WETLANDS MONITORING AND ASSESSMENT: CHICOPEE, MA WATERSHED

Massachusetts Department of Environmental Protection
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ACKNOWLEDGEMENTS

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Executive Summary

The Massachusetts Department of Environmental Protection's (MassDEP) Wetlands Program conducted a pilot study of the Chicopee watershed for the purposes of reporting on wetlands water quality in order to comply with Section 305(b) of the Clean Water Act. The study involved first time use of tools developed by the University of Massachusetts at Amherst ("UMass-Amherst") in partnership with MassDEP and the Massachusetts Office of Coastal Zone Management (MACZM). In accordance with the Environmental Protection Agency (EPA) recommended concept for wetland monitoring and assessment, [1] this study consisted of a landscape level GIS-based assessment using the Conservation Assessment and Prioritization System (CAPS) model, and a site level assessment (rapid and intensive) based on Indices of Biological Integrity (IBI's) developed specifically 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.

Using the CAPS landscape level GIS-based model, the primary causes of ecological stress of forested wetlands within the Chicopee watershed were identified as: loss of terrestrial connectedness, loss of similarity, the presence of non-native invasive plant species, and the loss of aquatic connectedness. Based on this assessment, strategies were identified to combat these sources of stress including: establish terrestrial wildlife passage structures between areas of similar forested wetland habitat; protect buffer zones; improve stream crossings to meet the Massachusetts Stream Crossing Standards; and identify and map the extent of invasive species and prevent further expansion.

In addition to the CAPS landscape level assessment, a site level assessment was conducted to assess actual wetland condition at targeted sites, since CAPS is based primarily on desktop GIS level mapping data. The site level assessment was also conducted to assess the reliability of the CAPS landscape level predictions. The Chicopee Watershed site level assessment was conducted by sampling plants at 45 sites across the watershed, and using the IBI's and the CALU framework to determine whether sites met expectations. The assessments are based on the CAPS output referred to as the Index of Ecological Integrity (IEI) - which is a surrogate for, or prediction of, wetland condition or health – for the site and the landscape around the site. Site selection was based on IEI value (40 low value sites (stressed) and 5 high value sites (good)) and all sites were forested wetlands that drained into impaired waters.

The results of the IBI and CALU analysis indicate that all 40 sampled sites with low IEI predicted by CAPS also had a low IBI value based on field data and met expectations. The analysis confirmed that the IBI's accurately assessed site condition as predicted by the CAPS model and thus were found to be reliable. The site level assessment also enabled us to identify sites that did not meet expectations. Of the five sampled sites in which the CAPS model predicted high IEI, three "failed" expectations. After further investigation, the cause of the failure to meet expectations could be explained in two of the three cases by natural causes that resulted in a transition of the plant community from that of a typical forested wetland to one that thrives with

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

increased sunlight. The third site cannot be explained without further investigation. This analysis confirmed that the biological site investigation and the use of IBI's and CALU for assessment were successful in some cases by identifying sites that did not meet expectations and were not as predicted by CAPS. Further investigation and research is required to test this approach.

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, prevention of pollution, protection of land containing shellfish, 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 and the benefits have been documented, for example:

- Mass Audubon estimated that freshwater and saltwater wetlands in MA provide $2.3 billion in annual ecosystem service value; [2]
- The Army Corps of Engineers estimated that wetlands in the Charles River Basin prevent $18 million in flood damage annually[3];
- The MWRA avoided the cost of a new $180 million filtration plant because of natural waste treatment provided by wetlands near the Quabbin and Wachusett reservoirs.
- The Massachusetts Department of Fish and Game, Division of Ecological Restoration estimates that the Town Creek restoration project in the Town of Salisbury will result in almost $2.5 million in avoided flood losses over the next 30 years.[4]

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[2] http://www.mass.gov/eea/agencies/massdep/water/watersheds/wetlands-the-preservation-of-wetlands-functions-and-th.html

[3] Thibodeau, F.R. & Ostro, B.D. (1981). An Economic Analysis of Wetland Protection. Journal of Environmental Management, 12: 19-30

1.2 Why Monitor and Assess

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. In Massachusetts, the most recent biennial report is called the *Massachusetts Year [2014] Integrated List of Waters.*[5]

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 Clean Water Act. Although the Massachusetts water quality standards are applicable to wetlands, wetlands are primarily protected through the Massachusetts Wetland Protection Act (M.G.L. C. 131, § 40) and 401 Water Quality Certification requirements, which are primarily implemented through a regulatory permitting program that address direct physical alterations such as dredging and filling and chemical alterations such as stormwater discharges.

Much of the current system of surface water quality standards is 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,

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[4] *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

[5] http://www.mass.gov/eea/docs/dep/water/resources/07v5/14list2.pdf

nutrients, pH, temperature, solids, turbidity, color, oil & grease, taste and odor). In general, water bodies and waterways that serve as drinking water supplies, as well as tributaries to those water bodies and waterways and associated wetlands, are included in Class A. Other wetlands and water bodies/waterways are included in Class B or coastal Classes SA and SB.

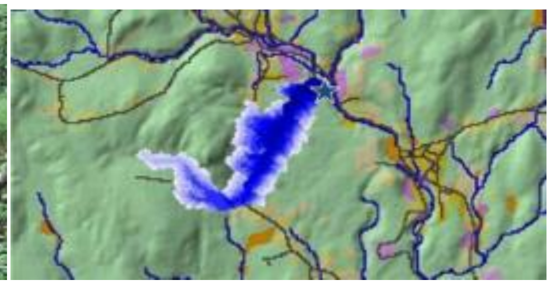
The designated use related to "fish, other aquatic life and wildlife" is also important and very relevant for wetlands. Fish, other aquatic life, and wildlife as a designated use is much more difficult to assess in the field than water quality-based uses. Biological integrity is affected by habitat connectivity 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. [6]It is not clear what the relationships are between water quality parameters and designated uses for wetlands. However, differences between wetlands and water bodies/waterways makes it likely that the way that water quality standards are applied for wetlands will differ from how they are applied in water bodies/waterways.

There are also key differences between wetlands and waters with regard to how they are assessed. 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 means that many more wetland sites would need to be surveyed to generate a comprehensive assessment than 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, since resources are limited. To develop this tool, data from hundreds of forested wetlands, salt marshes and wadable streams was used to calibrate and test the CAPS model.

Currently the Massachusetts Water Quality Standards include narrative criteria for fish, other aquatic life and wildlife use. The EPA is encouraging states to adopt numeric criteria in addition to narrative criteria in order to better determine and document whether Waters of the United States (including wetlands) 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.

[6] 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.

1.3 Wetlands Monitoring and Assessment Strategy

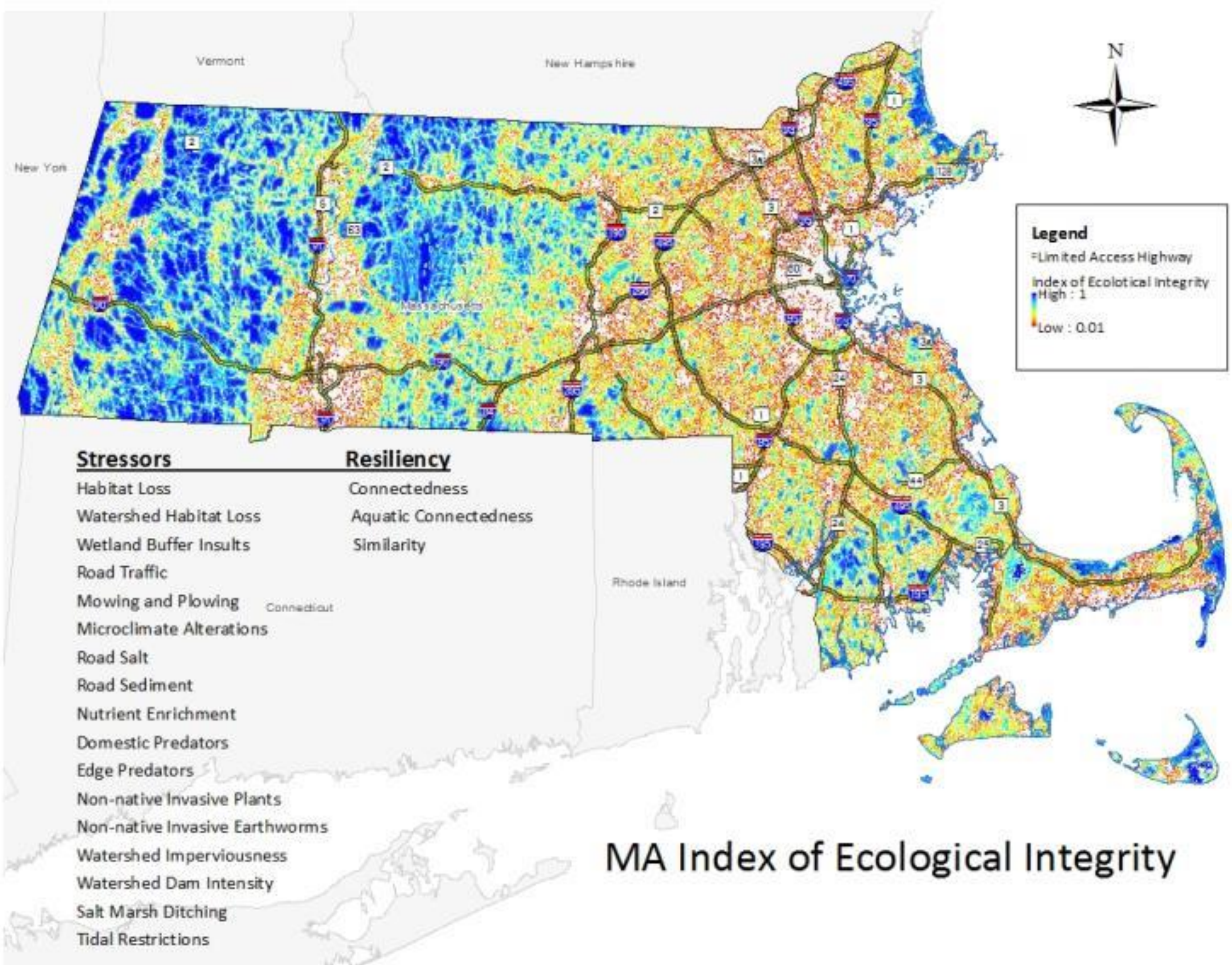



Wetland monitoring refers to the gathering of scientific information to use in answering one or more wetlands management questions. Wetland assessment refers to the companion task of evaluating data to reach conclusions regarding a specific wetland or group of wetlands. Wetland monitoring and assessment are not ends in themselves, but are used to guide decisions in a science-based manner. 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 M.G.L. C. 131 §40 (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 and an approach to prioritizing 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).[7] The CAPS model combines this data and calculates a value between 0 and 1[8] for every 30 m^2 point in the landscape. The CAPS value represents the index of ecological integrity (IEI) or prediction about the degree of wetland stress and suitability as biological habitat and 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.[9] Using these SLAMs, data was collected from 250 forested wetlands and 164 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 Planning have been used for testing the CAPS predictions and modifying (as needed) the CAPS models; and for the development of 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

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

FIGURE 1.3-1 Statewide CAPS IEI and Metrics



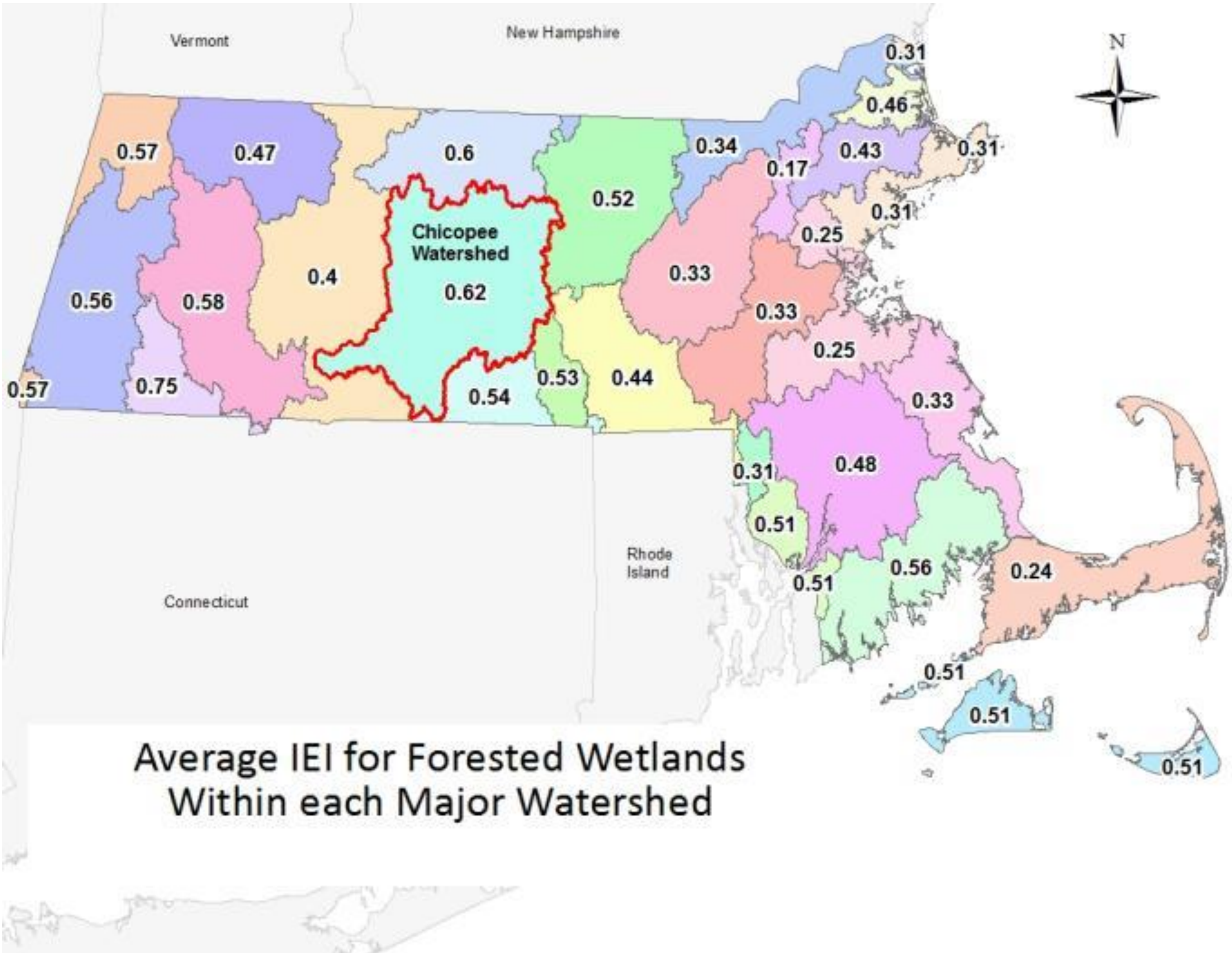
2.0 Application to Chicopee River Watershed

2.1 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 across watersheds and provides for direct comparison between them by identifying which wetland areas are most impacted by ecological stressors and what the likely source of those stressors is. The Chicopee Watershed was selected for a pilot analysis based on the MassDEP Division of Watershed Planning rotating basin scheme for sampling of water bodies and waterways. Because SLAMS have only been developed for forested wetlands and salt marshes, the focus of this report is on forested wetlands since there are no salt marshes in the Chicopee Watershed, and because that is the wetland community where CAPS has been most rigorously applied and field tested.

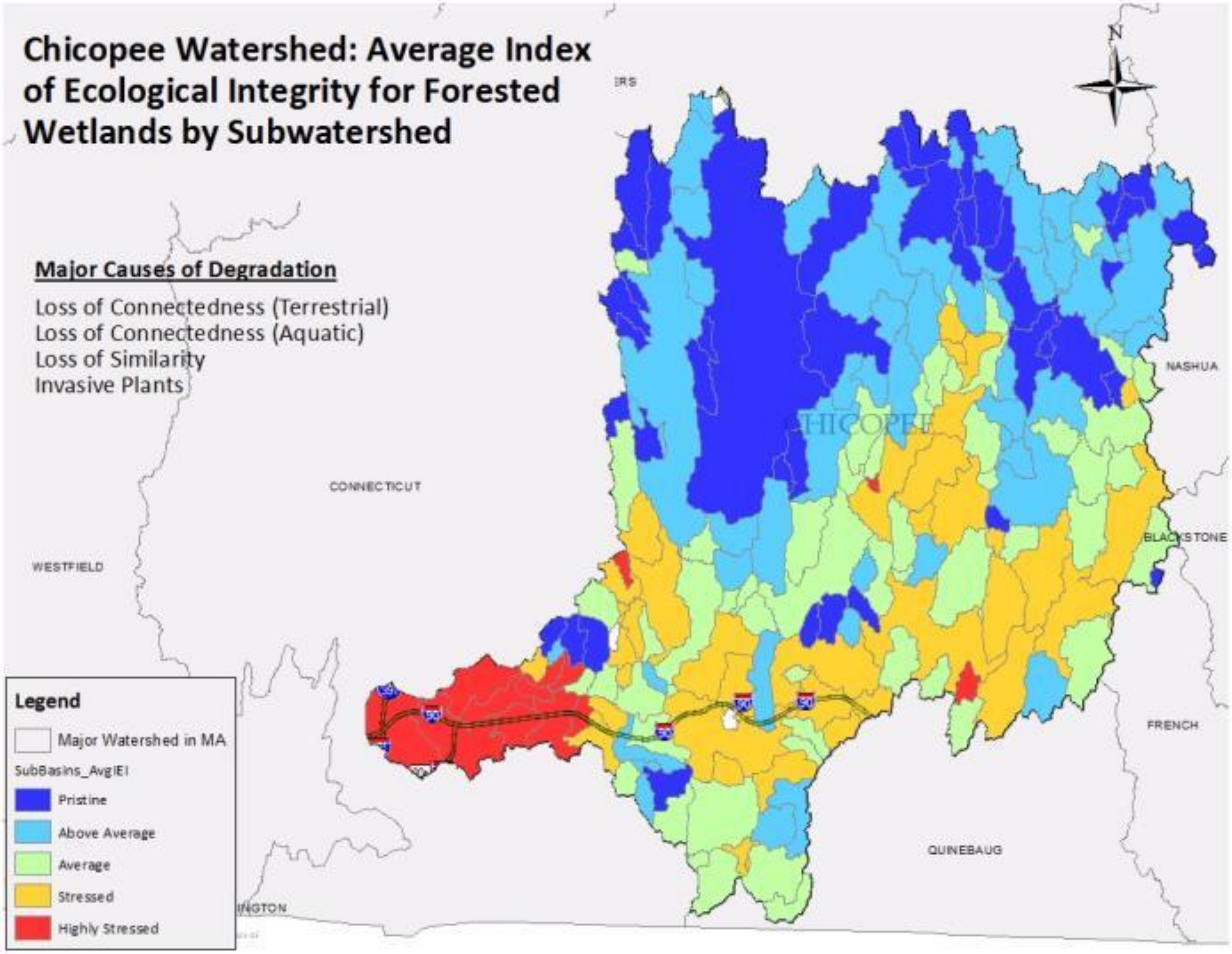
Using the spatial analysis tools in a geographic information system (ArcGIS), the average IEI value for forested wetlands within each major watershed in Massachusetts was calculated to gain an understanding as to whether the Chicopee Watershed is in overall better or worse condition than other watersheds. As depicted by Figure 2.1-1, watersheds with low average IEI for forested wetlands are identified as the most stressed by anthropogenic activities and the higher average IEI, the less stressed the forested wetlands are. The IEIs for forested wetlands in the Chicopee Watershed averaged 0.62 which is higher than all but one other watershed in Massachusetts.
This is likely due to the presence of the Quabbin reservoir and its associated undeveloped and protected lands, set aside to protect the water supply for the City of Boston, and other communities, comprising a significant portion of the watershed. In addition to calculating the average forested wetland IEI (i.e. all CAPS metrics combined); the value for each individual stressor in the CAPS model was averaged as well. By doing so, the stressors that are likely to have the most significant impact to forested wetlands in the watershed were identified. The average IEI was also calculated for each sub-basin (sub-watershed) within the Chicopee watershed to identify which are predicted to be the most impacted by anthropogenic stressors.

Figure 2.1-1 Average IEI for Forested Wetlands within each Major Watershed



The Chicopee Watershed forested wetlands (light blue, central MA) have an average IEI of 0.62, this is higher than most other watersheds in the state.

Figure 2.1-2 Chicopee Subwatershed IEI Average



The more developed sub-basins (shown in red), such as the City of Chicopee, have lower overall forested wetland IEI or condition; the less developed areas (shown in blue), such as the Quabbin Reservoir area have a higher overall forested wetland IEI or condition.

Figure 2.1-2 shows the range of IEI values (i.e. all CAPS stressor and resiliency metrics combined) averaged for all forested wetlands in each sub-watershed. Not surprisingly, the most stressed areas are densely developed such as the City of Chicopee and other municipal centers, and the least stressed areas are undeveloped such as the Quabbin reservoir reservation. Stressors found to have the greatest impact in the Chicopee Watershed include:

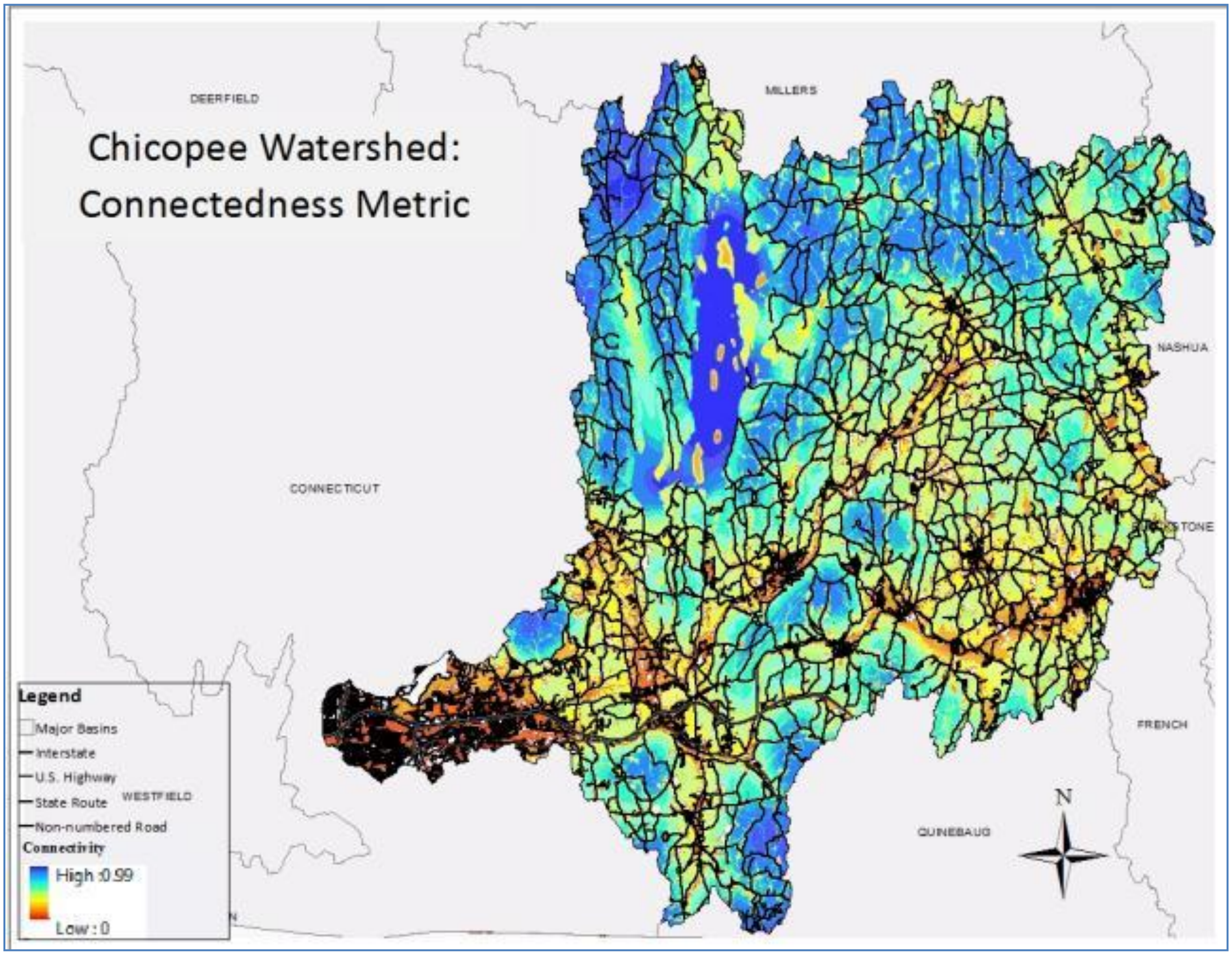
- loss of terrestrial connectedness;
- loss of ecological similarity
- invasive plants; and
- loss of aquatic connectedness

These stressors and how they affect the watershed are discussed in the following sections.

2.2 CONNECTEDNESS

Loss of connectedness has been identified as the greatest source of ecological stress of the forested wetlands in the Chicopee Watershed. In CAPS, connectedness is a resiliency metric, which means it measures the combined effect of anthropogenic stressors and landscape context in order to address the capacity of the ecosystem to recover from anthropogenic perturbations. As a measurement of resiliency, loss of connectedness considers both the natural landscape context of the ecosystem (e.g. large wetland complexes versus small isolated wetlands) as well as its anthropogenic impairment (e.g. road intensity surrounding an ecosystem). The metric then measures the disruption of habitat connections caused by impairments in the immediate vicinity as well as the surrounding landscape (See Figure 2.2-1). In other words, the connectedness 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 individuals or materials that contribute to the long-term ecological integrity of the wetland.

Figure 2.2-1 Connectedness Metric



Note that areas in yellow and brown represent low connectedness, and are consistent with dense road networks. The denser the road network, the lower the connectedness metric since roads serve as significant barriers to the movement of many species of wildlife

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

1) Restore Connections between Fragmented Forested Wetlands

Roadway Crossings

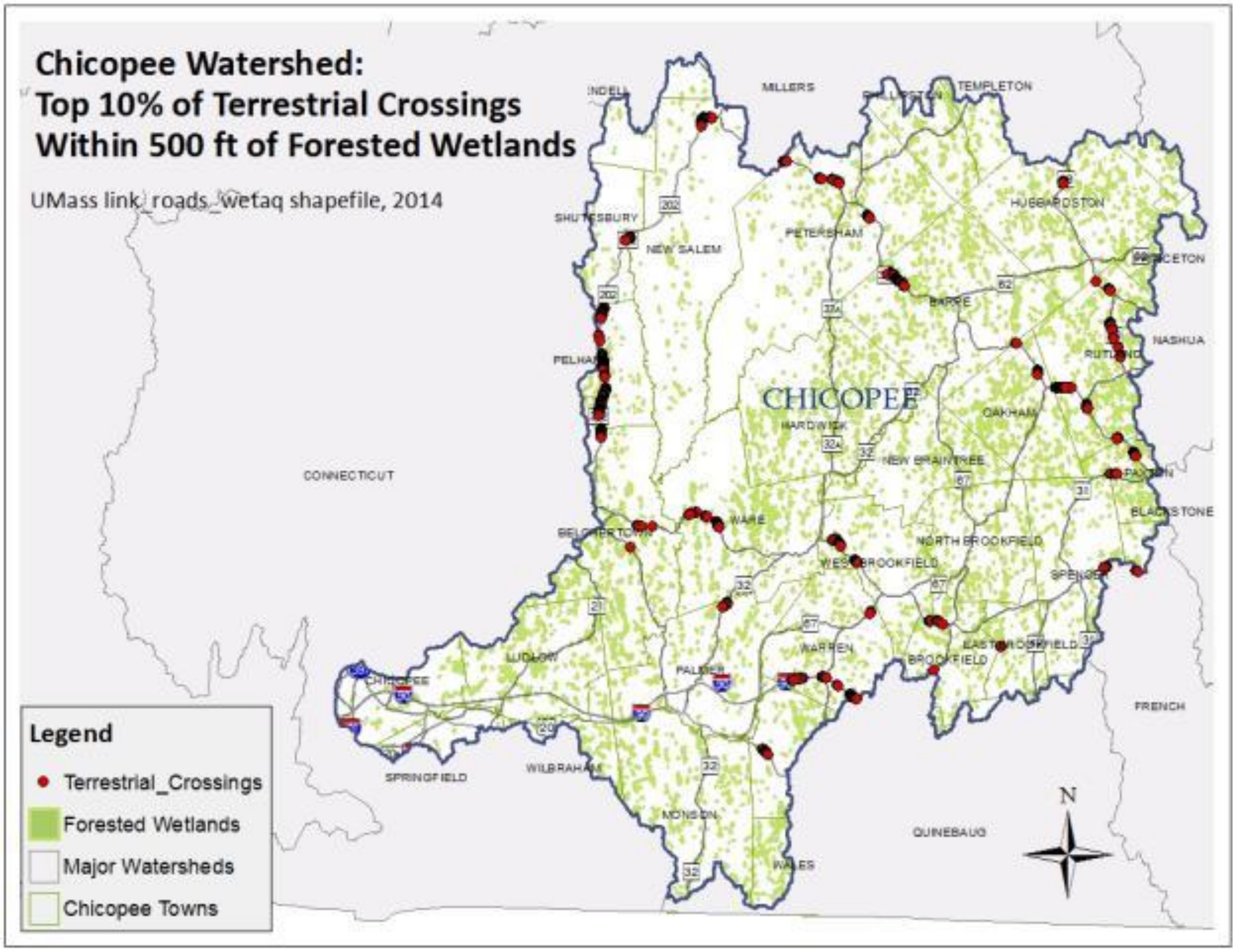
As previously noted in this section, one of the primary causes of loss of connectedness is roads. Roads present two opportunities to restore connectedness, terrestrial connectedness discussed in this section and aquatic connectedness discussed in Section 2.5 below. As long linear structures, roadways fragment habitat and impair the movement of wildlife. The traffic itself is a direct cause of wildlife mortality as animals attempt to cross the road to reach other 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. Wildlife crossing structures are essentially tunnels under the road that provide an opportunity for wildlife to travel under 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. Additionally, improved connections allow wildlife species that need to move between different ecosystems (such as wood frogs, that breed in wetlands but migrate to uplands) or species that move through large expanses of wetlands systems, such as beaver, to access the ecosystems they need in order to carry out their life cycle.

The University of Massachusetts-Amherst, in partnership with The Nature Conservancy, has 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 resources (Also, see Section 2.5 on Aquatic Connectedness). 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 was conducted and provides a baseline for comparison of wildlife crossing location options. The CAPS analysis then assessed the restoration potential of the location options and was applied statewide to road and highway segments that had traffic rates of 1000 cars per day or greater (the assumption being that roads with lower traffic rates pose less of a significant threat to wildlife crossings). Each point in the landscape along the road where a wildlife crossing could be established received a value (i.e. which is the change in connectedness weighted by IEI, known as the IEIdelta) that represents what the improvement in the ecological integrity would be if a wildlife crossing where to be established at that location. Once all points along major roads were analyzed, a relatively small number of well targeted wildlife crossings that would result in substantial improvements in connectivity were identified for this study. Figure 2.2-2 depicts the top 10% of all crossing locations that were identified within the Chicopee Watershed by the Critical Linkages Project, that are also within 500-feet of forested wetlands. Installation or improvement of crossings at these locations would improve the biological health of forested wetlands. Individual municipal maps have been developed and are located in Appendix D, and on the MassDEP website.[10] 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.[11]

[10] 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 Chicopee Watershed 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.

[11] http://www.umasscaps.org/applications/critical-linkages.html

Figure 2.2-2 Terrestrial Crossings



In this figure, the top 10 % of potential terrestrial crossings within 500 feet of a forested wetland were identified. Installation of terrestrial wildlife crossing structures at these locations would be likely to improve biological condition of forested wetlands

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 fragmented by anthropogenic disturbance. Information on funding sources may be available through the Massachusetts Ecological Restoration Program or other non-profit organizations. In Figure 2.2-3 below, an example of this concept is provided as a concrete service facility with appurtenant activities occurring in an adjacent upland area that, based on historical maps, was once a forested wetland. Based on an evaluation of historic photos, the disturbance at this site likely occurred prior to the promulgation of the Wetlands Protection Act. The result is a land use that creates a barrier to wildlife movement. Although this site is currently in active use, if activities at this facility or other similar facilities were discontinued or abandoned, or the land where to otherwise become available, the portion that was previously wetland could be targeted for acquisition. Wetlands could be restored, or the land could be allowed to revegetate naturally and, given its sandy nature near a riparian corridor, provide upland breeding habitat for turtles. By doing so, a large undisturbed tract would provide improved connectedness and similarity for the forested wetlands and thus, improve forested wetland condition.

Fig 2.2-3 Restoration Opportunity

This photo shows an example of a historically altered area where restoration would reconnect two large areas of forested wetland; sites similar to this should be identified and acquired if they become available.

2) Avoid New Fragmentation

Another component of reducing the ecological impacts of loss of connectedness is avoiding new impacts when possible; minimize them when they are unavoidable and then mitigating for the impact. The Massachusetts Wetlands Protection Act regulations prohibit the destruction or impairment of vegetated wetlands (310 CMR 10.55(4)(a)), except that the regulations allow the loss of up to 5000 square feet of bordering vegetated wetland (BVW) on a discretionary basis, provided that replication of the wetland occurs (310 CMR 10.55(4)(b)) . In approving this loss, the issuing authority 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, 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 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 all the filings MassDEP reviewed in calendar year 2015, a total of 47 new roadways/driveways across wetlands or waters were approved.[12]

To ensure that forested wetland condition in the Chicopee Watershed does not continue to be impacted, issuing authorities and project proponents should seek to avoid new fragmentation of forested wetland habitat. Where new crossings cannot be avoided, impacts should be minimized by: 1) not lengthening culverts to the point where wildlife will not cross through them; 2) limiting crossings under 10.53(3)(e) to one per Notice of Intent application filed; 3) locating crossings at the most narrow 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 " Complete Streets "[13] Where streams are being crossed, culverts should be designed appropriately (See Section 2.5 on Aquatic Connectedness).

In the example below (Figure 2.3-2), two new homes were constructed. In order to access the upland portions of the land a forested wetland had to be crossed. However, note that each home has its own driveway even though those driveways are directly abutting. In this situation a common drive could have minimized the wetland impact, essentially reducing the physical footprint by half. Providing a terrestrial wildlife crossing as discussed in the *Connectedness* section above, and where a stream is crossed, ensuring that the culvert is designed to facilitate aquatic connectedness (See Section 2.5) would improve the ability of wildlife species to access similar wetland systems and help mitigate the impact of this crossing on connectedness

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[12] While this represents only 0.14% of the total 5,107 filings, it also means that 47 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, 7 new crossings are limited projects where the issuing authority may waive standards, and 40 are not limited projects and should meet standards.

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

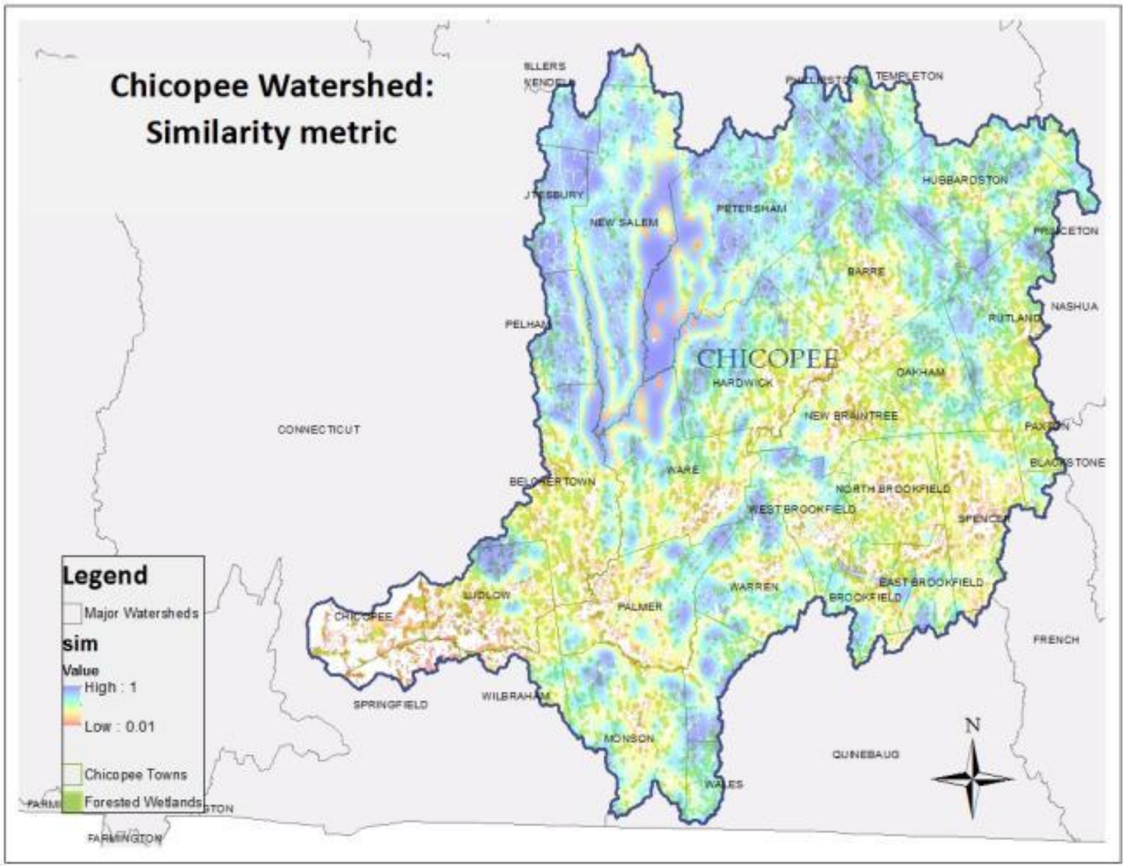
Figure 2.2-4 Driveway Crossing

Rather than two separate driveways, a common driveway could have been used to minimize wetlands alteration. Also, providing crossing structures for fish and wildlife passage should be considered.

2.3 SIMILARITY

The second greatest cause of ecological stress to forested wetlands in the Chicopee watershed is loss of similarity (See Figure 2.3-1). Similarity is also a resiliency metric, addressing the capacity of the ecosystem to recover from anthropogenic perturbations. Similarity is about how similar the surrounding landscape is to the focal cell, weighted by distance. In simplified terms, 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. To avoid confusion with the connectedness metric it is important to recognize that the accessibility issues addressed by similarity primarily pertain to flying organisms: birds, bats, insects, seeds etc. The connectedness metric deals with terrestrial connectivity for organisms that move overland. It doesn't account for things that can easily fly over obstacles (development, roads).

Figure 2.3-1 Similarity Metric



Loss of similarity (yellow-green areas) has stressed forested wetlands. Areas of high similarity are less developed (shown in blue).

To address the ecological stress caused by loss of similarity that is impacting forested wetlands in the Chicopee Watershed, 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 Massachusetts Wetlands Regulations establish a 100 foot buffer zone around vegetated wetland resources. As an area subject to regulation, any activity proposed within the buffer zone is subject to review.

Undeveloped wetland buffers, which are the upland areas immediately adjacent to a wetland, help to 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;

- vegetation acts as an obstruction to water flow, decreasing velocity and allowing for greater infiltration into the soil where soluble nutrients can be more efficiently removed or transformed by soil bacteria and the vegetation itself; this provides for better water quality, and reduces impacts of stormwater from paved surfaces;

- 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 (or vice versa), 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, issuing authorities should 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: 1) that the project incorporates best management practices for stormwater control; 2) that the project is set back as far as possible from the wetland; and 3) that a vegetated strip (a portion of the naturally occurring undisturbed vegetation in the buffer zone) is left intact between the wetland and the development.

2.4 INVASIVE PLANTS

Invasive plants are non-native species that have spread into native or minimally managed plant systems. 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 Chicopee Watershed. The CAPS model assesses the pervasiveness of non-native invasive vascular plant species[14] at the landscape level by measuring the intensity of development (i.e. anthropogenic land use) associated with invasive plants around each point in

[14] 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*).

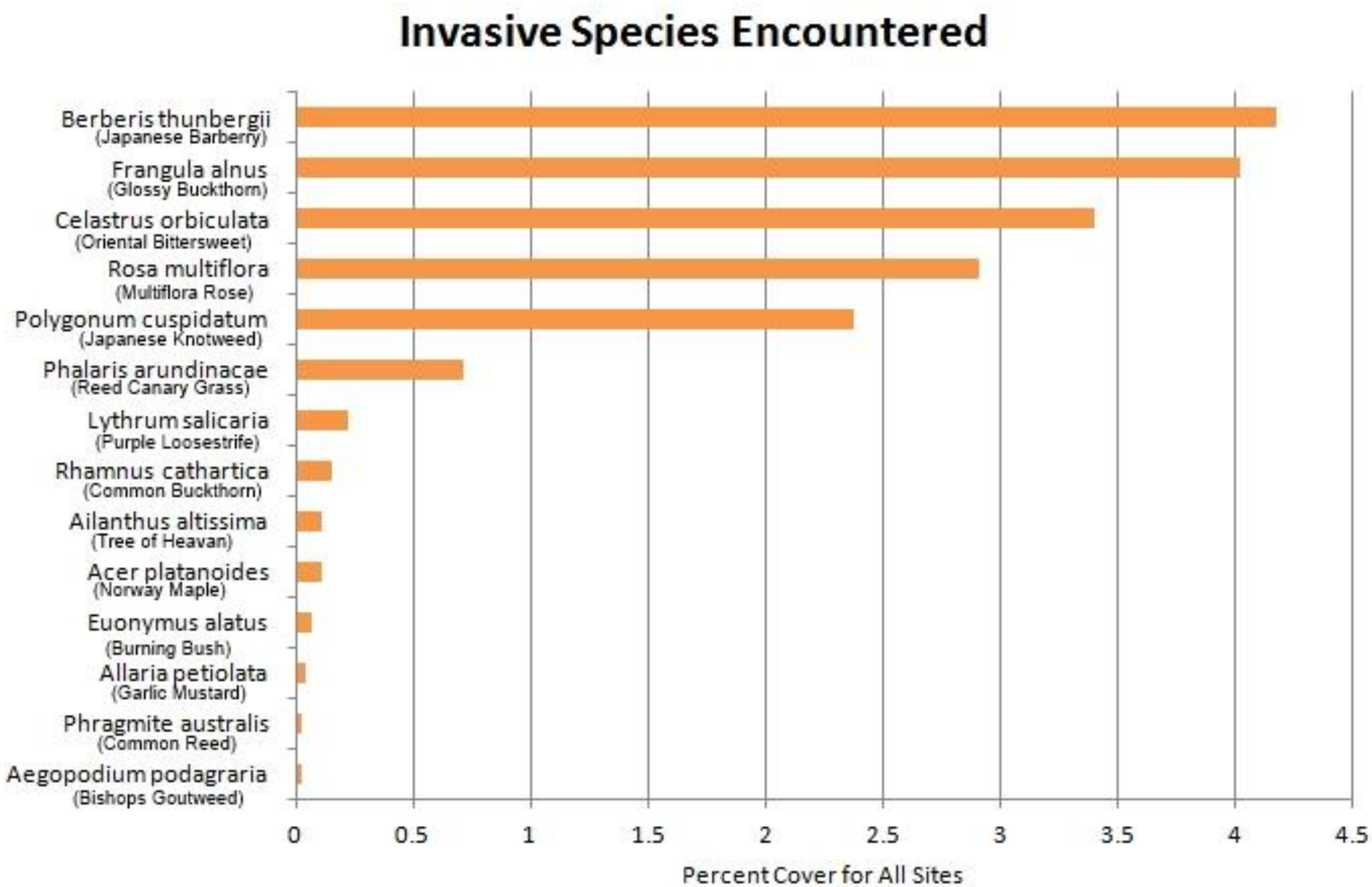
the landscape; it then assigns a value to that point based on its proximity to those types of development. Sources of potential invasive plants include residential development, roadways, and agriculture. The closer a point is to certain types of anthropogenic development, the more it is presumed to be 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).[15]

A major component of the assessment of the Chicopee Watershed was site sampling of 40 low IEI wetlands areas within the watershed and 5 high IEI sites in the watershed. The sampling primarily involved documentation of plant communities. That sampling is discussed in detail in Section 3.0 below. The plant community assessments identified invasive plant species present on 22 of the 45 sites. Each site collected plant data at 100 points, and so any invasive plant could be documented up to 4500 times. The most abundant invasive species encountered are shown in Figure 2.4-1 below, and include Japanese Barberry (*Berberis thunbergii),* followed by Glossy Buckthorn (*Frangula alnus) Oriental Bittersweet (Celastrus orbiculata), Japanese Knotweed (Polygonum cuspidatum), Reed Canary Grass (Phalaris arundinacea) Purple Loosestrife, (Lythrum salicaria) Tree of Heaven (Ailanthus altissima), and Burning Bush (Euonymus alatus).* Fortunately, invasive plants were not the most common plant species found during sampling (See Figure 2.4-2). Sites where invasive species were found are depicted in Figures 2.4-3 through 6 below. In addressing invasive species control it is important to understand that eradication of invasive species is often not feasible on a large (i.e. watershed) scale. However, 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 new invasive species for gaining a foothold, as well as to eradicate those that exist include:

- Work with landscapers and nurseries to discourage the use of invasive plants;
- Closely monitor wetlands projects, especially those involving wetlands creation, to track the occurrence of invasive plants and eradicate any occurrences before they are 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.

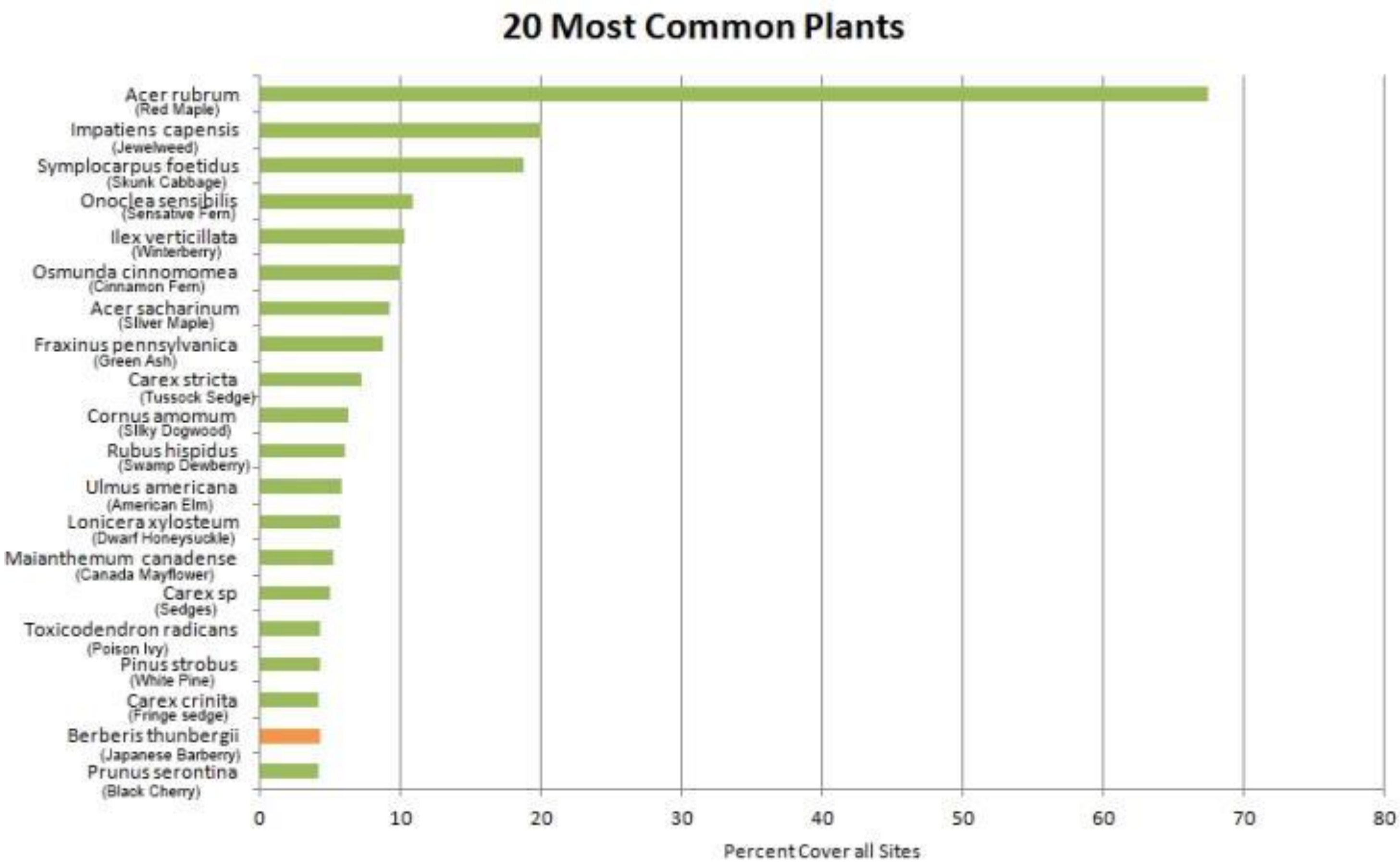
[15] Further information on invasive Plant management can be found at: http://www.mass.gov/eea/agencies/dfg/dfw/natural-heritage/land-protection-and-management/invasive-species/invasive-plants.html and (https://www.eddmaps.org/ipane/)

Figure 2.4-1 Invasive Plants Table



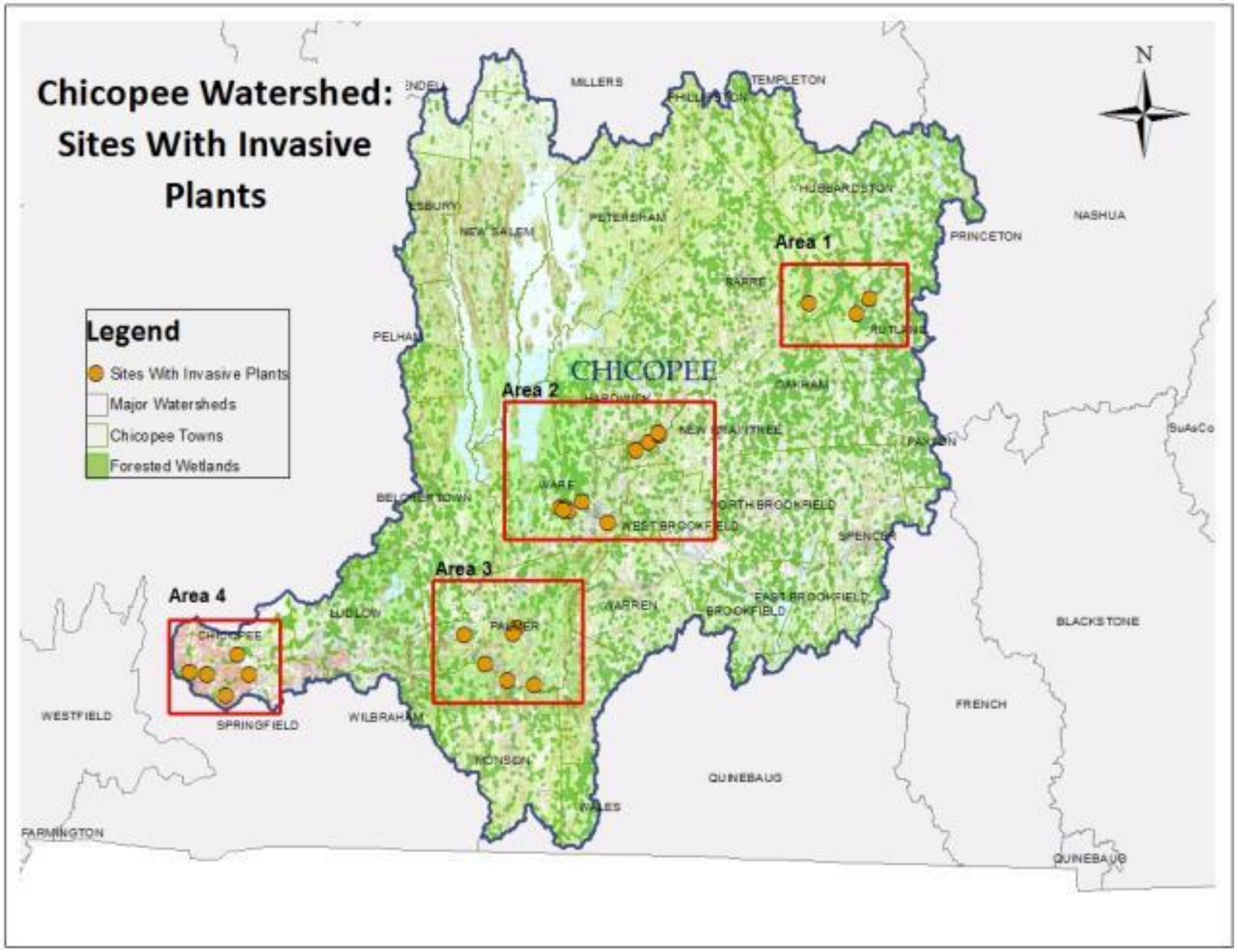
Invasive Species were tallied by the number of times they were encountered (X axis) throughout the sampling, divided by the total number of sample points (4500). The top 4 were by far the most prevalent.

Figure 2.4-2 Common Plants Table



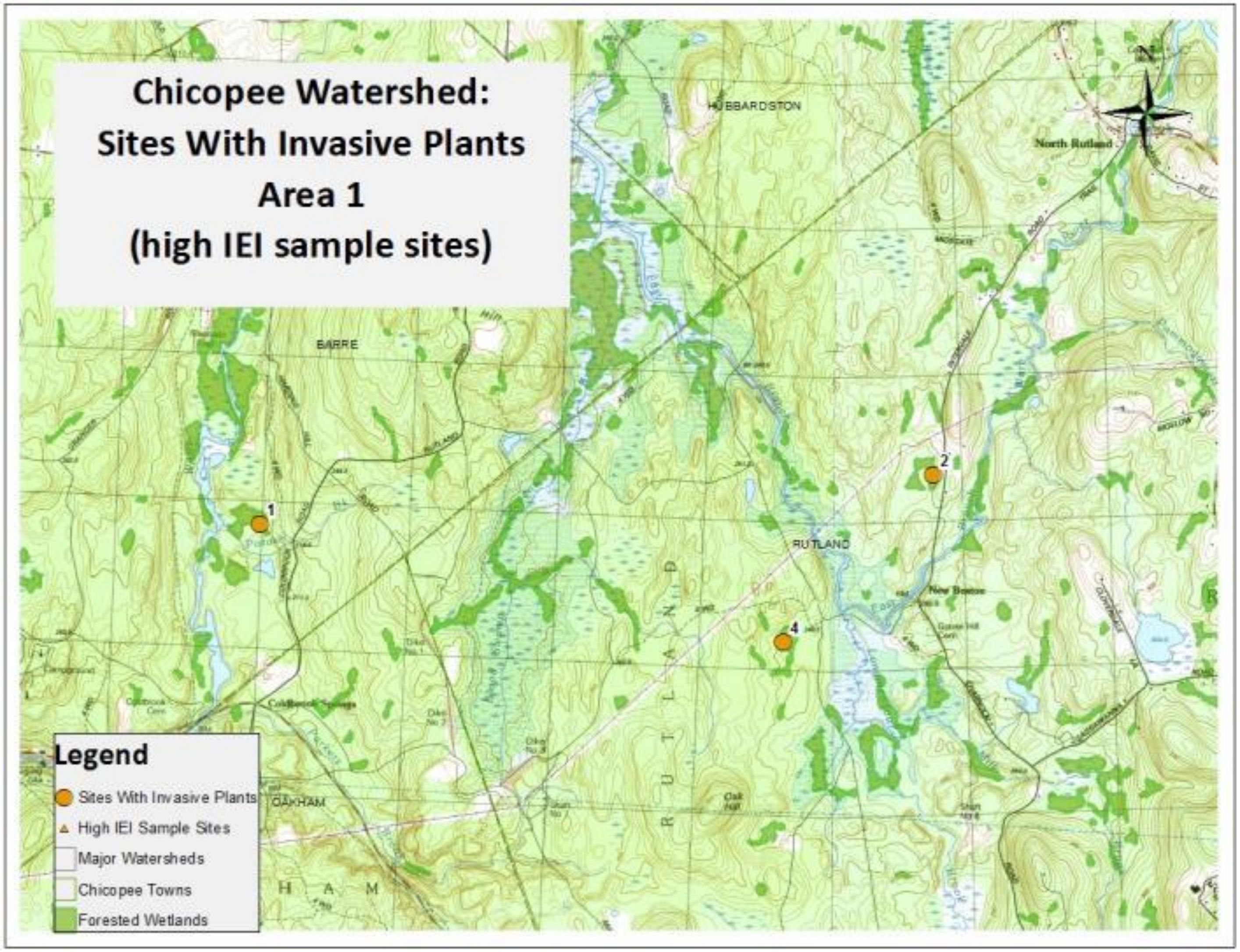
The most common plants documented during the sampling are shown in this graph. Japanese barberry was the most common invasive plant encountered but fortunately, it is much less common than other native species

Figure 2.4-3 Invasive Plant Sites



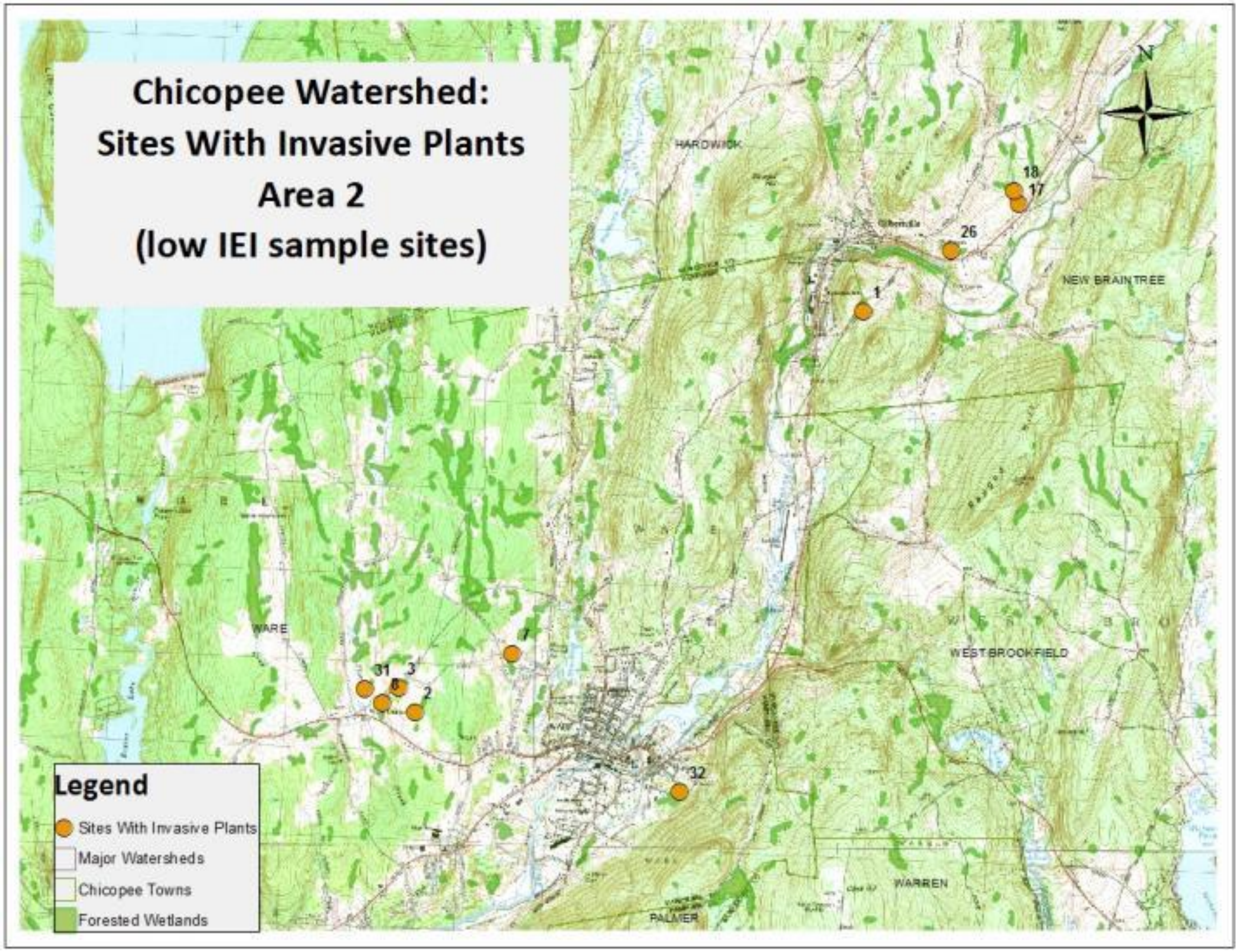
Common invasive plant species found during the Chicopee Watershed sampling and the locations where they were found. Non native invasive plants are more likely to be found in the more developed areas of the watershed.

Figure 2.4-4 Invasive Plants Area 1



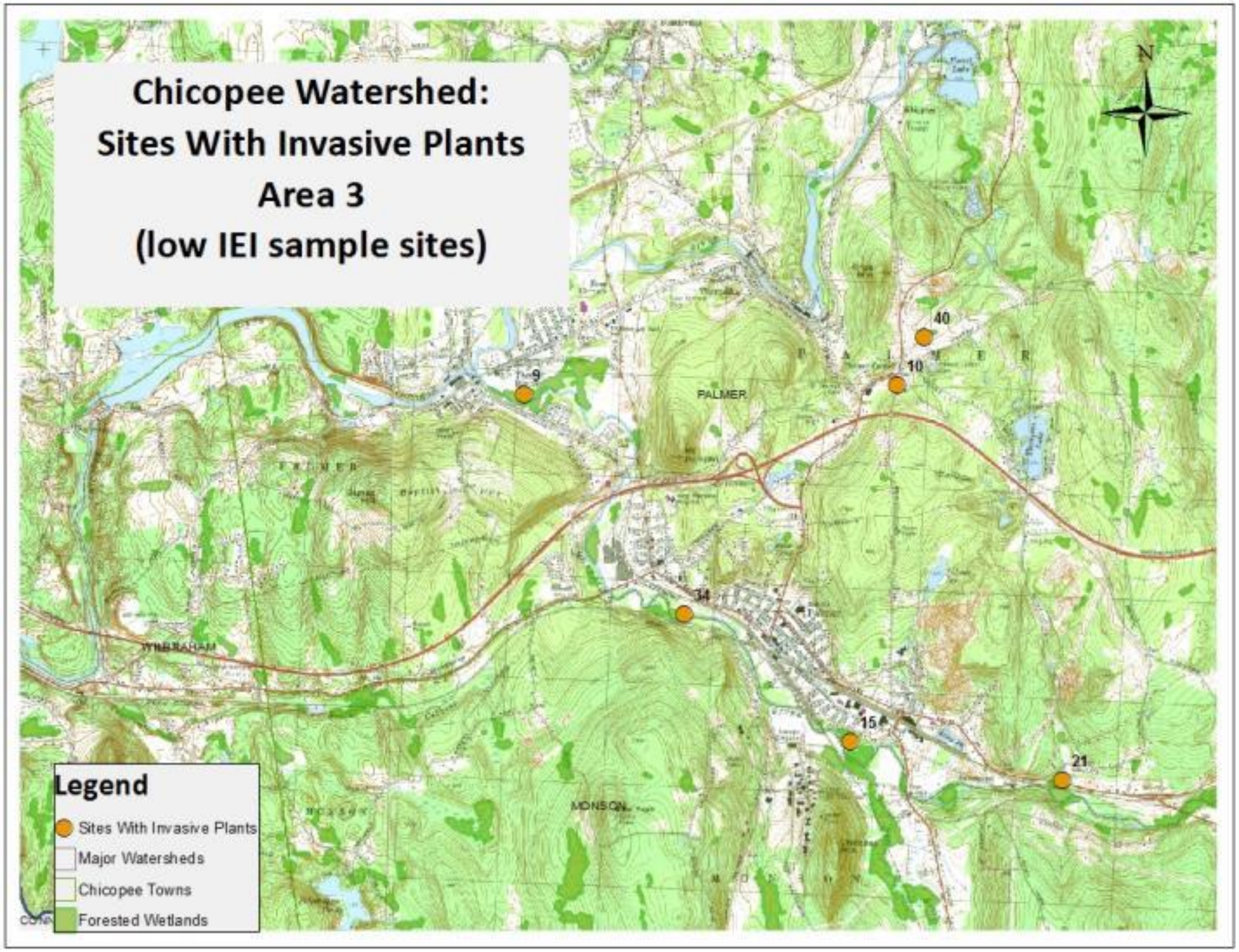
General locations where invasive species were found- See Appendix B for a list of specific species found at each site

Figure 2.4-5 Invasive Plants Area 2



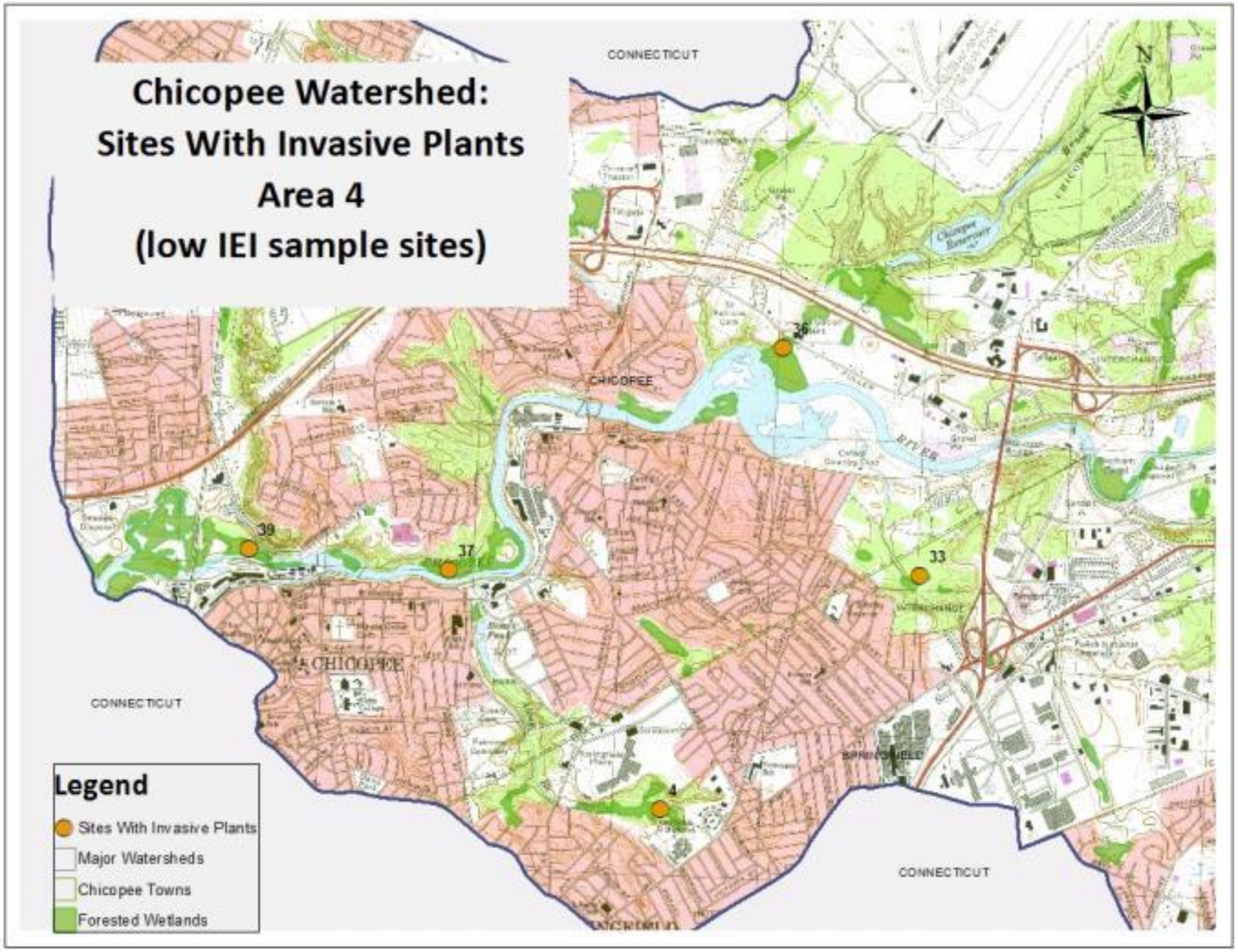
General locations where invasive species were found -See Appendix B for a list of specific species found at each site

Figure 2.4-6 Invasive Plants Area 3



General locations where invasive species were found- See Appendix B for a list of specific species found at each site

Figure 2.4-7 Invasive Plants Area 4



General locations where invasive species were found- See Appendix B for a list of specific species found at each site

2.5 AQUATIC CONNECTEDNESS

The analysis of the Chicopee watershed also identified loss of aquatic connectedness as being a major source of ecological stress to forested wetlands. Aquatic connectedness is also a resiliency metric, similar in nature to the connectedness metric, but as its name implies it addresses connectivity in relation to aquatic organisms. Because terrestrial organisms can go around an obstacle, the connectedness metric allows for wildlife flow overland and diagonal from a given point in the wetland. On the other hand, the aquatic connectedness metric only allows for linear movement along a stream, river, or water body since aquatic organisms can only move in that environment. Thus the aquatic connectedness metric directly addresses the effects of culverts, bridges and dams on aquatic fish and wildlife passability, rather than the impacts of the road itself. Improving aquatic connectedness has been a priority of MassDEP for several years. The Massachusetts Stream Crossing standards were incorporated into the Wetland Protection Act regulations in 2014 (310 CMR 10.00).[16] They require that new and replacement crossings provide for fish and aquatic organism passage.[17] Upgrading those culverts to meet the current standards is the best way to improve aquatic connectedness (See Figure 2.5-1). Specific targeting of stream crossings can also occur as part of ecological restoration projects or in association with infrastructure projects requiring an Order of Conditions from the Wetlands Protection Act. As with terrestrial connectedness, data from the Critical Linkages Project was used to identify which crossings are causing the greatest restriction to aquatic passage and should be upgraded.[18] The aquatic connectedness score of the existing area which is impacted by the substandard crossing due to a dam(s) or culvert(s) is compared to the score that would result if a new or improved wildlife crossing (i.e. a bridge) were established. The change in aquatic connectedness weighted by IEI (the IEIdelta) then reflects the degree of the improvement. By focusing on potential wildlife crossings that are near forested wetlands (in Figure 2.5-2 below, within 500 feet) and have a high IEIdelta (within the top 10%), a relatively small proportion of culvert replacements or dam removals would result in substantial improvements in aquatic connectivity for forested wetlands.[19]

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[16] The standards can be accessed at the following link. See the version dated March 1, 2006, revised March 1, 2011 and corrected March 8, 2012. Note that the correction is depicted in the footer and not on the front page. http://www.streamcontinuity.org/pdf_files/MA%20Crossing%20Stds%203-1-11%20corrected%203-8-12.pdf

[17] For more information go to: http://www.mass.gov/eea/docs/dfg/der/pdf/stream-crossings-handbook.pdf

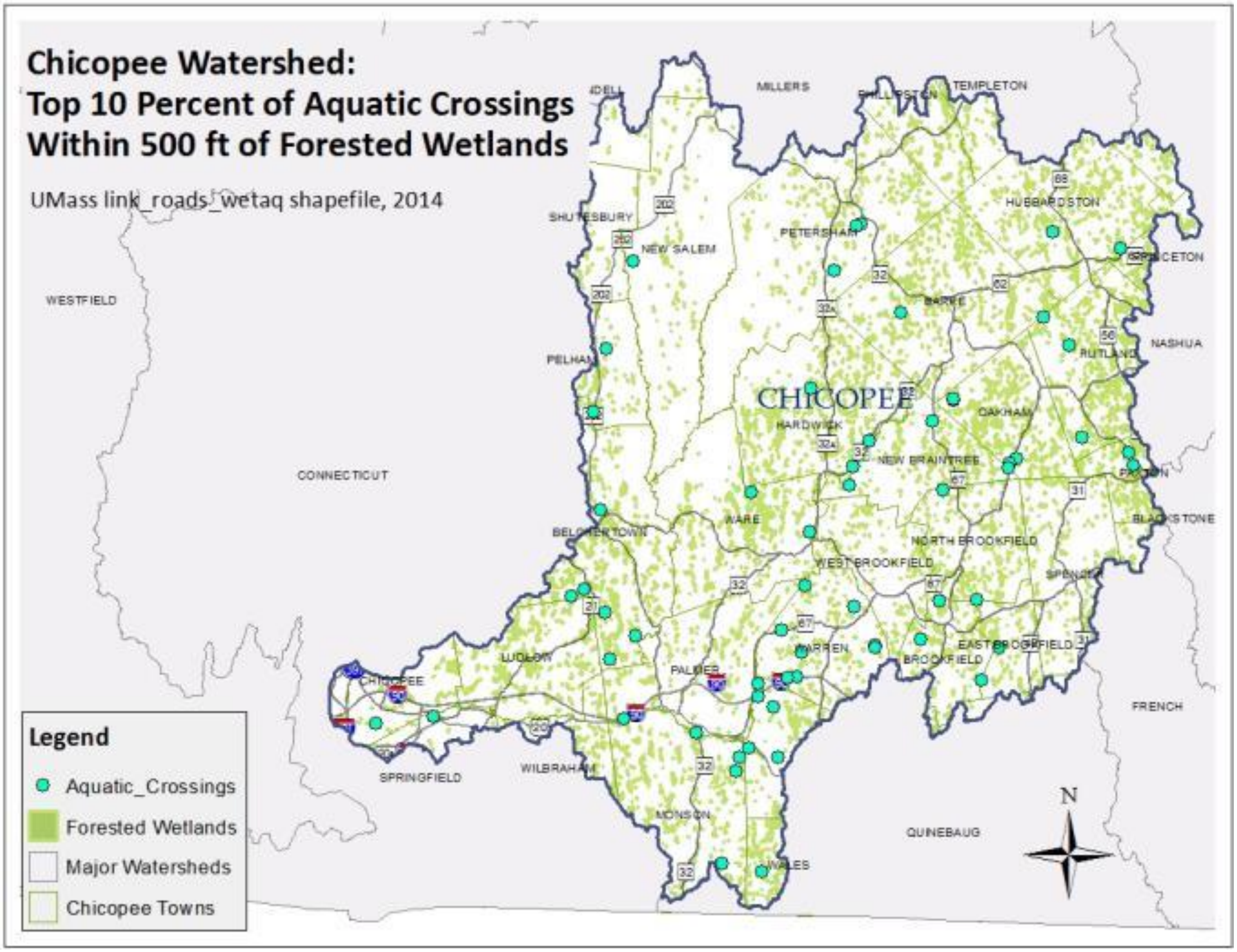
[18] The full, state wide, CAPS analysis of potential wildlife crossings as well as a detailed description of how it was developed, is available at: http://www.umasscaps.org/applications/critical-linkages.html

[19] Maps depicting this data are available for each city and town in Appendix D and at http://www.mass.gov/eea/agencies/massdep/water/watersheds/wetlands-protection.html#2;
Data in shapefile format is available for download into a GIS at:
http://www.mass.gov/eea/agencies/massdep/water/watersheds/wetlands-protection.html#2

Figure 2.5-1 Stream Crossing Standards

Massachusetts Stream Crossing Standards include detailed requirements that maintain natural stream flow and provide for fish and wildlife passage

Figure 2.5-2 *Aquatic Crossing Points*



Utilizing critical Linkages Data can allow for targeting of specific stream crossings in order to maximize the benefits from the cost of the upgrade.

3.0 Chicopee Watershed: Site Level Analysis

3.1 Site Analysis Procedure

In 2014, MassDEP sampled a total of 45 deciduous dominated (<30% conifer cover) forested wetland sites in the Chicopee River watershed. A total of 40 of the 45 had low IEI values (ranging from 0.1 to 0.25) and drain to waters which have been determined to be impaired and for which a TMDL has not yet been developed. Those impaired waters were identified by the MassDEP Watershed Planning Program 2012 Integrated List of Waters (305(b)/303(d)).[20] A total of 5 of the 45 sites are deciduous forested wetlands with high IEI values (0.75-0.9) that also drain to impaired waters. The Chicopee watershed was selected in accordance with the MassDEP 5-year basin cycle for water quality sampling and reporting pursuant to the Clean Water Act. The goal of this sampling was to assess forested wetland condition and see if sites meet expectations for ecological condition as predicted by the CAPS model. A second and equally important goal is to test the reliability of the IBI's.

The assessment methodology consisted of vascular plant sampling. 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 percent cover class of 1%.

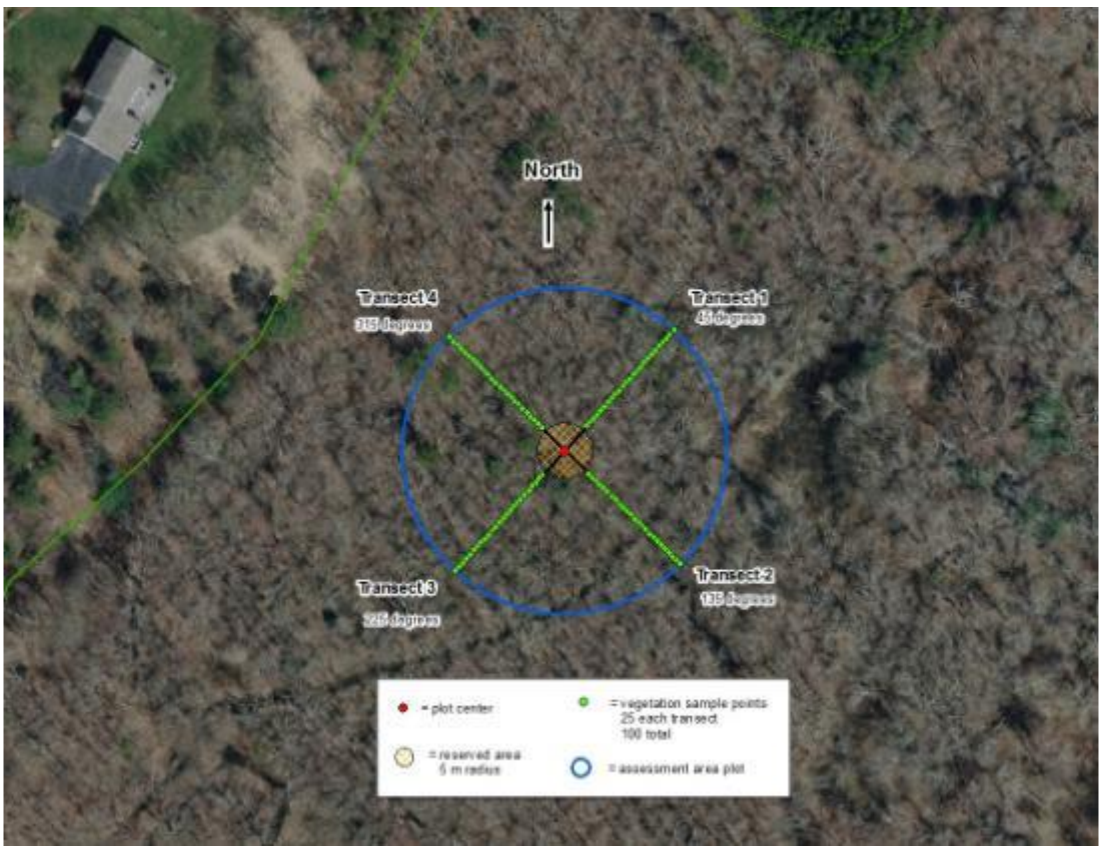
While it was the intent of this study that the field crew implements the 30-meter radius plot sampling described above, "finger-like" or other odd shaped wetlands were encountered. If the standard plot described above did not fit within the wetland to be sampled, the plot could be

[20] http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/wbs2012.html

reconfigured in accordance with the approved Quality Assurance Project Plan (QAPP).[21] 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 be 4 transects established and vegetation tallies always occurred at one meter intervals along those transects. A five meter reserved area at plot center always remained reserved (i.e. no plant sampling is to occur within this area).

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.[22]

Figure 3.1-1 *Sample Plot Set-up*



Typical Plot set up in a forested wetland. Plant species are tallied in the four ordinal directions. Plant species are not sampled in the 5 meter reserved area at point center since vegetation in this area typically get trampled in establishing the point.

[21] http://www.mass.gov/eea/agencies/massdep/water/watersheds/quality-assurance-project-plans-qapps.html

[22] http://plants.usda.gov/java/

3.2 Indices of Biological Integrity (IBI's)

The onsite component of this study was to apply an empirically-based assessment method using Indices of Biological Integrity (IBI's) for forested wetlands within the Chicopee Watershed. The IBI reflects the field determined assessment of biological condition, as compared to the CAPS modeled prediction of biological condition - the IEI. The method to develop IBI's involved comprehensive sampling of biota, including vascular plants, diatoms, bryophytes, lichens, and macroinvertebrates on 250 forested wetland sites across a range of stressor gradients in three different watersheds across the state.[23] The IBI's were then developed based on 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 various taxa and groups of taxa (e.g. diatoms, 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[24] 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. IBI analysis was conducted for 14 of the CAPS stressor metrics and for IEI (i.e. all metrics combined) but only the IEI and the following three metrics showed a strong enough statistical correlation to be reliable:

- Habitat Loss-the degree to which wetland habitat has been lost to development or other anthropogenic uses
- Loss of Connectedness-the degree to which wetland systems are fragmented
- Edge Predators-the degree to which mesopredators[25] are unchecked and impacting the wetland.

[23] 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

[24] 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 0.0 to 1. 0.0 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.

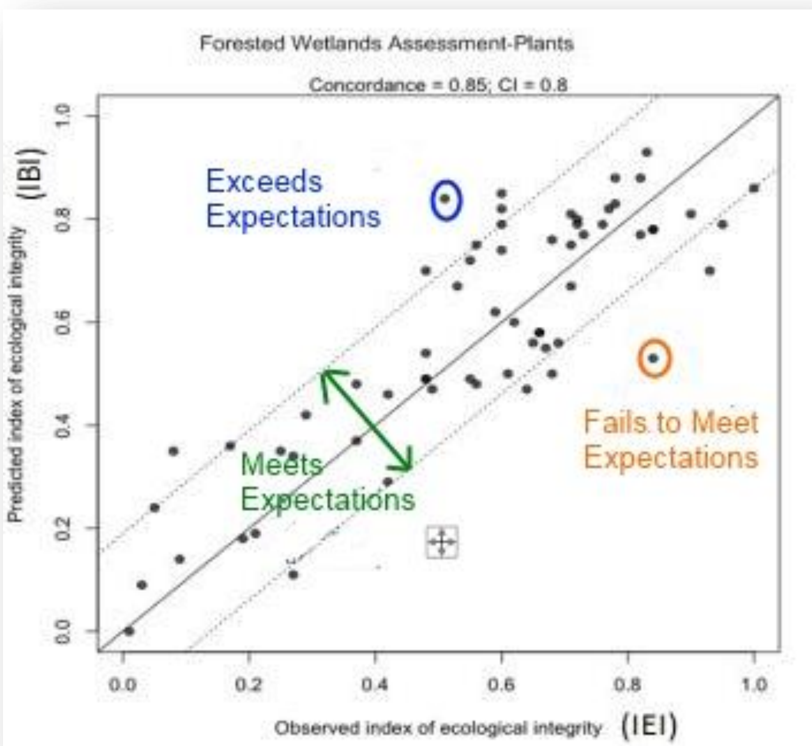
[25] Mesopredators are medium sized, middle trophic level predators that both predate and are predated upon. Examples include raccoons, skunks, and crows. In the absence of higher trophic level predators, such as coyotes, bobcats, and hawks, the mesopredator level is unchecked and can lead to a decline in small prey species such as songbirds, frogs, and small mammals.

Plant data collected for each site was evaluated for each of the four IBI's developed for forested wetlands.

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 3.3-1). 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 below the 10th and above the 90th percentile are presumed to be outside the expected range, and thus indicative that the site either 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.

Figure 3.3.-1 CALU Model



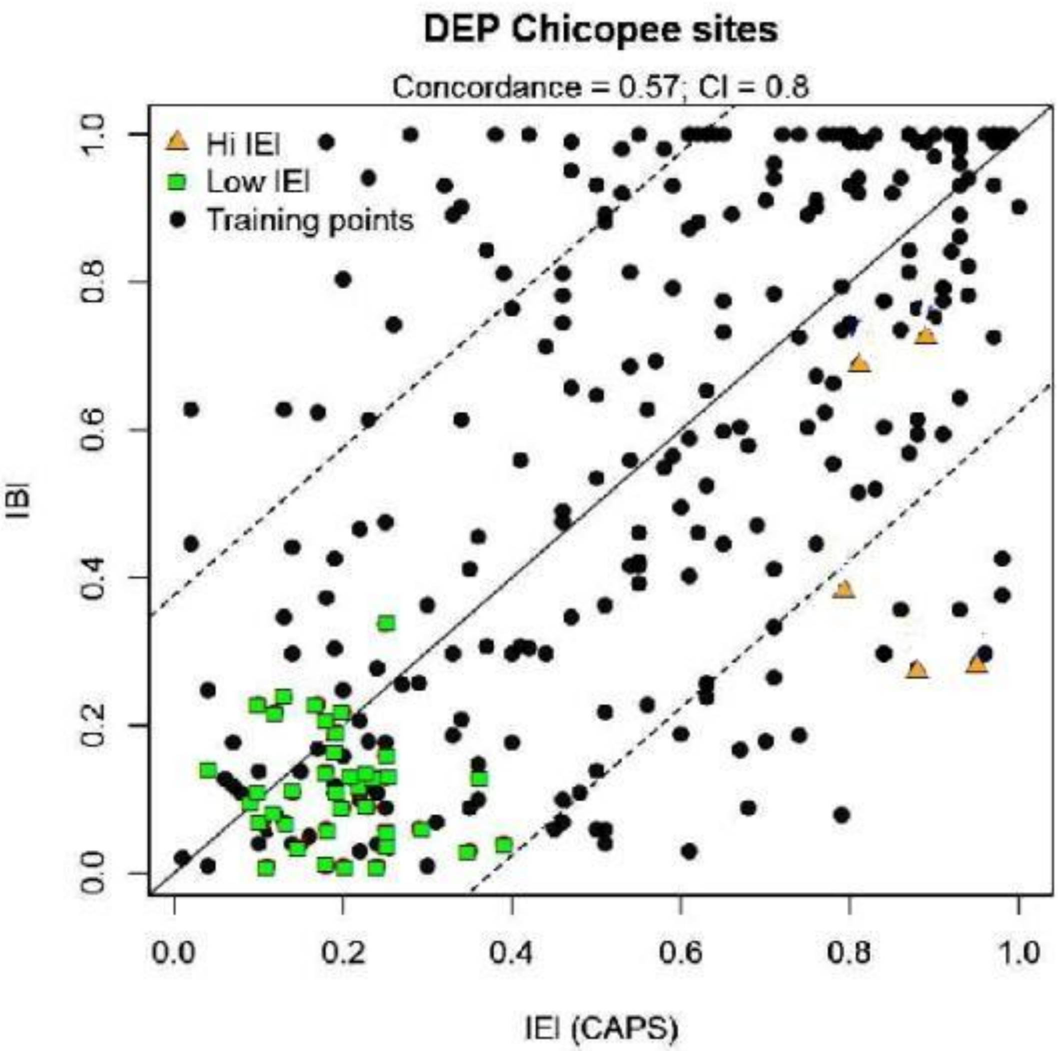
The CALU model example to the left is the basis for determining whether sites sampled in the Chicopee Watershed meet expectations, , or whether they exceed or fail expectations

3.4 Site Data Results

Low IEI Sites

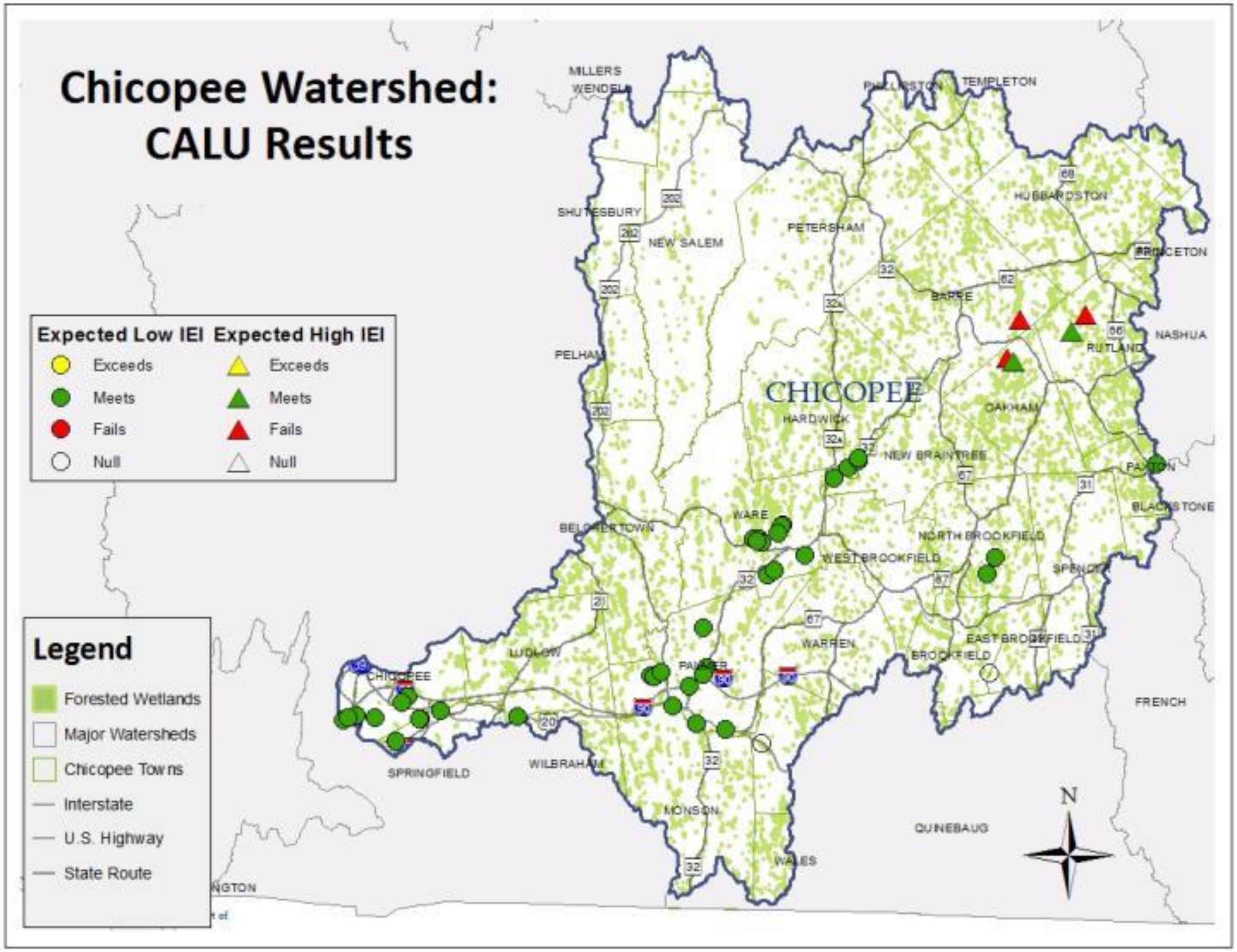
Of the 40 Low IEI sites sampled, sampling confirmed the IBI value to be low, meaning site condition is stressed. However, all sites met expectations as predicted by the CAPS model (See Figures 3.4-1 and 2). Plant data collected for each site is presented in Appendix B.

Figure 3.4.-1 CALU Graph for all Chicopee Sites



The CALU assessment shows that all 40 low IEI sites (shown as squares) are within the two dashed lines and thus, "Meet" expectations. Two of the High IEI sites (shown as triangles) "Meet" expectations, but three "Fail" to meet expectations because they fall below the range between the dotted lines

Figure 3.4.-2 CALU Assessment and Location of Chicopee Sites



This graphic shows the approximate locations of the sampled sites, and the assessment of forested wetland condition for each site according to the CALU model

The finding that all low IEI sites met expectations means sites that were predicted to have low biological condition by the CAPS model were confirmed to have low biological condition based on site sampling. This provides a confirmation of the IBI performance. As low IEI sites, they are all near, to some degree, anthropogenic stressors. Based on that landscape position it is anticipated that those stressors are impacting the sites. The site level assessment confirms that. But one limitation that has become apparent is that when a site is predicted to have a low IEI by the CAPS model, the site cannot "fail" because the acceptable range of variability intersects the lower end of both the IBI and the IEI scale at approximately 0.35. Additionally, to perform above expectations, the IBI would have to be at least above 0.4 (depending on the IEI), which was not established for any of these sites, likely due to their developed landscape position.

The reliability of a statewide IBI requires further study. The IBI's used for this analysis were initially developed based on data collected in three watersheds within the Worcester plateau/Eastern Connecticut Upland, and the Gulf of Maine coastal plain ecoregions.[26] These are very similar ecoregions, with similar forested wetland plant communities. However once sampling for IBI development occurred in the Southeast portion of the state (Southern New England coastal Plain and Hills ecoregion),[27] the coefficients of concordance between IBI and IEI became less reliable. That revealed some weakness in the previous approach and required a change in the statistical analysis used to develop the IBI's. [28] Forested wetlands in different ecoregions can have a significantly different plant community. For instance Coastal Sweet Pepperbush (*Clethra alnifolia*) is by far the most prevalent shrub in forested wetlands throughout the Southeastern part of Massachusetts. However it occurs sporadically, if at all, in the Berkshire Hills. The fact that Massachusetts has multiple ecoregions makes developing a robust set of IBI that can be applied state-wide difficult. Given the extensive data used to develop IBI's here, IBI's and FQAI approaches used elsewhere may also have difficulty when applied to a widespread geographic area.

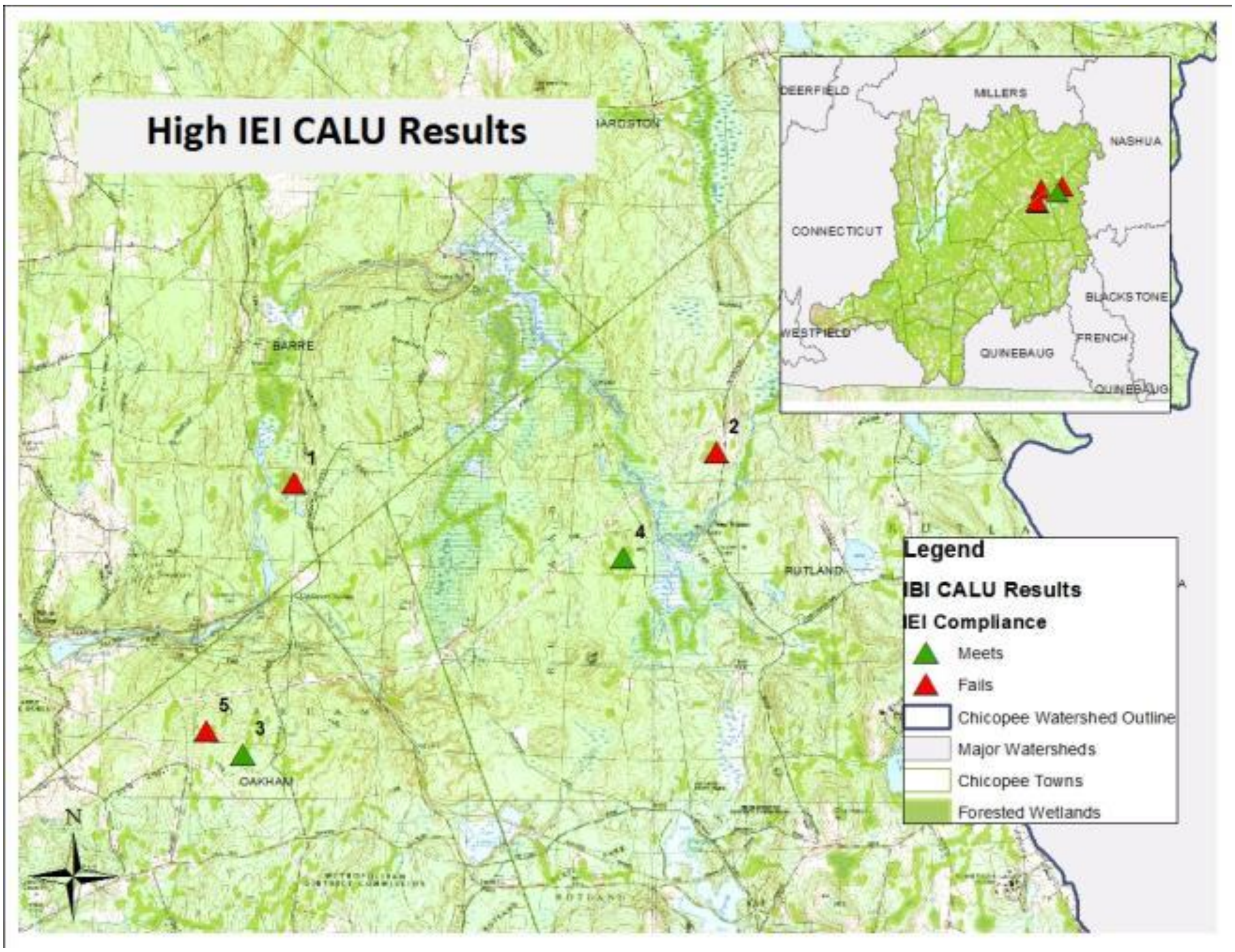
The IBI's for the individual stressor/resiliency metrics can help identify which anthropogenic stressors are affecting the site and causing them to have low IBI values. The IBI runs for the individual stressor/resiliency metrics, provided in Appendix C indicate that habitat loss is an important stressor at these sites, with 31 sites performing below expectations for that metric.

[26] Watersheds sampled were the Chicopee, Concord and Millers.
[27] The Taunton Watershed was sampled in the Southern New England Coastal Plain and Hills ecoregion.
[28] A discussion of the IBI approach can be found in a UMass report entitled "Creation of CAPS-IBI Software and Lake Nutrient Modeling: Components the Massachusetts Comprehensive Wetlands Assessment and Monitoring Program Final Report Wetlands Program Development Grant Cooperative Agreement# 96168701" dated July 28, 2015 at the following link: http://www.mass.gov/eea/agencies/massdep/water/watersheds/wetlands-protection.html#2

High IEI Sites

Since the focus of this Chicopee Watershed pilot wetland assessment was to sample sites with low IEI values, only 5 high IEI sites were sampled and thus, this is a very small sample size. However, of the five sites sampled, 3 failed to meet expectations (Figures 3.4-1 and 2.) As explained above, it is expected that most sites would fall within the "Meets" range. When a site falls out of that range it suggests that there is something different about the site that warrants further investigation. The sites that failed are referred to as sites 1, 2 and 5 (See Figure 3.4-3) and further investigation was conducted and is described below.

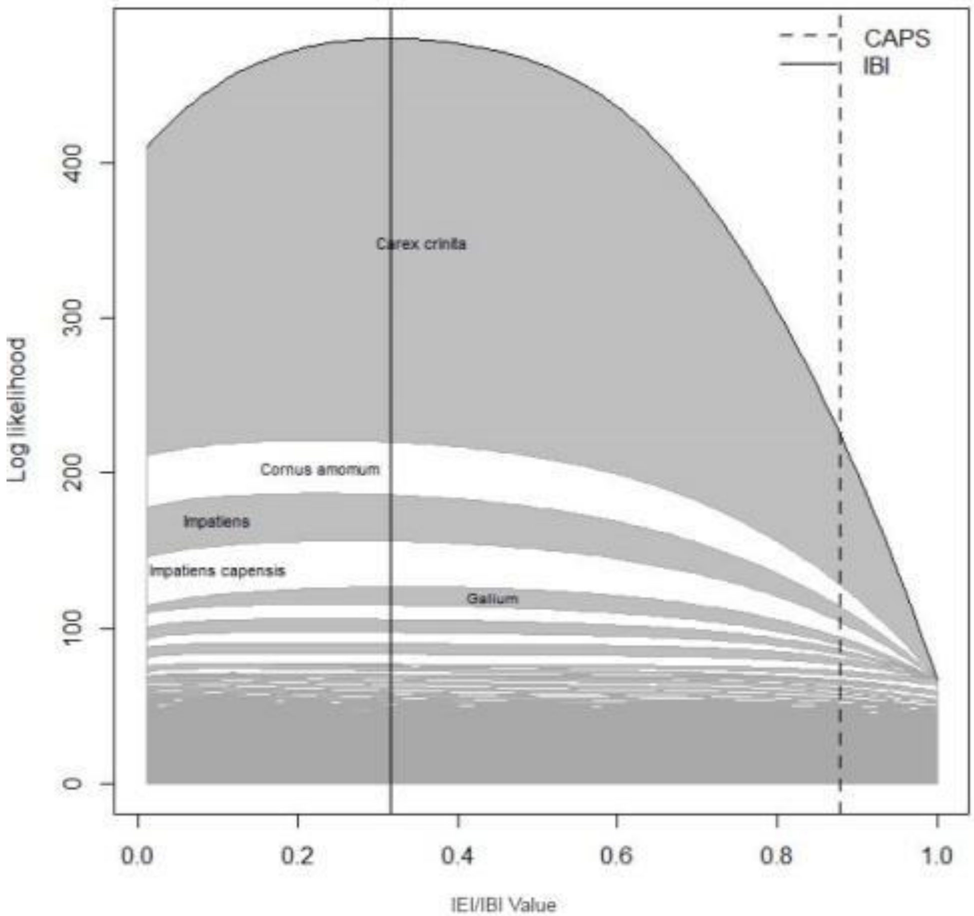
Figure 3.4-3 High IEI Site Locus



High IEI Site 1

Site number 1 is a forested wetland well within the Massachusetts Department of Conservation and Recreation (DCR) water supply area and far from any anthropogenic stressors. Based on its landscape position it is predicted to have an IEI value of 0.88, which makes it close to being one of the top 10% of forested wetland sites. However the IBI score, based on the site evaluation of the plant community, scored it at 0.27. The plant community encountered at this site is found in Appendix B however the following plot depicts the key plant species that are affecting the CALU assessment.

Figure 3.4-4 Site 1 IBI Plant Community Plot



The CAPS predicted 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. Sites with a label are sites that are the 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 dominant plant at this site is *Carex crinita* (fringed sedge) and is shown as the top grey layer. The graph presents the label at less than 0.4 and so this plant would influence the overall site IBI to be lower than the IEI. *Cornus amomum* (silky dogwood), while much less prevalent has a label around 0.2, meaning it is an indicator of a 0.2 IBI, and *Impatiens capensis* (jewelweed) has an even lower value. At the point where the layers peak is where the IBI value for the site is estimated. Thus, while the landscape level predicts a high IEI site at 0.88, the onsite plant community assessment indicates a low IBI site at 0.27.

During the site visit, no anthropogenic stressors were noted. However evidence of beaver activity, in form of gnawed trees and cut channels in the soft soil were noted. A review of the aerial imagery of the site again revealed no anthropogenic stressors, but the aerial imagery does reveal that the area has been extensively affected by beaver activity. Figures 3.4-5 through 8 show the impact of beaver activity at this site since 2001.

Figure 3.4-5 Site 1 Investigation 2001 (Blue Triangle Represents Site)

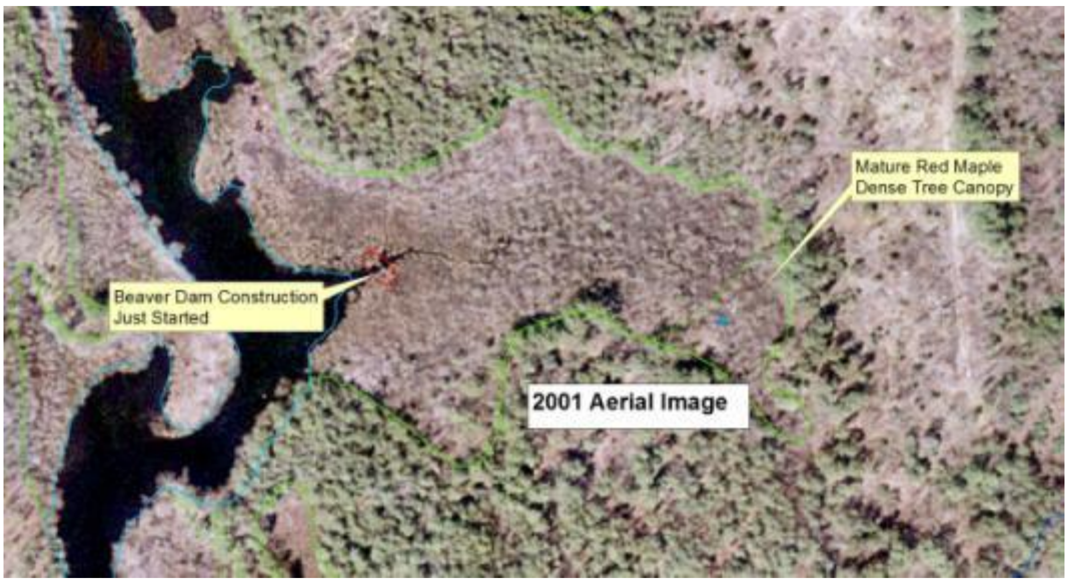


Figure 3.4-6 Site 1 Investigation 2005 (Blue Triangle Represents Site)

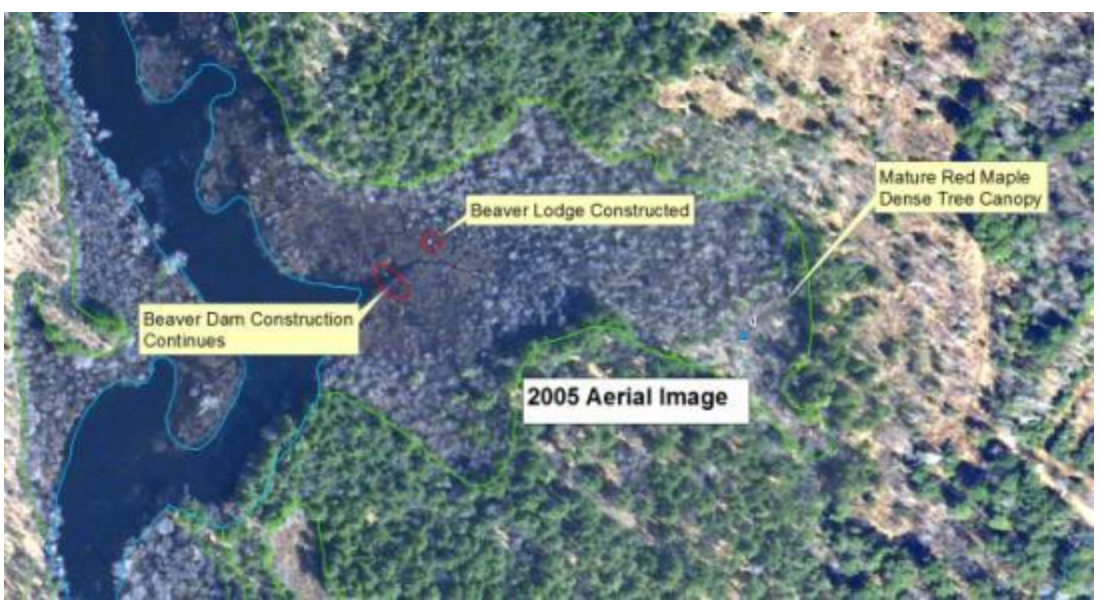


Figure 3.4-7 Site 1 Investigation 2008

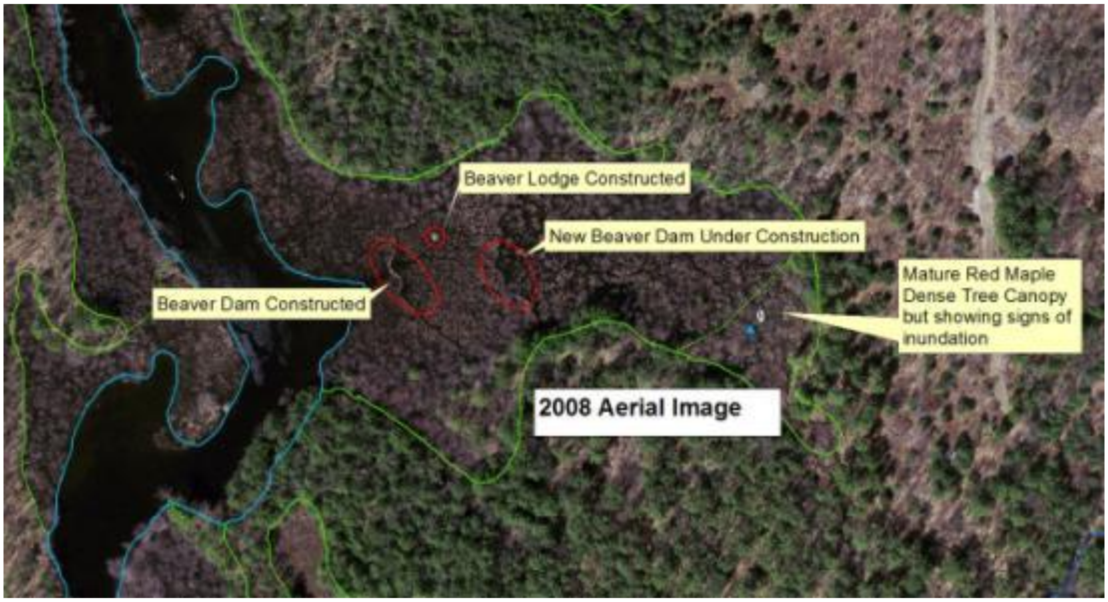
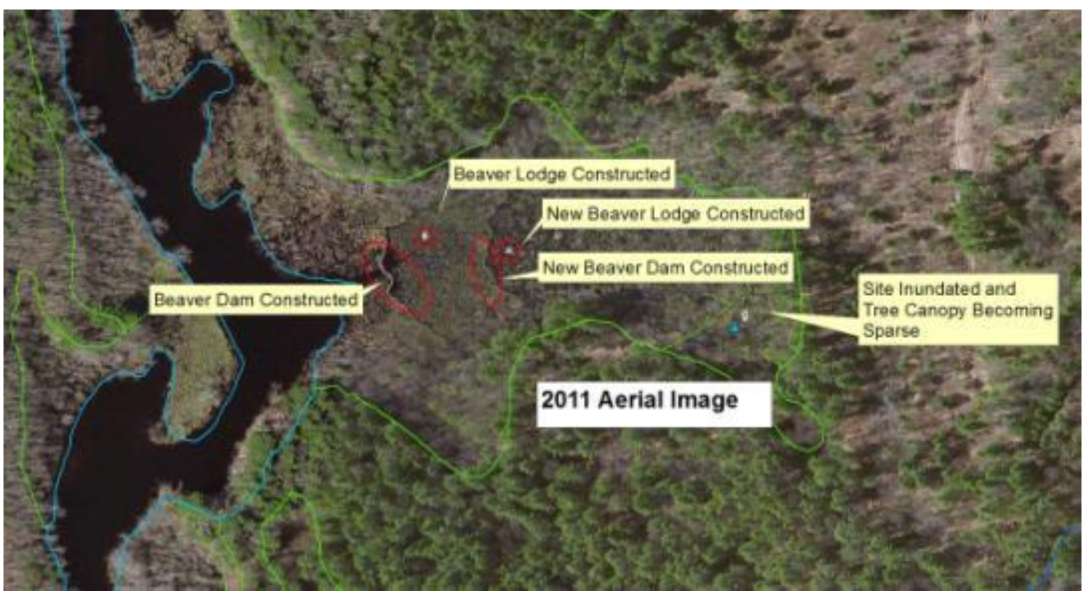


Figure 3.4-8 Site 1 Investigation 2011



Orthoimagery obtained in 1992 and 2001 show a mature forest canopy but no sign of beaver activity until 2001. However in 2005, it appears that beaver activity, consisting of dam construction and a lodge is underway. It does not yet appear to be affecting the site, but is evident of the aerial image. In 2008, the beaver activity is clearly visible. Two dams and a lodge are visible and water has backed up, inundating the site. The tree canopy appears stressed, in that it is less dense--likely die back from inundation. 2011 Orthoimagery depicts a second beaver lodge getting established, along with the two dams and also shows that the understory

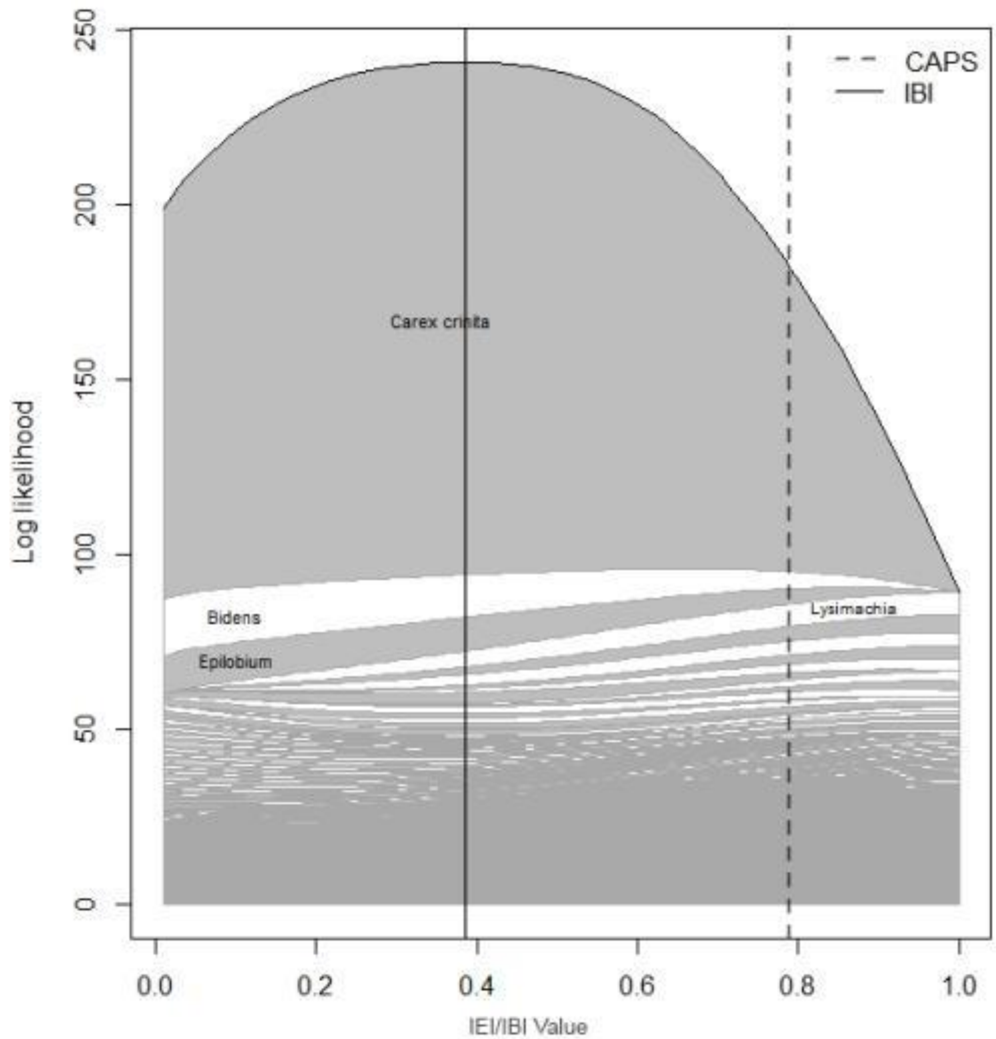
(forb layer) in the forested wetland is not saturated and extremely lush. Excess water and plentiful sunlight has created almost marsh like conditions in this forested wetland.
The CAPS IBI software identified that this site was performing lower than expected, but none of the anthropogenic stressors in the landscape model explained why. However by reviewing the site in a series of aerial photos, a stressor could be identified—beavers. There is no GIS layer that identifies beaver activities. Beavers are a natural occurrence in wetlands ecosystems. However it is clear that there presence and activity cause change in wetlands systems, and in particular forested wetlands. Trees adapted for growing in seasonally saturated or seasonally flooded hydrologic regimes cannot tolerate permanent or semi-permanent standing water. The tree essentially "drowns" (more specifically, its roots are unable to properly take up nutrients). The model identified this site as outside the normal range of variability and that flagged the site for further review. That review indicated that the site was undergoing change, but the change was unrelated to any anthropogenic stressor. Thus, the CALU assessment accurately identified a change in the biological condition of this forested wetland in that it has been transitioning to a wetter hydrology. This stressor had not been identified prior to the completion of the CALU analysis.

It is important to note that this assessment that Site 1 "failed" expectations does not mean that the site is considered "degraded" in the same manner a site would be if it were impacted by anthropogenic stressors. In fact, this site might be assessed as a healthy shrub swamp or emergent marsh if those assessments were available. Beaver activity is natural and so obviously, no corrective action would be needed at this site. However, it is promising for future assessments that the use of IBI's and CALU flagged a site that was undergoing changes in biological condition.

High IEI Site 2

Another site that failed to meet expectations was Site 2. This is another wooded swamp within the DCR watershed that is not near any identified stressors. The CAPS model predicted an IEI of 0.79 however the onsite plant community assessment indicates an IBI of 0.39. Again, the plant community encountered at this site is found in Appendix B. The following plot depicts that plant community and the effect it is having on the IEI.

Figure 3.4-9 Site 2 IBI Plant Community Plot



Again, *Carex crinita* (fringed sedge) is the dominant plant, and has an IBI of about 0.4 and so it draws the site IBI down. *Bidens spp*. (beggarticks) and *Epilobium spp*. (herb willows) are the next most common plant and they also are located to the left on the graph indicating very low IBI of approximately 0.1 for both. The next most common is *Lysimachia spp* (loosestrifes) are located on the right of the graph, indicating that they have IBIs typically found in high IEI sites, however they are not influential enough on the site (as depicted by the depth of the layer) to pull the IEI up from the low determined by the *Carex crinita*, *Bidens spp and Epilobium spp*.

A review of historical imagery in this area identified the same issue-beaver (See Figures 3.4-10 through 12). In 2005 the site is dense canopy of red maple, with a large occurrence of white pine at the southern extent of the wetland. The 2008 aerial image shows a beaver dam has been established and water is starting to back-up. By 2011, much more of the area is inundated, many of the pines have died, blow downs have occurred due to shallow rooting and the tree canopy at the edges is much sparser. MassDEP staff evaluated the site in 2013, and there was still enough tree canopy for the site to be considered forested wetland; however the beaver dam had caused a significant rise in water level, likely changing a forested wetland herb layer from forbs to graminoids. Again, the site assessment and CALU analysis accurately identified this site as not meeting expectations for a forested wetland. As discussed in Site 1 above, beaver activity is natural and no corrective action would be expected at this site.

Figure 3.4-10 Site 2 Investigation 2005

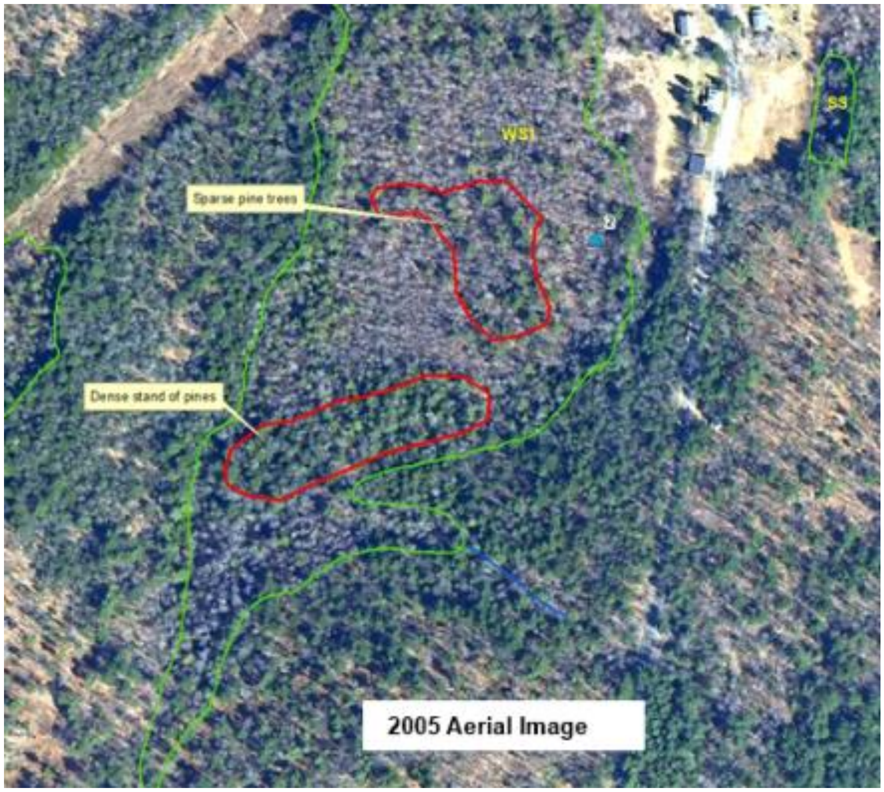


Figure 3.4-11 Site 2 Investigation 2008

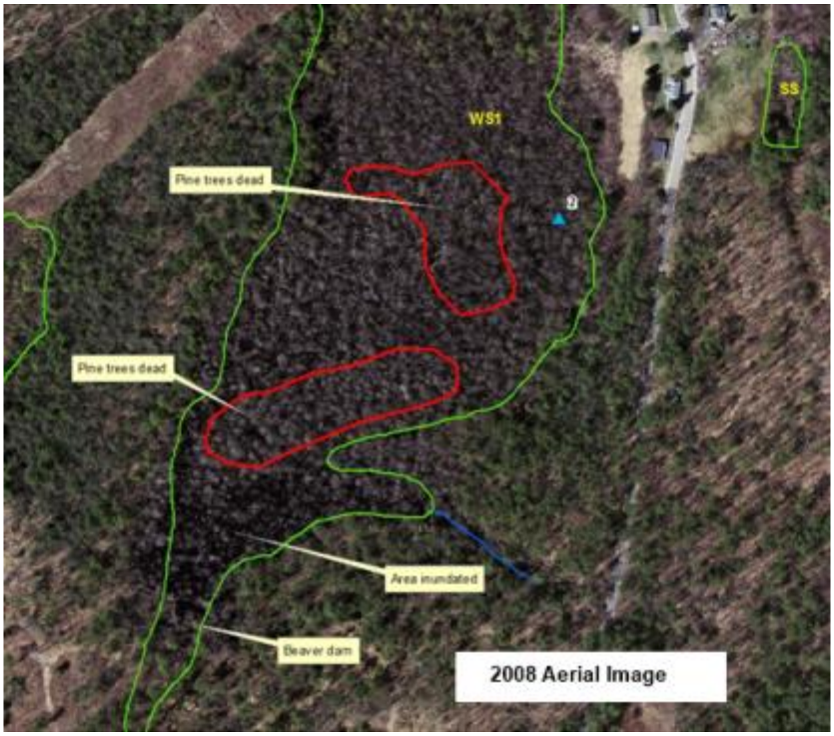
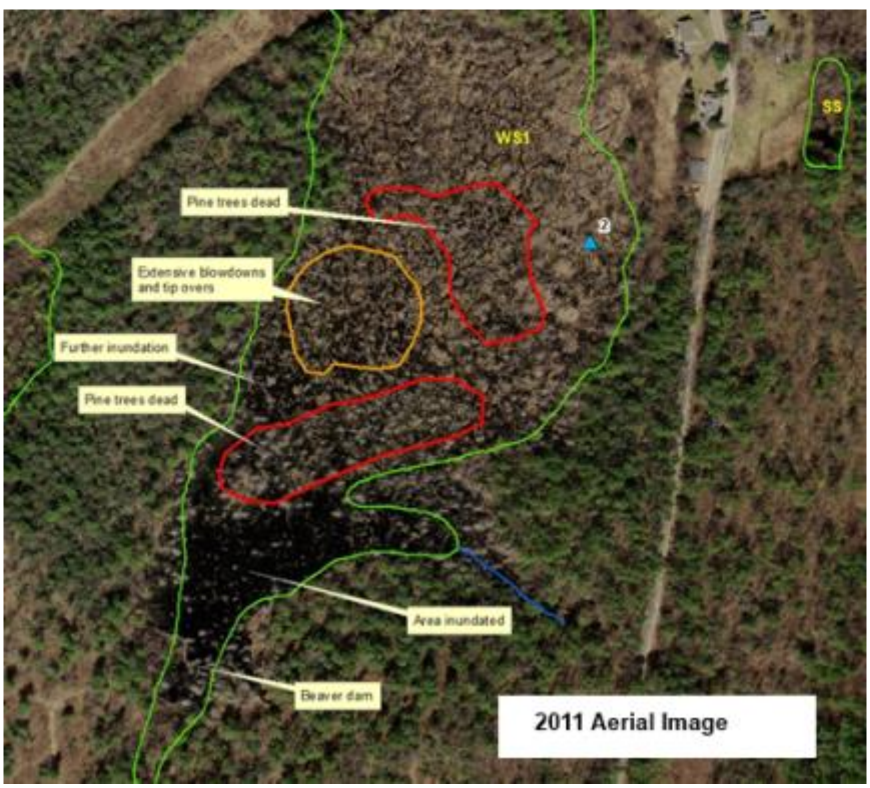


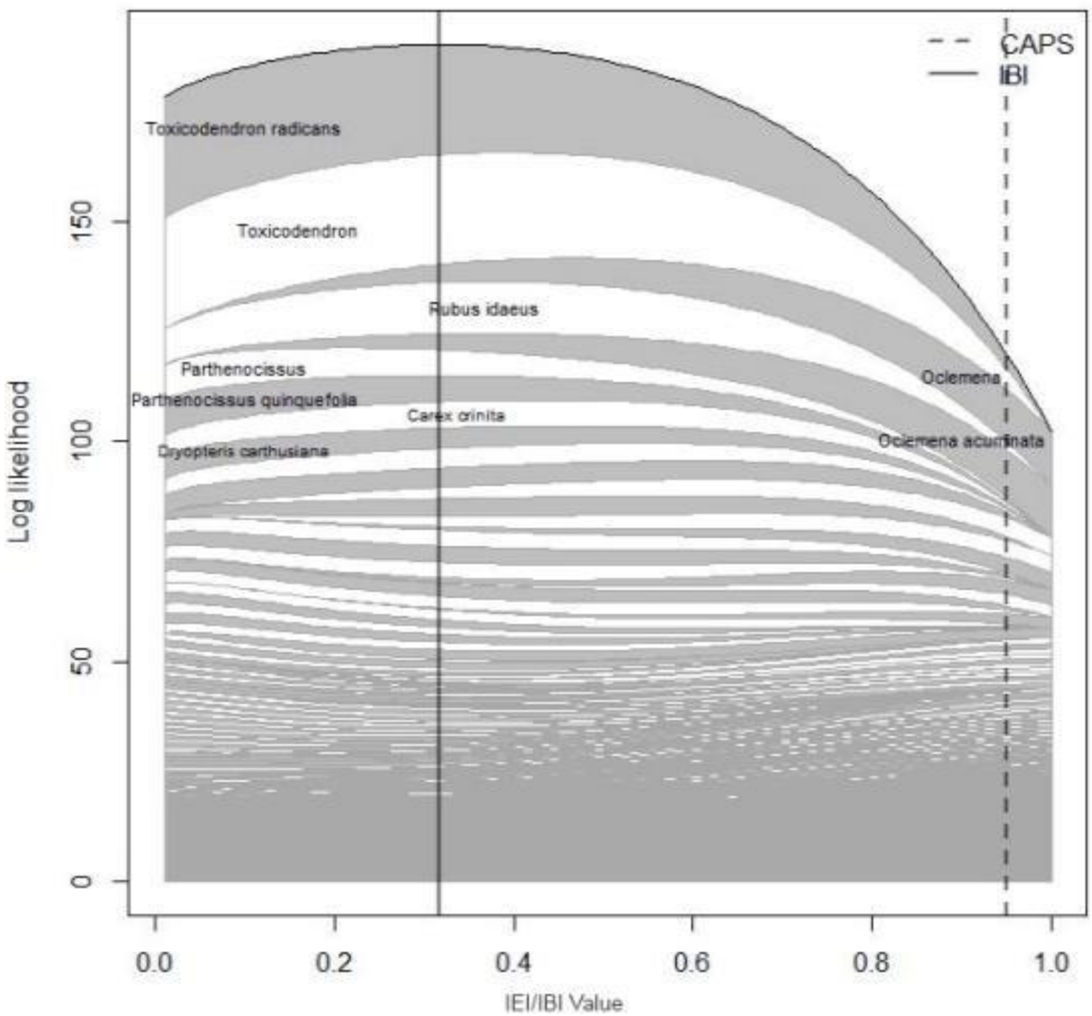
Figure 3.4-12 Site 2 Investigation 2011



High IEI Site 5

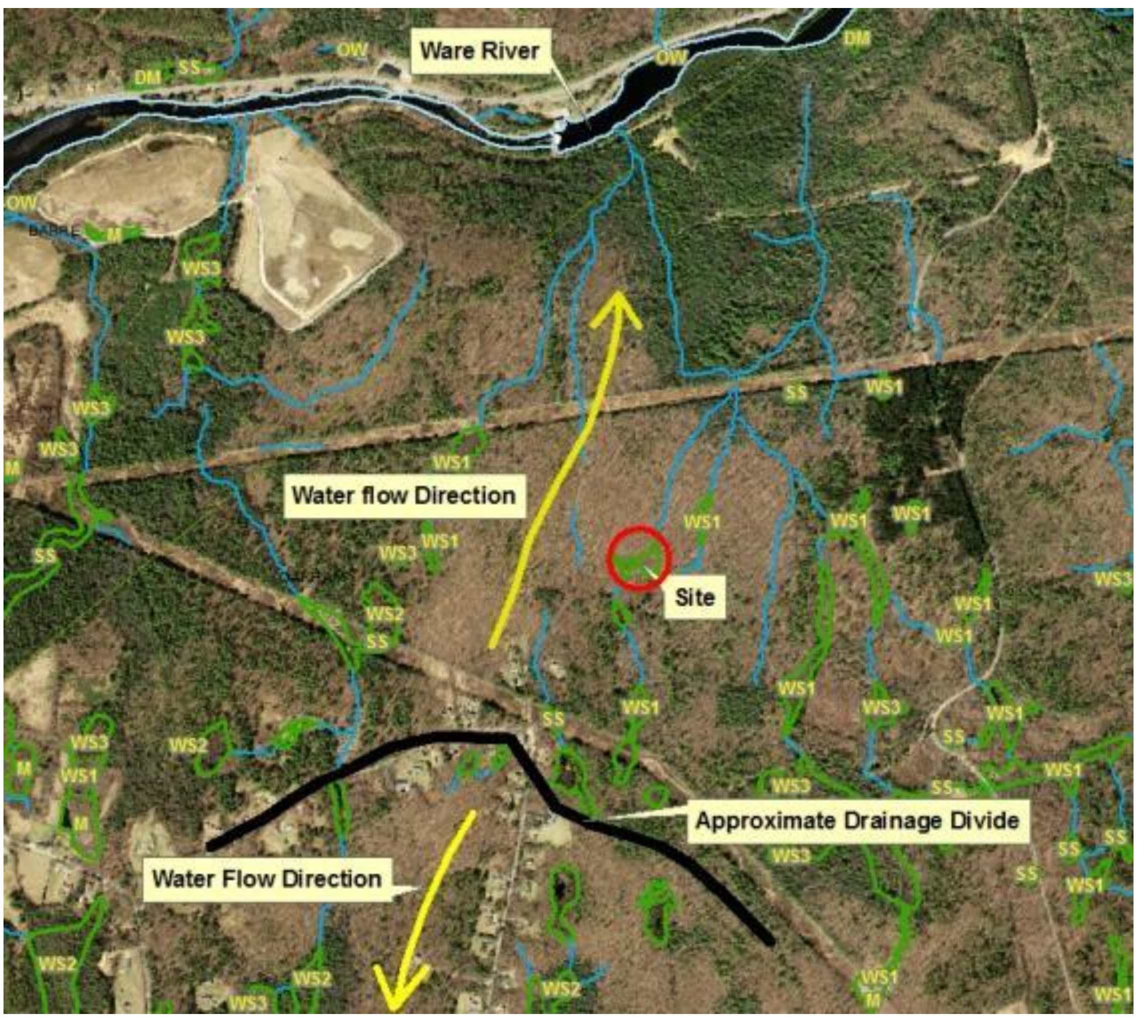
The third site that failed to meet expectations was site 5. Based on its landscape position the predicted IEI is 0.95 however, the field determined IBI valued it at only 0.29. The full plant community assessment is also included in Appendix B, however the following plot depicts the plant community and which species are having the most influence on the IBI.

Figure 3.4-13 Site 5 IBI Plant Community Plot



In this case the dominant plant affecting IBI is *Toxicodendron radicans* (poison ivy) which is an indicator of low IBI, typically found in stressed wetlands. Another important plant is *Oclemena acuminata* (whorled wood aster) which leans to the right, indicating that they have IBI's of high, or more pristine sites. *Rubus idaeus* (red raspberry) and the remaining common plants *Parthenocissus quinquefolia* (Virginia creeper), *Carex crinita* (fringed sedge) and *Dryopteris carthusiana* (spinulose woodfern) all lean to the left indicating low IBI. So while there are some plants with high IBI's that are indicative of a more pristine site, they are not prevalent enough to overcome the influence of vascular plants that have low IBI, indicative of stressed sites. In this situation it is difficult to determine a reason why the site would fail to meet expectations. The site is within the DCR protected watershed. The site visit and a review of historical aerial imagery do not show any beaver activity, nor does it show forestry or any other obvious anthropogenic stressors (See Figure 3.4-14). Despite no obvious cause being found, the site failed to meet expectations for IEI and failed to meet expectations for each of the metrics. There are other reasons why site condition might fail to meet expectations that are not explained by the CAPS model. One such example would be chemical contamination. CAPS stressor metrics were only included in the model if sufficient information was available on a statewide basis. Chemical contamination would be impossible to know without site specific data however, MassDEP online 21E Site File Review was consulted and no reported sites were located in the vicinity of this site. There is some type of utility right of way in the vicinity of this site both upstream and downstream-potentially herbicides are used here. Further investigation would be warranted to determine why this site fails expectations.

Figure 3.4-14 Site 5 Locus 2011



While it is possible there are stressors of some sort that have not been identified, it is more likely that this site represents the enormous variability within the population of wetlands. The CAPS model sampled 317 forested wetlands in order to determine a range of variability within wetlands and then bases the IBI valuations on that range. However, in any given population it is expected that certain individuals will be outside of the range of variability for natural reasons, or no reason at all. Site 5 may be one of these sites. Its plant community was somewhat atypical in that the dominant tree species was Green Ash (*Fraxinus pennsylvanica*) as opposed to the much more frequently encountered Red Maple (*Acer rubrum*). There was also a dense understory of poison ivy (*Toxicodendron radicans*) and Spinulose Woodfern (*Dryopteris spinulosa*), however, there were no invasive species encountered on this site.

4.0 CONCLUSIONS

This pilot assessment of the Chicopee Watershed is the first time MassDEP has used tools that have been under development for several years for the purpose of wetland monitoring and assessment: the CAPS model, the SLAM for forested wetlands, the IBIs and the CALU analysis. Throughout this analysis, strengths and weaknesses have been identified in the approach. The site assessments and CALU analysis have demonstrated that the IBI's appear to be accurately predicting wetland condition in most cases. The CALU results indicate that all 40 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. This should not be interpreted as acceptable, but rather, expected. 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.[29] Opportunities for restoration that would improve wetland condition have been discussed in this report and include improvements in terrestrial connectedness and similarity, improvements in aquatic connectedness, and eradication of invasive species.

The CALU analysis of the High IEI sites indicated that three of the five sites failed expectations. Upon further investigation it was determined that two of the three failed sites were in fact stressed due to beaver activity, and the third cannot be fully explained without further investigation. Although the model did not predict what stressor caused 2 of the sites to fail, it did correctly identify stressed biological condition. While the beaver activity is naturally stressing the forested wetland condition, the result may be a healthy shrub or emergent wetland. Regardless, no corrective action is recommended or required for these two sites.

[29] 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.

One limitation that this study identified was the difficulty in assessing sites predicted to have a low IEI by CAPS. In this study predominately low IEI sites were targeted. 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.

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 targeted/probabilistic sampling, whereby low IEI forested wetlands that drained into impaired waters were targeted for sampling, then 40 sites were randomly selected from all available sites that met this criteria (the five high IEI sites were selected in a similar manner).The purpose of a probabilistic sample is to get a representative sample (of wetlands) in order to draw inferences about a larger population (all wetlands in a watershed).
With a targeted sampling approach, rather than target a specific IEI as was done in the current study, or even sample along the entire stressor gradient, a specific stressor is identified that is not addressed in the CAPS model, such as salt storage sheds or landfills. Sampling is then targeted to learn more about how that stressor is affecting the biological condition of the selected sites. Targeted sampling could also be conducted to answer a specific question (e.g. are wetlands that drain into impaired waters less healthy than wetlands that drain into waters that are not impaired) or to validate certain metrics of the CAPS model such as invasive species. As the need arises for a targeted approach to sampling, site selection may be modified to address that need.

Another potential limitation that has been identified is the robustness of the IBI’s across the ecosystems of the state. 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 relationship became less robust. IBI development has yet to incorporate any data from the Berkshires, a significantly different ecoregion from any of the others, although that sampling is underway. 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, it is resource intensive to collect data from each ecoregion for IBI development purposes and so, IBI development based on the best available data appears to be sufficient if not perfect.

Lastly, MassDEP is considering the need and feasibility of developing a 2nd tier to our site level assessment that we would apply on sites that fell outside of the normal range of expected values. That second tier would focus on further site assessment in order to help identify why the site is either below or above expectations. That further site assessment could consist of simply a site visit for further investigation into potential disturbance (both natural and anthropogenic) within the wetland and in the adjacent buffer zone, or it could include other investigation such as water quality (e.g. temperature, pH, conductivity), soils (e.g. nutrients) etc. 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.

MassDEP continues to apply and advance its monitoring and assessment program. This study has been a 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.