WETLANDS MONITORING AND ASSESSMENT:
IPSWICH, PARKER, AND SHAWSHEEN WATERSHEDS

Massachusetts Department of Environmental Protection
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Table of Contents

List of Figures & Tables:

Appendices:

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EXECUTIVE SUMMARY

The Massachusetts Department of Environmental Protection's (MassDEP) Wetlands Program conducted a study of three watersheds within the Northeast Basin Group to report on wetland water quality in compliance with Section 305(b) of the Clean Water Act (CWA). The study area was selected to coincide with the MassDEP 5-year basin cycle for water quality sampling and reporting pursuant to the CWA and includes the Shawsheen, Ipswich, and Parker Watersheds. Based on EPA's concept for wetland monitoring and assessment,[1] the study consists of a landscape level GIS-based assessment using the Conservation Assessment and Prioritization System (CAPS) model developed by the University of Massachusetts at Amherst ("UMass-Amherst") in partnership with MassDEP and the Massachusetts Office of Coastal Zone Management (MACZM), and a site level assessment based on Indices of Biological Integrity (IBIs) developed for forested wetlands. This study also used the Continuous Aquatic Life Use (CALU) assessment framework to determine whether individual sites meet, exceed, or fail to meet expected condition as predicted by the CAPS model.

The landscape level assessment of the Shawsheen River, Ipswich River and Parker River Watersheds identified the primary causes of ecological stress of forested wetlands. The CAPS model outputs a score referred to as the Index of Ecological Integrity (IEI) which ranges from 0 to 1 for each 30 square meter point on the landscape. A zero score indicates areas of lowest ecological integrity and a score of one, a pristine ecosystem. IEI is a prediction of the ecological health of the wetland and surrounding landscape. The primary causes of ecological stress of forested wetlands within the study area were identified as: loss of connectedness, traffic, habitat loss, loss of similarity, and the presence of non-native, invasive plant species. Based on this assessment, strategies were identified to combat these stressors including establishing terrestrial wildlife passage structures to connect forested wetland areas; protecting buffer zones; improving stream crossings to meet the Massachusetts Stream Crossing Standards; encouraging efforts to manage invasive species; and preservation of important wildlife habitat.

Site level assessments were conducted to evaluate the actual wetland field conditions. The process for selecting sites consisted of first identifying the forested wetlands in the study area, calculating the IEI for forested wetlands in each subwatershed and then randomly selecting (40) forested wetland sample sites from the low IEI value (stressed) subwatersheds. Site assessments consisted of surveying plant distribution and communities at each site, calculating the site specific IBI value using the survey data, and then using the IBI's and the CALU framework to determine how closely each site met the expectations provided by the landscape level IEI.

Analysis of the IBI values for the field assessed sites found that 36 of 40 sampled sites accurately reflect the landscape level condition predicted by the CAPS model with IBI values that fell within the expected range of IEI values. Of these four sites that did not meet the predicted IEI value, two were found to have IBI values greater than the predicted range of variability for IEI and are said to "Exceed" expectations and two sites had lower IBI values than expected that are said to "FAIL" expectations. The two sites that failed to meet expectations were reviewed and revisited to ascertain if potential impacts exist in the vicinity of the site that explain the lower IBI values.

In addition to forested wetland sampling, MACZM led an effort to sample 20 salt marshes in the Parker and Ipswich watersheds. The data is included within this report; however, more research is needed to improve assessment methods before any findings about salt marsh condition can be made.

[1] http://www.epa.gov/wetlands/wetlands-monitoring-and-assessment

1.0 Introduction

1.1 WHAT ARE WETLANDS AND WHY PROTECT THEM

Wetlands are part of our Commonwealth's water resources and are vital to the health of waterways and downstream communities. Wetlands contribute to the protection of public and private water supply, protection of ground water supply, flood control, storm damage prevention, protection of land containing shellfish, prevention of pollution, protection of fisheries, and protection of wildlife habitat. Wetlands vary widely because of differences in landscape position, soils, topography, hydrologic regime, water chemistry, vegetation and other factors, however all wetlands resources are critical contributors to quality of life. Wetlands also contribute to a strong economy. For example, in 2014 the Massachusetts Department of Fish and Game estimated that the Town Creek restoration project in the Town of Salisbury would result in almost $2.5 million in avoided flood losses over the next 30 years.[2]

1.2 WHY MONITOR AND ASSESS

MassDEP's mandate and goal is to reduce wetland loss and degradation. Approximately 5,000 wetland permits are issued annually under the Wetlands Protection Act (M.G.L. c. 131, §40) (WPA) for projects that propose to alter wetlands and impact the quality of waters in our rivers and streams. Though Massachusetts regulations require replacement of all wetlands lost, monitoring is essential to understanding how effective the permit process is in replacing wetlands, protecting wetland water quality and maintaining ecosystem functions such as important wildlife habitat. Monitoring also allows us to identify land uses that result in secondary impacts to wetlands that are not directly altered.

Section 303 of the federal Clean Water Act (CWA) at 33 U.S.C. 1251 et. seq. requires that states adopt water quality standards. Since the CWA defines waters as including wetlands (40 CFR 230.3), water quality standards are also applicable to wetlands. Water quality standards are narrative (descriptive) or numeric standards used to define the range of physical, chemical, and/or biological conditions in "normal" ("clean" and uncontaminated) waters within the state or tribal boundaries. Waters that have been polluted or degraded have characteristics that fall outside of the normal conditions defined by the standards. States are obligated to provide a biennial report to EPA that defines the extent of waters that fail to meet either state water quality standards, or to meet federal fishable/swimmable goals. The most recent biennial report is called the *Massachusetts Year [2014] Integrated List of Waters.*[3]

[2] *Estimates of Ecosystem Service Values from Ecological Restoration Projects in Massachusetts, Summary of Report Findings*, January 2014 http://www.mass.gov/eea/docs/dfg/der/pdf/eco-services-summary-ma-der.pdf
[3] http://www.mass.gov/eea/docs/dep/water/resources/07v5/14list2.pdf

In Massachusetts, regulations have been developed to administer Section 401 of the federal Clean Water Act (314 CMR 9.00) and to define standards for Waters of the Commonwealth (314 CMR 4.00). In the regulations (314 CMR 9.02), wetlands are included in the definition of “Waters of the Commonwealth” (hereafter referred to as ‘Waters’). Up until this point, traditional surface water quality standards to restore and maintain the chemical, physical, and biological integrity of Massachusetts Waters have been developed primarily for water bodies and waterways (rivers, streams, lakes and ponds). Those standards are used as the basis for anti-degradation policies and water body/waterway monitoring and assessment programs tied to federal reporting requirements under the CWA. Although the Massachusetts water quality standards are applicable to wetlands, wetlands are primarily protected through WPA and 401 Water Quality Certification requirements, which are largely implemented through regulatory permitting programs that address direct physical alterations such as dredging and filling as well as chemical alterations from sources such as stormwater discharges.

The surface water quality standards are focused on protecting designated uses related to human health and safety (drinking water, irrigation, recreation), and fisheries and shellfish that are strongly influenced by water quality (dissolved oxygen, bacteria, nutrients, pH, temperature, solids, turbidity, color, oil & grease, taste and odor). Regular mixing of water in water bodies and waterways makes it possible to sample for water quality parameters in one or a few areas within a water body or stream reach and make generalizations about the entire water body or reach. Our ability to generalize about wetland water quality from a limited number of sampling points is much more problematic due to the lack of regular mixing. In order to report accurately about wetland condition from site level assessments, many more wetland sites would need to be surveyed to generate a comprehensive assessment than would typically be required for water bodies or waterways. Thus, our strategy relies heavily on use of a landscape level assessment tool called the Conservation Assessment Prioritization System (CAPS) that can assess all wetlands. To develop this tool, data from hundreds of forested wetlands, salt marshes and wadable streams was used to calibrate and test the CAPS model.

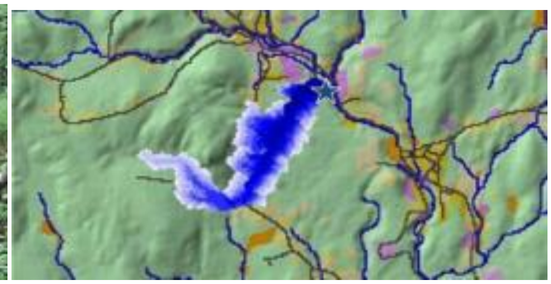
The designated use related to “fish, other aquatic life and wildlife” is also important and very relevant for wetlands. Fish, other aquatic life, and wildlife as a designated use is much more difficult to assess in the field than water quality-based uses. Biological integrity is affected by habitat connectivity and continuity as well as stressors that are derived from surrounding land uses and are difficult to detect in the field (e.g. domestic predators, edge predators and brood parasites, microclimatic alterations, traffic related road kill). Although “fish, other aquatic life and wildlife” is included as a designated use in all Classes of Waters, the biological condition or quality of those Waters is not currently a consideration in the designation of Class A, B and C Waters.[4] It is not clear what the relationships are between water quality parameters and designated uses for wetlands. However, the differences between wetlands and

[4] However, a variety of Qualifiers are used to further refine the classification system, some of which (“cold water,” “warm water,” “aquatic life,” and “shellfishing”) are relevant for aquatic life use.

water bodies or waterways makes it likely that the way in which water quality standards are applied for wetlands will differ from how they are applied in water bodies or waterways.

Currently the Massachusetts Water Quality Standards include narrative criteria for fish, other aquatic life and wildlife use. The EPA is encouraging states to adopt wetland water quality standards in order to better determine and document whether all Waters of the United States are meeting standards for aquatic life and wildlife use. EPA is also encouraging states to develop water quality standards that are specific for wetlands. The work described in this report will better help us to develop narrative and/or numeric biological criteria to be used in assessing attainment goals for fish, other aquatic life and wildlife. Further work may be done to assess chemical and physical criteria pertaining to wetlands.

1.3 WETLANDS MONITORING AND ASSESSMENT STRATEGY

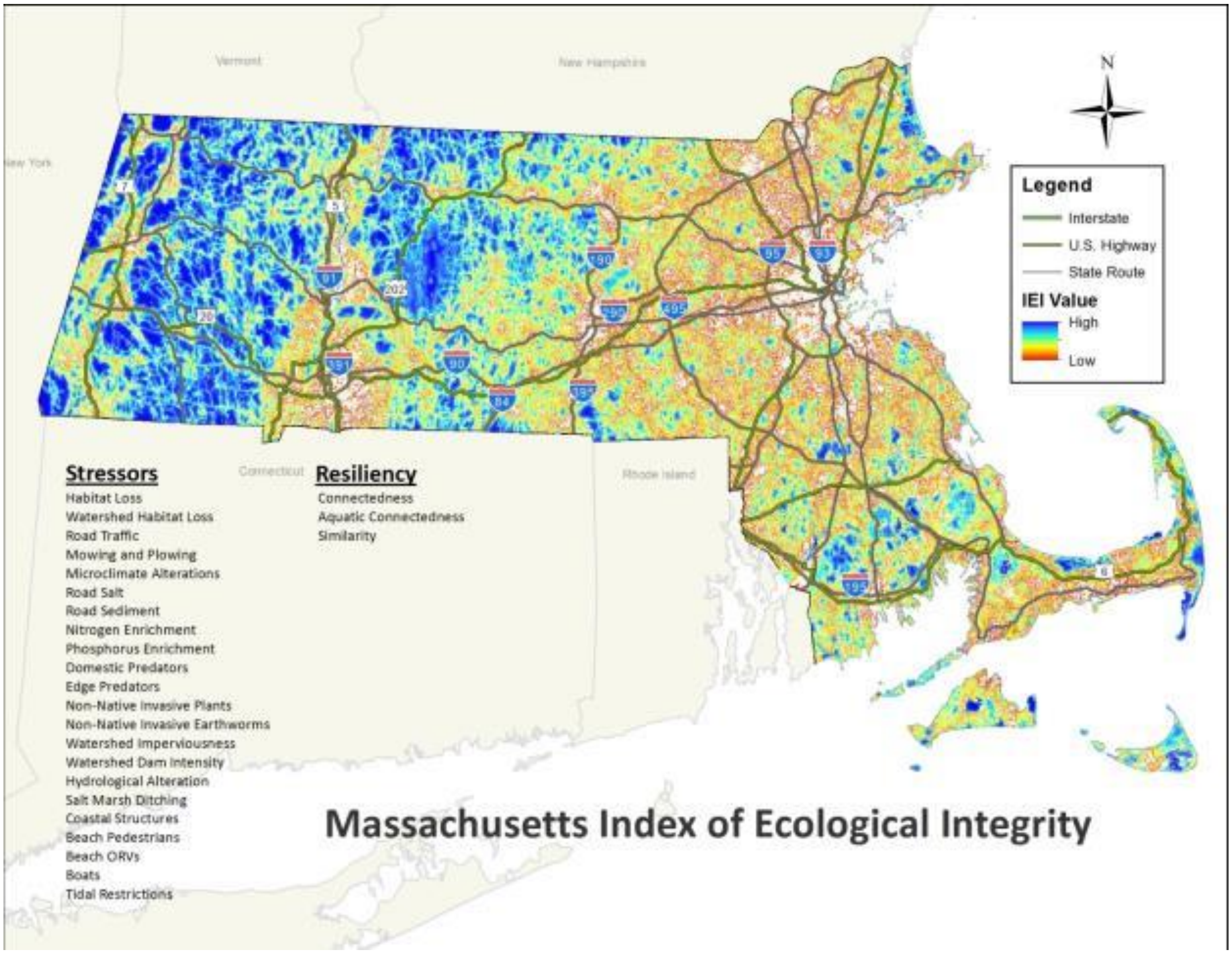
Monitoring and assessment allows MassDEP to better understand the health and condition of our wetlands and to allocate limited resources to the greatest benefit. Understanding trends and concerns is a critical component of protecting wetland resources and allows for knowledgeable decisions to be made about wetland interests identified in the WPA (e.g. public and private water supply, flood control, wildlife habitat) which can result in reduced costs for taxpayers.

The central feature of the Massachusetts monitoring and assessment strategy is CAPS, a landscape-level assessment model that has been under development by UMass since 2000. CAPS is a computer software program used to prioritize land for conservation based on an assessment of ecological integrity for various ecological communities (e.g. forested wetlands, marshes, streams). Key components of CAPS are GIS and land cover mapping and the integration of 20 inland and coastal stressor or resiliency metrics (See Figure 1.3-1).[5] The CAPS model combines this data and calculates a value between 0 and 1[6] for every 30 m^2 point in the landscape. The CAPS value is referred to as the index of ecological integrity (IEI) and represents a prediction about the degree of wetland stress and suitability as biological habitat as well as the ability of the wetland to sustain its ecological condition in the long term and to recover from stress. Since CAPS is based primarily on GIS level mapping data, Site-Level Assessment Methods (SLAMs) have been developed to provide consistent standard operating procedures for data collection. To date, SLAMS have been developed for forested wetlands and salt marshes.[7] Using these SLAMs, data was collected from 317 forested wetlands and 190 salt marshes that were randomly selected along a gradient of IEI values. These data, plus additional data from 490 wadable streams collected by MassDEP's Division of Watershed Management Watershed Planning Program (WPP) have been used for testing the CAPS predictions and modifying (as needed) the CAPS models; and for the development of

[5] Note that CAPS has been updated since the version that was used for this report. There are now approximately 25 stressor/resiliency metrics.
[6] Zero is stressed, 1 is pristine.
[7] A shrub swamp SLAM is under development.

Indices of Biological Integrity (IBI) for use in assessing site specific wetland condition. For more information on CAPS development, please go to www.umasscaps.org .

Figure 1.3-1: Statewide CAPS IEI and Metrics



2.0 Landscape Level Analysis: Ipswich, Parker, and Shawsheen Watersheds

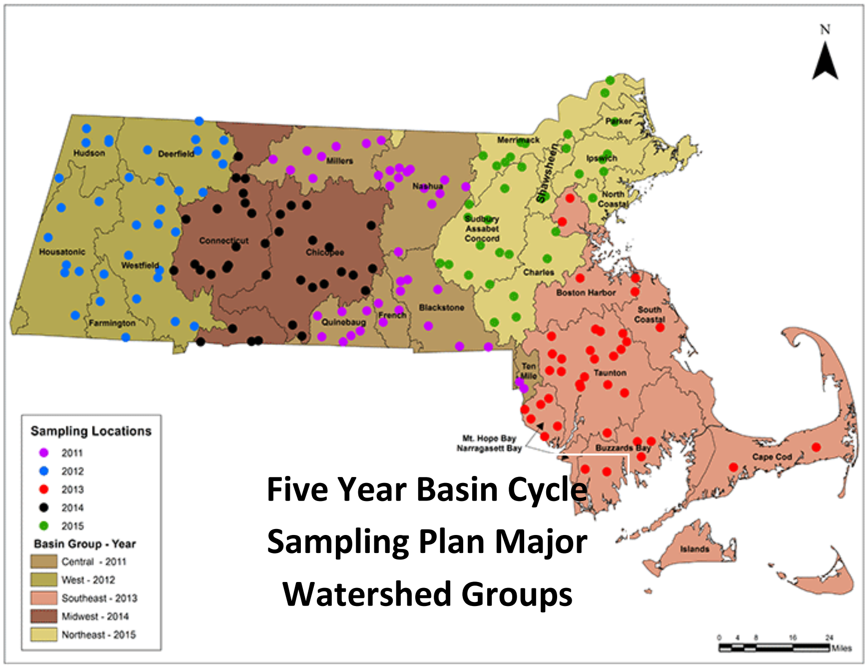
2.1 WATERSHED SELECTION

The MassDEP WPP administers the program to monitor and assess the quality of surface waters in the Commonwealth and provide periodic status reports to the U.S. Environmental Protection Agency (EPA), and the public as required under sections 305(b) and 303(d) of the Federal Clean Water Act (CWA).[8] One program goal is to determine whether the waters meet the State Water Quality Standards. To assist in this process our landscape and site level assessments were planned to occur in some of the same watersheds as those being monitored and assessed by WPP for reporting purposes. Figure 2.1-1 shows the Five Year Basin Cycle used by WPP. The Northeast Basin Group was the focus for surface water

[8] A copy of the Federal Water Pollution control Act (Clean Water Act) can be obtained at http://www.epw.senate.gov/water.pdf or on the EPA Web page at https://www.epa.gov/laws-regulations/summary-clean-water-act

quality monitoring in 2015 and includes the Charles, Concord, Ipswich, Merrimack, Parker, Shawsheen and North Shore Coastal watersheds.

Figure 2.1-1: Major Watershed Groups for the Five Year Basin Cycle for Surface Waters



The Northeast Basin group is a large reporting basin that covers the area from the town of Franklin (at the Rhode Island border) to Shrewsbury (adjacent to Worcester), North to the New Hampshire Border, and Dunstable East to the coastline. Due to limited resources available, we focused on three watersheds within the reporting Basin to conduct wetland sampling: the Shawsheen, the Ipswich, and the Parker. The Shawsheen Watershed was selected because it has the second lowest average IEI for forested wetlands in the state and the identification of stressors may aide in improving wetland condition. The Parker and Ipswich River watersheds were chosen because they have salt marsh that allowed us to coordinate with sampling being conducted simultaneously by our partners at the Massachusetts Office of Coastal Zone Management. [9]

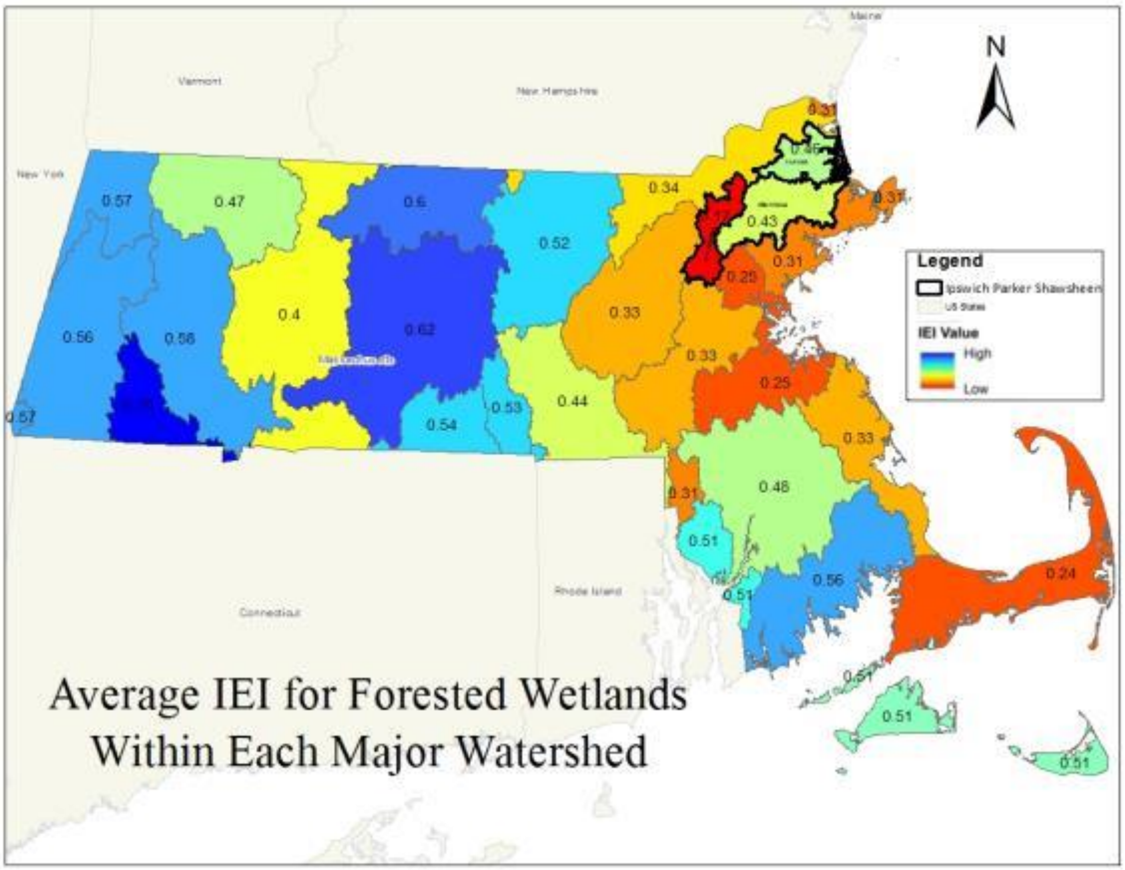
2.2 INDEX OF ECOLOGICAL INTEGRITY IN FORESTED WETLANDS

As a landscape level tool, CAPS is particularly well suited for reporting on wetlands condition. It can be applied statewide across both watershed boundaries and corporate borders and it enables a direct comparison between watersheds to identify which wetland areas are most impacted by ecological stressors and what the likely source of those stressors might be. The landscape level assessment conducted for this study is based on the CAPS model simulation run in November, 2011. Using the spatial analysis tools in a geographic information system (ArcGIS), the average IEI value for forested wetlands within each major watershed in Massachusetts was calculated to gain an understanding as to whether the watersheds in our study area are in overall better or worse condition than other watersheds in the state. See Figure 2.2-1. Watersheds with low average IEI for forested wetlands are identified as the most stressed by anthropogenic activities. Conversely, watersheds with higher average

[9] See Section 4.0 of this report, and Appendix E.

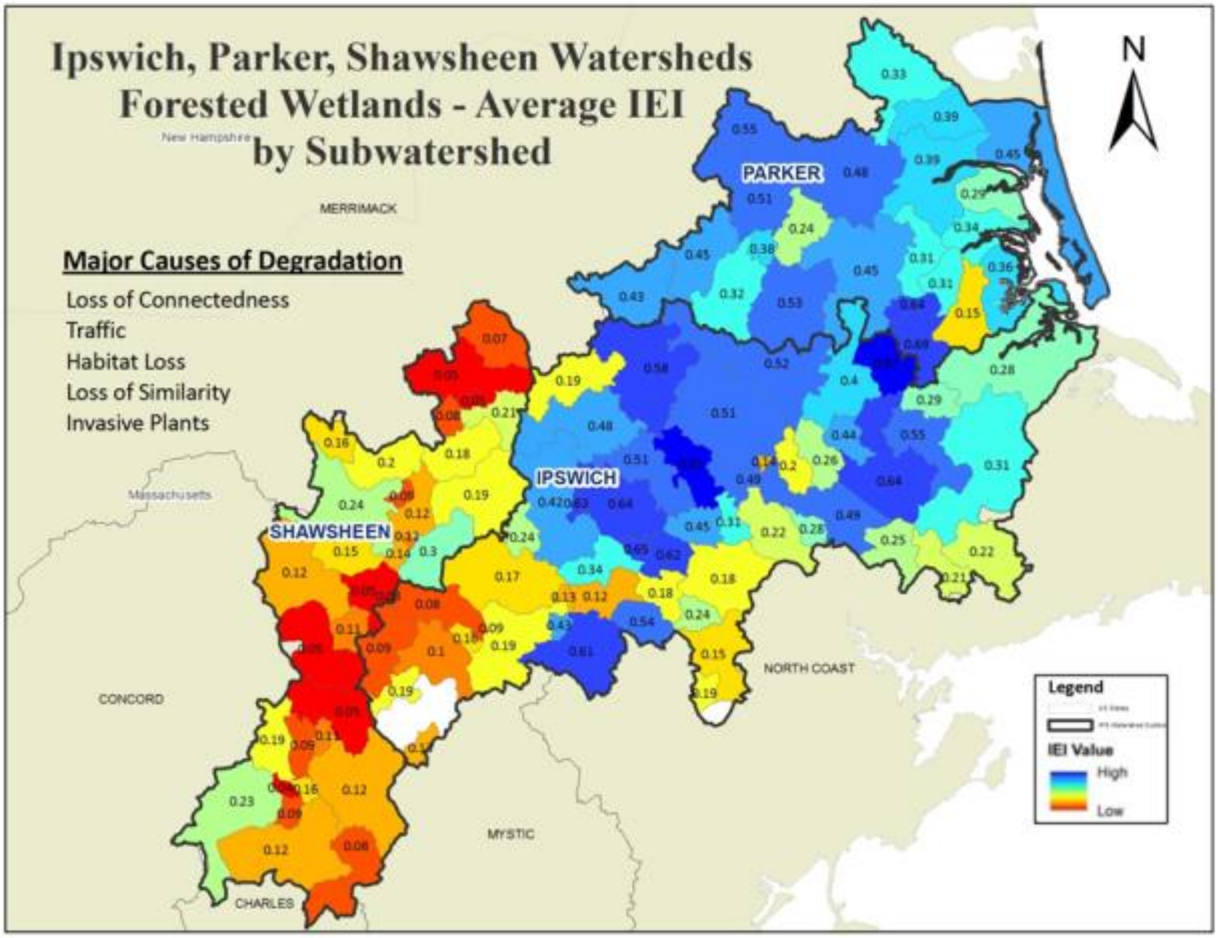
IEI for forested wetlands are considered to be less stressed by anthropogenic activities. The Ipswich and Parker River Watersheds have mid-range average IEIs for forested wetlands with values of 0.43 and 0.46 respectively, while the Shawsheen Watershed has the lowest average IEI in the state at 0.17.

Figure 2.2-1: Average IEI for Forested Wetlands by Major Watershed



The average IEI for forested wetlands was also calculated for each subwatershed within the Shawsheen, Ipswich, and Parker River Watersheds to identify which are predicted to be the most impacted by anthropogenic stressors. Figure 2.2-2 illustrates the range of average IEI values for forested wetlands (i.e. all CAPS stressor and resiliency metrics combined) by subwatershed throughout the study area watersheds. The more stressed subwatersheds (shown in red) in the region are located in densely developed areas with communities such as Billerica, Burlington, and Wilmington in the Shawsheen River Watershed contributing to a lower overall average IEI for forested wetlands. The Parker Watershed and parts of the Ipswich Watershed appear to be less stressed, encompassing several subwatersheds with higher average IEI values for forested wetland (shown in blue) that contribute to an overall higher ecological index for the each of the watersheds. These areas contain sparsely developed land with no major cities and more open space which may, in part, help to sustain intact ecosystems.

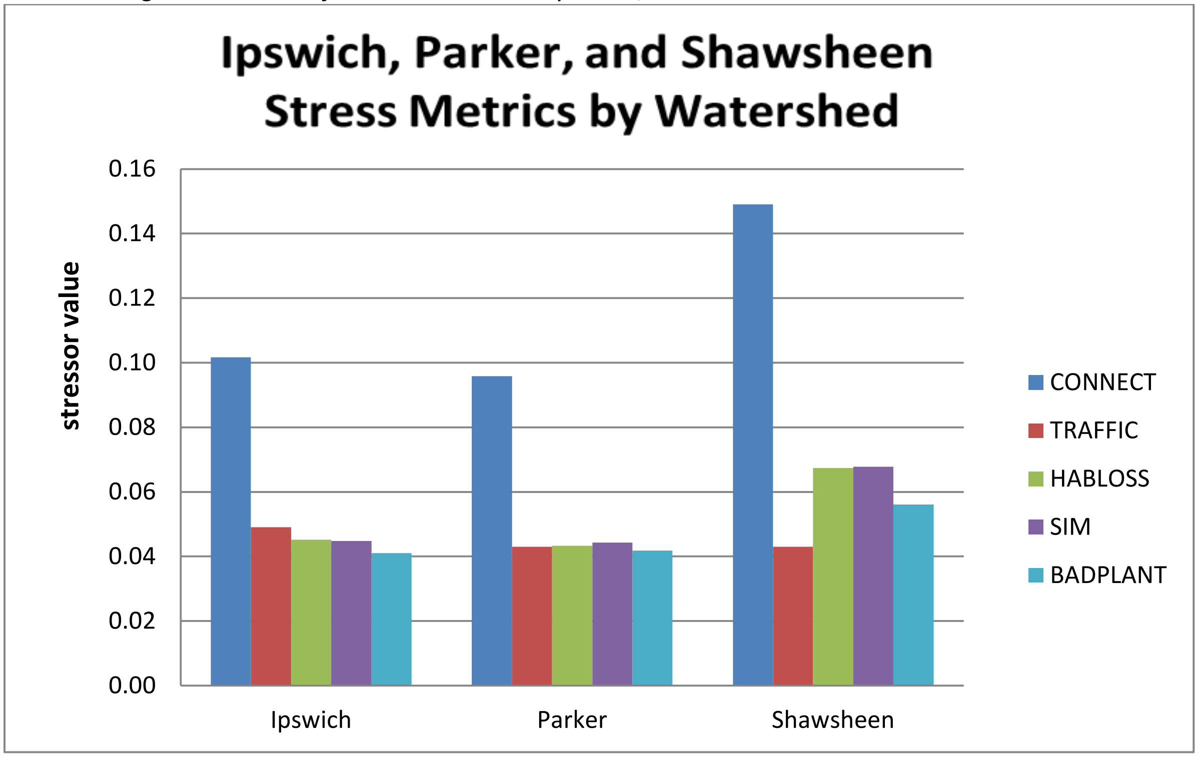
Figure 2.2-2: Average IEI for Forested Wetlands by Subwatershed



2.3 MAJOR CAUSES OF DEGRADATION

In addition to calculating the average forested wetland IEI for every major watershed in Massachusetts, and for the subwatersheds in our study area, we calculated values for each of the 20 individual stressors used in the CAPS model for our study area. This allowed us to identify the stressors that are likely having the most significant impact to forested wetlands. Calculating the stressor metrics provides a measure of the physical, chemical, and biological constraints placed on species productivity and the ability to sustain intact ecosystems. It allows us to identify the human influences that impose the most significant impact to forested wetlands in the watershed. The major stressors impacting forested wetlands and how they affect the study watersheds are discussed in the following sections, and displayed in Figure 2.3-1. The stressors found to have the greatest overall impact in the Ipswich, Parker, and Shawsheen Watersheds include, in order of magnitude of stress, loss of terrestrial connectedness, traffic, loss of habitat, loss of ecological similarity, and invasive plants. Although the major stressors are the same, the degree of stress in each watershed is different.

Figure 2.3-1: Major Stressors in the Ipswich, Parker and Shawsheen Watersheds.



The individual stressor metrics represent the separate components of the composite IEI into its individual components. Results from the stressor metrics are rescaled, weighted, and then combined into the overall index of ecological integrity (which is presented on a scale of 1 – 10).

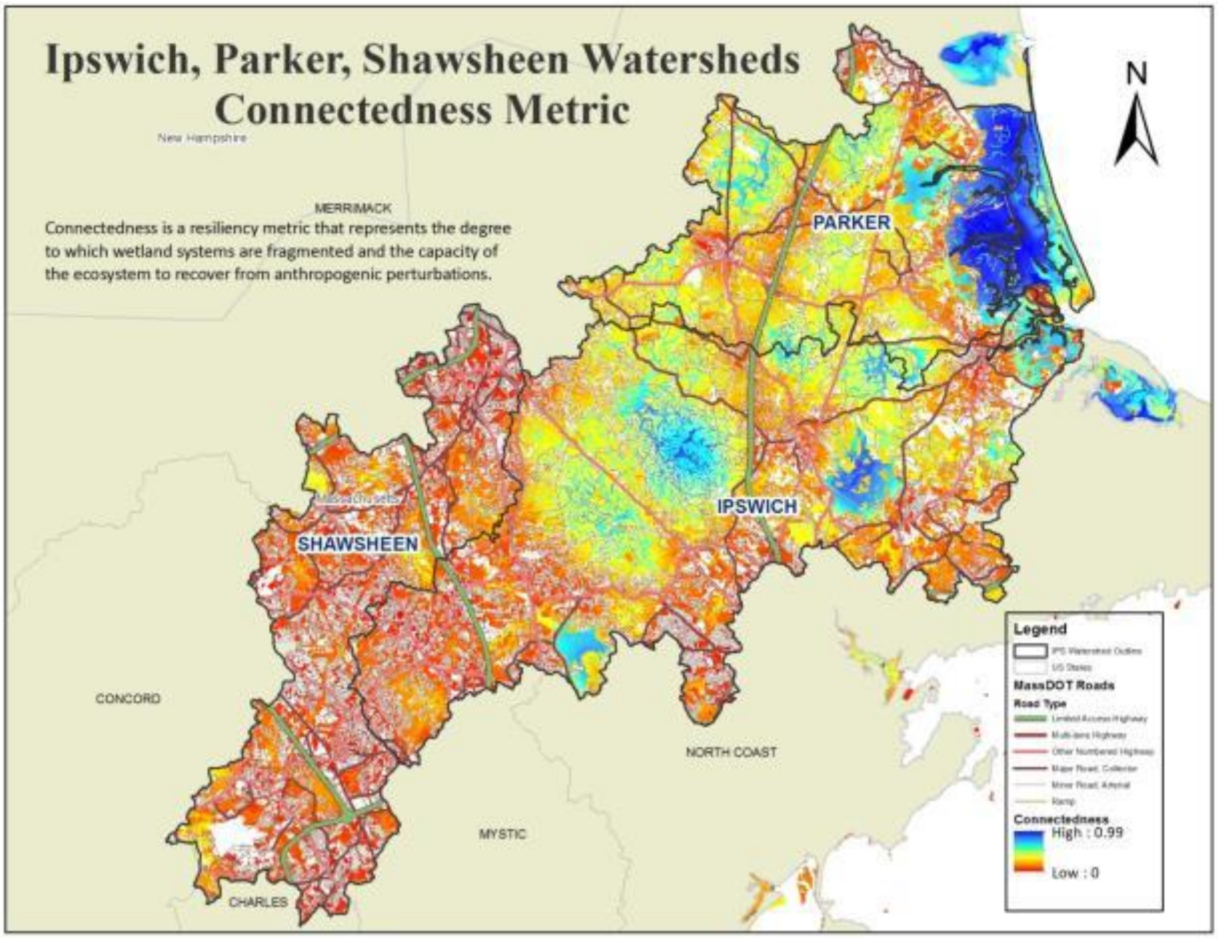
2.4 CONNECTEDNESS AND TRAFFIC

Connectedness is an ecological integrity metric that measures the disruption of habitat connectivity in a given landscape. The disruption can result from all forms of development including roadways, buildings, impervious surfaces, and other anthropogenic activities. In a highly connected ecosystem, an organism can access a large area of ecologically similar patches without crossing disrupted terrain.

Loss of connectedness is identified as the greatest source of ecological stress of the forested wetlands in the Northeast Basin study area. In the landscape assessment, connectedness is also a resiliency metric whose value represents the ability of an ecosystem to recover from anthropogenic perturbations. The loss of connectedness metric incorporates both the natural landscape context of an ecosystem (e.g.

large wetland complexes versus small isolated wetlands) and the anthropogenic impairment of an ecosystem at any given patch or point in the landscape and its immediate vicinity (e.g. road intensity surrounding an ecosystem). The value assigned to the metric is a measure of the degree to which a point in the landscape is connected with other points in the landscape that serve as a potential source of individual organisms or materials that contribute to the long-term ecological integrity of the wetland. The traffic metric assesses direct organism mortality from road traffic.

Figure 2.4-1: Connectedness Metric



Roads serve as significant barriers to the movement of many species of wildlife and so the denser the road network, the lower the connectedness metric. Note that areas ranging from yellow to red, particularly in the Ipswich and Shawsheen Watersheds, represent low connectedness, and are most pronounced in the vicinity of dense road networks around Billerica, Burlington and Wilmington.

To address the ecological stress caused by the loss of connectedness impacting forested wetlands in the Watersheds, two main strategies are recommended:

1) Restore Connections between Fragmented Forested Wetlands

Terrestrial Connections at Roadway Crossings

As previously noted in this section, one of the primary causes of loss of connectedness is roads. Roads present two opportunities to restore connectedness as discussed in this section. As long linear structures, roadways fragment habitat and impair the movement of wildlife. Traffic is a direct cause of mortality to wildlife traversing the gap on their journey to more extensive habitats. While it is impractical to suggest that roads be torn up and traffic re-routed, there are techniques that can be implemented to ameliorate those impacts. One such approach is the construction of terrestrial wildlife crossing structures that allow for improved wildlife passage. Creation of wildlife corridors that link separate habitat zones would make it easier for wildlife to move freely from one patch of habitat to another without injury.[10]

Wildlife crossing structures are essentially tunnels under the road or dedicated, vegetated bridges over the roadway that provide an opportunity for wildlife to travel across the road without risk of mortality from vehicle strikes. Along with their obvious role in avoiding road kills, such structures allow for reconnection between habitats that can increase resiliency by providing access to additional habitat in the event of disturbance. Improved connections allow wildlife species of all varieties and sizes such as wood frogs that breed in wetlands but migrate to uplands, beavers that move through large expanses of wetlands systems, or larger mammals such as deer in search of greater food supply to safely access a greater expanse of ecosystem needed to carry out their life cycle.

The University of Massachusetts-Amherst, in partnership with The Nature Conservancy, developed the Critical Linkages project which is a comprehensive analysis of areas in Massachusetts where terrestrial and aquatic connections could be employed in order to support the Commonwealth's wildlife and biodiversity. The Critical Linkages Project used the scenario testing capabilities of CAPS to assess how the construction of wildlife passages and culvert improvements at given points along major roads will improve the ecological integrity of adjoining wetland communities. It is an approach that does not focus on any particular species but instead considers ecological systems holistically, allowing for broad application and multi-species benefits.

An assessment of the connectedness metric value for ecosystems in the study area was conducted to provide a baseline for evaluation of wildlife crossing location options. Roadways with lower traffic rates are assumed to pose a less significant threat to wildlife from traffic, so the CAPS analysis focused on assessing the restoration potential for wildlife crossings at locations along roadway and highway segments statewide that have traffic rates of 1000 cars per day or greater. Each point in the landscape along the road where a wildlife crossing could be established is assigned a numeric value that characterizes the improvement in ecological connectivity that could be attained if a wildlife crossing were established at that location. The calculated value for change in connectedness is weighted by the IEI and known as the IEIdelta.

Analysis of all the potential points along major roadways identified a relatively small number of optimal sites for establishing wildlife crossings that would result in a substantial improvement in connectivity if restored. Figure 2.4-2 depicts the top 10% of all crossing locations identified in the three Watersheds by the Critical Linkages Project that are within 500-feet of forested wetlands. Installation or improvement of crossings at these locations would improve the

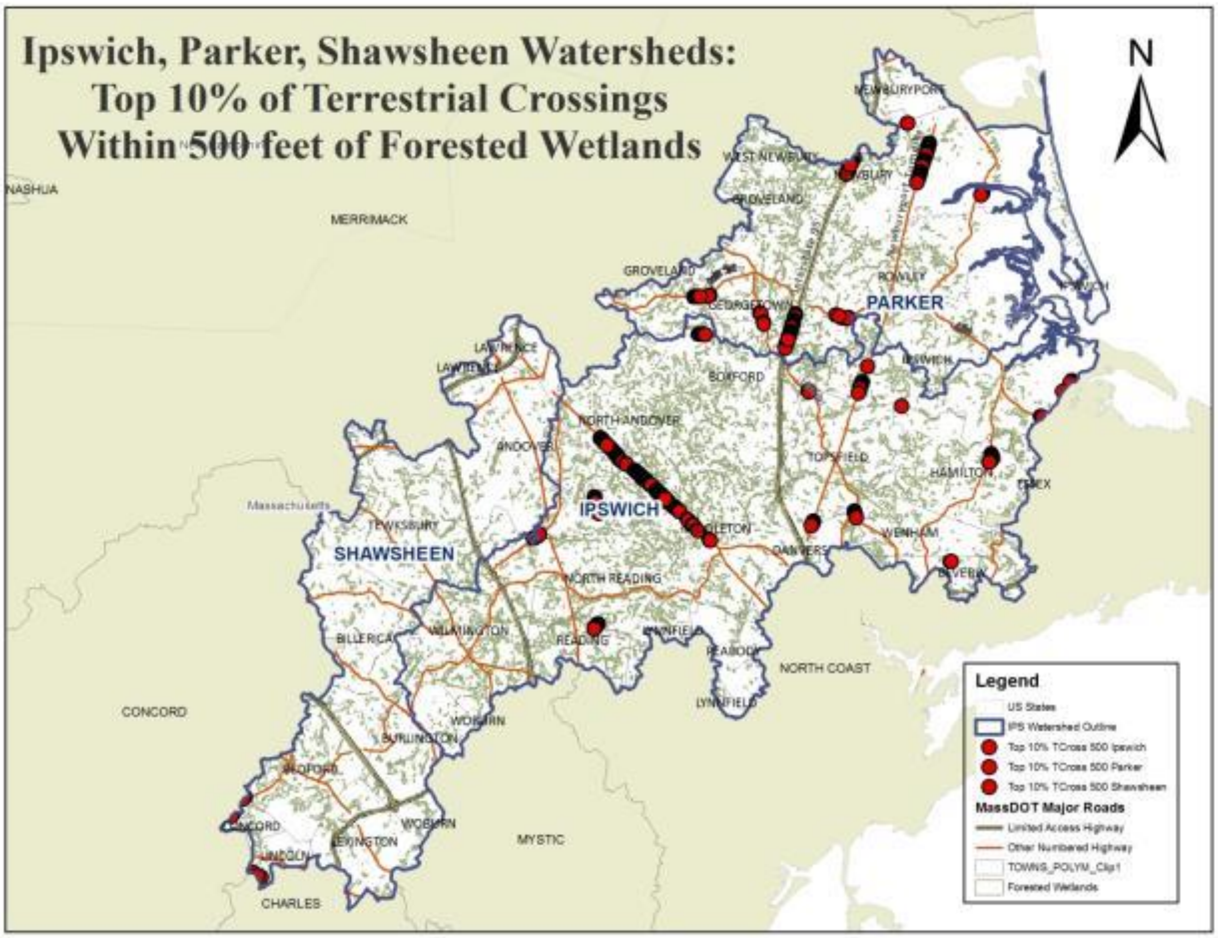
[10] Douglas J. Levey et al., "Effects of Landscape Corridors on Seed Dispersal by Birds," *Science*, vol. 309, July 1, 2005, pp. 146–48; Cornelia Dean, "Home on the Range: A Corridor for Wildlife," *New York Times*, May 23, 2006, p. F1.

biological health of forested wetlands. Individual municipal maps have been developed and are located in Appendix D, and/or on the MassDEP website.[11] Information on the Critical Linkages project, as well as the shapefile data for all municipalities statewide is available for download at the UMass CAPS website.[12]

Restore Disturbed Land to Reconnect Habitat

Where funding is available for wetland restoration, opportunities should be identified to reconnect large areas of similar habitat that have been disturbed by fill, clearing or other non-linear anthropogenic disturbance. Information on funding sources may be available through the Massachusetts Department of Fish and Game, Division Ecological Restoration or other non-profit organizations.

Figure 2.4-2: Terrestrial Crossings - Top 10% within 500 feet of Forested Wetlands



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11 http://www.mass.gov/eea/agencies/massdep/water/watersheds/wetlands-protection.html#2 Note that these maps present the top 10% of terrestrial and aquatic crossing improvement locations within the Shawsheen, Parker and Ipswich Watersheds identified by the Critical Linkages model that are also within 500 feet of forested wetlands. Some municipalities do not have sites within the top 10% that are also within 500 feet of forested wetlands and thus, municipal maps were not developed for these towns.

12 http://www.umasscaps.org/applications/critical-linkages.html

2) Avoid New Fragmentation

The best and most effective way to avoid further loss of connectedness in forested wetlands and larger ecosystems is for municipalities, non-profit organizations, the state and others to purchase open space as it becomes available and protect the land by putting a Conservation Restriction on the property "In perpetuity." Loss of connectedness can also be reduced with use of innovative planning and zoning bylaws and regulations. Another component of reducing "loss of connectedness" is to avoid new ecological impacts when possible; minimize impacts when they are unavoidable, and mitigate for the impact. The Massachusetts Wetlands Protection Act regulations prohibit the destruction or impairment of vegetated wetlands (310 CMR 10.55(4)(a)). The regulations allow for the loss of up to 5000 square feet of bordering vegetated wetland (BVW) on a discretionary basis, provided that replacement of the wetland occurs (310 CMR 10.55(4)(b)). In approving this loss, the issuing authority (i.e. local conservation commissions or MassDEP) is required to consider "*the magnitude of the alteration and the significance of the project site to the interests identified in MGL c. 131, §40, the extent to which adverse impacts can be avoided, [and] the extent to which adverse impacts are minimized…*" Some projects may have a footprint of alteration below 5000 sf, but may affect a much larger ecosystem by fragmenting the habitat (e.g. new roadway crossings). Wetland fragmentation can also result from projects that are authorized pursuant to the "limited project" section of the regulations at 310 CMR 10.53(3)(e). This regulation allows for new roadways or driveways to be constructed where reasonable alternative means of access from a public way to an upland area of the same owner is unavailable. In these instances, the issuing authority may approve greater than 5000 square feet if it can be justified. In considering whether to approve a limited project, issuing authorities must consider "*the magnitude of the alteration and the significance of the project site to the interests identified in MGL c. 131, §40, the availability of reasonable alternatives to the proposed activity, the extent to which adverse impacts are minimized…"* Of the 5220 filings MassDEP reviewed in calendar year 2016, a total of 46 new roadways or driveways across wetlands or waters were approved.[13] New roadways and driveways that cross streams must now be designed to meet stream crossing standards[14] that provide for wildlife passage and serve to maintain stream and ecosystem continuity through the crossing.

To ensure that forested wetland condition in the Watersheds does not continue to be impacted, issuing authorities and project proponents are advised to seek alternative proposals that avoid new fragmentation of forested wetland habitat. Where new crossings cannot be avoided, impacts should be minimized by: 1) designing stream crossings for aquatic organism passage by meeting the Massachusetts Stream Crossing Standards; 2) limiting crossings under 10.53(3)(e) to one per Notice of Intent application filed; 3) locating crossings at the narrowest point; 4) use of retaining walls to minimize impacts; and 5) collaboration with other municipal agencies such as the Planning Board to ensure that project impacts are minimized (e.g. roadways and driveways should be designed to the minimum legal and practical width, parking lot sizes are minimized, etc.). Mitigation should include providing wildlife crossing structures that connect terrestrial habitats. This effort will be competing with the incorporation of bicycle lanes and sidewalks that improve cyclist and pedestrian safety, an initiative known as

[13] While this represents only small portion of the total number of NOI filings in calendar year 2016 (note one filing had six crossings), it also means that 46 stream segments are now culverted or bridged that were not before - some which may restrict stream flow. The new stream crossing standards promulgated in 2014 require that new stream crossings fully meet standards. However, 5 new crossings are limited projects where the issuing authority may waive standards, and 41 are not limited projects and should meet standards.

[14] *River and Stream Crossing Standards* dated March 2006, revised March 2011, and corrected March 8, 2012. Note that the correction is depicted in the footer and not on the front page. http://www.nae.usace.army.mil/Portals/74/docs/regulatory/StreamRiverContinuity/MA_RiverStreamCrossingStandards.pdf

"Complete Streets "[15] Where streams are being crossed, culverts should be designed according to the Massachusetts Wetland regulations' stream crossing standards.

2.5 SIMILARITY

Similarity is a resiliency metric that expresses the ability of an ecosystem to recover from anthropogenic perturbations. The loss of similarity is among the major causes of ecological stress to forested wetlands in the Watersheds. Similarity is a measure of how closely surrounding landscape cells resemble a focal cell and the distance of similar cells from the focal cell. For example, a given point within a large wooded swamp has a great deal of similarity to other wooded swamp points that are close by, whereas a given point in a small wooded swamp where there are few or no other wooded swamps nearby has a low degree of similarity. The distance between similar cells is, in effect, a measure of dissimilarity between two landscapes. To avoid confusion with the connectedness metric, it is important to recognize that the connectedness metric deals with terrestrial connectivity for organisms that move overland and does not account for organisms that can easily traverse between ecosystems disrupted by roadways, buildings, and other obstacles to terrestrial migration. Ecosystem accessibility issues addressed by similarity primarily pertain to flying organisms: birds, bats, insects etc.

The landscape analysis predicted low values of similarity in the Shawsheen Watershed and portions of the Ipswich Watershed. Areas of high similarity tend to be located in the less developed areas of the Ipswich and Parker Watersheds. To address the ecological stress caused by the loss of similarity impacting forested wetlands, it is recommended that undeveloped buffer zones surrounding forested wetlands be protected wherever possible. Land use surrounding wetlands can be the source of stress on the adjacent wetland, yet preventing and or controlling development in that buffer area can be a challenge. The WPA Regulations establish a 100 foot buffer zone immediately adjacent to all bordering vegetated wetlands. As an area subject to regulation, any activity proposed within the buffer zone is subject to review. Undeveloped wetland buffers significantly reduce or minimize impacts to the adjacent wetland in several ways:

- Erosion and sedimentation, which can adversely impact the health of wetlands, is reduced when soils adjacent to wetlands are stabilized by vegetation and leaf litter;
- Vegetated buffers help improve water quality and reduce the impacts of storm flows from impervious surfaces. Vegetation acts as an obstruction to water flow, decreasing velocity and allowing water to infiltrate into the soil where soluble nutrients and other pollutants can be more efficiently removed or transformed by soil bacteria and the vegetation itself;

[15] http://www.smartgrowthamerica.org/complete-streets

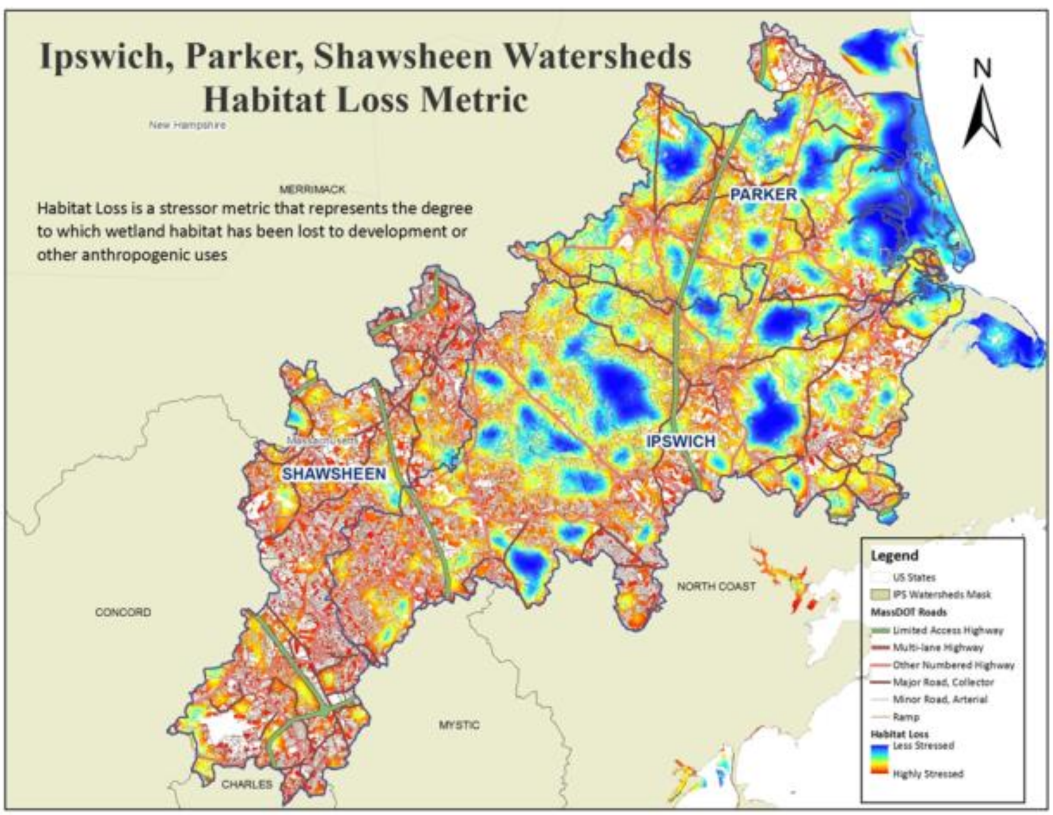
- Groundwater that has infiltrated into the soil in the buffer zone is then slowly released into the wetland allowing for less abrupt fluctuations in water levels within the wetland;
- Buffers provide habitat for species that utilize wetlands and uplands, such as wood frogs, which breed in wetlands but spend much of the year in uplands, certain turtles which spend most of the year in wetlands but breed in uplands, or flying organisms requiring similar habitats.

In order to protect the buffer zones around wetlands, permit issuing authorities can request that project proponents consider alternatives to buffer zone development. When development in the buffer zone cannot be avoided, it should be minimized and efforts should be undertaken to ensure that: 1) the project incorporates best management practices for stormwater control; 2) the project is set back as far as possible from the wetland; and 3) a vegetated strip (a portion of the naturally occurring undisturbed vegetation in the buffer zone) is left intact between the wetland and the development.

2.6 HABITAT LOSS

Land use change is a major driver in the fragmentation (breaking apart of habitat into several smaller pieces) [16] and loss of habitat as well as reduction of terrestrial biodiversity. Conversion of intact ecosystems to anthropogenic land uses such as urban development, agriculture, highways and dams can reduce or degrade the usefulness of an ecosystem as suitable habitat for plants and animals to survive and flourish. It is one of the top three stressors impacting the Ipswich, Parker, and Shawsheen Watersheds (Figure 2.6-1).

Figure 2.6-1: Habitat lost to development or other anthropogenic uses.



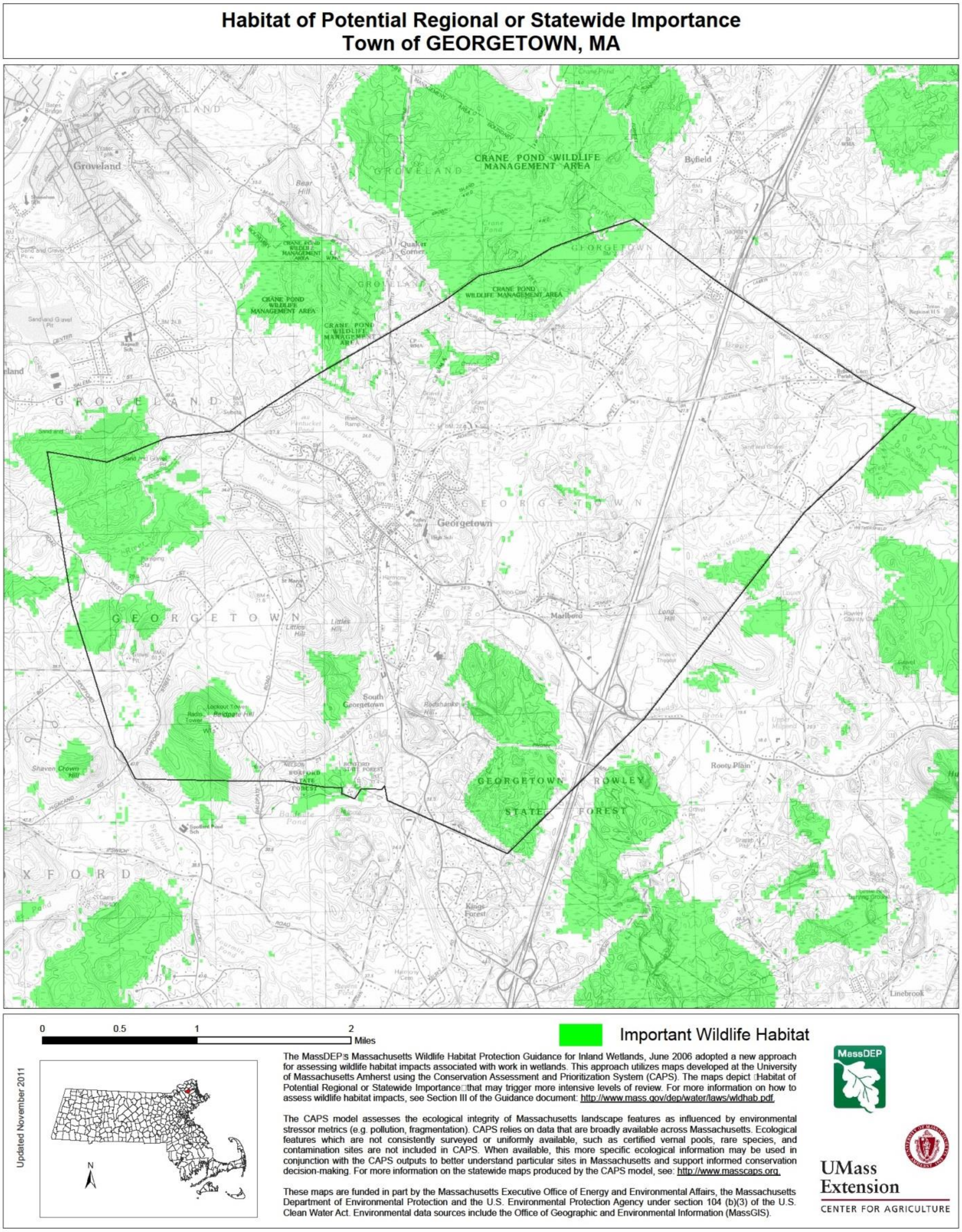
16 Bird Jackson, H. and Fahrig, L., *Habitat Loss and Fragmentation*, Carleton University, Ottawa, ON, Canada 2013 Elsevier Inc.

The habitat loss metric measures the intensity of habitat loss caused by all forms of development in the area surrounding each cell on the undeveloped landscape. The first step in developing the metric is to characterize both the developed and undeveloped elements of the landscape. Land uses in developed areas are grouped into categories such as roads and highways, high-intensity urban, low-density residential, agriculture, and other elements of the human-dominated landscape. Mapping natural or undeveloped landscape is based on an ecological community classification such as swamp, marsh, bog, forest, meadow, or pond. With a computer base map depicting the various land cover classes, each point on the landscape can be assessed to determine the magnitude of habitat loss in the vicinity of the point.

One way habitat loss can be addressed is by avoiding alterations in high quality habitat areas, and preserving these areas where possible. MassDEP, in partnership with UMass-Amherst, has developed maps for each municipality depicting *Habitat of Potential Regional or Statewide Importance* (See Figure 2.6-2). Each map displays polygons (in green) that depict the top 40% IEI from CAPS, and are expected to have high ecological integrity. The polygons represent land parcels that may be good candidates for preservation due to the expected high ecological integrity, and should be investigated where habitat loss is a major cause of degradation. A map for each municipality is available on the UMass website.[17] The maps were originally developed for MassDEP's Massachusetts Wildlife Habitat Protection Guidance for Inland Wetlands, June 2006. They are used to determine if a detailed wildlife habitat evaluation is required to be completed as part of an inland wetland permit application under the WPA and should also be used to identify important wildlife habitat worthy of preservation.

[17] Go to www.umasscaps.org Click on Data & Maps, then click on MassDEP Important Habitat Maps on the left hand side. Scroll down for individual maps of each municipality.

Figure 2.6-2: Habitat of Potential Regional and State Importance



2.7 INVASIVE PLANTS

Invasive plants are non-native species that have spread into native or natural plant community. Invasive plants cause economic and/or environmental harm by developing self-sustaining populations and becoming dominant and/or disruptive to naturally occurring ecosystems. The CAPS model identified invasive plants as a major cause of stress to forested wetlands in the study Watersheds. The CAPS model assesses the pervasiveness of non-native invasive vascular plant species[18] at the landscape level by measuring the intensity of development (i.e. anthropogenic land use) associated with invasive plants around each point in the landscape; it then assigns a value to that point based on its proximity to those types of development. The potential for invasive plants to become established exists at any disturbed land that might include, for example, sites of residential development, roadway construction or improvement, and agricultural disturbance. The closer a point in the landscape is to certain types of anthropogenic development the more likely it is to be impacted by invasive plants. Lists of invasive plant species specific to Massachusetts and New England have been compiled by the Massachusetts Invasive Plant Advisory Group (MIPAG) and the Invasive Plant Atlas of New England (IPANE).[19]

A major component of the assessment of the Shawsheen, Parker and Ipswich Watersheds were site sampling on 40 forested wetland areas. The sampling primarily involved documentation of plant communities. That sampling is discussed in detail in Section 3.0 of this report. A point intercept method was used to collect 100 points of plant data on each site that was used to calculate the species abundance of all vascular plants onsite. Theoretically, for the overall study area, any invasive plant could be documented up to 4000 times. Several invasive plant species were encountered during the project site sampling. By far the most abundant invasive species encountered in each of the watersheds studied was *Frangula alnus* (glossy buckthorn) with an overall relative abundance of 27% for all sampled sites. The relative abundance of *Frangula alnus* for the Ipswich, Parker, and Shawsheen Watersheds is 31%, 10%, and 30% respectively. In order by species abundance, *Frangula alnus* is followed by Rosa multiflora (multiflora rose) which is less than 4.0% in all watersheds. All other invasive species documented represent less than 1% relative abundance for the watershed. Figures 2.7-1, 2.7-2 and Table 2.7-1 show the relative abundance for the most common plant species and invasive species in the entire study area. Invasive plants among the most common are highlighted in Orange, with invasive *Frangula alnus* placing as the third most common plant in the study area. The plant community assessments identified invasive plant species present on 34 of the 40 sites (See Figure 2.7-3).

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[18] CAPS assesses terrestrial (both wetland and upland) invasive plant species. However, it does not assess invasive aquatic plant species. Aquatic plants are plants that grow in permanent standing or flowing water (i.e. lakes, rivers, ponds) and disperse their seeds via that water. Examples of invasive aquatic plants include Eurasian milfoil (*Myriophylum, spicatum*) or Fanwort (*Cabomba caroliniana*). Terrestrial plants grow on a soil substrate and depending on individual species, can tolerate a wide variety of hydrologic regimes, and thus may occur in wetlands or uplands. They may disperse their seeds via numerous methods, such as wind, water, animals or some combination thereof. Examples of invasive terrestrial plants include: Glossy buckthorn (*Frangula alnus*) or Purple Loosestrife (*Lythrum salicaria*).

[19] Further information on invasive Plant management can be found at: http://www.mass.gov/eea/agencies/dfg/dfw/natural-heritage/land-protection-and-management/invasive-species/invasive-plants.html and (https://www.eddmaps.org/ipane/)

Figure 2.7-1: Relative Abundance for the most common plants found in all sites sampled.

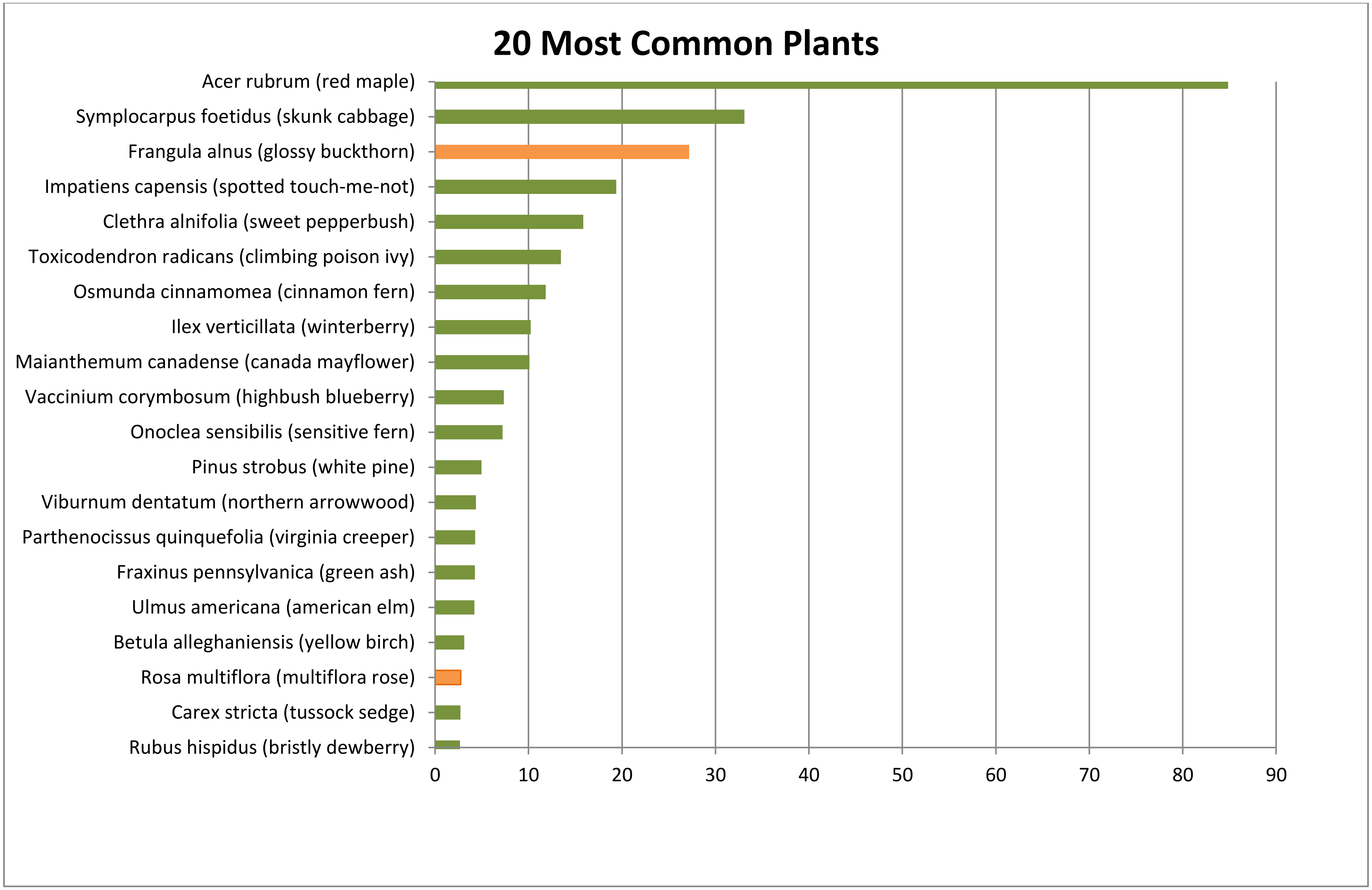


Figure 2.7-2: Relative Abundance for the most common invasive plants in all sites sampled.

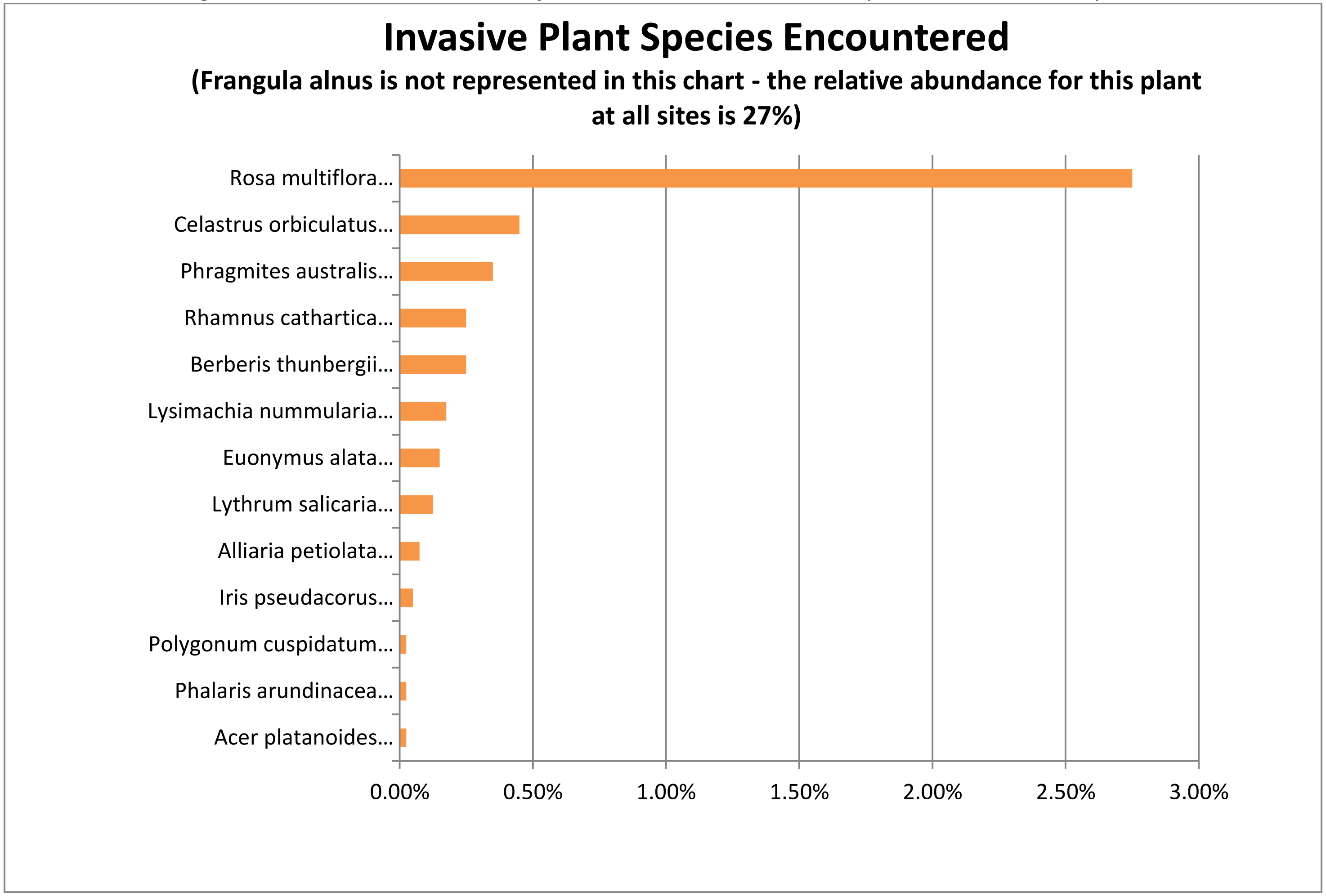
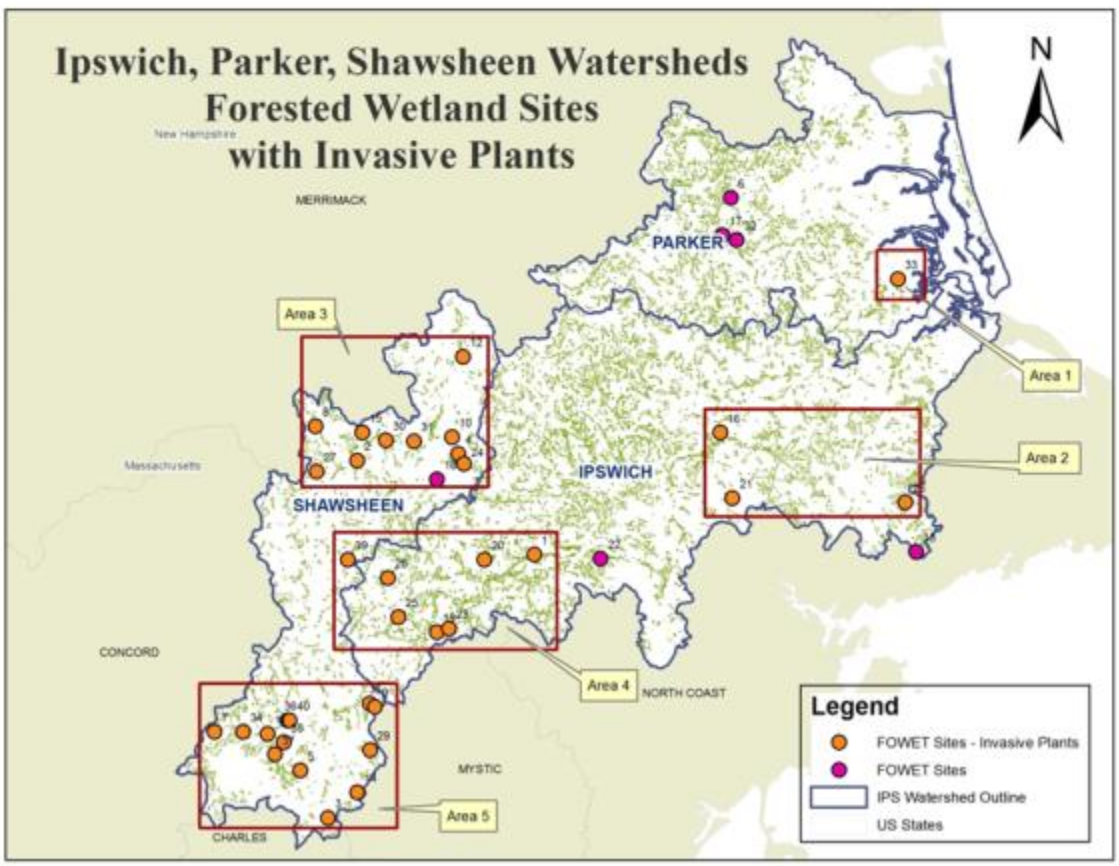


Table 2.7-1: Relative abundance of invasive plants by Watershed

Invasive Plant	Parker	Ipswich	Shawsheen
Frangula alnus (Glossy buckthorn)	10.00	30.91	29.88
Rosa multiflora (multiflora rose)	0.25	2.09	3.92
Rhamnus cathartica (common buckthorn)	0.00	0.27	0.28
Celastrus orbiculatus (oriental bittersweet)	0.00	0.00	0.72
Berberis thunbergii (Japanese barbery)	0.00	0.18	0.32
Lythrum salicaria (purple loosestrife)	0.00	0.18	0.12
Phragmites australis (common reed)	0.00	0.00	0.56
Euonymus alata (burning bush)	0.00	0.00	0.24
Alliaria petiolate (garlic mustard)	0.00	0.00	0.12
Lysimachia nummularia (creeping jenny)	0.00	0.00	0.08
Iris pseudacorus (yellow flag)	0.00	0.00	0.08
Phalaris arundinacea (reed canary grass)	0.00	0.00	0.04
Polygonum cuspidatum (Japanese knotweed)	0.00	0.00	0.04

Figure 2.7-3: Forested Wetland Sample Sites Containing Invasive Plants.



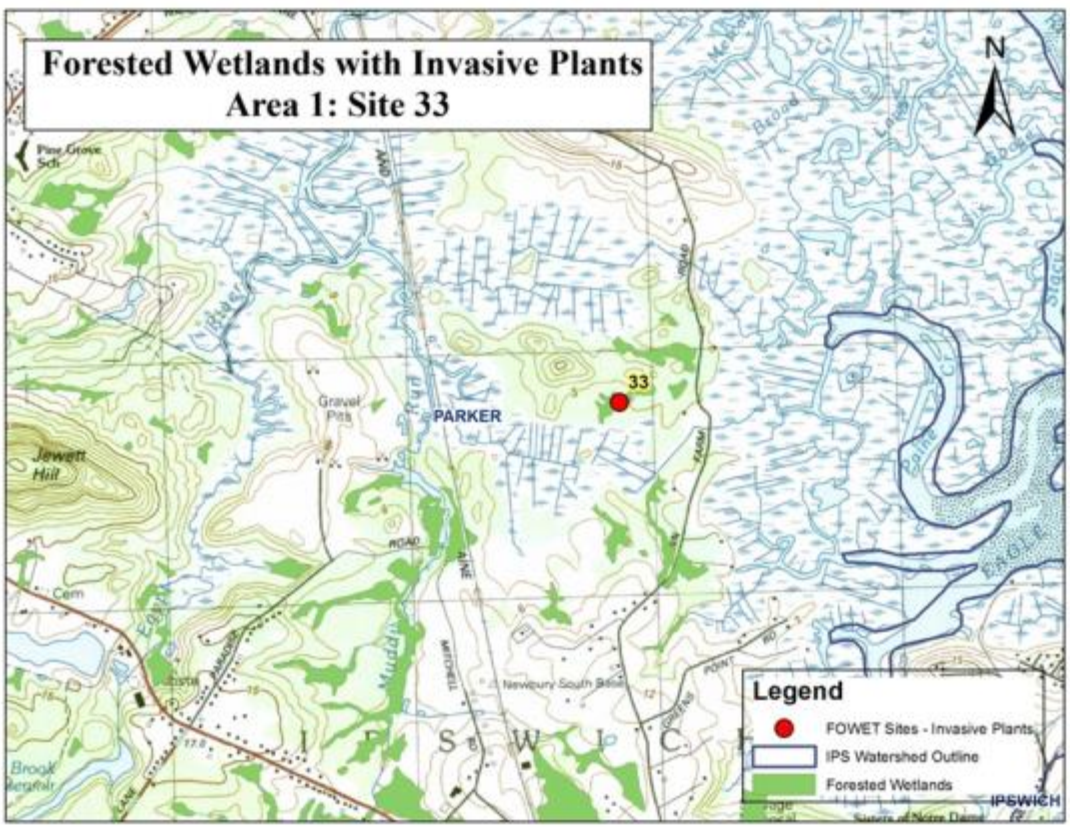
Locations of forested wetland sample sites with invasive species (orange circles) and without invasive species (pink circles) are shown here.

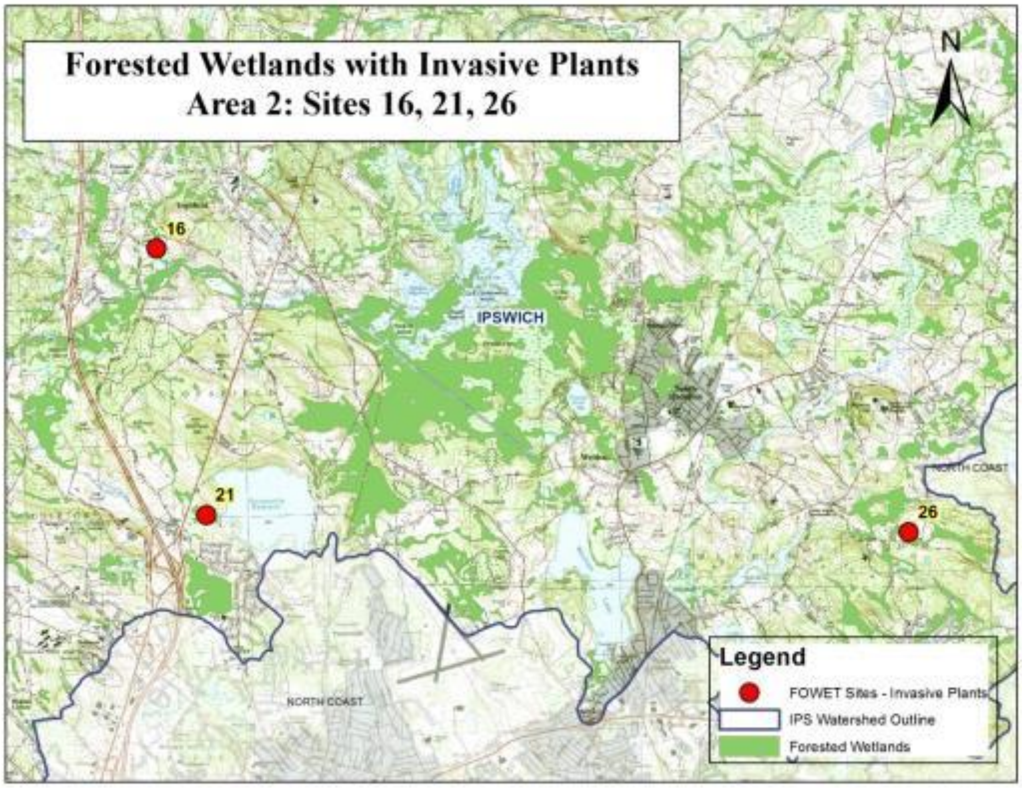
Eradication of invasive species is often not feasible on a large (i.e. watershed) scale. However, control or eradication of specific invasive species on targeted sites can be accomplished to prevent the spread of these unwanted plants. Efforts that can be taken to reduce the number of new sites on which invasive species can gain a foothold, as well as to eradicate those that exist include:

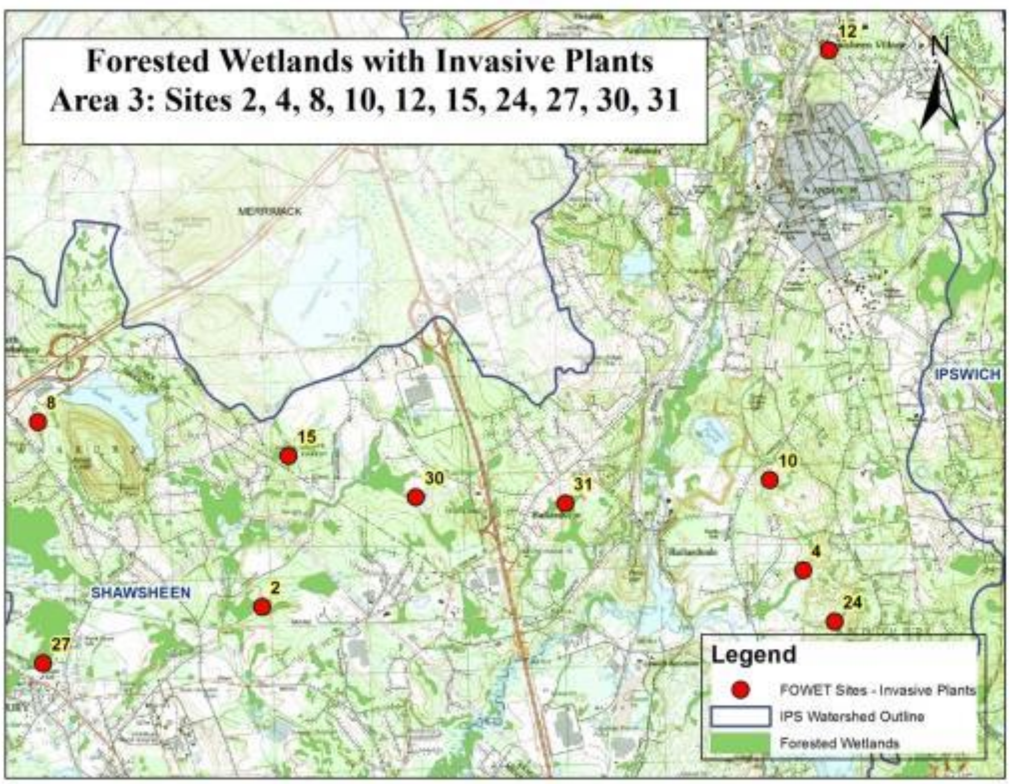
- Work with nurseries and landscapers to discourage the sale of invasive plants and the use of invasive plants in landscape plans;
- Monitor wetland replacement and restoration projects closely for pioneer communities of invasive plants and eradicate any occurrences before they become fully established.
- Look for funding opportunities to target specific sites for eradication (e.g. consult with the Department of Fish and Game, Division of Ecological Restoration).
- Participate with The Invasive Plant Atlas of New England to map, inventory, and track the location of invasive species.
- Work with Conservation Commissions and local Planning Boards to develop plans for controlling invasive plant species throughout the Town and to develop guidelines for residents interested in controlling invasive species on their property

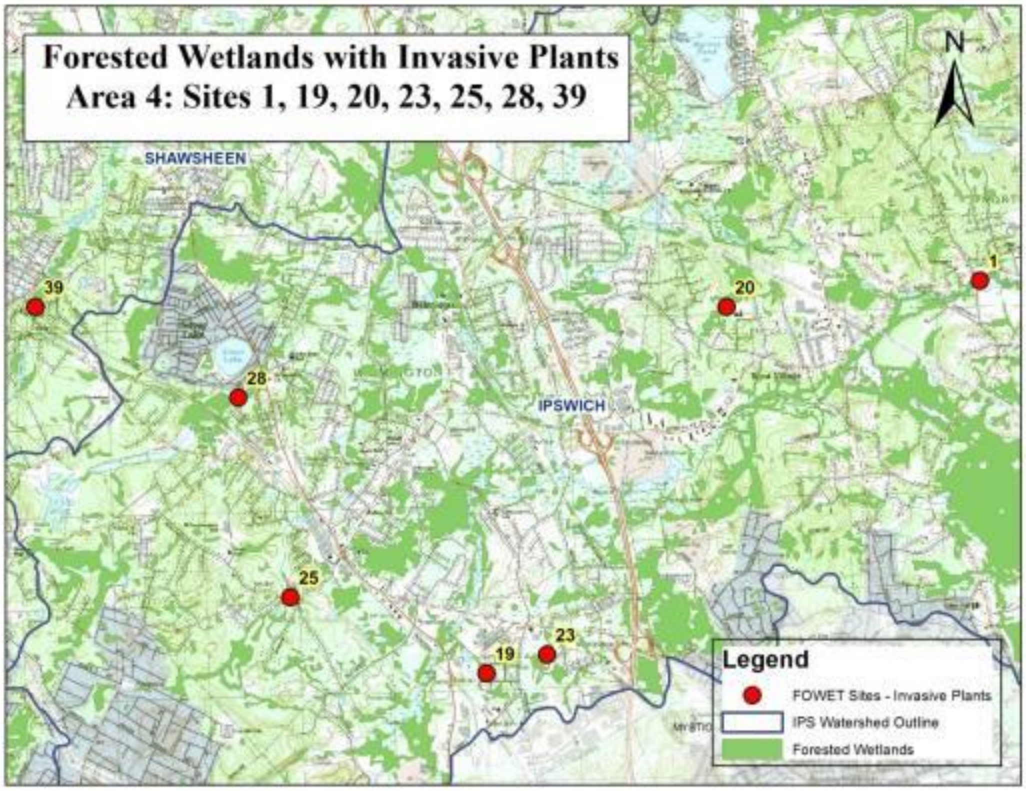
Figure 2.7-4 thru 2.7-8: Site locations of Invasive Plants

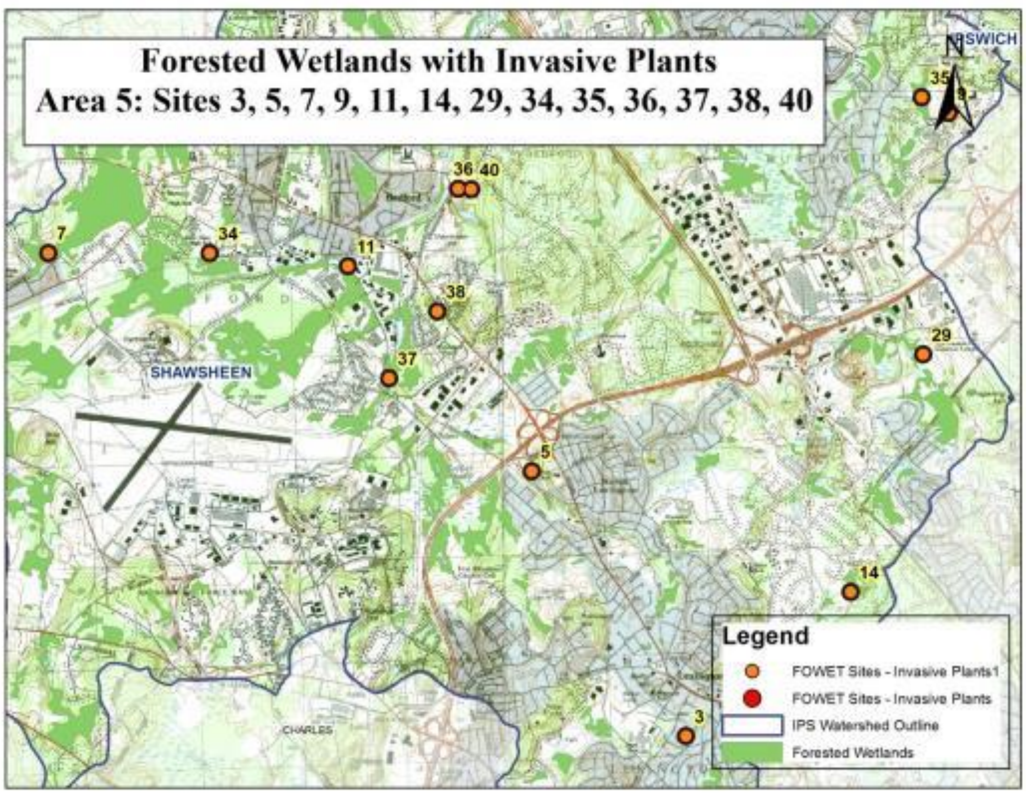
These figures illustrate the general locations where invasive species were encountered. See Appendix B for a list of specific species found at each site.




Forested Wetlands with Invasive Plants
Area 2: Sites 16, 21, 26
N
16
21
26
IPSWICH
NORTH COAST
Legend
FOWET Sites - Invasive Plants
IPS Watershed Outline
Forested Wetlands


Forested Wetlands with Invasive Plants
Area 3: Sites 2, 4, 8, 10, 12, 15, 24, 27, 30, 31
N
12
8
15
30
31
10
4
24
2
27
MERRIMACK
IPSWICH
SHAWSHEEN
Legend
FOWET Sites - Invasive Plants
IPS Watershed Outline
Forested Wetlands


Forested Wetlands with Invasive Plants
Area 4: Sites 1, 19, 20, 23, 25, 28, 39
N
SHAWSHEEN
IPSWICH
39
28
25
19
23
20
1
Legend
FOWET Sites - Invasive Plants
IPS Watershed Outline
Forested Wetlands


Forested Wetlands with Invasive Plants
Area 5: Sites 3, 5, 7, 9, 11, 14, 29, 34, 35, 36, 37, 38, 40
N
IPSWICH
SHAWSHEEN
CHARLES
7
34
11
36
40
38
37
5
29
35
14
3
Legend
FOWET Sites - Invasive Plants1
FOWET Sites - Invasive Plants
IPS Watershed Outline
Forested Wetlands

3.0 Site Level Analysis: Ipswich, Parker, and Shawsheen Watersheds

3.1 SITE ANALYSIS PROCEDURE

In 2015, MassDEP sampled 40 deciduous dominated (<30% conifer cover) forested wetland sites in the Ipswich, Parker, and Shawsheen River watersheds. The goal of this sampling was to assess the forested wetland condition to determine if the sample sites meet the expectations for ecological condition predicted by the CAPS model. A second and equally important goal was to test the reliability of the IBI's. The majority of the sample sites were randomly selected from subwatersheds with low Average IEI. Thirty one (31) of the forty (40) sites had low IEI values ranging from 0.01-0.25, six (6) of the 40 sites are deciduous forested wetlands with IEI values that range from 0.25-0.45, and two (2) sites have IEI values of 0.70 and 0.74.

The assessment consisted of sampling vascular plants at each site following the methodology outlined in the Quality Assurance Project Plan (QAPP) for Forested Wetland Monitoring and Assessment: North Coastal Watershed – QA Tracking #: 15057[20] for collecting vascular plant data. The procedure for sampling plants is:

a. Calculate species abundance of all vascular plants in a 30 m radius plot by using a point intercept method. Calculate percent cover as the tally of each plant species that is directly intercepted by a vertical projection from forest floor to canopy at one meter interval points along four 30 m transects (excluding a 5 meter reserved area at plot center) placed in the four ordinal directions. This creates 25 sample points along each of the four transects (See Figure 3.1-1).

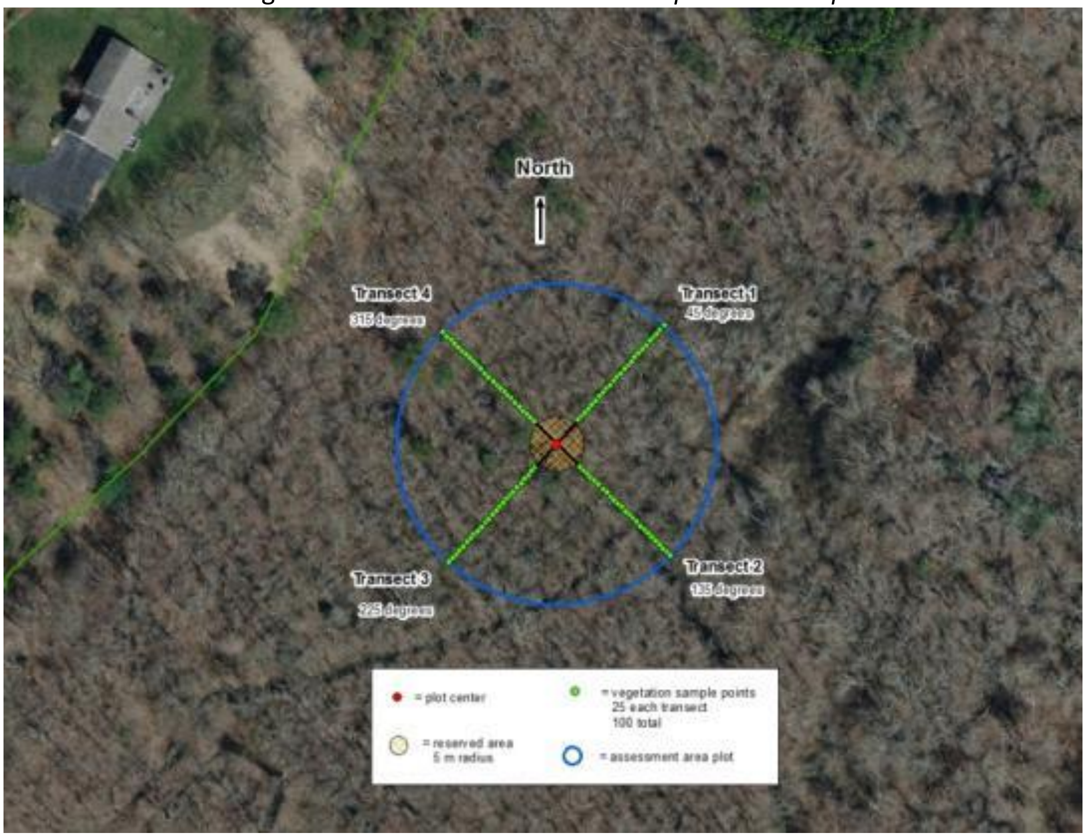
b. Following transect sampling, conduct a 20-minute walk around (within) the entire plot and list species not encountered on transects. Assign these additional species a relative abundance class of 1%.

While it was the intent of this study that the field crews implement the 30-meter radius plot sampling described above, "finger-like" or other odd shaped wetlands were encountered. If the standard plot described above did not fit within the wetland to be sampled, the plot could be reconfigured in accordance with the approved QAPP. A wetland was sampled as long as it was at least 30m across the short axis and long enough to add the difference onto the long axis (for example 30m wide x 90m long, and could be longer on one end of the long axis than the other). There were always 4 transects established and vegetation tallies always occurred at one meter intervals along those transects. Plant species were not sampled in the 5 meter reserved area at point center since vegetation in this area

[20]"Quality Assurance Project Plan for Forested Wetland Monitoring and Assessment: North Coastal Watershed – QA Tracking #: 15057" Version 1 EPA RFA # EPA- 2015-2016 http://www.mass.gov/eea/docs/dep/water/resources/n-thru-y/qapp-northcoastal.pdf

typically gets trampled in establishing the point. Transects were measured from the five meter radius from central point of the plot. In most cases, taxonomic identification at the species level was achieved through the use of Regional Field Guides and technical keys. In a few cases taxonomic identification occurred at the genus level, i.e. when a *Carex sp*. without an inflorescence was encountered. All plants were identified in accordance with the USDA Plants Database nomenclature.[21]

Figure 3.1-1: *Forested Wetland Sample Plot Set-up*



Plant species are tallied along the green transects.

21 http://plants.usda.gov/java/

3.2 INDICES OF BIOLOGICAL INTEGRITY (IBI)

The onsite component of this study employs an empirically-based assessment method using Indices of Biological Integrity (IBI's) for forested wetlands within the study area. The IBI reflects the field determined assessment of biological condition, as compared to the CAPS modeled prediction of biological condition - the IEI. The method developed for determining the value of IBI's relies on a comprehensive sampling of biota that included vascular plants, diatoms, bryophytes, lichens, and macroinvertebrates on 317 forested wetland sites across a range of stressor gradients in various watersheds across the state.[22] The IBI's could then be computed using a statistical analyses that identified strong relationships between specific taxa or groups of taxa and specific stressor or resiliency metrics, or the IEI which is a combination of all metrics .

The IBIs developed for forested wetlands performed well for taxa and groups of taxa such as diatoms and macroinvertebrates however, vascular plants performed the strongest. Forty-eight of 120 IBI's developed across taxonomic groups and stressor metrics for forested wetlands had coefficients of concordance[23] ranging from 0.5 to 0.79 with vascular plants outperforming all other taxon. Of particular importance to this assessment is that certain taxa or groups of taxa were shown to have a strong relationship with sites that were predicted by CAPS to have a low or high IEI value. Plant data collected for each site was used to determine IBI values for each site.

3.3 CONTINUOUS AQUATIC LIFE USE (CALU)

The Continuous Aquatic Life Use (CALU) framework is based on the relationship between IEI (representing the constraints on biological condition due to the nature of the surrounding landscape) and IBI (representing the actual condition of a site based on assessments conducted in the field) (See Figure 3.4-1). In order to determine whether the biological condition at a given site is at the level where it is expected, a "normal" range was identified. The range reflects the dispersion and difference between the highest and the lowest values in the training dataset (i.e. data that were collected for development of the model) and was established to include 80% of the data. This means that scores that fall within that range are within the normal spread of values which would be expected. Sites that fall above the 90th and below the 10th percentile are presumed to be outside the expected range, and thus indicative that the site exceeds expectations and is near pristine, or fails expectations and something else is going on at that wetland site that is causing stress or transition.

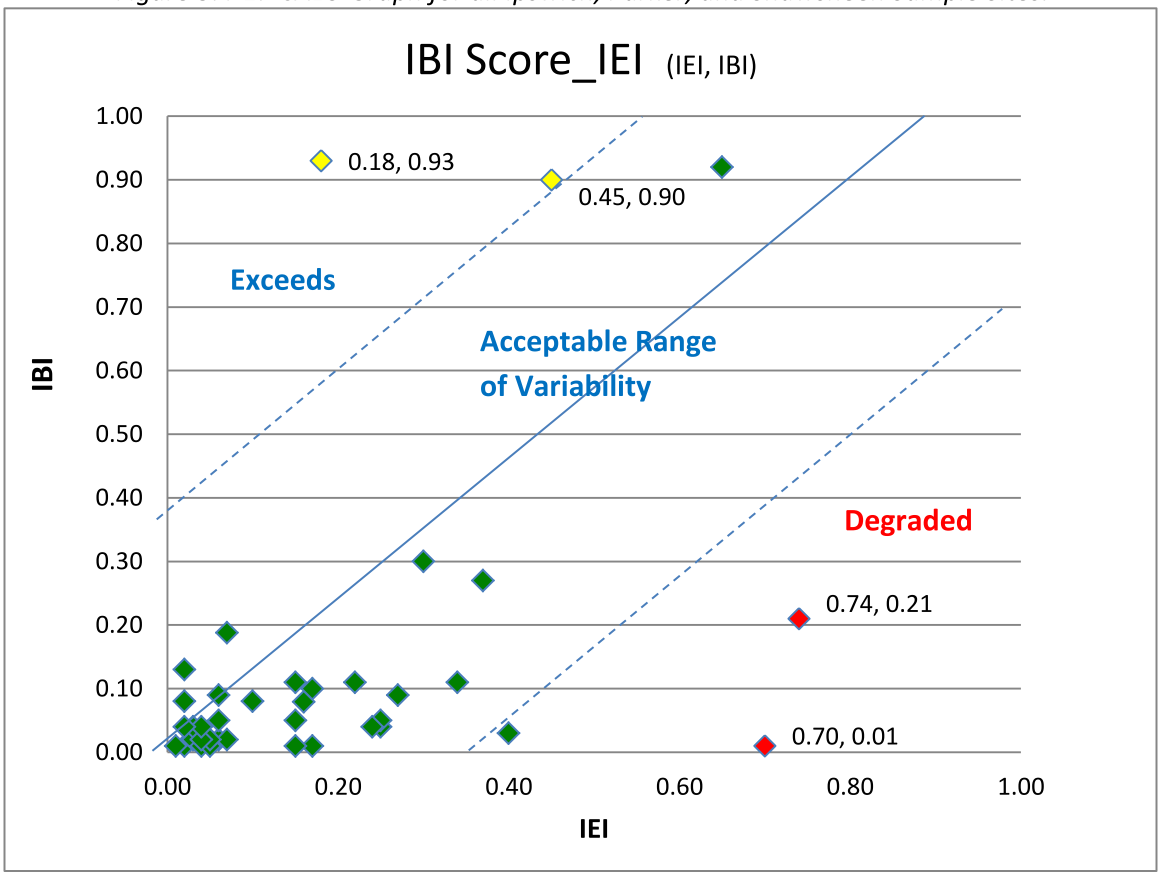
[22] A detailed description of the methods used to develop the IBI's is contained in: *Empirically Derived Indices of Biotic Integrity for Forested Wetlands, Coastal Salt Marshes, and Wadable Freshwater Streams* which is available at: http://www.mass.gov/eea/docs/dep/water/resources/a-thru-m/ibifin.pdf

[23] Coefficient of concordance is a statistical test of agreement or consistency between two or more variables using the same scale. Coefficient of concordance ranges from 0 to 1, where 0 means there is no correlation and a 1 means there is total positive correlation. The closer the value is to 1, the stronger the correlation between the taxa and the stressor.

3.4 SITE DATA RESULTS

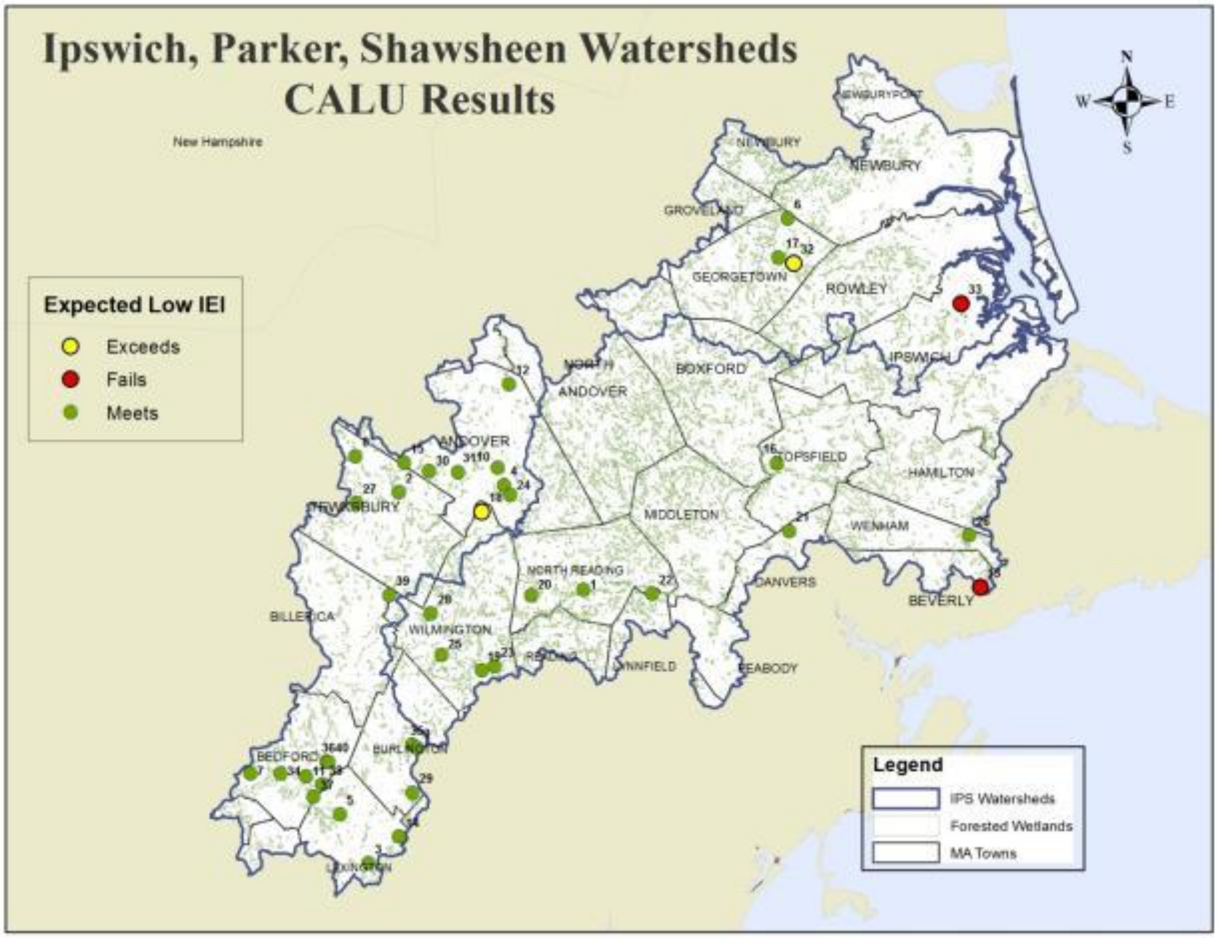
Overall, the IBI's for the sample sites confirm IEI predictions that many forested wetlands in the study area are stressed. The CALU graph in Figure 3.4-1 shows that of the 40 sites sampled, 36 sites (shown as green diamonds) met expectations. Sites numbered 18 and 32, shown as yellow diamonds, "Exceed" expectations with IBI values much greater than the predicted IEI. Sites numbered 13 and 33, shown as red diamonds, fall well below the expected IEI predicted by CAPS model and thus "Fail" to meet expectations. Plant data collected for each site is presented in Appendix B.

Figure 3.4-1: CALU Graph for all Ipswich, Parker, and Shawsheen Sample Sites.



Sites that meet the biological condition are presumed to be performing at the ecological level that is expected given their landscape position. Sites #13 in Beverly and #33 in Ipswich fall below the predicted level and so were flagged for further evaluation to identify potential sources of stress that could explain the discrepancy and to explore regulatory or best management practices that could address the failure of the site to meet its predicted level. Applying the same color scheme to CALU results, Figure 3.4-2 shows the approximate locations of sampled sites in the study area, and the assessment of forested wetland condition for each site according to the CALU model.

Figure 3.4-2: CALU Assessment Results and Location of Sample Sites.

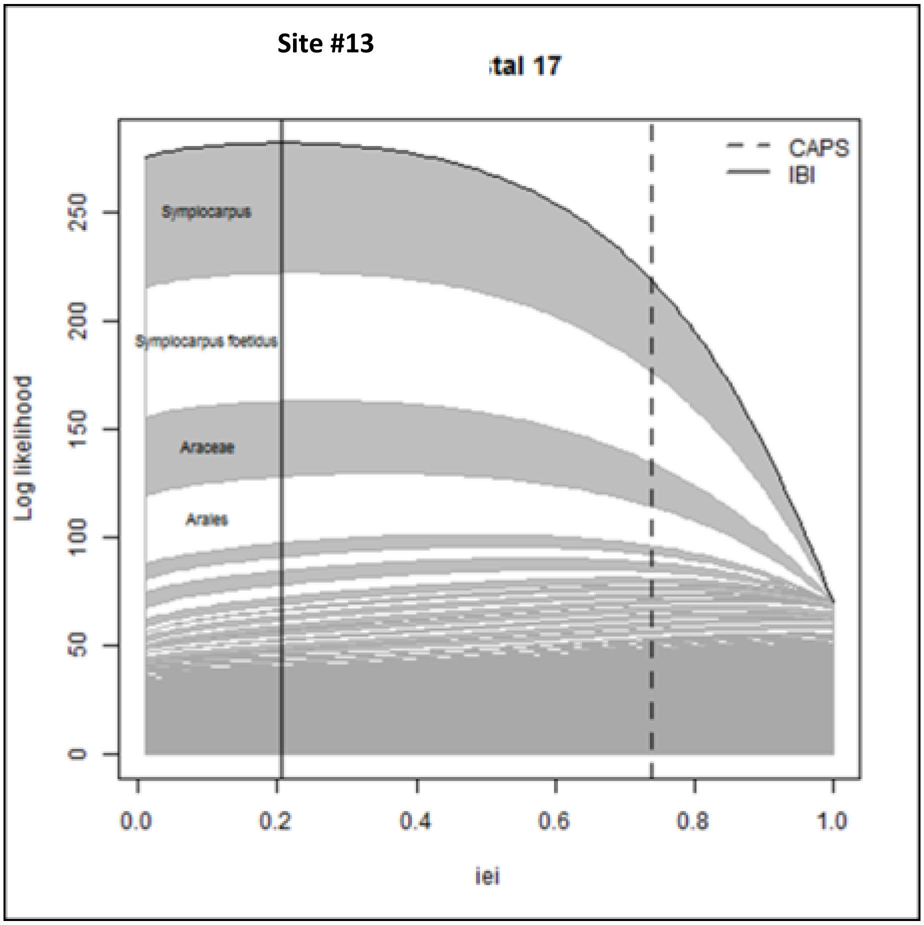


<u>Low IEI FAIL Sites</u>

<u>FAIL Site #13</u> is located at the outer edge of the Ipswich River Watershed in Beverly. The site is a relatively untouched forested wetland surrounded by an expansive wooded upland of mixed coniferous and deciduous trees. The site is characterized by an extensive canopy of Acer rubrum (Red maple) with 94% cover, Betula alleghaniensis (Yellow birch) at 24% cover, and Pinus strobus (Eastern white pine) at 10%. The list of twenty six (26) sampled and documented plant species does not include invasive plants. Ilex verticillata (Common winterberry) and Clethra alnifolia (Coastal Sweet pepperbush) dominate the shrub layer with 75% and 30% cover respectively and at 59% cover, Symplocarpus foetidus (Skunk cabbage) rules the herbaceous layer. See Appendix B for a complete list of plants at each site.

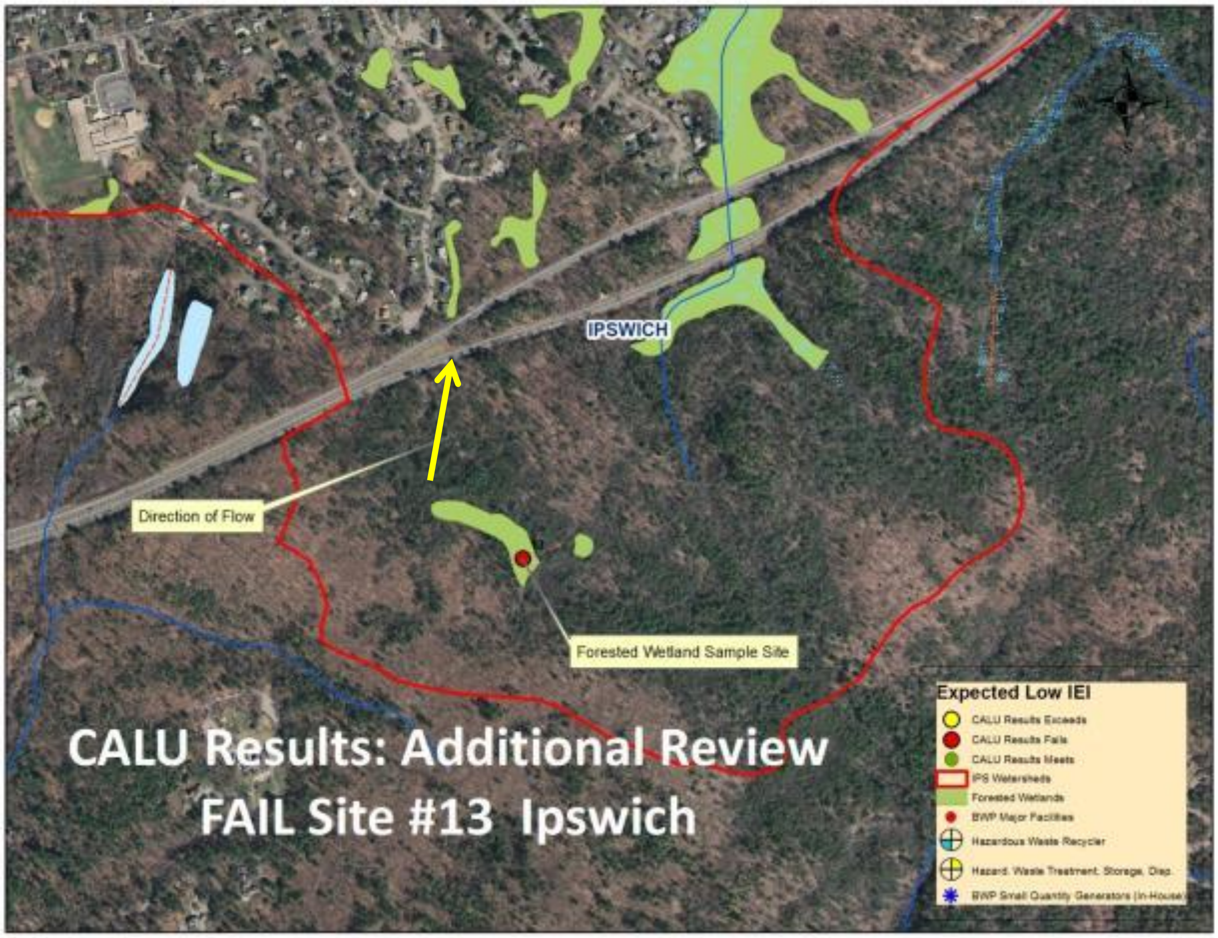
Figure 3.4-3 below is referred to as a “sediment plot,” and depicts the contribution of sampled plants to the overall IBI value for the site. The CAPS IEI value is shown as a dashed vertical line, and the actual IBI value is shown as a solid vertical line. Each alternating layer in the graph represents the likely contribution of each taxon. Plants with a label are primary contributors to the IBI value. The thickness of the layer indicates its dominance and the location of the plant name indicates the IBI value for that plant. Plants with a label to the left of the dashed vertical IEI line will draw the IBI down from the predicted IEI; plants to the right will increase the IBI. The most influential plant contributing to the lower site IBI is Symplocarpus foetidus (i.e. skunk cabbage).

Figure 3.4-3: FAIL Site #13 IBI Plant Community Sediment Plot



The most prominent land use in the vicinity of Site #13 is Route 128, a heavily used highway located north of Site #13, downgradient of the site. A well-formed channel conveys stream flow away from the watershed boundary and out of the wetland toward and under Route 128 through a large culvert approximately 0.25 miles away. The wetland is topographically isolated from the stormwater influences of Route 128. No stormwater outfalls were located along the stretch of roadway bordering the forested wetland area and there are no impaired waters in the vicinity of the wetland site (See Figure 3.4-4). A review of ArcGIS data indicate that there are no land uses, 21E sites, waste site facilities, brownfields, landfills, underground storage units, or hazardous releases upgradient of the wooded wetland or in the surrounding areas that could contribute to degradation of the resource area. The additional review and second site visit failed to uncover any field conditions or land use changes that reasonably explain the low IBI score (IEIdelta) and thus, the result may be an error in the CAPS model calibration, or a cause that was not investigated such as contamination. The dense canopy of Red Maple, with a large stands of Eastern White Pine in the landscape surrounding the wetland that is evident from the site walk and in aerial images from 2001 remains unchanged in 2008 and 2014.

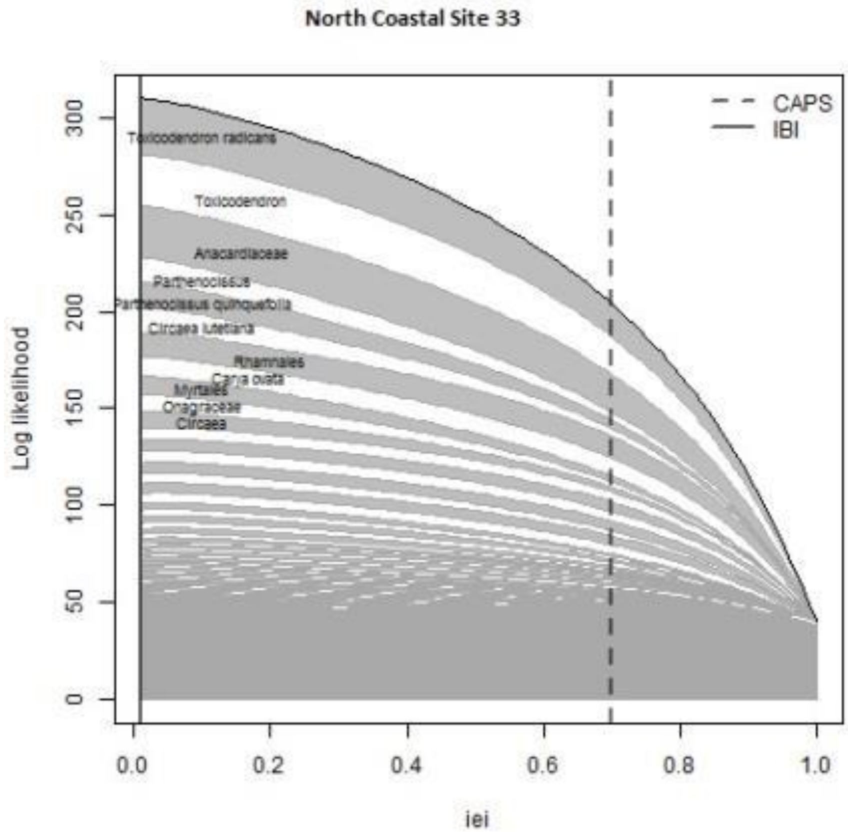
Figure 3.4-4: FAIL Site #13 Additional Review Aerial Images



FAIL IBI site #33 was also a site that failed to meet expectations and so this site was revisited and reviewed in greater detail. See Figures 3.4-5 and 3.4-6. The site is located in the coastal reaches of the Parker River Watershed on a wooded island surrounded by an extensive and heavily ditched salt marsh. The forested wetland is in a transition zone from primarily inland wetland types to salt marsh and coastal wetland types. The distance between like patches of wooded wetland is large and the number of forested wetlands in the area is diminishing, so the similarity metric is low. The wetland plant community (See Appendix B) contains 92% canopy cover of *Acer rubrum* (Red maple) with 40% shrub cover of invasive *Frangula alnus* (Glossy buckthorn) and 57% *Toxicodendron radicans* (Poison ivy). No stormwater discharges were observed in the area and no direct sources of impact to the wetland were apparent upon visual inspection, except for a few downed trees.

The CAPS model predicted an IEI of 0.70 however the onsite plant community assessment resulted in an IBI value of 0.01. The sediment plot below depicts that plant community and the effect it is having on the IEI.

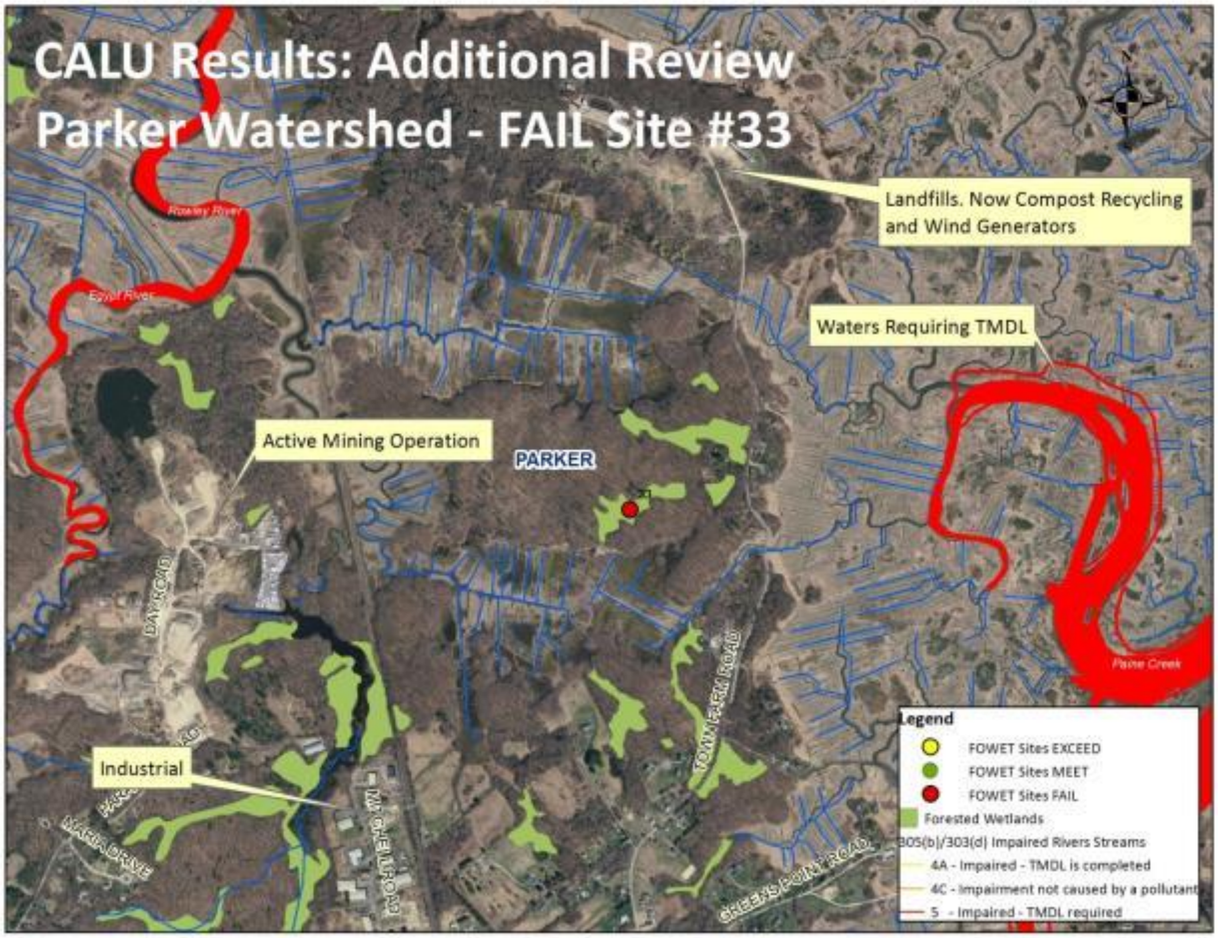
Figure 3.4-5: FAIL Site #33 IBI Plant Community Sediment Plot



Several plants with IBI values less than 0.2 contributed to the IBI being much lower than the predicted IEI for this site. Toxicodendron radicans (poison ivy) at 57% cover is the dominant plant affecting IBI and is typically an indicator of low IBI found in stressed wetlands. In this case it is a major contributor in drawing down the site IBI value to 0.01. Other common plants influencing the overall site IBI value are all on the left side of the graph and include Parthenocissus quinquefolia, (Virginia creeper), Carya ovata (Shagbark hickory), and Circaea lutetiana (Enchanter's nightshade) with 16%, 15%, and 12% cover respectively.

Aerial orthophotos show little change in land use from 2001 to 2014.An active mining operation and two landfills, one a lined municipal landfill and the other an unlined sludge landfill, are located within 0.5 miles of the forested wetland. No plumes are documented as originating from the landfills. The surrounding waters are listed as impaired and requiring a TMDL for pathogens. It is not clear when the landfills were closed, but both landfills now operate as an active compost and yard waste recycling center and accommodate two recently added wind generators. ArcGIS review of MADEP data layers indicates that there are no wastewater treatment facilities or hazardous waste sites in the area. Large dump trucks filled with compost materials were observed traveling on roads near the wetland site several times during the day. Several large and small drift logs provide evidence of storm surges or extreme high seasonal tides encroaching into a freshwater plant area near the wetland, but not into the wetland directly. There is no indication of plant impact due to salt spray or growth of salt tolerant plants in the wetland that would indicate saltwater intrusion. Groundwater salinity data would provide additional information regarding the potential for salt water intrusion into the wetland, but this was not collected.

Figure 3.4-6: FAIL Site #33 Additional Review Aerial Images



The site could have failed to meet expectations for reasons other than those explained by the CAPS model or observed in the field such as chemical contamination or excess nutrients.[24] It is also possible that the active composting facility nearby, as well as the frequent truck trips carrying material to that facility, serves as a constant source of weed seeds that could be affecting the plant community. Combined with the harsh coastal environment that may frequently cause temporary openings in canopy or ground cover from coastal storms, this might be enough to allow an undesirable plant community to take root.

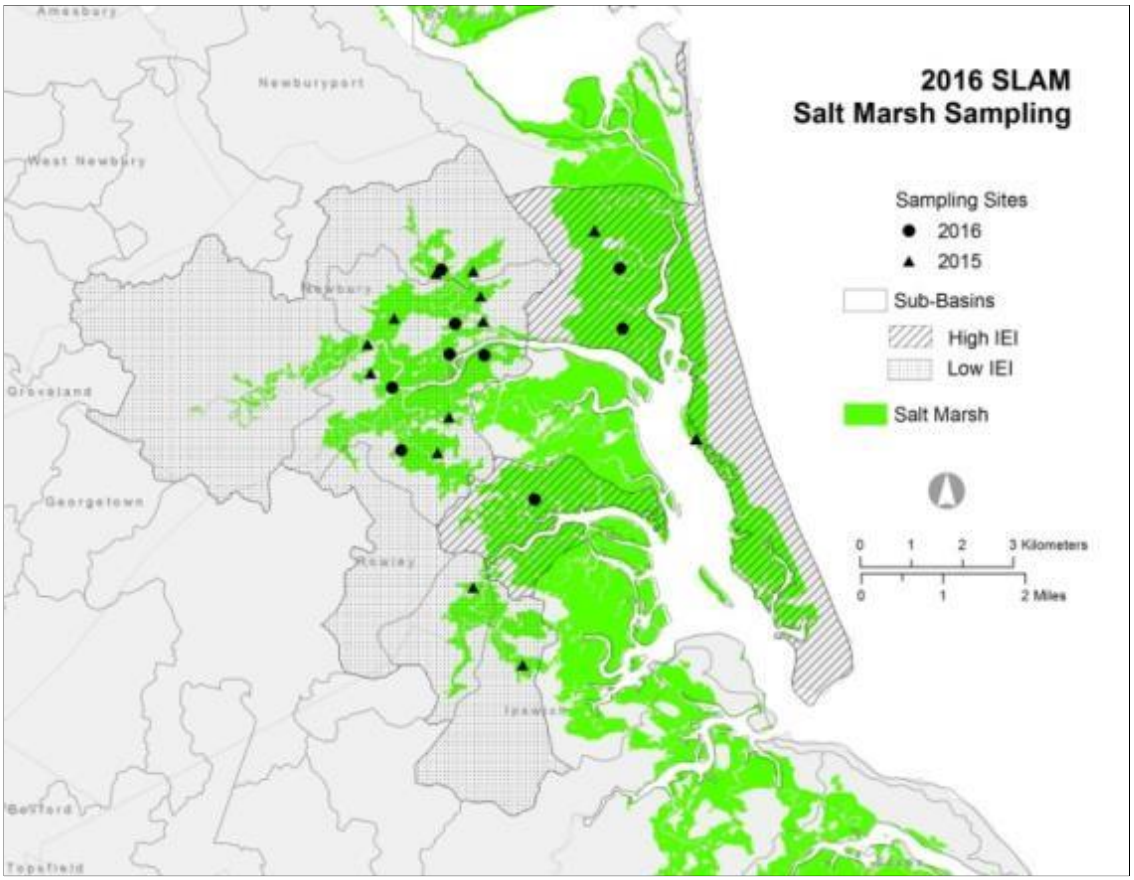
4.0 SALT MARSH DATA COLLECTION IN THE IPSWICH AND PARKER WATERSHEDS

Salt marshes perform important physical, chemical, and economic functions, such as filtering and trapping sediment and contaminants from stormwater runoff, producing plant matter that serves as a source of nutrients in the larger coastal and marine food web, and stabilizing the shoreline against storm damage and sea level rise. Urban development and human activities in coastal areas have resulted in the degradation and loss of these valuable coastal resources. The 2015 wetland sampling of the Northeast Basin Group, in support of MassDEP's 5-year basin cycle for sampling and reporting pursuant to the

[24] Note that the CAPS nutrient metric has recently been improved, and future reports will incorporate that change. Additional work on the nutrient metric is desired.

CWA, includes a coastal wetlands component to monitor and assess the environmental health of salt marshes in MA. Salt Marsh sampling was conducted, led by our partners at MACZM, at 20 salt marsh sites within the Parker and Ipswich River Watersheds. The 20 sites were selected at random salt marsh locations from coastal subwatersheds in the Parker and Ipswich Watersheds that were predicted to have stressed salt marsh wetlands based on low average salt marsh IEI values (<0.5). Five sites were also randomly selected within subwatersheds that had the highest average IEI scores (>0.8).

Figure 3.4-7 Salt Marsh Sampling Sites



Vegetation, macroinvertebrate, and physical integrity data was collected at each of the 20 sites sampled. The sample data is available in Appendix E: *Wetland Monitoring and Assessment Salt Marsh Data Collection and Processing Report* dated December 30, 2016 and prepared by the Massachusetts Office of Coastal Zone Management. However, statistical analysis of existing IBIs for salt marshes indicates that little concordance exists between the predicted Landscape Assessment value of (IEI) and the site specific field evaluation of wetland condition (IBI). The best performing salt marsh metric (connectedness) had an R^2 value of 0.32 and the second best metric had an R^2 value of 0.27. In order to be considered credible, an IBI must have an R^2 value of at least 0.5. Therefore, none of the IBI's have been incorporated or applied. [25]

[25] http://www.mass.gov/eea/docs/dep/water/resources/a-thru-m/ibifin.pdf

The reason for this lack of concordance is currently under review. Several hypotheses are being considered.

1) It may be that salinity in tidal waters is such an overwhelming factor that it masks other stressors;
2) It may be that the CAPS model metrics failed to capture the most significant stressors (e.g.. nutrients, sea level rise);
3) It may be that further refinement of the IBI data gathering protocol is necessary (i.e. use of larger plot size to incorporate more comprehensive plant community data, physical features such as bank slumping etc.);
4) Other-there may be a factor or factors we have not yet identified.

In order to address this need in our coastal wetland Monitoring and Assessment Program MassDEP is reevaluating our salt marsh monitoring program. MassDEP, along with our partners MACZM and UMass-Amherst are planning to convene an expert team to review our current protocol and discuss ideas for improvement. The Monitoring and Assessment team recognizes that salt marshes are one of the Commonwealth's most valuable wetland resources and that strong regulatory standards prohibiting the direct alteration (i.e. filling in) may not be enough to protect and preserve their ecological integrity. However, the team is also aware of the difficulties in developing meaningful models to evaluate stressors to coastal wetlands. Further research will be necessary to achieve this goal.

5.0 CONCLUSIONS

MassDEP used tools to assess the Ipswich, Parker, and Shawsheen Watersheds that were developed specifically for the purpose of wetland monitoring and assessment. They include the CAPS model, the SLAM for forested wetlands, the IBIs and the CALU analysis. The site assessments and CALU analysis demonstrate that the IBI's appear to be accurately predicting wetland condition in most cases. The CALU results indicate that most low IEI sites sampled met expectations; meaning that the CAPS model predicted these sites would have low ecological integrity based on the developed landscape around each site, and the sampling and IBI analysis accurately reflected the condition of the site. These sites, and likely many other forested wetlands in the watershed, are adversely affected by the developed landscape, and opportunities for restoration should be actively evaluated to improve wetland condition at all low IEI forested wetlands in the watershed.[26] Opportunities for restoration that would improve wetland condition have been discussed in this report and include improvements in terrestrial connectedness and similarity, eradication of invasive species, and preservation of important wildlife habitat.

One limitation was the difficulty in assessing sites predicted to have a low IEI by CAPS. Unfortunately, low IEI sites (below about 0.35) cannot "fail" because the acceptable range of variability intersects the lower end of both the IBI and the IEI scale at about 0.35. Thus, these sites fall into the "meets" category. Further consideration may be needed on how to assess sites with low IEI, but it may be more beneficial to focus on medium and high IEI sites where perhaps more can be done to improve condition. The sites studied in the Northeast Basin were selected before we had identified this limitation. In future studies we may focus more on sites with medium IEI (e.g. 0.30 – 0.70).

[26] CAPS IEI data is available in GIS format at www.umasscaps.org Maps depicting the top 50% IEI are available by Town at the same website.

Another ongoing discussion is whether wetland sampling for monitoring and assessment purposes should be based on probabilistic or targeted sampling. The current approach was a hybrid of targeted and probabilistic sampling. Forested wetlands in subwatersheds with low average IEI were first identified or targeted for sampling. Then 40 sites were randomly selected from the set of all forested wetlands within those subwatersheds that met the low IEI criteria. Thus the selected sites had a range of IEI's, but were primarily low. The purpose of a probabilistic selection of sample sites is to get a representative sample of wetlands from which to draw inferences about the larger population of all wetlands in a watershed.

The robustness of IBI's across ecosystems within the state has been identified as a potential limitation of this monitoring and assessment approach. When IBI's were developed within a limited number of ecoregions (i.e. Worcester plateau/Eastern Connecticut Upland, and the Gulf of Maine coastal plain) the relationship between the IBI and IEI (concordance) was strong. However once new data from a very different watershed (Southern New England Coastal Plains and Hills) was incorporated the IBI/IEI relationship became less robust. IBI development has yet to incorporate data from the Berkshires, a significantly different ecoregion from the watershed ecosystems currently used to develop the IBIs. Cape Cod has also not been sampled, which again is significantly different. It may be that IBI's work best on a watershed or ecoregion basis rather than on a statewide basis. However, data collection from each ecoregion for IBI development purposes is a resource intensive activity and so, IBI development based on the best available data, if not perfect, is sufficient to meet current monitoring and assessment needs. MassDEP will likely conduct more basin specific analyses before deciding on a specific approach.

Lastly, MassDEP applied a second tier of site level assessment for wetland sites whose IBI values fell outside of and below the range of predicted IEI values. A follow-up site visit was conducted to further investigate potential disturbances resulting from natural and anthropogenic sources within the wetland or surrounding area that would contribute to the observed wetland field condition. While it is understood that a certain number of sites, due to chance alone, could naturally fall out of the normal range of variability, it is important to be able to discern when it is due to chance and when it is due to a stressor that has either not been identified or perhaps underestimated by the model.

Additionally, MassDEP is learning more about what the data does and does not tell us with each new basin study. At the conclusion of this second monitoring and assessment study of the Northeast Basin Group, as well as the first study of the Chicopee Watershed dated April 2016[27], we have found the following:

1. Not all degradation is anthropogenic, some is natural. For example. in the Chicopee Watershed study we found that the reason for the "fails" assessment at two sites was due to beaver activity;

2. Anthropogenic land uses may be having secondary impacts that are not immediately apparent during permit review, or that are due to land uses beyond the buffer zone. For example, in this study, Fail Site #33 may be influenced by nearby composting, or by transport of composting materials introducing a weed seed source. Combined with a coastal environment that periodically affects the site due to storm flows or winds, canopy openings and disturbance may allow new species to take root;

[27] http://www.mass.gov/eea/agencies/massdep/water/watersheds/chicopee-watershed-wetland-monitoring-and-assessment.html

3. Sometimes causes cannot be identified, and could be due to model error or causes that were not investigated and not addressed in the model, such as contamination;

4. Low concordance between IEI and IBI, as is the case with salt marshes, indicates the need to reevaluate the model and/or the sampling protocol to determine if additional factors need to be taken into account.

MassDEP continues to apply and advance its monitoring and assessment program. A shrub swamp SLAM and IBI's and a strategy to improve salt marsh assessment are under development. This study is another critical step in its implementation. Now, with real world application MassDEP is better able to see the strengths and weakness of its approach and will continue to refine it to meet the needs of the program.