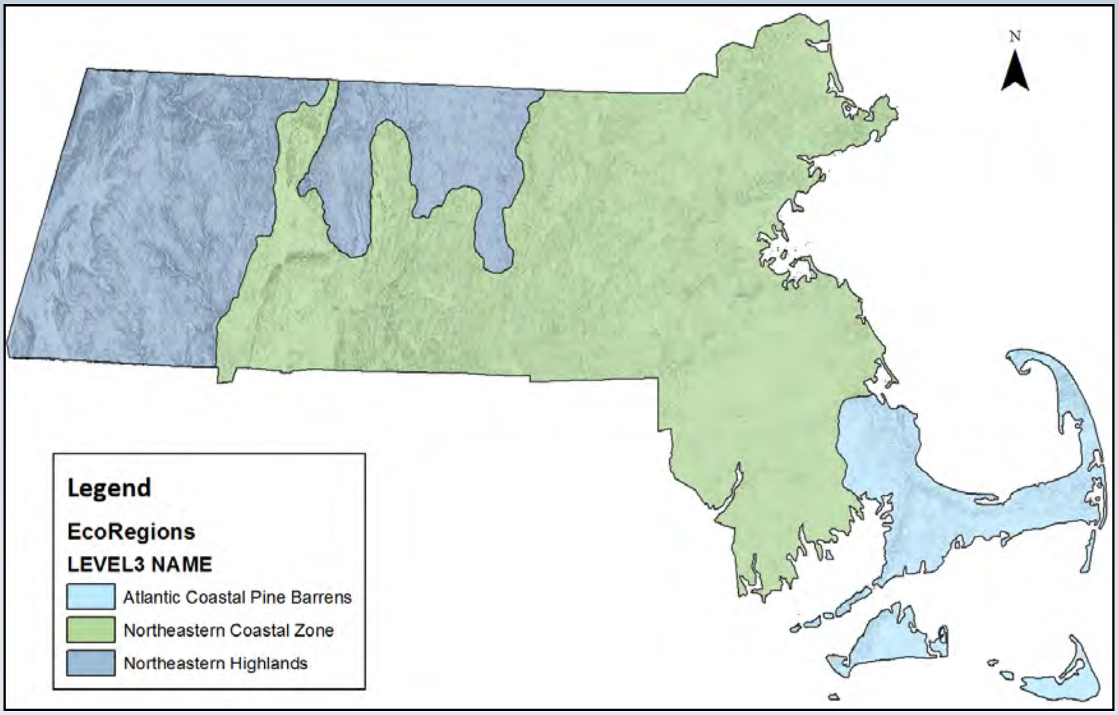
- ·public and private water supply protection
- ·groundwater supply protection
- ·flood control
- ·storm damage prevention
- ·prevention of pollution
- ·land containing shellfish protection
- ·fisheries protection, and
- ·protection of wildlife habitat

Wetlands also support commercial fishing, tourism, recreation and educational opportunities, all of which play a crucial role in the state's economy and help to preserve a superior quality of life for Massachusetts citizens.

Massachusetts is comprised of three major ecological regions: the Northeastern Highlands, the Northeastern Coastal Zones, and the Atlantic Coastal Pine Barrens (figure 1). While different wetland types may exist in different ecological regions, they all play a role in protecting our Commonwealth.

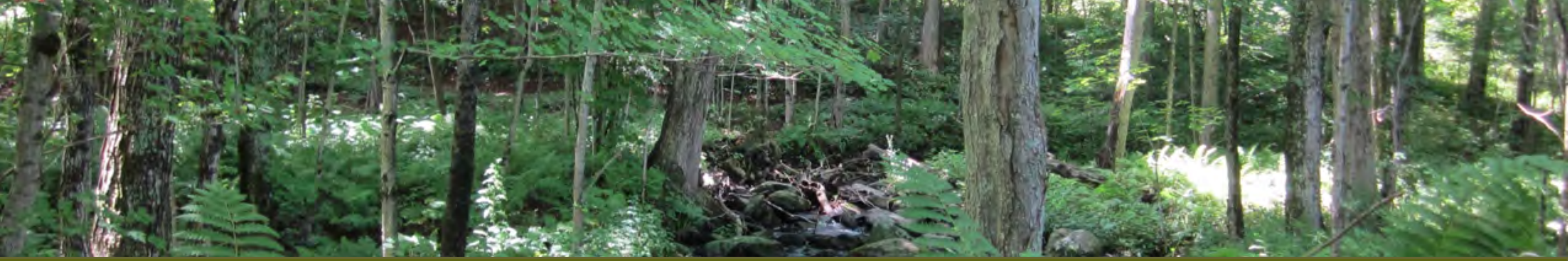
Freshwater wetlands comprise 82% of the acreage of all wetland resources in Massachusetts and include wooded swamps, shrub swamps, shallow and deep marshes, natural bogs, and commercial cranberry bogs. The plants and soils of freshwater wetlands remove or detain pollutants that occur in runoff and flood waters, thus protecting both drinking water and ground water quality. Freshwater wetlands prevent flooding by temporarily storing and then slowly releasing stormwater. The water stored in freshwater wetlands recharges groundwater, which maintains flows in rivers and streams. Freshwater wetlands also provide critical habitat for wildlife and fish to thrive.

Figure 1: Major Ecoregions of Massachusetts



The map above shows the three major eco-regions in Massachusetts determined by the United States Environmental Protection Agency. [1]

[1] https://www.epa.gov/eco-research/level-iii-and-iv-ecoregions-continental-united-states



Massachusetts has approximately 1,519 miles of coastline and as a result has extensive areas of salt marshes. Salt marshes and coastal resource areas such as dunes, beaches, coastal banks, barrier beaches, and rocky intertidal shores are areas that are influenced by the ocean environment and tides. Salt marshes filter pollutants from the water, and reduce flooding and wave damage during storm events. Massachusetts' salt marshes provide nursery habitat for fish, as well as habitat for many wildlife species. Coastal dunes and banks play an important role in storm damage prevention by protecting inland areas from waves during storm events and by serving as a sand reservoir to help nourish coastal beaches. In addition to their ecological values, the Massachusetts coastline provides scenic and recreational opportunities that draw millions of visitors each year.

Freshwater wetlands are non-tidal vegetated areas where water is at or near the surface of the ground during a significant part of the growing season. Freshwater wetlands support a plant community that has adapted to growing in saturated or flooded conditions (see figure 2).

Salt marshes are vegetated wetlands regularly inundated by tidal waters and support a plant community adapted to salt water exposure (see figure 3).

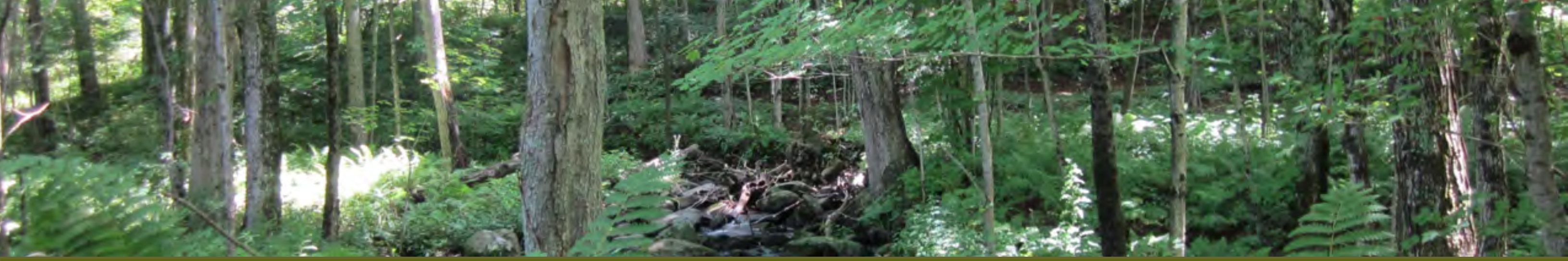
Coastal resource areas are landforms situated adjacent to the ocean or estuaries. They may be vegetated or un-vegetated. Coastal resource areas include beaches (figure 4), tidal flats, dunes, coastal banks, rocky intertidal shores, and barrier beaches. Rocky intertidal shores consist of boulders or exposed bedrock, whereas the other coastal resources typically consist of soil or unconsolidated sediment.

For the purpose of this report "coastal wetland resources" include both salt marshes and coastal resource areas.

Figure 2: Freshwater Wetland

Figure 3: Salt Marshes

Figure 4: Cobbles on a Coastal Beach

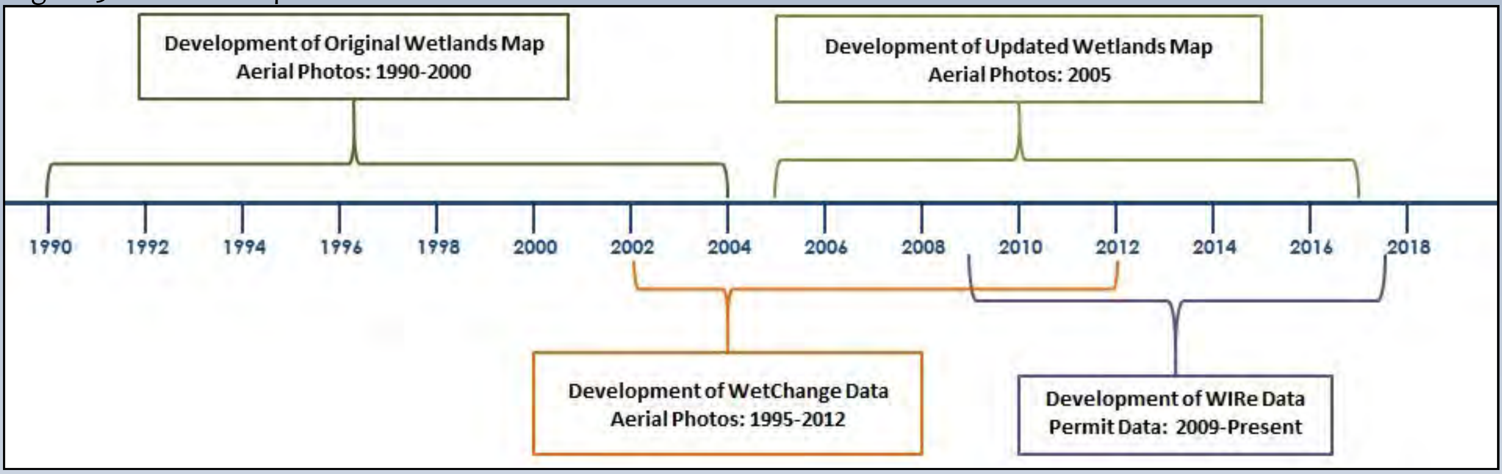


Study Methods and Objectives

In order to provide a comprehensive analysis of the current status and overall trends of wetlands resources in Massachusetts, this report utilizes data from five different sources. Figure 5 is a data development timeline for the first four data sources listed below that were used in this report and developed by MassDEP. MassDEP also contributed to the development of the UMass model listed below and used in this report.

- The MassDEP Original Statewide Wetlands Maps
- The MassDEP Updated Statewide Wetlands Maps
- The MassDEP Wetlands Change Maps
- The MassDEP Wetlands Information Resource Database
- The UMass Conservation Assessment and Prioritization Model

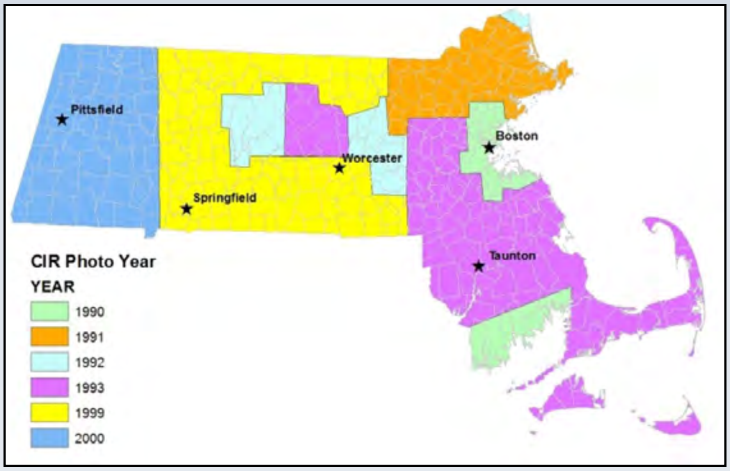
Figure 5: Data Development Timeline



Original Wetlands Map Data

In 1990, MassDEP implemented an innovative program to map and inventory freshwater wetlands and coastal wetland resources in Massachusetts. The mapping process involved photo-interpreting wetlands resources from aerial photographs. A series of color infra-red (CIR) aerial photographs were taken during leaf off periods in the early spring (figure 6). The CIR light spectrum was used because it provides better penetration through atmospheric haze and its subsequent reflectance off the ground allows for the identification of plant communities and places where water at or near the surface. The aerial photographs were taken in early spring when the water table is typically highest and tree leaves, which would obscure the view of the ground, have not yet emerged. When viewed in a stereoscope, the aerial

Figure 6: Years Aerial Photos Flown for Original Wetland Maps



photographs were displayed in three dimensions whereby hills, valleys, and other topographic features are apparent. By looking for plant communities where water is at or near the surface in low lying areas the photo-interpreter identified vegetated wetlands. Coastal resource areas were identified by their shape and landscape position. Those wetland resources were then manually delineated directly on the aerial photographs and subsequent extensive field work was conducted to confirm the delineations. The final delineations were then converted to a digital format so that they could be used in a geographic information system (GIS) and displayed on a map. The development of the original map layer was a long term project and as a result, the aerial photographs used to delineate the wetland resources where taken over a period of several years. State-wide mapping was completed in 2005.

Updated Wetlands Map Data

At the time the original MassDEP wetland maps were developed, the best technology available was used, however advances in mapping technology increased significantly over the years. Higher resolution provides a clearer view of features on the ground. Computer based mapping allows for easier and more refined display of that imagery whereby a photo-interpreter can zoom in on a feature to more accurately delineate it (figure 7). These improvements in mapping technology allow the photo-interpreter to better identify features that may have been overlooked using previous analog mapping techniques. In 2005, Massachusetts again acquired a series of spring leaf-off CIR aerial photos. This time, the aerial photographs were digital and the entire state was flown at one time. Since wetlands resources are not static, rather they can change over time, the MassDEP Wetlands Program used this opportunity to initiate an update to the original wetland maps.

Working in a GIS environment, a digital copy of the original wetlands map was overlaid on the 2005 aerial photos. The original maps were then edited to reflect changes that were visible in the 2005 aerial photos and to capture features that were overlooked.

Figure 7: CIR Image Zoomed

Left, CIR aerial image at scale of 1:12,000; Right, same aerial image, zoomed into a scale of 1:2,000

Study Methods and Objectives

In some cases, new areas were added, former areas deleted, existing areas were reconfigured (either enlarging or reducing) or classifications were changed (e.g. wooded swamp to marsh). When edits were made, the reason for the edit was also noted. The following 5 categories were used to track the edits: 1) Natural Change, 2) Beaver Activity, 3) Human Change, 4) Improvements in Technology, and 5) Undetermined. Assessments of the different categories provides the basis for determining the major causes of wetland resource loss and gain.

Wetland Change Maps

This study also utilizes data from the MassDEP Wetland Change Project. In the fall of 2002, the MassDEP Wetlands Program initiated the Wetlands Change Project to evaluate its wetlands protection efforts in more detail by utilizing remote sensing to map locations where human activity altered wetland resources. This methodology involves overlaying the wetland map data onto aerial photography and using image analysis software to compare aerial photographs from different years. The result is that changes within mapped wetland resource areas were identified. A photo-interpreter then reviewed the change to determine which changes were caused by human activity. This data was then used to create a map and database that identifies the extent and type of the human caused activity that altered wetland resources. The data was then shared with the MassDEP Regional offices where it was compared to permit applications in order to determine if the activity is permitted or unauthorized. Unauthorized activities were referred for compliance and enforcement efforts. The MassDEP Wetlands Program has conducted 4 wetland change analyses from 2002 through 2012, and is currently evaluating updated software to improve and continue this program.[2]

Figure 8: Wetland Change

These two pictures depict how the GIS feature extraction software identified wetland change in red (left) on a more recent photograph (right).

[2] *The human caused wetland losses identified in the updated wetlands map were not exactly the same as those identified by the WetChange analysis due to the different methodologies. The WetChange analysis identified approximately 92 percent of the same acreage as the human caused wetland loss acreage identified in the updated wetlands map.*

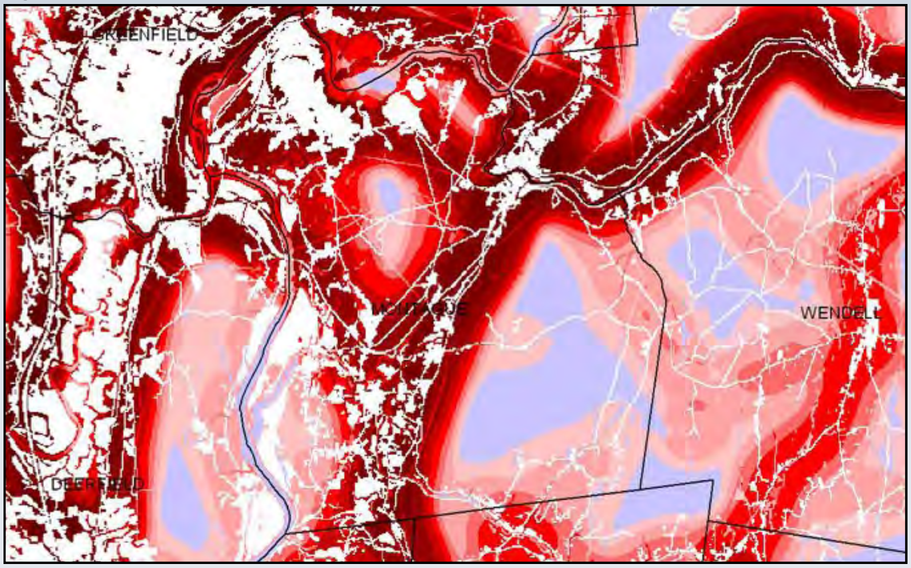
The Wetland Information Resource Database (WIRe)

In 2009, MassDEP launched a new wetland data management system that integrates MassDEP's permitting, enforcement and wetland map databases, and links the data to an innovative map viewer. The Wetland Information Resource ("WIRe") system provides a digital database via an on-line data collection and management system allowing staff to more easily determine the location and extent of wetland resource alteration/loss, the history of permit and enforcement actions on a site, and to systematically record and calculate project data. The map viewer allows MassDEP to locate projects in relation to wetland resources, floodplains, rare species habitat and many other MassGIS datalayers. In order to understand the more recent trends in permit activity, WIRe data from 2012 to 2017 was used for this report. The development of WIRe was funded by Wetlands Program Development Grants from the EPA.

The Conservation Assessment and Prioritization System Model

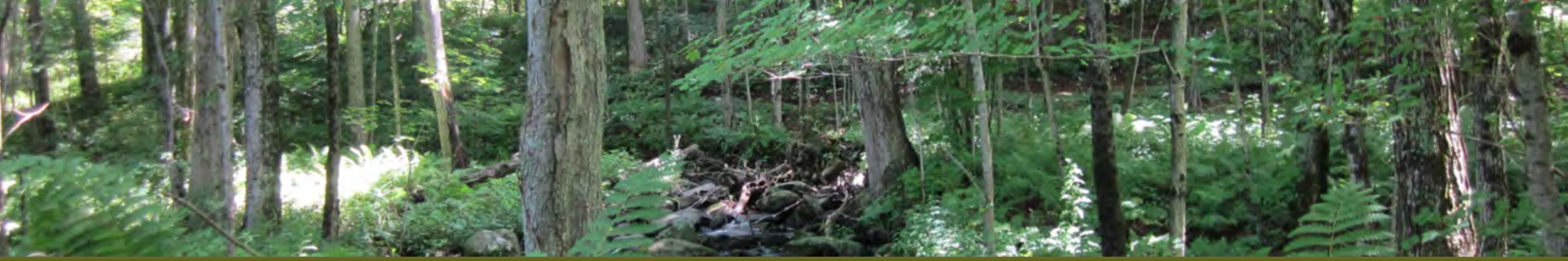
For more than a decade, the University of Massachusetts at Amherst has developed and refined the Conservation Assessment and Prioritization System (CAPS) model. CAPS is a landscape level approach which uses GIS analysis for assessing the ecological integrity of lands, wetland resources, and waters that are most likely stressed by surrounding land uses. For example, wetland resources surrounded by developed areas are presumed to be more impacted by that development, and thus have lower ecological integrity, than wetland resources in pristine areas. CAPS factors in 21 metrics to calculate the ecological integrity for Massachusetts; figure 9 shows the Traffic Intensity Metric. CAPS is used by MassDEP to assess the ecological integrity of different wetland resource types (e.g. forested wetlands, shrub swamp, salt marsh) as part of its ongoing wetland monitoring and assessment efforts under the Clean Water Act, funded by Wetland Program Development Grants from EPA.

Figure 9: CAPS Model Traffic Intensity Metric



Traffic intensity metric for the town of Montague. Areas in darker red are more highly impacted by road and railroad traffic. Blue areas are relatively unaffected by traffic. White areas are developed land.[3]

[3] Photo and Description from UMass CAPS Website http://www.umasscaps.org/about/metrics.html



Resource Definitions

MassDEP's wetlands map data identify and define the following wetland resources. Note that these are not regulatory definitions and should not be used as such.

Freshwater Wetlands

Marsh is a wetland that is dominated by herbaceous plants, such as yellow pond-lilies (*Nuphar lutea*), pickerelweeds (*Pontederia cordata*), cattails (*Typha spp.*), reeds (*Juncaceae*), grasses (*Poaceae*), or sedges (*Carex spp.*). The water table may vary from semi-permanent standing water to periods when water is below the ground's surface.

Shrub Swamp is a wetland dominated by woody vegetation that is less than 20 feet tall. That woody vegetation may be true shrubs or it may be trees that have not yet reached maturity. The water table in shrub swamps can vary from semi-permanent standing water to periods when the water is below the surface of the ground.

Wooded Swamp is a wetland dominated by woody vegetation that is greater than 20 feet tall. The most common tree in forested wetlands in Massachusetts is red maple (*Acer rubrum*). Similar to shrub swamps, the water table in wooded swamps can vary from periods of standing water to periods when the water is below the surface of the ground.

Bog is a wetland where the surface of the ground is covered by a dense mat of sphagnum moss (*Sphagnum spp.*). That mat is generally fully saturated with water and may be several feet thick. In some cases, it is actually floating over a pocket of water. Bogs are generally acidic and the plants typically have adaptions for tolerating harsh environments such as ericaceous (waxy) leaves.

Cranberry Bog is an area being used for the commercial production of cranberries (*Vaccinium macrocarpon*). The soils and water are typically manipulated to promote a healthy cranberry harvest. Cranberry production is the number one food crop in Massachusetts.

Salt Marshes

Salt Marsh is a vegetated wetland adjacent to marine or estuarine waters. Because of the high salt content in such waters, only plants that can tolerate saline conditions can survive. Typical plants in salt marsh include Cord grasses (*Spartina spp.*) and Spike grass (*Distichlis spicata*).

Coastal Resource Areas

Tidal Flats are nearly level intertidal areas adjacent to coastal waters. They often occur in sheltered areas and are regularly exposed during low tide. The

sediment generally consists of fine grain material such as fine sands, silts and clay.

Beaches are gently sloping areas adjacent to coastal waterbodies. They are usually exposed to wave action. The sediment is typically coarse material such as sand, gravel, or cobbles.

Dune is a mound, hill, or ridge of sediment adjacent to beaches. Wind and wave action from the adjacent shore serve to migrate the sand landward, forming the mounds of sand. Dunes may be vegetated by plants that can tolerate the shifting dry sands, such as American Beachgrass (*Ammophila breviligulata*) or Beach Heather (*Hudsonia tomentosa) or* they may be un-vegetated.

Barrier Beaches are narrow, low-lying strips of land derived from wind or wave sediment that are roughly parallel to the trend of the coastline and are separated from the mainland by a body of water or wetland. Since barrier beaches are derived from wind and wave deposited sediment, in their unaltered state they generally consist of beaches and dunes. However, because of the long history of land use in Massachusetts, many barrier beaches in Massachusetts are partially or even fully developed.

Rocky Intertidal Shore refers to rocky areas, such as bedrock or boulder strewn areas located between mean high water and mean low water and thus, they are inundated during high tide, but are exposed during low tide. The rocks and boulders are often covered by barnacles (Cirripedia) and/or macro-algae such as rockweed (*Fucus spp.).*

Coastal Bank is the seaward face of an elevated landform adjacent to coastal waters. The seaward facing slope is generally somewhat steep. Sea cliffs and coastal bluffs are other names for coastal banks.

Open Water

Open Water includes areas of permanent standing or flowing water, such as lakes, ponds, rivers, and the ocean. Open water is generally unvegetated. Open Water is not included in this analysis.

Wetland Resources, Coastal Wetland Resources

Wetland Resources, for the purpose of this report and unless otherwise specified, include freshwater wetlands, salt marshes, and coastal resource areas.

Coastal Wetland Resources includes only salt marshes and coastal resource areas.

MassDEP Original and Updated Statewide Wetland Maps 1990-2005

Status of Wetlands in Massachusetts

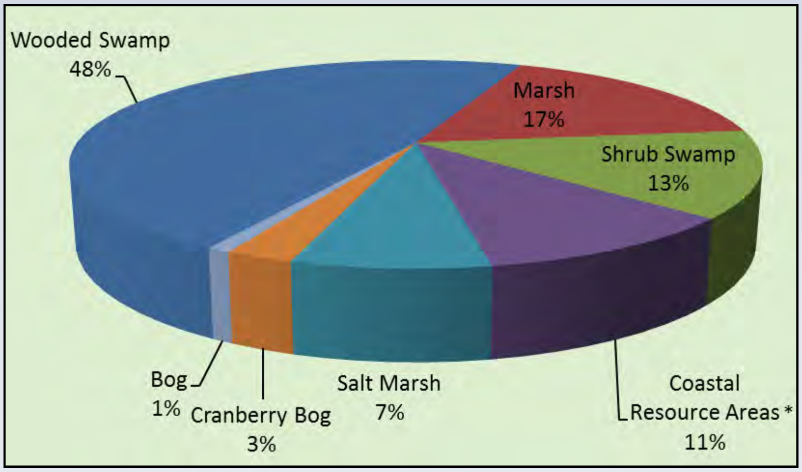
The statewide wetlands map update revealed that an estimated 590,457 acres of wetland resources existed in Massachusetts in 2005. Approximately 82% of wetland resources are freshwater wetlands and 18% are in coastal wetland resources (Figure 10). The acreage of each type of wetland resource is shown in Table 1.

While wetland resources occur throughout the state, watersheds along the coast of Massachusetts and in the southeastern part of the state have the highest overall density of wetland resources. The highest density is in the Parker River Watershed, with 33.5% of the land area consisting of wetland resources (figure 11).

Table 1: Massachusetts Wetland Resource Acreage by Type in 2005

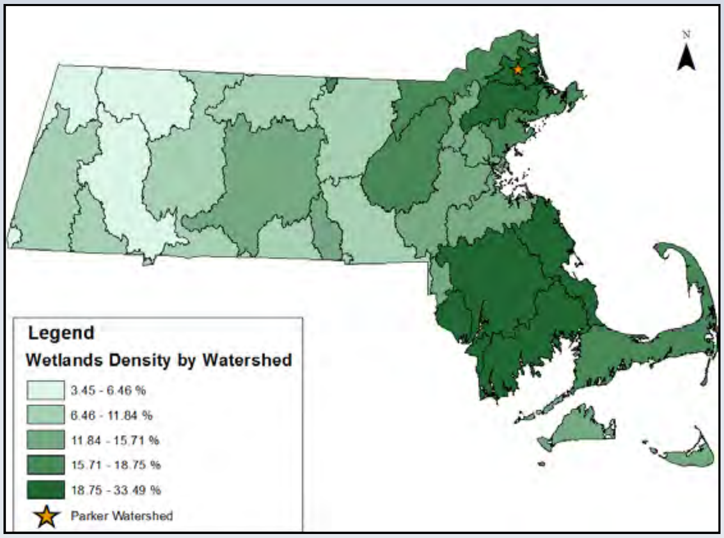
Wetland Resource Type	Acreage
Freshwater Wetlands	**482,380**
Wooded Swamp	281,610
Marsh	100,418
Shrub Swamp	79,337
Commercial Cranberry Bogs	15,651
Bog	5,364
Salt Marshes	**45,055**
Coastal Resource Areas	**63,022**
Coastal Bank	2,072
Barrier Beach	6,384
Beach	14,043
Dune	10,879
Rocky Intertidal Shore	1,583
Tidal Flat	28,061
TOTAL	**590,457**

Figure 10: Wetlands Resources in Massachusetts - Percent Total of Acreage in 2005



** Coastal Resource Areas Includes: Coastal Banks <1%, Barrier Beach 1%, Beach 2%, Dune 2%, Rocky Intertidal Shore <1%, and Tidal Flat 5%*

Figure 11: Percent of Area Wetland Resources Occupy by Watershed



Wetland Trends in Massachusetts

Changes in wetland resources can occur as a result of human or natural causes. For instance humans can impound water thereby expanding wetlands, fill wetlands thereby reducing wetlands, or create wetlands as part of ecological restoration projects. Natural occurrences such as beaver dams can also impound water causing wetlands to expand, storms can cause salt marshes to erode, or wetlands can transition as part of natural succession. In some cases the cause of wetland resource changes can be determined by reviewing aerial photographs. Beaver dams, new roads, or dune erosion can be readily identified. However In other cases, the cause of the wetland resource change cannot be determined by aerial photointerpretation. The area may be obscured by evergreen trees, or the cause of the change may simply be unclear. In those cases, the cause of the change is undetermined. However, by noting the trend of differences between the original wetland maps to the updated wetland maps, and where possible the cause of that difference, general trends in wetland resource changes have been identified.

Massachusetts had an estimated net gain of 4,925 acres of all wetland resources between the original and updated wetland mapping efforts. While many would have expected an overall net loss in wetland resources, this gain was primarily attributed to beaver activity (discussed further in Natural Trends section), the expansion of commercial cranberry bogs, and coastal storm events changing the extent of coastal landforms. Freshwater wetlands had a larger overall net gain of 4,188 acres and coastal wetland resources had a combined net gain of 737 acres. It is important to note that data from the Massachusetts Office of Coastal Zone Management Shoreline Change Project (https://www.mass.gov/service-details/massachusetts-shoreline-change-project) is available and may draw different conclusions about shoreline change. Because the Shoreline Change Project covered a different timeframe, defined resource areas differently, and focused on rates of change rather than areal extent, they cannot be directly compared to this study. Further, the majority of the coastal wetland resource gain identified in this study involved beaches and tidal flats. Because the aerial photos used for the mapping did not have specifications for tidal stage, this may have influenced the mapping of these resource areas.

See Table 1 for Massachusetts Wetland Resource Acreage by Type in 2005, and Figure 12 for the Losses and Gains between the Original and Updated mapping efforts.

Advancements in mapping technology have resulted in identification of additional acres of wetlands resources (table 2). This increase in wetland resource acreage due to advancements in mapping technology are not necessarily actual changes; they are wetland resources that likely existed at the time of the original mapping effort, but due to the limitations of the older technology they were not captured, or were only partially captured. Therefore gains and losses that were categorized as new technology are not considered as actual trends in wetland resources for this study.

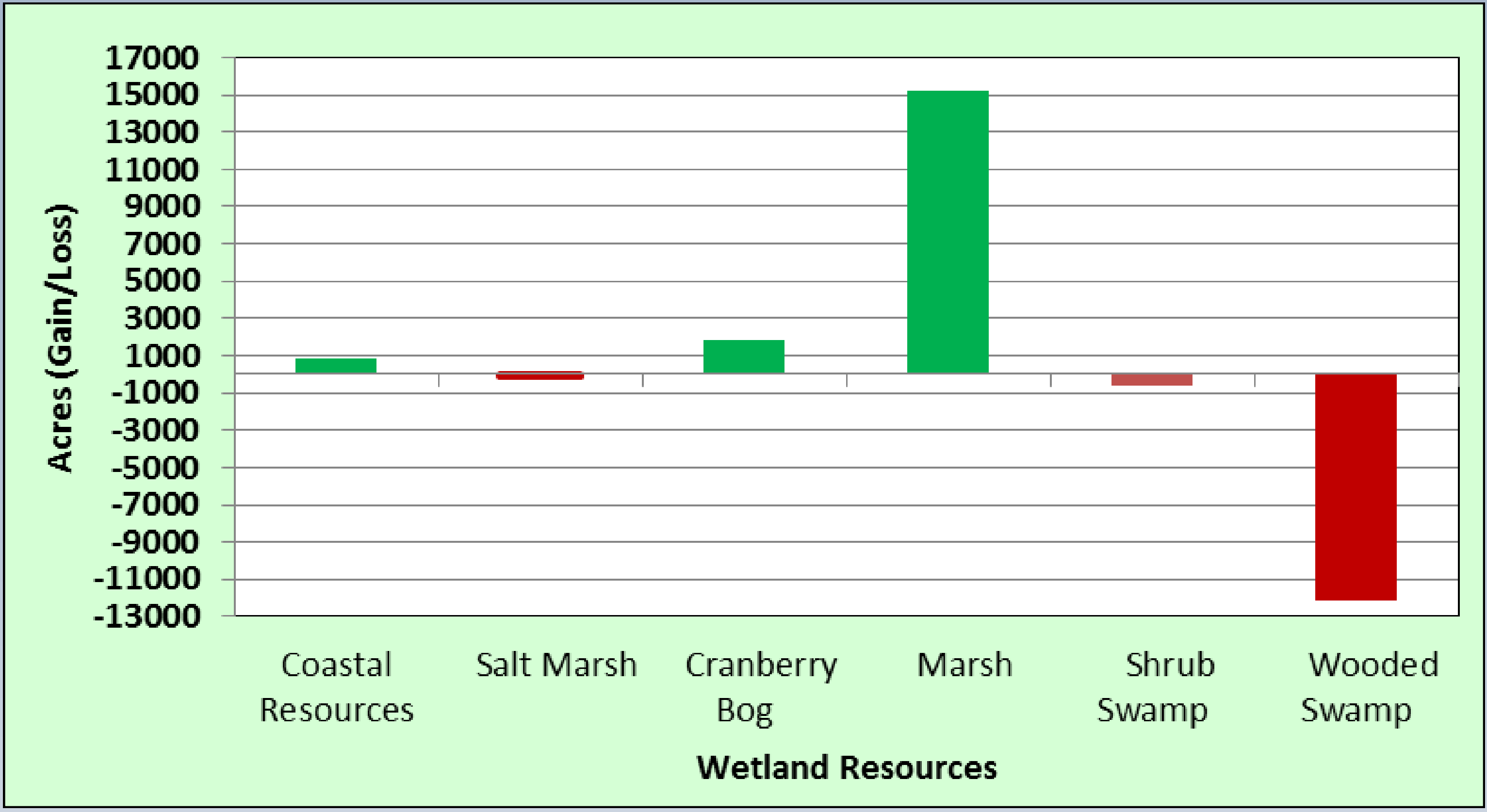
MassDEP Original and Updated Statewide Wetland Maps 1990-2005

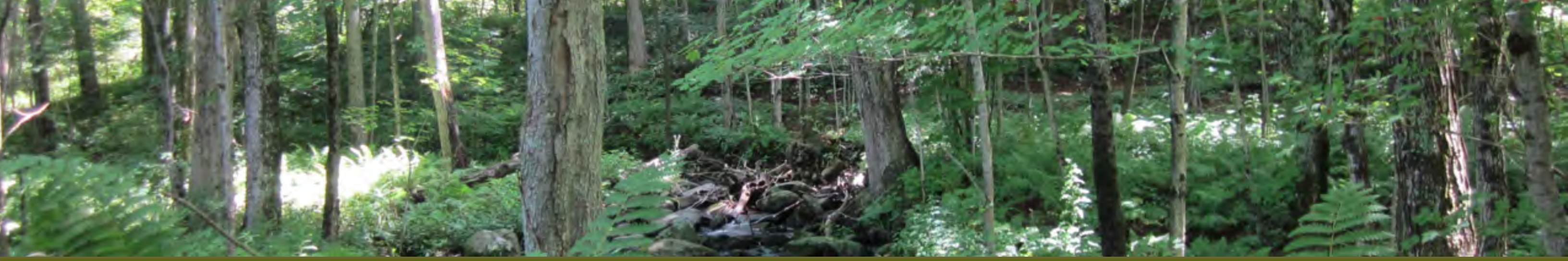
Table 2: Table of Wetland Resources in Massachusetts

Wetland Resource Type	Acres				
	Original Mapped Acres	2005 Mapped Acres	Map changes Attributed to Advancements in Mapping Technology	Mapped Actual Changes 2005 [4] (Natural/Human/ Undetermined)	Actual Change (percent)
Coastal	**96,521**	**108,077**	**10,819**	**737 (234 / 22 / 481)**	**0.76 %**
Coastal Bank	2,117	2,072	-42	-3 (-3 / 4 / -4)	-0.14 %
Barrier Beach	5,062	6,384	1,347	-26 (-13 / -1 / -12)	-0.51 %
Beach	11,615	14,043	1,801	625 (368 / -11 / 268)	5.38 %
Dune	11,733	10,879	-656	-197 (-196 / -1 / 0)	-1.68 %
Rocky Shore	1,192	1,583	385	6 (0 / 4 / 2)	0.50 %
Salt Marsh	45,344	45,055	-199	-89 (-89 / 19 / -19)	-0.20 %
Tidal Flat	19,458	28,061	8,183	421 (167 / 8 / 246)	2.16 %
Freshwater	**466,480**	**482,380**	**11,709**	**4,188 (2,664 / 1,027 / 497)**	**0.90 %**
Bog	5,407	5,364	70	-114 (-70 / -32 / -12)	-2.11 %
Commercial Cranberry Bog	13,764	15,651	50	1,837 (4 / 1,828 / 5)	13.35 %
Marsh	82,811	100,418	2,395	15,211 (11,871 / 1,308 / 2,032)	18.37 %
Shrub Swamp	77,143	79,337	2,828	-635 (-55 / -256 / -324)	-0.82 %
Wooded Swamp	287,355	281,610	6,366	-12,111 (-9,086 / -1,821 / -1,204)	-4.21 %
Grand Total	**563,001**	**590,457**	**22,528**	**4,925 (2,898 / 1,049 / 978)**	**0.95 %**

[4] "Mapped actual changes", are the net changes of loss, gain, and transition (to or from another wetland resource) that were caused by human or natural causes.

Figure 12: Wetland Resources - Losses and Gains Original to Update





MassDEP Original and Updated Statewide Wetland Maps 1990-2005

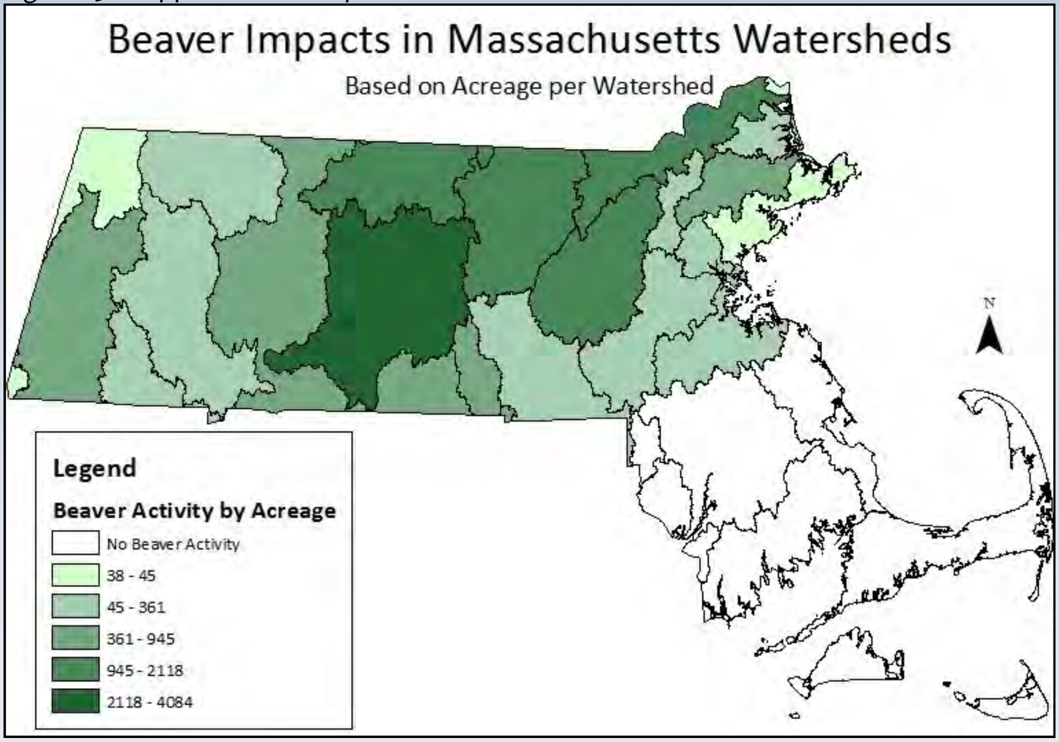
Natural Trends—Beaver Activity

Beavers expand wetland resources by damming streams which causes flooding of the land upstream. As a result, areas that used to be dry now have water at the surface and become wetlands. Areas that are completely inundated with water develop anaerobic (absence of oxygen) conditions and a buildup of organic material in the soil making it difficult for large trees, particularly in New England, to survive. As the trees die-off and the ground below receives full sunlight, shrub and marsh vegetation, which can tolerate such conditions, flourishes. Beaver activity has created 2,403 acres of new freshwater wetlands and changing 12,871 acres of existing freshwater wetlands to other types (e.g. forested to shrub or emergent) between 1990 and 2005.

Table 3: Statewide Changes in Wetland Resources Due to Beaver Activity

Wetland Resource Change or Expansion Due to Beavers Creating Wetter Conditions	Acreage
Wooded Swamp to Marsh	7,108
Shrub Swamp to Marsh	3,643
Wooded Swamp to Shrub Swamp	2,037
Wetland Expansion into Upland	2,403
Other	83
TOTAL	**15,274**

Figure 13: Mapped Beaver Impact in Massachusetts Wetlands

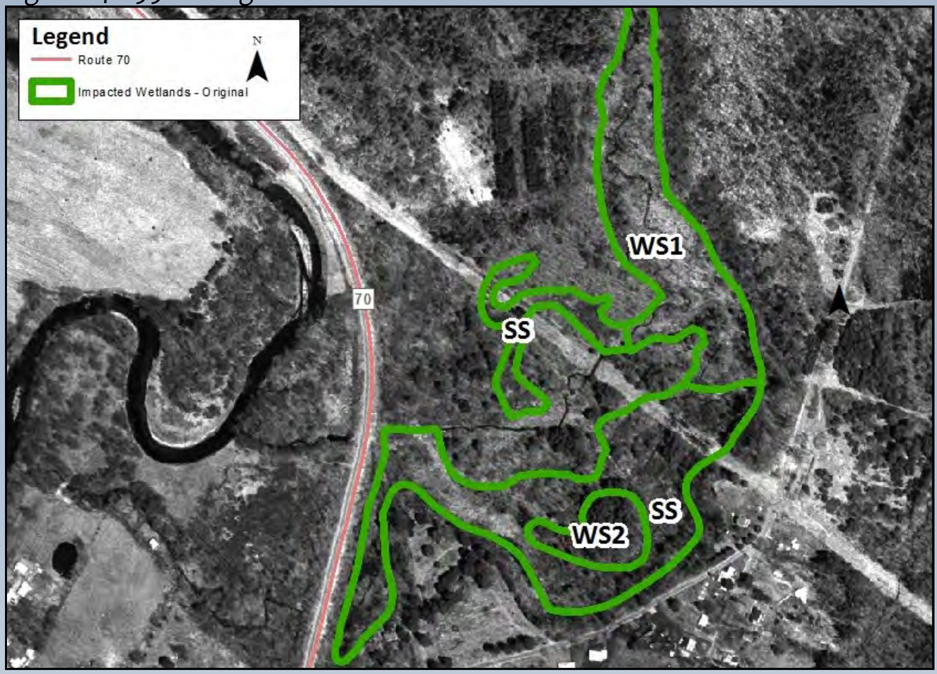


This figure depicts the wetland acres associated with beaver activity in freshwater wetlands by watershed. The Chicopee watershed has the greatest amount of beaver activity of all of the Massachusetts watersheds. In general the central and northeast regions of the state have the most acreage of beaver activity in wetlands.

Case Study—Beaver Activity: Ponakin Brook

Ponakin Brook in Lancaster, MA drains west into the Nashua River. In 1992 the freshwater wetlands along Ponakin Brook east of route 70 had an estimated 21 acres of wooded swamp and shrub swamp (figure 14). At some point between 1992 and 2005 beaver established a dam at the culvert under Route 70. This caused the water to impound and back up on the upstream side of the dam. As a result, 27 acres of new freshwater wetlands were created from the adjacent upland and the original 21 acres of wooded swamp (WS1, WS2) and shrub swamp (SS), transitioned to marsh (M) (figure 15).

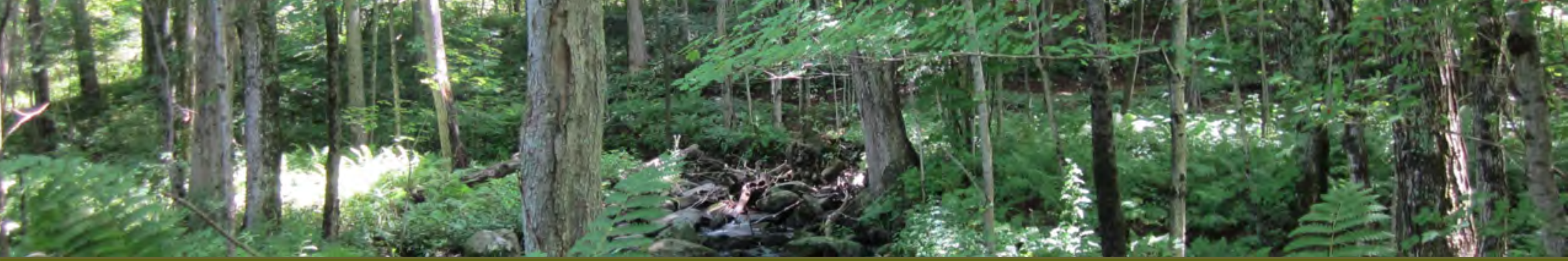
Figure 14: 1991—Original Freshwater Wetlands at Ponakin Brook



Originally mapped as 21 acres of shrub swamp and forested wetland.

Figure 15: 2005—Expanded Freshwater Wetlands at Ponakin Brook

The beaver (Former Beaver Dam shown in orange circle) impounded Ponakin Brook and created 27 acres of new wetlands, and altered the hydrology of existing wetlands by making them wetter.



MassDEP Original and Updated Statewide Wetland Maps 1990-2005

Natural Trends—Coastal Processes

The Massachusetts coastline is a dynamic place. While some coastal wetland resources such as rocky intertidal shores are generally stable, many coastal wetland resources like beaches and dunes are comprised of sediment, and therefore are subject to change by the energies of wind, waves, and tidal action. Between 1990 and 2005 Massachusetts experienced numerous coastal storms. For instance, Hurricane Bob, in 1991, produced sustained winds of 100 mph. Other significant coastal storms during that period include "The Perfect Storm" in 1991, the Blizzard of 1992, and an un-named Winter Storm in December of 2003.[5,6] The effects of these storms were evident in the wetlands map update.

The greatest amount of natural change in coastal areas occurred on Cape Cod, Martha's Vineyard, and Nantucket. These parts of the state are exposed to the open ocean, and intense waves cause movement of the sediment that makes up the beaches and dunes. Beaches and dunes can change form becoming larger (accrete) or smaller (erode) depending on where they are located and wave intensity. On barrier beaches, dunes may erode or even be breached by storm waves. In some cases, new dunes will become re-established in the area of the breach, while in other cases the breach becomes a new inlet for water. When coastal banks erode as a result of wave action, the resulting sediment nourishes the adjacent beaches and dunes however there is no natural process that restores them. These natural events create a dynamic process of change in the coastline. Table 4 and Figure 16 show where and how much natural change has occurred along the Massachusetts coastline.

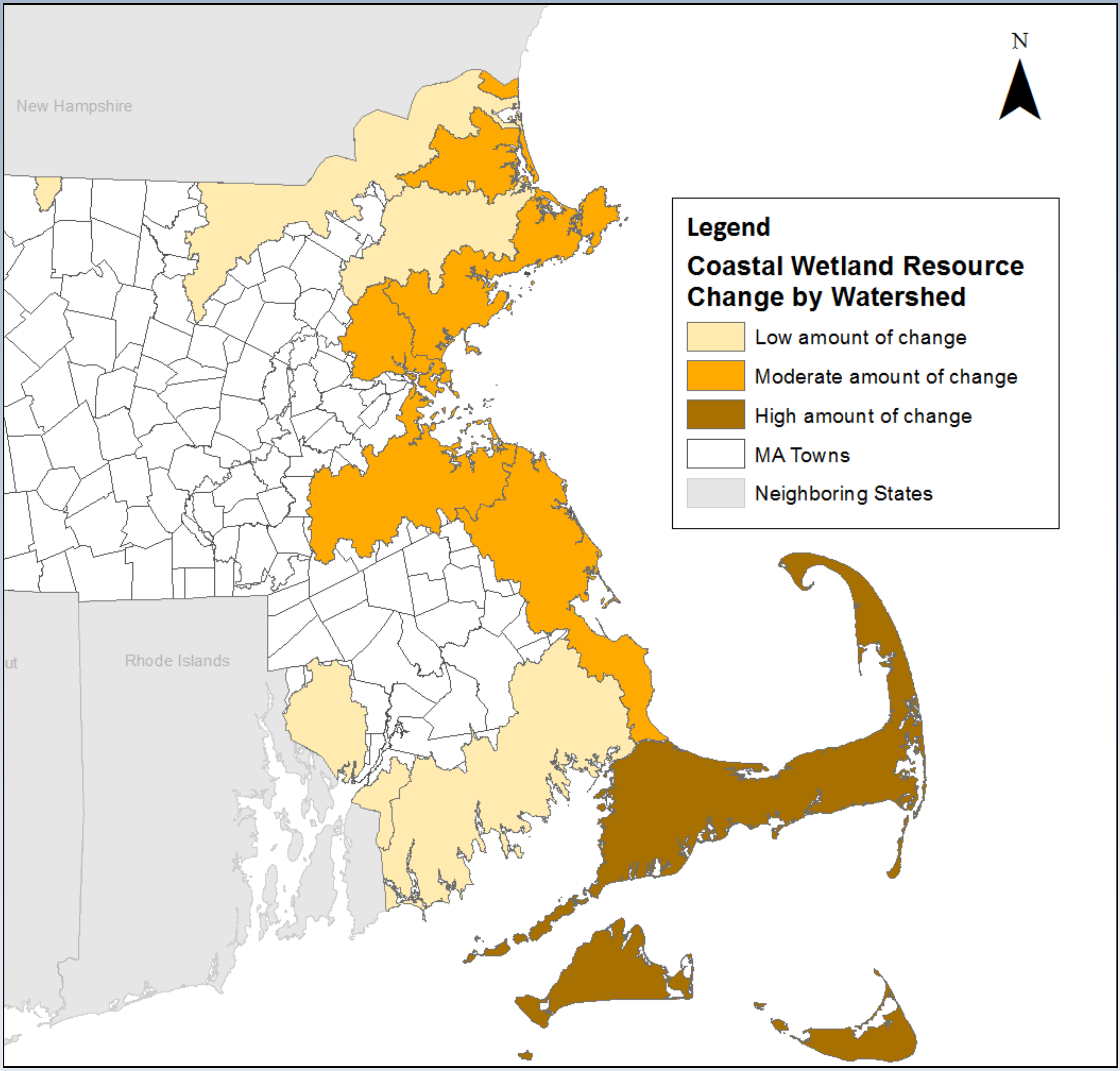
Table 4: Major Changes in Coastal Wetland Resources by Acres 1990-2005

Coastal Wetland Resource Type	Natural Gain - change from Other Wetlands Types	Natural Loss—change to Other Wetland Types	Natural Gain from Uplands	Natural Loss to Uplands	Sum of Natural Change
Coastal Banks	2	-9	5	-1	-3
Barrier Beach	18	-32	1	0	-13
Beach	1635	-1314	47	0	368
Dune	399	-604	9	0	-196
Rocky Shore	3	-3	0	0	0
Salt Marsh	155	-244	0	0	-89
Tidal Flat	867	-700	0	0	167
Grand Total	3079	-2906	62	-1	234

[5] https://pubs.er.usgs.gov/publication/70032928

[6] Other major storms occurring since 2005 such as Tropical Storm Irene were not captured in the updated wetlands map or the Wet-Change project that evaluated only human changes. Thus they are not discussed in this report although undoubtedly, changes occurred.

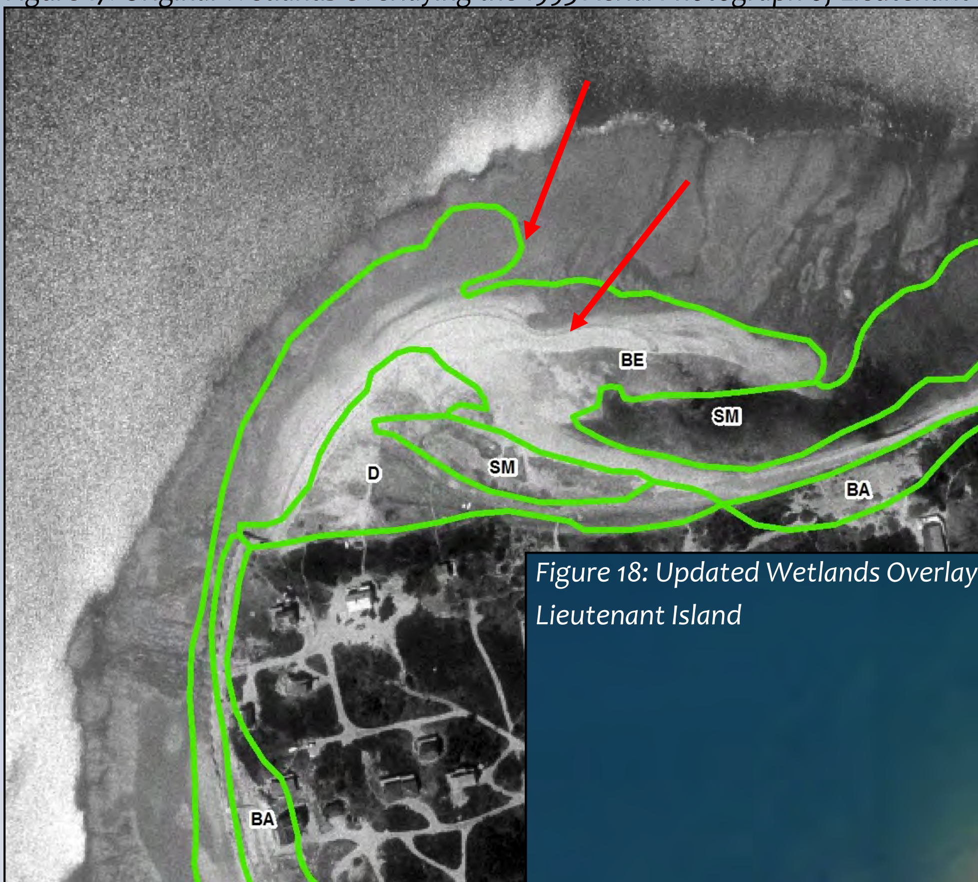
Figure 16: Natural Change in Coastal Wetland Resources by Watersheds Original to Update



MassDEP Original and Updated Statewide Wetland Maps 1990-2005

Case Study—Coastal Processes: Lieutenant Island

Figure 17: Original Wetlands Overlaying the 1993 Aerial Photograph of Lieutenant Island



This beach system was originally mapped based on 1993 aerial photography. There is a finger of beach (BE) that is parallel to the coastline. This type of feature is referred to as a "spit." Adjacent to it is salt marsh (SM).

Figure 18: Updated Wetlands Overlaying the 2005 Aerial Photograph of Lieutenant Island

On the 2005 aerial photograph the beach has migrated to the Northeast. The adjacent salt marsh to the south has expanded. These mapped changes in coastal wetland resources allow for the quantification of natural change along the shoreline.

Case Study—Coastal Processes: Pochet Neck

Salt Marshes are among the most productive and valued wetlands in Massachusetts. As a result, the Massachusetts WPA prohibits direct alteration of salt marsh with few exceptions. Despite this, there has been a net loss of 89 acres of salt marsh in Massachusetts between 1990 and 2005. The causes for this loss are outlined in Table 5.

Salt marshes often occur in coastal areas that are sheltered by the direct energy of waves such as coves, lagoons, estuaries, or other waters behind a beach and dune complexes. During storm conditions large waves may overwash the adjacent dunes, resulting in sediment being deposited directly on the salt marsh. This is referred to as an overwash fan. The two aerial photographs of Pochet Neck, Orleans show a salt marsh behind a beach and dune complex. Figure 19 was taken in 1993 and figure 20 was taken in 2005. As the dunes expanded and the salt marsh was buried, the natural function of the salt marsh was diminished. However, the dunes also provide significant functions of storm damage prevention, flood control and protection of wildlife habitat as well. As sea level rises it is anticipated that the frequency and intensity of coastal storms will likely increase, and overwash fans may become more prevalent.

Table 5: Salt Marsh Loss and Gain

Occurrence	Change Type	Acreage Change
Salt Marsh Loss	Natural	-244
	Anthropogenic	-3
	Undetermined	-94
Salt Marsh Gain	Natural	155
	Anthropogenic	22
	Undetermined	75
Net Total		**-89**

Figure 19: Original Wetlands Overlaying 1993 Aerial Photograph of Pochet Neck

This aerial photo of Pochet Neck, Orleans, taken in 1993 shows a salt marsh located in an estuary that is protected from the open ocean by beach and dunes.

Figure 20: Updated Wetlands Overlaying 2005 Aerial Photograph of Pochet Neck

In the same area as the photo to the left in 2005, a portion of the salt marsh has been buried in sand due to the landward movement of the dune from wind and wave action creating an overwash fan, most likely during a coastal storm event.

Human Caused Trends – Wetland Resource Losses

The statewide wetland map update identifies the number of acres mapped as losses from human activity, but does not track specific activities that result in the losses. A discussion detailing the specific types of human activities that caused wetland resource loss and the frequency that each type occurred is located in the *Wetland Change Project – Wetland Resource Losses* section of this report. Based on the evaluation of the statewide wetlands map updated as compared to the original statewide wetlands map, MassDEP identified 1,548 acres of wetland resource loss from human activity. Wooded swamps were the wetland resource type with the highest acreage of loss from human activity (table 6).

Table 6: Human Caused Wetland Resource Losses

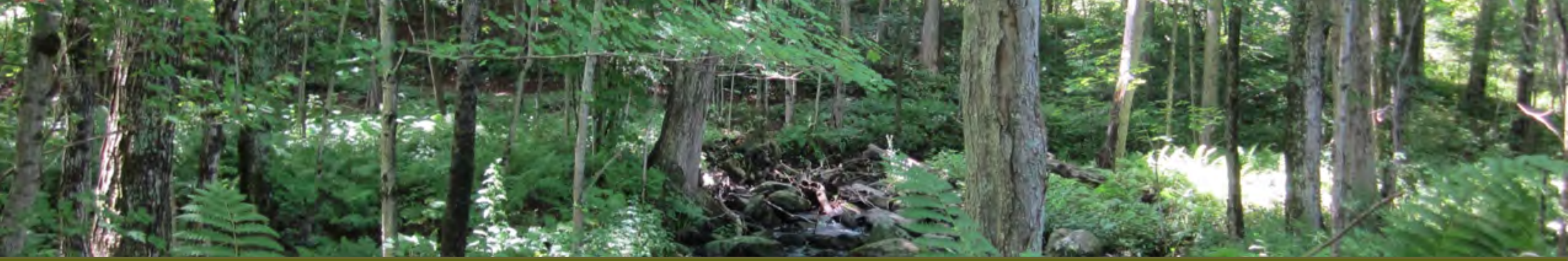
Wetland Resource Area Classification	Acres of Loss
Wooded Swamp	948.8
Marsh	278.6
Shrub Swamp	171.9
Cranberry Bog	129.8
Beach	8.2
Coastal Bank	4.4
Salt Marsh	2.8
Dune	1.2
Bog	1.1
Tidal Flat	1.0
Rocky Intertidal Shore	0.2
Barrier Beach	0.0
Total Wetland Losses from Human Activity	**1,548.0**

Human Caused Trends—Case Study: New Road

New residential development often requires the creation of new roads for access. Figure 21 shows a dirt road crossing between two freshwater wetlands. Between 1992 and 2005, a residential subdivision was constructed to the west of the freshwater wetland. A paved road was built to provide access to the new housing. In figure 22, the area highlighted in red shows the area of freshwater wetland loss from the road construction, and the area in the lighter green shows a new freshwater wetland area which was created to compensate for the area of lost freshwater wetland.

Figure 21: Human Caused Freshwater Wetland Alteration in 1993 (before)

Figure 22: Human Caused Freshwater Wetland Alteration in 2005 (after)



Human Caused Trends – Wetland Resource Gains

Human activity is typically associated with wetland resource loss but some human activity can result in wetland resource gains. New cranberry bogs, dam impoundment, ecological restoration, and new stormwater management systems[7] can all create new wetland resources. Commercial cranberry bog expansion and dam impoundments accounted for the largest acreage of wetland resource area gain due to human activity between 1990 and 2005 (table 7).

Case Study—Human Caused Change: Barre Falls Dam

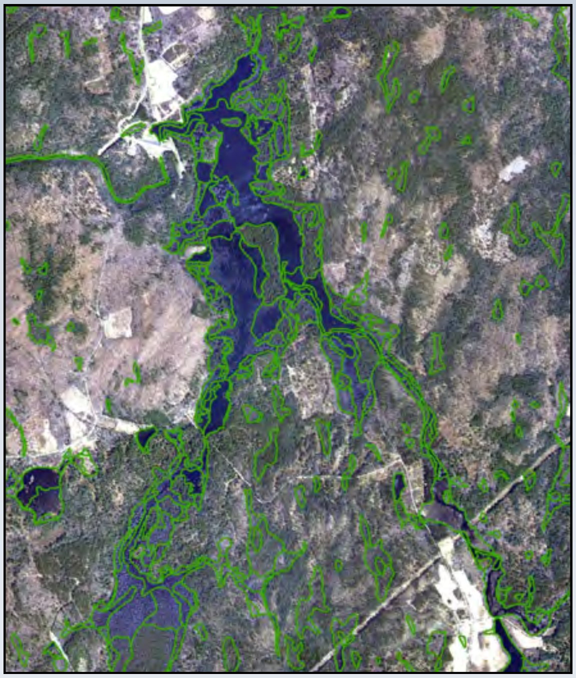
The Barre Falls Dam – along the Ware River in Barre, MA – has been operational since July 1958, and reduces flood damage along the Ware, Chicopee, and Connecticut Rivers.[8] The Dam is maintained by the Army Corps of Engineers and managed in coordination with the Massachusetts Department of Conservation and Recreation. Under normal flow conditions the storage area upstream of the dam does not contain impounded water. During flood events the storage area holds impounded floodwater, which can result in an increase in the extent of freshwater wetlands. Shown are aerial photographs from Spring 2001 while the dam was open (figure 23) and from Spring 2005 when the dam was closed (figure 24). The resulting impounded water caused the freshwater wetland to increase by over 200 acres.

Table 7: Acreage of Wetland Resource Area Gains Due to Human Activity

Wetland Resource Area Classification	Acres of Gains
Cranberry Bogs	1,839.7
Marsh	652.1
Wooded Swamp	166.4
Shrub Swamp	34.5
Salt Marsh	20.9
Tidal Flat	9.0
Coastal Bank	5.6
Beach	2.8
Dune	1.4
Rocky Intertidal Shore	0.6
Barrier Beach	0.0
Bog	0.0
Total Wetland Gains from Human Activity	**2,733.0**

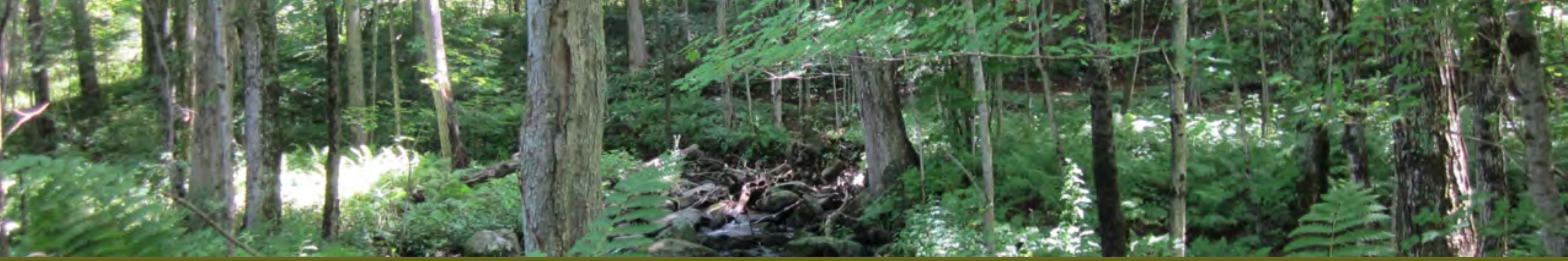
Figure 23: Barre Falls Dam Wetlands 2001, Dam Open

Figure 24: Barre Falls Dam Wetlands 2005, Dam Closed



[7] Stormwater management systems do not by themselves constitute areas subject to protection under the Wetlands Protection Act or Buffer Zone provided certain conditions are met (see 310 CMR Wetlands Protection Act 10.02(2)(c)). For the purpose of this study, stormwater management features may have been identified as vegetated wetlands even if they aren't jurisdictional.

[8] http://www.nae.usace.army.mil/Missions/Civil-Works/Flood-Risk-Management/Massachusetts/Barre-Falls/



Case Study—Human Caused Change: Wetland Mitigation Projects

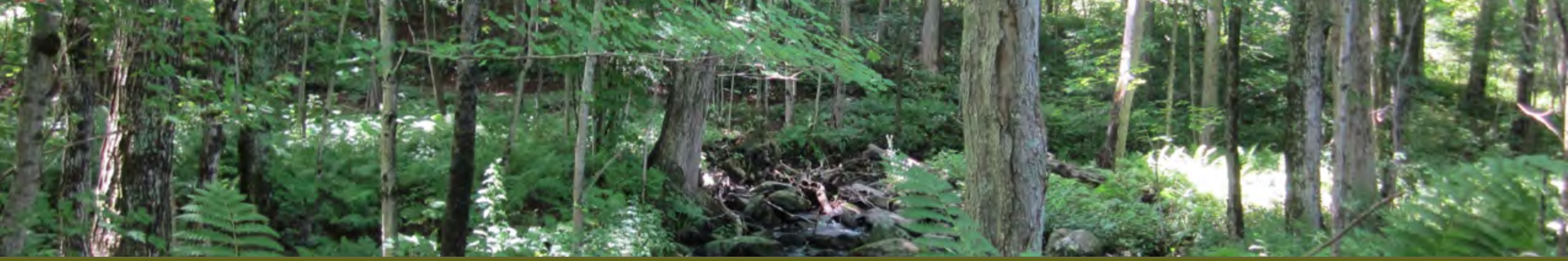
Massachusetts WPA regulations require that all wetlands lost due to development be replaced by creation of a similar wetland of the same size or larger. Additionally, Massachusetts also has strong regulations protecting salt marshes; however, 3 acres were lost between 1990 and 2005. This loss was primarily due to residential activity from unauthorized lawn and yard expansion. Offsetting this loss, there has been a 19 acre net gain in salt marsh acreage due to human activities including wetland creation required as mitigation and ecological restoration projects.

One example is in Revere, MA. In the late 1960's, prior to the WPA regulations being authorized, a plan to extend Interstate 95 from Revere to Lynnfield was developed. That plan involved running the proposed highway directly through Rumney Marsh, the largest salt marsh in the metropolitan Boston area. Then, in 1972, after the project was already well underway, the work was halted due to changes in Massachusetts' transportation priorities. However, the fill remained in place.

In the early 1990's, the Central Artery Project ("The Big Dig") was undertaken. In order to mitigate for the impacts associated with the Big Dig, MassDEP required that a portion of Rumney Marsh be restored. That restoration involved removing a targeted area of fill material and re-establishing the elevation to allow for the flow and ebb of tides and planting salt marsh vegetation. The result was an approximately 12.5 acre increase of salt marsh.

Figure 25: Rumney Marsh Transportation Fill, 1995 — The white finger-like area is the fill material associated with the construction of the proposed Interstate 95 extension. The green line represents the 12.5 acre area where salt marsh was proposed. This black and white aerial photograph is dated 1995.

Figure 26: Rumney Marsh Created Salt Marsh, 2005 — This 2005 aerial photograph shows the successfully created salt marsh. In addition to providing wildlife and fisheries habitat, this strategically located salt marsh restoration helps protect nearby homes and businesses by providing significant floodwater storage capacity during coastal storm events.



Human Caused Trends – Change in Wetland Resource Type

Statewide, 1,923 acres of wetland resources changed from one type of wetland resource to another (with no loss or gain of overall wetland resources) as a result of human activity between 1990 and 2005.

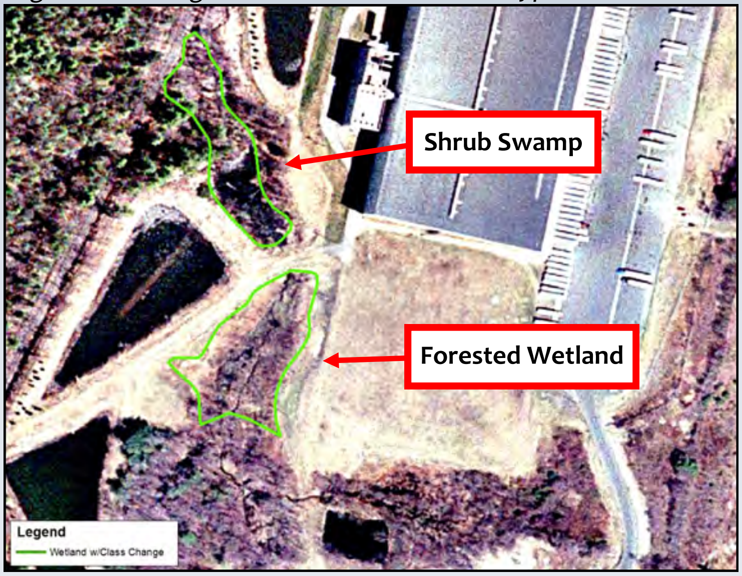
Case Study: Human Caused Trends: Change in Wetland Type

The photos shown are an example of a shrub swamp and forested wetland changing into freshwater marshes as a result of human activity. The extension of the warehouse increased impervious surfaces, which likely led to an increase of stormwater runoff. It is also possible that the freshwater wetland's water table is being raised due to displacement from the foundation of the adjacent building extension. Increased runoff – or the rising water table – into shrub swamp and forested wetland made the freshwater wetlands wetter and better suited for the herbaceous vegetation of freshwater marshes.

Table 8: Acreage of Wetland Resource Area Change Type Due to Human Activity

Wetland Resource Area Classification	Change Acres Gain	Change Acres Loss
Coastal Bank	7.0	-4.5
Barrier Beach	2.6	-3.5
Beach	3.2	-8.4
Bog	0.0	-30.9
Cranberry Bog	143.5	-25.1
Dune	0.0	-1.5
Marsh	1,110.9	-176.0
Rocky Intertidal Shore	4.1	-0.6
Salt Marsh	1.0	-0.3
Shrub Swamp	300.9	-419.1
Tidal Flat	0.1	-0.2
Wooded Swamp	3.9	-1,042.6
Total	**1,922.9**	**-1,922.9**

Figure 27: Change in Freshwater Wetland Type in 2001



In 2001 the wetlands next to the warehouse are shrub swamp and forested wetland.

Figure 28: Change in Freshwater Wetland Type in 2005

In 2005, there is an expansion of a warehouse and increased runoff or rise in groundwater caused wetlands to change to marsh.

MassDEP Wetlands Change Maps 1995-2012

The Wetland Change Project mapping identifies human caused loss to wetlands resources throughout Massachusetts. Unlike the statewide wetland mapping update, the Wetland Change Project tracked the type of activity that caused the resulting loss to wetland resources including but not limited to: residential development, commercial development, new roads, infrastructure, agriculture, logging/clearing, dock/pier, etc. The data was developed by overlaying the original wetland maps on aerial photos flown in 2001-2003, 2005, 2008-2009 and 2011-2012 to identify wetland resource losses. The Wetland Change Project focused on human activities that caused the loss of wetland resources and the dates which they occurred.

Wetland Resource Losses

The Wetland Change Project data indicates that 1,049 acres of wetland resources were lost as a result of human activity from 1995 to 2005. Residential development accounted for the greatest acreage of that loss, with the number of individual impacts being almost double that of any other activity type. Cranberry growing activity was the second largest cause of wetland resource loss due to human activity, and commercial development was the third. As a result of this information, MassDEP undertook an enforcement initiative to identify the most egregious violations. Subsequent to that enforcement initiative, Wetlands Change Project data from 2006 to 2012 indicates that 143 acres of wetland resources were lost as a result of human activity. This is a substantial reduction in wetland resource loss. During this time period commercial development was the largest human cause of wetland resource loss, with residential development second and new road construction third. Using the Wetlands Change data to identify un-permitted wetland resource loss that took place between 1995 and 2012, MassDEP took enforcement action in 77 wetland loss cases. As a result, $3,311,337 in combined penalties were issued and 68.2 acres of wetland have been ordered to be restored. MassDEP is currently evaluating updated software to improve and continue this program.

Figure 29: WetChange Human Activity Percentages 1995-2005 [9]

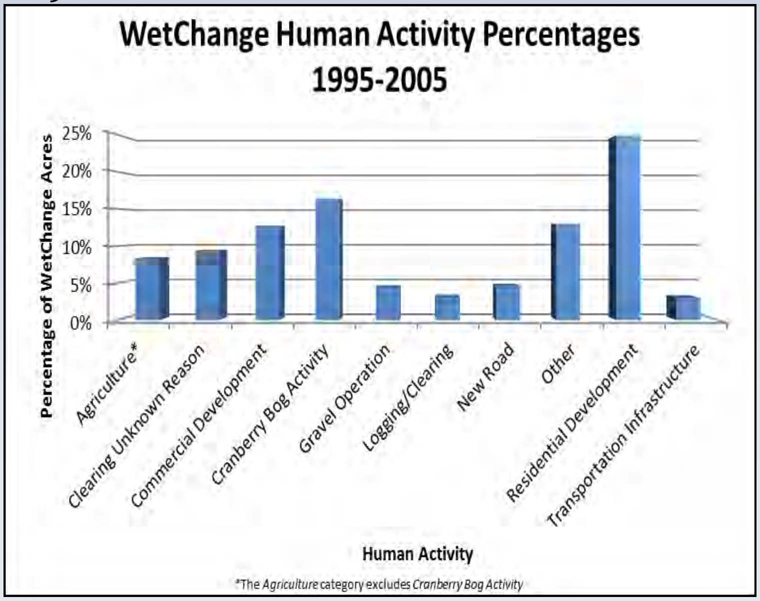
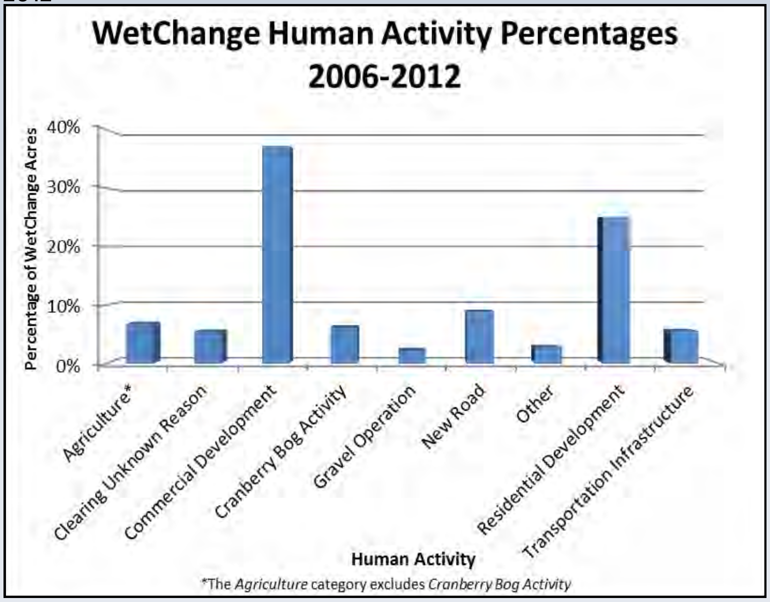


Figure 30: WetChange Human Activity Percentages 2006-2012



[9] The human caused wetland resource losses identified in the updated wetlands map were not exactly the same as those identified by the WetChange analysis due to the different methodologies. Of the human caused wetland resource loss acreage identified in the updated wetlands map, the WetChange analysis identified approximately 92 percent of the same acreage.

Case Study- Wetland Change Project: Cranberry Bogs

The commercial cranberry industry started in Massachusetts 200 years ago and cranberries are the number one agricultural food product grown in Massachusetts. Cranberry bogs are actively managed agricultural areas, not natural ecosystems. Cranberry bogs are technically wetlands since they have the wetland plants, hydric soils and hydrology needed to be considered wetlands. They are intensively managed for the purpose of growing one specific crop and therefore do not provide the ecological diversity that is typical of natural wetlands.[10]

As noted in the previous section, cranberry bog activity was the second largest human cause of loss of natural freshwater wetlands between 1995 and 2005, with the largest frequency of impacts occurring prior to 2001. While the alteration of natural freshwater wetlands for commercial cranberry bog farming may be allowed under the Massachusetts WPA and its regulations under certain circumstances,[11] [12] not all of the alterations that occurred were allowed. MassDEP's Wetland Change Analysis demonstrated that it had the technology to document the conversion of natural freshwater wetlands to commercial cranberry bogs and enforce against these changes. As a result, the cranberry industry took pro-active steps and worked with MassDEP in helping to reduce these occurrences. Subsequently, natural freshwater wetland alteration from cranberry bog activity had a noticeable drop in occurrences between 2006 and 2012 (Figure 32).

Figure 31: Aerial Image of an Active Cranberry Bog

Figure 32: Impacts of Cranberry Bog Activity - Tracked by Wetland Change

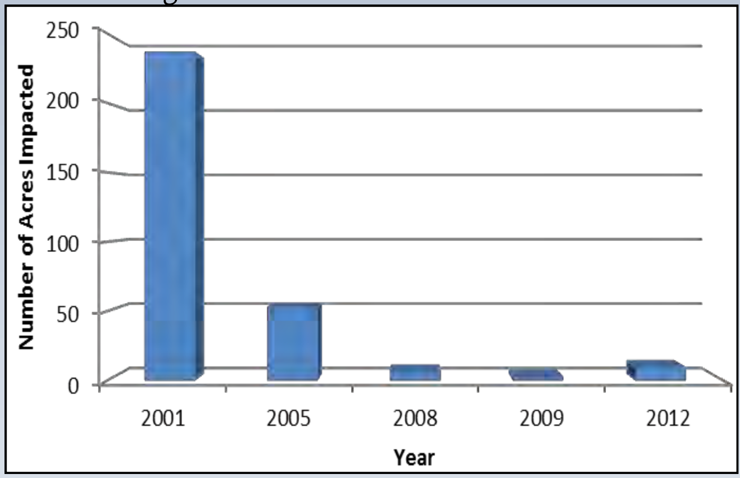


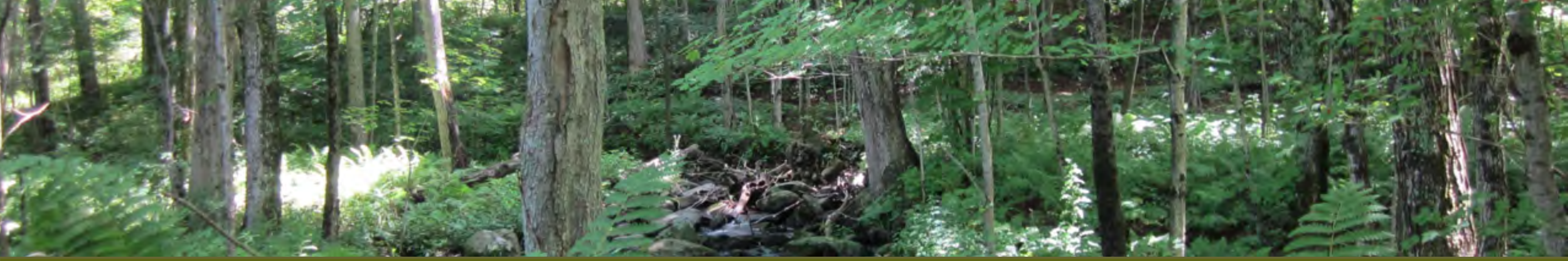
Table 9: Overall Gains of Commercial Cranberry Bogs

Original Land Use for NEW Commercial Cranberry Bogs	ACRES
Natural Freshwater Wetlands	142
Uplands	1,897
TOTAL New Cranberry Bog Acres	**2,039**

10 http://www.umass.edu/cranberry/downloads/Cranberry%20Water%20Use.pdf).
http://www.umass.edu/cranberry/downloads/CP-08.pdf
https://www.epa.gov/sites/production/files/2015-10/documents/ma_eel.pdf
https://www.macalester.edu/academics/environmentalstudies/threerivers/studentprojects/envi_194_lsr/cranberry_bogs/cranberries%20on%20the%20croix/FloraFauna.html

11 310 CMR Wetlands Protection Act 10.53(3)

12 Massachusetts General Laws Chapter 131 § 40 and 310 CMR Wetlands Protection Act 10.04 Agriculture



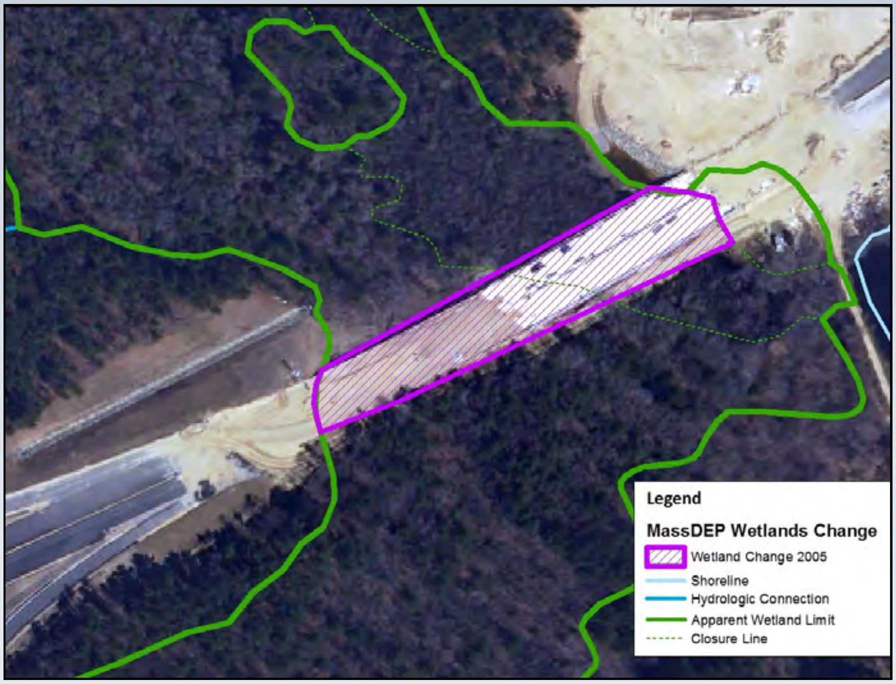
MassDEP Wetlands Change Maps 1995-2012

Case Study– Wetland Change Project: Transportation

New roads and transportation infrastructure account for 8 percent of human caused loss of wetland resources between 1995 and 2005.This activity increased to 15 percent of human caused loss between 2006 and 2012. Fills from new infrastructure projects resulted in the largest individual wetland resource impact per project. Figure 33 and 34 show the construction of Route 44 in the Town of Carver, before and after. This project improved overall mobility in the Southeast region however it required two acres of wetland resource alteration. During the review of the project MassDEP worked with the Massachusetts Department of Transportation to avoid and minimize the extent of wetland alteration. Approximately 17 acres of wetland replacement was required to mitigate for 13.3 acres of wetland loss.

Figure 33: Route 44 in Carver, MA—2000 (before)

Figure 34: Route 44 in Carver, MA—2005 (after)



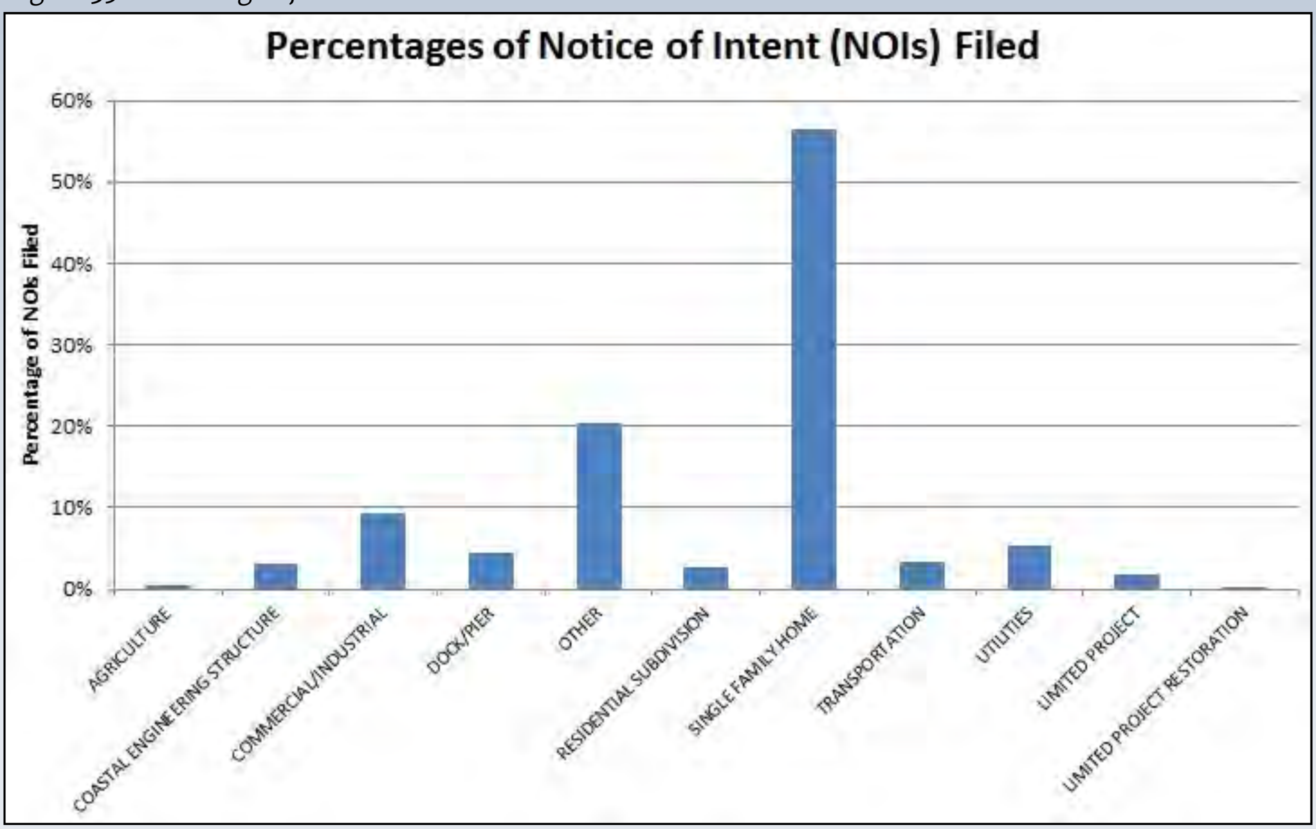
MassDEP Wetland Information Resource Database (WIRe) 2012-2017

In 2009 MassDEP put into service a new wetland data management system, WIRe.[13] For this report, MassDEP evaluated Notice of Intent (NOI) filings under the WPA based on WIRe data. To obtain a permit to alter wetlands, applicants must file an NOI form with MassDEP and the local Conservation Commissions describing the project, the wetland alterations proposed and the proposed mitigation. The data from the permit applications are entered into the WIRe Database. The analysis of the WIRe data identifies the activity of the proposed alteration, the acreage of proposed alteration to wetland resources, and the acreage of proposed mitigation documented between 2012 and 2017.

The graph in Figure 35 shows the percentages of activity types proposed in NOI filings between 2012 and 2017. Single family homes account for the most filings throughout the state, "other" or project types that could not be determined from the data are second, commercial/industrial is third, and utilities are fourth.

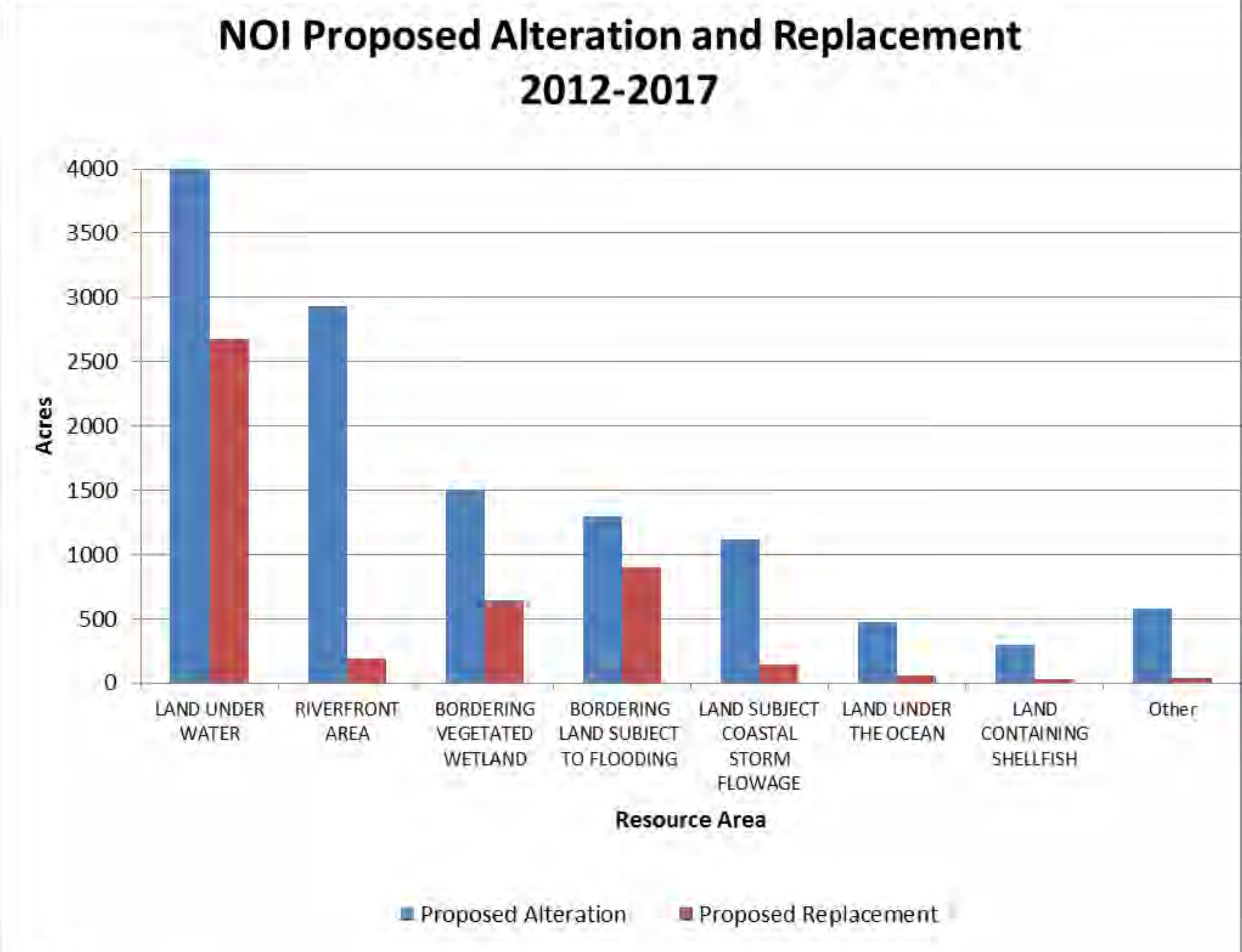
Figure 36 shows the acreage of proposed alteration and replacement permitted for each wetland resource area between 2012 and 2017. The largest area of alteration and replacement proposed is in *Land Under Water*, one-third of which is for aquatic plant management. Other activities frequently proposed in Land Under Water include dam maintenance, dock construction and culvert replacement and maintenance. *Riverfront Area* has the second largest area of proposed alteration, primarily due to single family homes and commercial/industrial projects. *Bordering Vegetated Wetlands* are the third largest area proposed to be impacted, most by single family homes and utilities projects.

Figure 35: Percentage of NOI's Filed in WIRe



[13] http://www.mass.gov/eea/agencies/massdep/water/watersheds/massdeps-wetland-information-resource-wire.html

Figure 36: NOI Proposed Alteration and Replacement 2012-2017



Notes:
Land Under Water acreage is truncated in this graph in order to make the smaller alterations more visible. Approximately 11,368 acres of Land Under Water were proposed to be altered during the study period.

Note that the acreage reported in this graph includes wetland resource loss as well as alteration that is not a complete loss (such as vegetation management). Unfortunately, WIRe cannot distinguish between the two. Thus, not all impacts require replacement as mitigation. Enhancements to WIRe reporting functions are needed to improve the data.

Ecological Condition of Wetland Loss 2005

The Conservation Assessment and Prioritization System (CAPS) model, developed by University of Massachusetts at Amherst, is a landscape level approach which uses GIS analysis for assessing the ecological integrity of lands, wetland resources, and waters that are most likely stressed by surrounding land uses. For example, wetland resources surrounded by developed areas are presumed to be more impacted by that development, and thus have lower ecological integrity, than wetland resources in pristine areas. This study uses the CAPS model to determine the Index of ecological integrity for wetland resources lost between the original statewide wetlands mapping and the statewide wetlands map update.

Figure 37 depicts the ecological integrity of wetland resources and other undeveloped lands throughout Massachusetts predicted by CAPS. In the figure, areas of higher ecological integrity or condition are shown in blue, and areas of low ecological integrity, or stressed condition, are shown in red. Maps can be displayed for individual communities, watersheds or regions and can be viewed with higher resolution using the UMass-Amherst website www.umasscaps.org.

Figure 37: Massachusetts Index of Ecological Integrity (IEI)

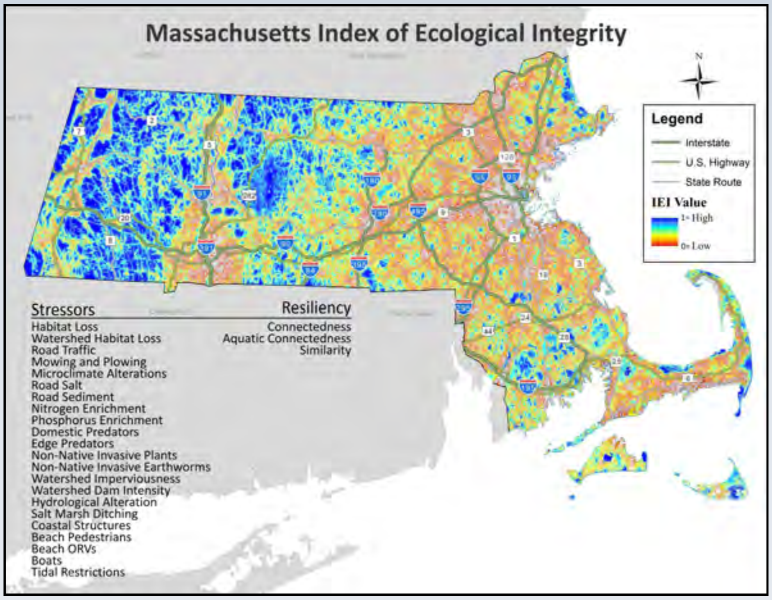
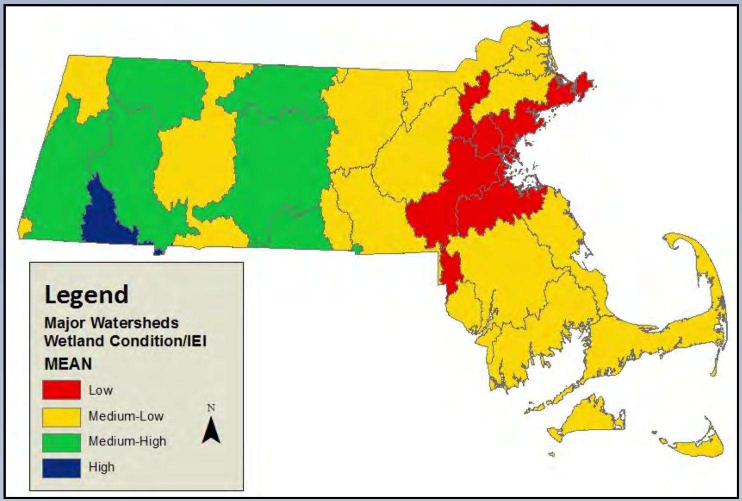


Figure 38: Average Condition of Lost Wetland Resources by Watershed



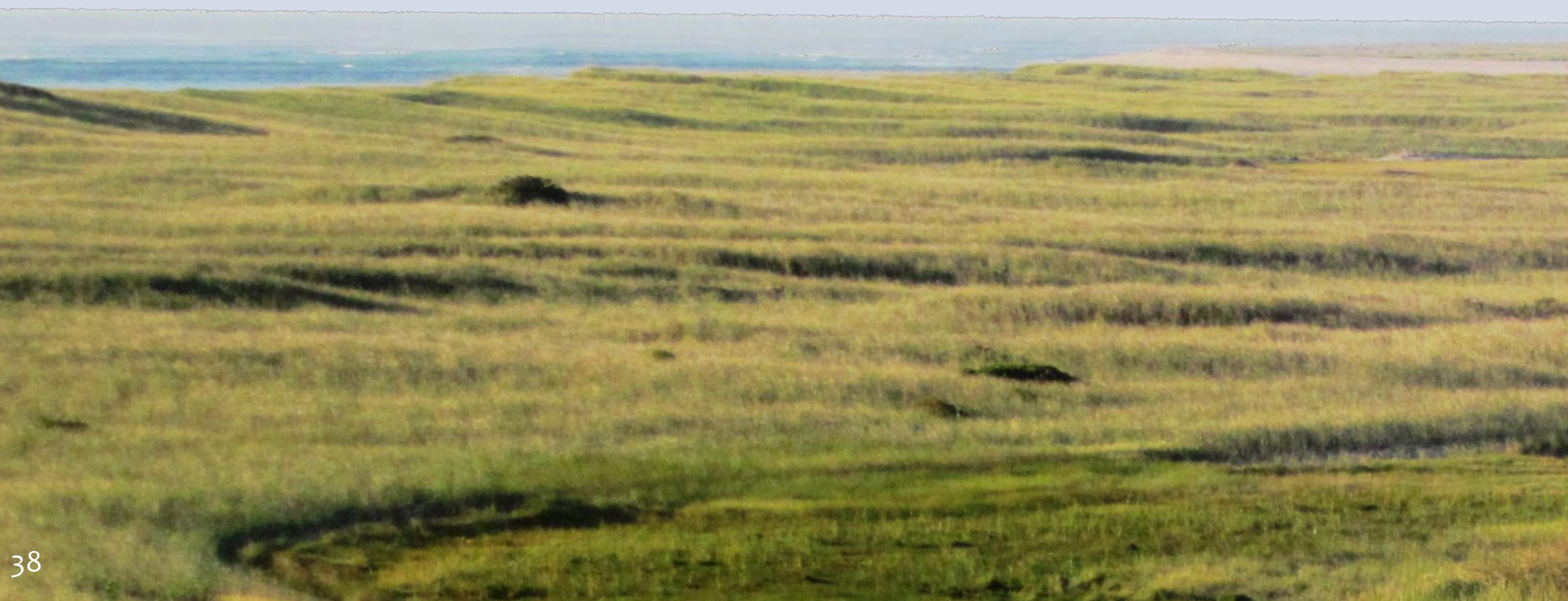
In general, the wetland resource ecological integrity is higher in western Massachusetts than in eastern Massachusetts, which is a reflection of the greater density of development in eastern Massachusetts. Figure 38 depicts the average ecological integrity of wetland resources that were lost due to human causes during this study period. On average, wetland resources lost had low to medium ecological integrity in most watersheds. This indicates that new development is occurring in close proximity to existing developed areas, likely due to better access to roads and utilities. It is important to note that wetland resources with lower ecological integrity still serve critical functions, such as flood control and pollution attenuation in their locality, however adjacent development may stress their ability to provide other functions such as wildlife habitat.

Summary and Conclusions

The MassDEP Wetlands Program conducted an analysis of five major data sources developed by MassDEP (or where MassDEP contributed significant effort) that covers the period of time between 1990 and 2017. The data sources include the Original Statewide Wetland Map, the Updated Statewide Wetlands Map, the MassDEP Wetland Change Maps, the MassDEP Wetland Information Resource Database, and the UMass Conservation Assessment and Prioritization System maps.

An evaluation of the Updated Statewide Wetlands Map showed that in 2005, the wetlands resources mapped in Massachusetts cover approximately 590,457 acres or 14% of the state. A comparative analysis of the Original Statewide Wetlands Map based on aerial photos taken between 1990 and 2000, and the Statewide Wetlands Map update based on 2005 aerial photos showed that although there are numerous individual gains and losses, overall there has been a small net increase of wetland resources throughout Massachusetts of 4,925 acres. Of the increased wetland resources, 4,188 are freshwater wetlands and 737 are coastal wetland resources.

The comparative analysis of the Original and Updated Statewide Wetland Maps showed that wetland resource gains and losses were attributed to both natural causes and human activities. The greatest change attributed to natural causes is due to beaver activity. Beavers were particularly active in Central Massachusetts, creating 2,403 acres of new wetlands and changing 12,871 acres of existing freshwater wetlands to other types (e.g. forested to shrub or emergent) between 1990 and 2005. The second largest change attributed to natural causes was from coastal storms, erosion and accretion processes, particularly on Cape Cod and the Islands. Over 2,900 acres of coastal wetland resources changed from one type to another (e.g. salt marsh to dune). Additionally, natural events caused salt marsh acreage to decrease, possibly due to increased frequency and intensity of storm events causing sand, cobbles and other materials to overwash and bury the marsh. While natural causes resulted in the greatest overall change in wetland resources, human activities also caused changes. Approximately 1,548 acres of wetland loss and 2,733 acres of wetland gain due to human activities were identified.



The MassDEP Wetland Change maps have been used to determine trends associated with human caused losses. Residential development, commercial cranberry bogs, and commercial development are the human activities that contributed the most to wetland losses between 1995 and 2005. Between 2006 and 2012, commercial development, residential development, and new roads/transportation infrastructure combined as the top three human activities causing wetland loss.

The MassDEP WIRe database was used to identify trends of permitted wetland changes between 2012 and 2017. The largest number of permit filings where the proposed activity could be determined was from single family homes, commercial/industrial development. Using the UMass CAPS model, it was determined that the statewide ecological value of the wetland resources lost was generally low to moderate, which suggests that much of the loss is happening in developed areas.

MassDEP is continuing to evaluate updated strategies and technologies to improve wetland mapping and development of other data that can be used to understand trends that are affecting wetland resources. This effort is critical to improve wetland protection through improved regulation, policy development and outreach. This effort is also important to educate the public on the essential functions that wetlands perform, which are flood control, storm damage prevention, protection of public and private water supplies, protection of groundwater supply, prevention of pollution, protection of fisheries, protection of wildlife habitat and protection of land containing shellfish.