WETLANDS MONITORING AND ASSESSMENT: WESTERN REPORTING BASIN

Massachusetts Department of Environmental Protection
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Executive Summary

The Massachusetts Department of Environmental Protection (MassDEP) Wetlands Program conducted a study of the Western Massachusetts Reporting Basin for the wetlands water quality compliance with Section 305(b) of the Clean Water Act (CWA). The study used 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 U.S. Environmental Protection Agency (EPA) recommended concept for wetland monitoring and assessment,[1] this study consisted of a landscape level Geographic Information System(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.

The primary causes of ecological stress of forested wetlands within the Western Basin identified by the CAPS model are: loss of terrestrial connectedness, increased traffic intensity, loss of similarity, the presence of non-native invasive plant species, and habitat loss. 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; identify and map potential important wildlife habitat for conservation and preservation; and identify and map the extent of invasive plants to help prevent further range expansion.

In addition to the CAPS assessment, a site level assessment was conducted to assess wetland condition at randomly selected forested wetlands. That assessment was conducted by sampling vascular plants at 20 wetland sites across four watersheds within the reporting basin, and using the IBI's and the CALU framework to determine whether sites met expected condition given the surrounding landscape. The assessments are based on the CAPS output, referred to as the Index of Ecological Integrity (IEI) -which predicts expected wetland condition or health – for the site and the landscape around the site. CAPS IEI values range from 0, which represents sites predicted to be highly stressed, to 1.0 which represents sites that are predicted to be unaffected by anthropogenic stressors. Sites were selected at random, using a probabilistic sampling approach, from all forested wetlands within the Western Reporting Basin that fell within an IEI range of 0.4-0.7.

The goal of our study is to document the ecological integrity of forested wetlands in order to assess the wetland health within Massachusetts and better understand some of the secondary impacts that are affecting wetland health. Therefore, the focus of the report is on the sites that "fail to meet expectations". The results of the IBI and CALU analysis indicate that six of the 20 forested wetland sites throughout Western Reporting Basin did not meet expected condition. Further investigation revealed that four of the six sites are located in areas that appear to be subject to frequent flooding from both natural and anthropogenic causes. Those wetlands had low IBI scores, which indicate that the sediment laden waters may be impacting wetland

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

biological condition (i.e. plants); however the wetlands' functional values of flood storage, sediment reduction and groundwater recharge appear to be intact. Historical land use that resulted in the introduction of invasive species may be the cause of two wetlands sites (one which also experiences frequent flooding) not meeting expectations. Invasive plant species, such as Japanese barberry (*Berberis thunbergii*), appear to be stressing the ecological community by outcompeting the native vegetation, affecting the site condition by reducing biodiversity. In one case, a site that failed to meet expectations was located in close proximity to a major interstate highway, and also had forest clearing observed upstream from the site.

It can be difficult to identify the specific stressor that causes a site to not meet predicted expectations. Multiple stressors are present in the vicinity of the six , and the IBI score means that the biotic community exhibits structure in relation to those stressors, but cannot always identify which specific stressor, or combination of stressors, is having the greatest impact. However, given their landscape position, and the fact that the sites are still an intact forested wetland, the sites are likely to continue to provide some of the services and values one would expect from a forested wetland, such as pollution attenuation, sediment control, storm damage prevention and flood control.

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 riparian communities. Wetlands contribute to the protection of public and private water supply, protection of ground water supply, flood control, storm damage prevention, and 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 wetland resources are critical contributors to quality of life. Wetlands also contribute to a strong economy. For example, the Massachusetts Department of Fish and Game, Division of Ecological Restoration, estimates that the Town Creek restoration project, a marsh restoration project in the Town of Salisbury, is likely to save almost $2.5 million in avoided flood losses over the next 30 years.[2]

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

1.2   Why Monitor and Assess

Section 303 of the federal 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 also apply 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 the 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 report is called the *Massachusetts 2014 Integrated List of Waters*, however, a Draft 2016 report is currently posted to MassDEP's website.[3]

In Massachusetts, regulations have been developed to administer Section 401 of the federal CWA (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'). 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 the Massachusetts Wetland Protection Act (M.G.L. C. 131, § 40)(WPA) and 401 Water Quality Certification requirements, which are largely 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, nutrients, pH, temperature, solids, turbidity, color, oil & grease, taste and odor).
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 are 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

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[3] https://www.mass.gov/lists/integrated-lists-of-waters-related-reports

uses but 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, 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, and much more effort is needed to fully understand these differences. 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 encouraging states to develop water quality standards that are specific for wetlands. The work described in this report will help us to develop narrative and/or numeric biological criteria to be used in assessing attainment goals for fish, other aquatic life and wildlife, and perhaps other designated uses. Further work may be done to assess chemical criteria pertaining to wetlands.

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.

1.3   Wetlands Monitoring and Assessment Strategy

Monitoring and assessment allows the 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 decision-making. Protection of ecosystem services and the public interests

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[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.

identified in WPA (e.g. public and private water supply, flood control, wildlife habitat) provides a meaningful and sustainable economic benefit to taxpayers.

The core feature of the Massachusetts monitoring and assessment strategy is the CAPS model, a landscape-level assessment model that has been under development by UMass-Amherst 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 a GIS utilizing land cover mapping and the integration of 25 inland and coastal stressor or resiliency metrics (see *Figure 1.3-1*). The CAPS model combines this data and calculates a value between 0 and 1.0[5] for every 30 m^2 point in the landscape. The CAPS value represents the Index of Ecological Integrity (IEI), which is a 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, salt marshes and shrub swamps. Using these SLAMs, data was collected from 388 forested wetlands, 190 salt marshes, 190 shrub swamps that were randomly selected along a gradient of IEI values.[6] These data, plus additional data from 490 wadable streams collected by the MassDEP Division of Watershed Planning (WPP) have been used for testing the CAPS predictions and modifying (as needed) the CAPS models; and for the development of IBI for use in assessing site specific wetland condition. To date, reliable IBI's have been developed for forested wetlands, but additional work is needed to develop reliable IBI's or other assessment tools for salt marshes and shrub swamps. For more information on CAPS development, please visit www.umasscaps.org

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[5] Zero is stressed, one is pristine.
[6] *Empirically Derived Indices of Biotic Integrity for Wetlands in Massachusetts and an Evaluation of their Utility for Assigning Coefficient of Conservatism Scores for FQA*

Figure 1.3-1: Statewide CAPS 2015 IEI and Metrics
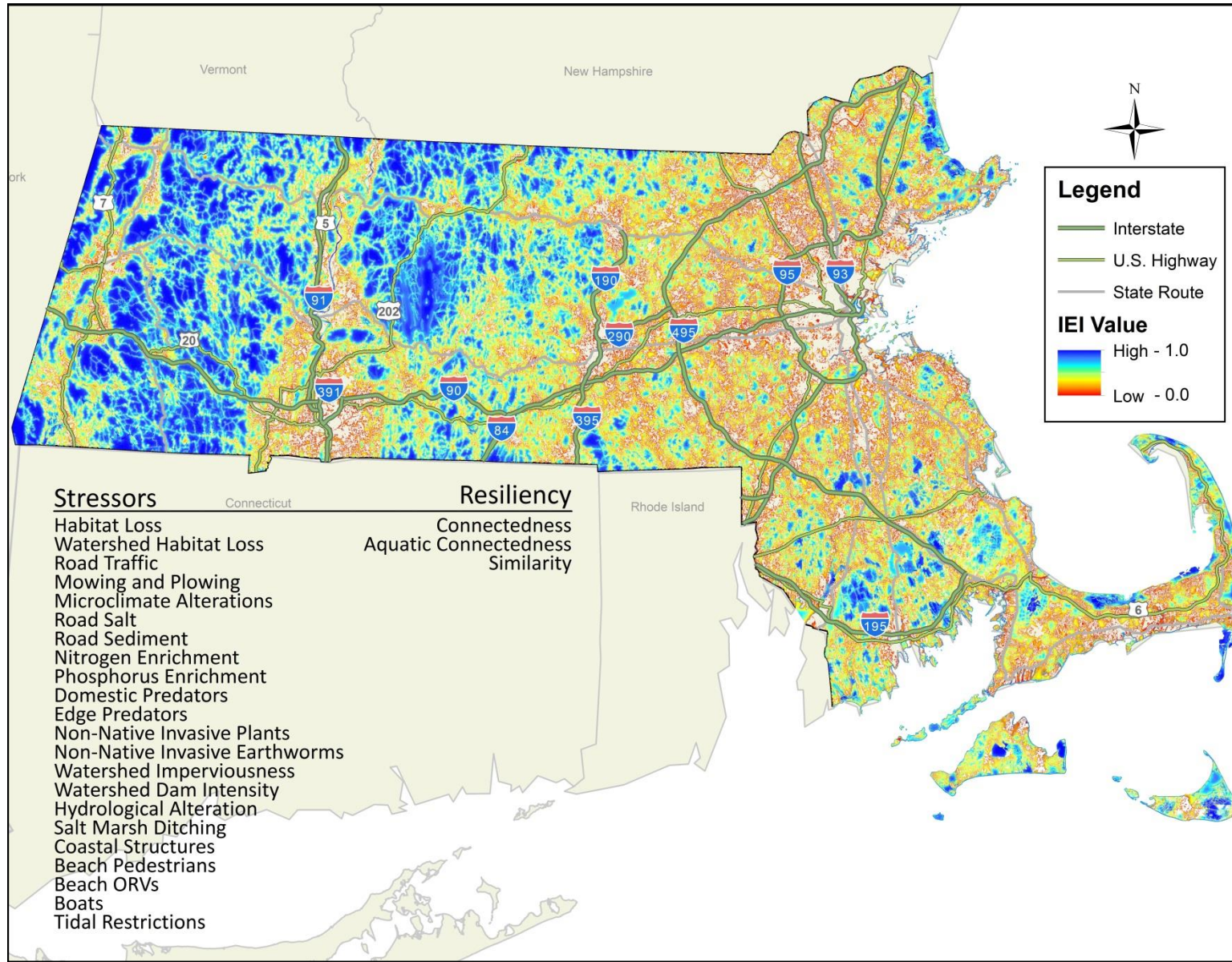
2.0　Landscape Level Analysis: Western Basin Watersheds

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 watersheds by identifying which wetland areas are most impacted by ecological stressors and the likely source of those stressors. The Western Basin was selected for the study based on the WPP rotating basin scheme for sampling of water bodies and waterways. Because SLAMS have only been developed for forested wetlands, salt marshes, and shrub swamp the focus of this report is on forested wetlands since there are no salt marshes in the Western Basin, and because that is the wetland community where CAPS has been most rigorously applied and field tested. Also, reliable shrub swamp IBI's have not yet been developed.

Using the spatial analysis tools in ArcGIS, the average IEI value for forested wetlands within each major watershed in Massachusetts was calculated in order to gain an understanding as to whether the watersheds within the Western Basin are in overall better or worse condition than other watersheds in the state. As depicted by *Figure 2.1-1*, watersheds with low average IEI for forested wetlands are identified as being the most stressed by neighboring anthropogenic activities while the watersheds with higher average IEI forested wetlands are less stressed by those activities.

The IEIs for forested wetlands in the Farmington Watershed averaged an IEI score of 0.75. This is the highest IEI average of forested wetlands for the watersheds in Massachusetts and is due to the watershed having a large extent of undeveloped areas. Low levels of anthropogenic activity typically mean low levels of anthropogenic induced stressors. The Housatonic, Hudson, and Westfield Watersheds had IEI averages ranging between 0.56-0.58, which is above the average IEI of all the watersheds in Massachusetts. The Deerfield Watershed average IEI score is 0.47, which is close to the statewide watershed average of 0.45 and the lowest in the Western Basin. All the watersheds in the Western Basin scored relatively well in comparison to the rest of the state due to a lack of development and greater amount of open space in the region.

Figure 2.1-1: Average IEI for Forested Wetlands within Each Major Watershed
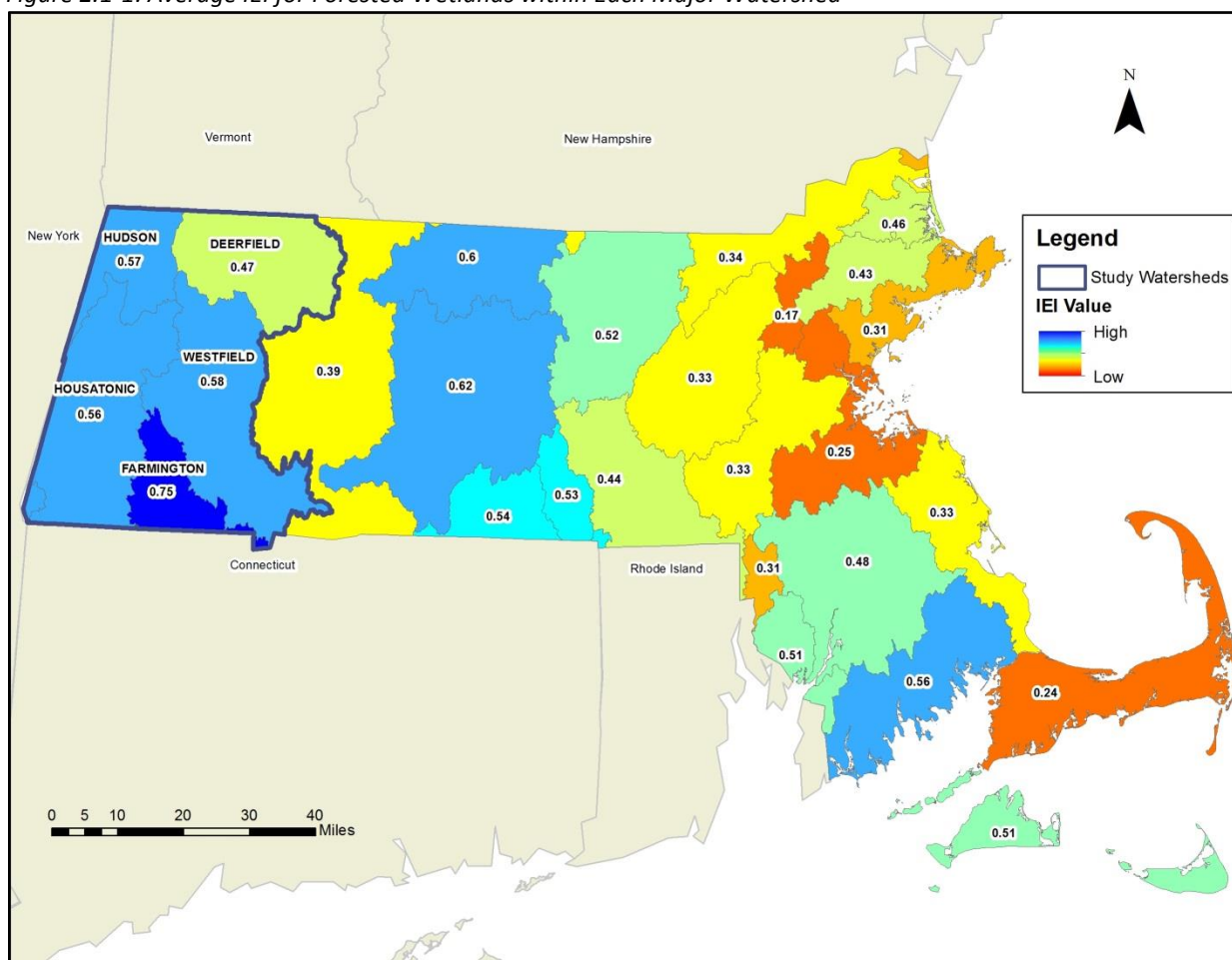
Overall, the Western Basin has many of the highest quality forested wetlands in the state.

In addition to calculating the average forested wetland IEI, the average values for each individual stressor / resiliency metrics in the CAPS model was calculated as well. By doing so, the stressors that are likely to have the most significant impact to forested wetlands in the watershed are identified. Forested wetlands throughout Massachusetts generally have the same stressor and resiliency metrics impacting their IEI score, however the intensity with which they affect a given wetland will differ based on the wetland's landscape position. The stressor and resiliency metrics that have been found to impact all forested wetlands the most are:

- loss of terrestrial connectedness;
- intensity of road traffic;
- invasive plants;
- habitat loss; and
- loss of similarity

Figure 2.1-2: Stressor Metrics by Study Watershed
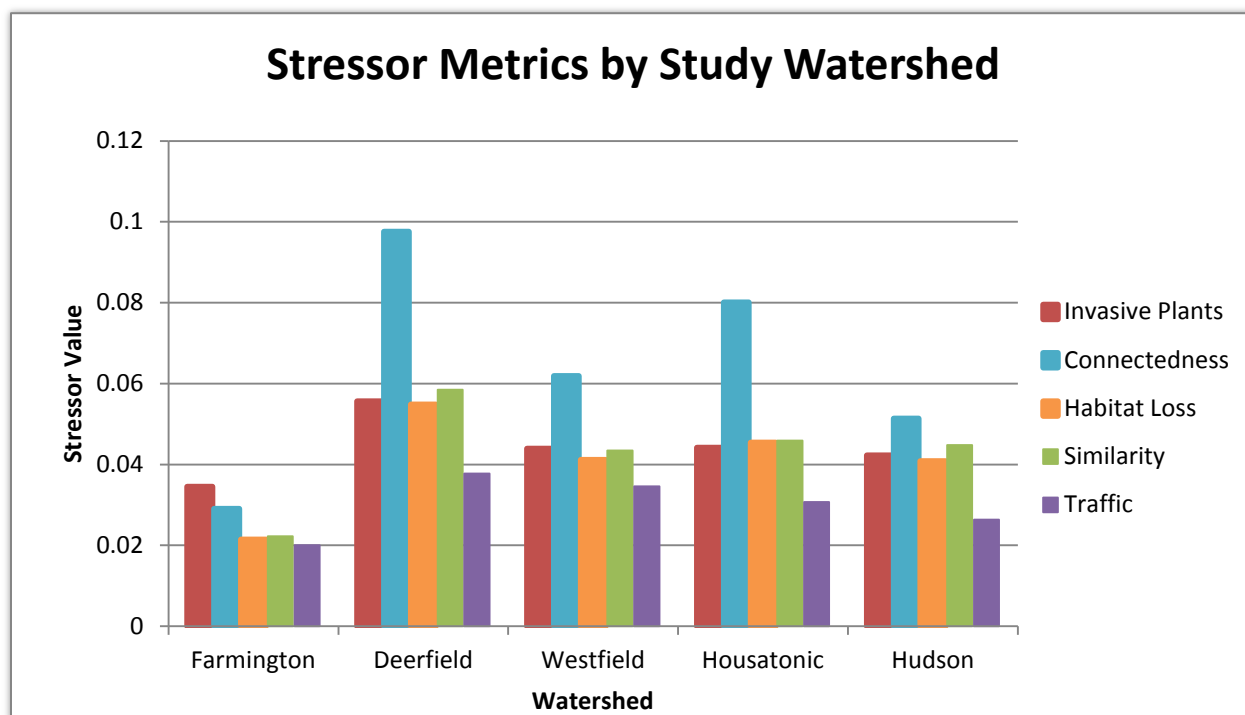
The statewide IEI is composed of 21 metrics, and the importance of the metric is community (forested wetlands, shrub swamp, forests, etc.) dependent. Not all metrics are used for all communities, nor are they weighted equally. The stressor value in the graph represents the weighted and scaled value for the top five major stressor metrics for the forested wetland community in the Western Basin. Forested wetlands share the same top five stressor metrics, but the intensity of each of the metrics within each watershed differs. The combination of all the weighted and scaled metrics for the individual community determines the IEI score, which ranges between 0.0-1.0. The stressor metrics of the Farmington Watershed are lower than the other watersheds in the basin. This indicates that the watershed is less stressed and more resilient to ecological stressors.

The intensity of the metrics coincides with developed areas such as urban landscapes and interstate highways within each watershed and results in a lower IEI value due to the associated stressors. An example of a stressed area within the reporting basin would be the sections with commercial, infrastructure, and residential land uses like those in or near the City of Pittsfield in the Housatonic Watershed. The least stressed areas are undeveloped tracts such as the large amounts of open space in the Hudson Watershed, for example Mount Greylock State Reservation. An analysis of land use and CAPS found that as a whole, the Western Basin has the most open space out of the five state-wide reporting basins, and open space is a strong contributor to the high IEI values throughout the Western Basin.

2.2 Connectedness and Traffic

Loss of connectedness has been identified as the greatest source of ecological stress of the forested wetlands in the Western Basin. 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.

Traffic intensity was identified as the fifth greatest source of ecological stress of forested wetlands in the Western Basin. Traffic is a stressor metric which is an indicator of road mortality, as well as noise and other local effects. It does not measure fragmentation, which is addressed in the connectedness metric. Instead, it focuses on the direct physical impacts that traffic creates.

Although these two metrics measure different things, they are highly correlated, and a strategy to address the connectedness metric will also address the traffic metric as well.

Figure 2.2-1: Connectedness Metric
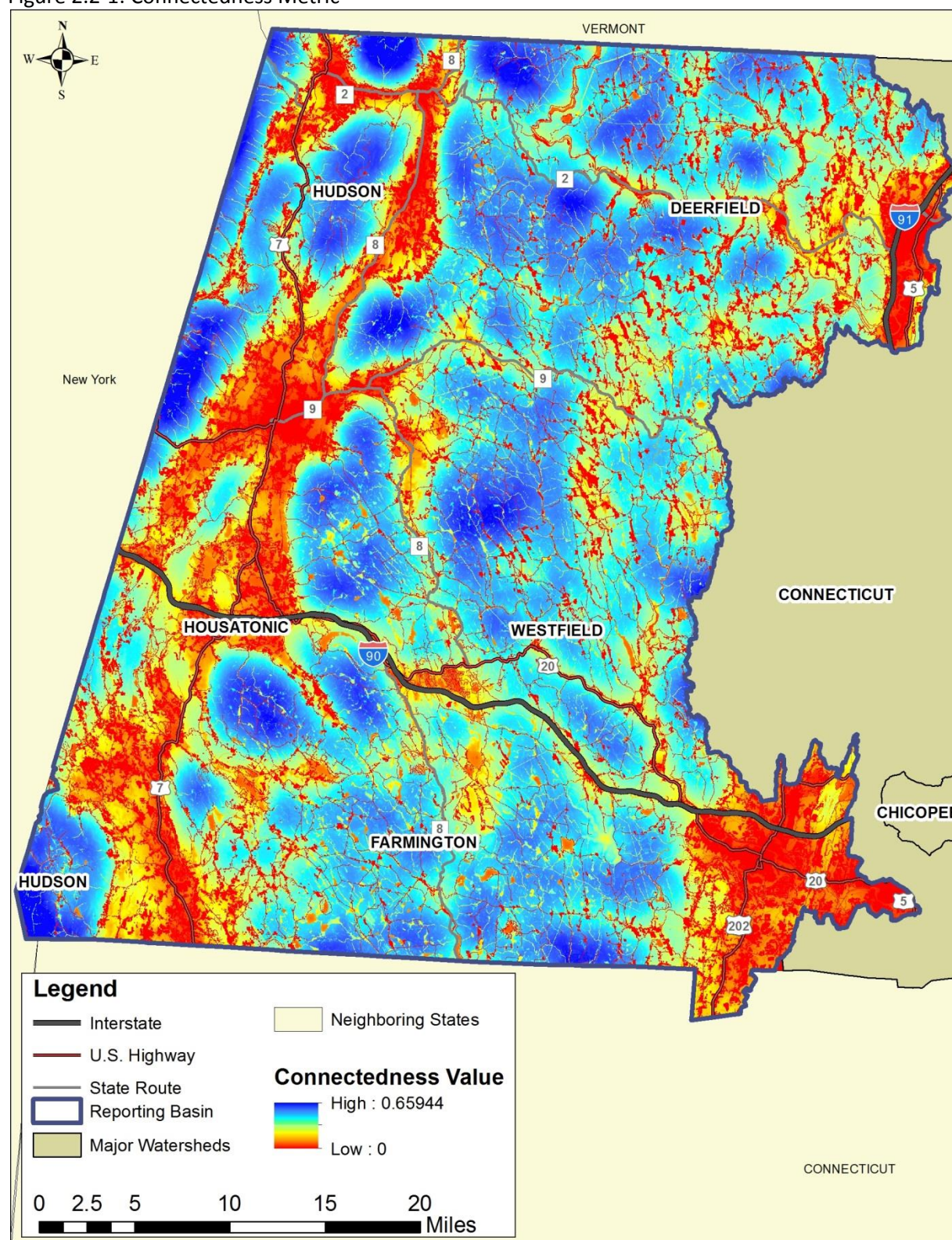
Note that areas in red and yellow represent low connectedness, and are consistent with dense road networks. The denser the road network, the lower the connectedness metric since roads serve as significant barriers to the movement of many species of wildlife.

To address the ecological stress caused by loss of connectedness and traffic intensity that are impacting forested wetlands in the Western Basin, two main strategies are recommended:

1) Restore Connections between Fragmented Forested Wetlands

Terrestrial Wildlife Crossings

As previously noted in this section, one of the primary causes of loss of connectedness is roads. 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 reducing 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, which breed in wetlands but migrate to uplands) or species that move through large expanses of wetlands systems, such as River Otter, to access the ecosystems they need in order to carry out their life cycle.

UMass-Amherst, in partnership with The Nature Conservancy, has developed the Critical Linkages project which is a comprehensive analysis of areas in Massachusetts where connections could be employed in order to support the Commonwealth's wildlife and biodiversity resources. 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 IEI-delta) 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 Western Basin 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.[7] Information on the Critical Linkages project, as well as the shapefile data for all municipalities statewide is available for download at the UMass-Amherst CAPS website.[8]

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[7] 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 Central Study 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 those cities or towns.
[8] http://www.umasscaps.org/applications/critical-linkages.html

Figure 2.2-2: Terrestrial Crossings
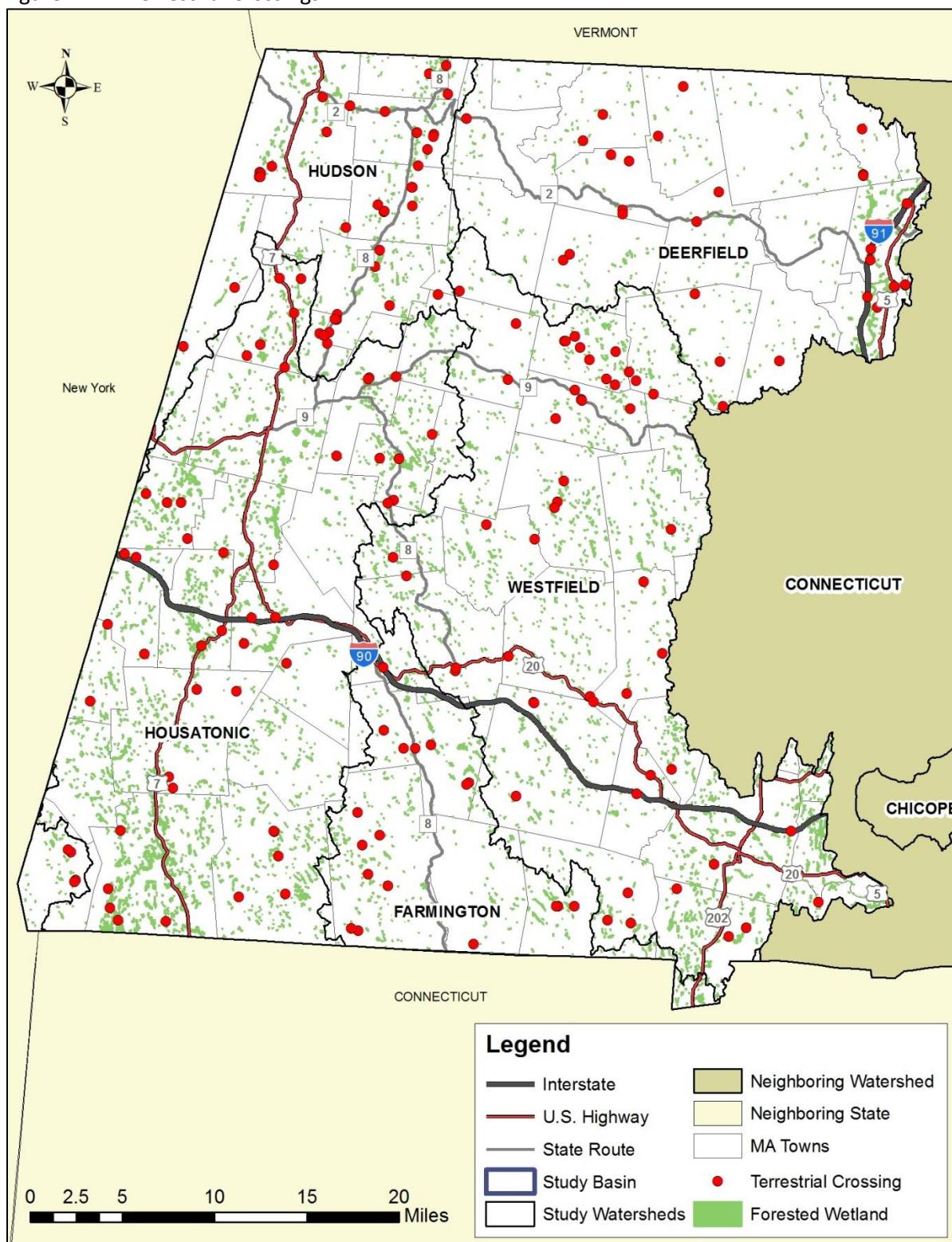
In this figure, the top 10% of the potential terrestrial crossings within 500 feet of a forested wetland were identified. Installation of terrestrial wildlife crossings structures at these locations would be likely to improve biological conditions of forested wetlands.

Figure 2.2-3: Terrestrial Crossing Opportunity
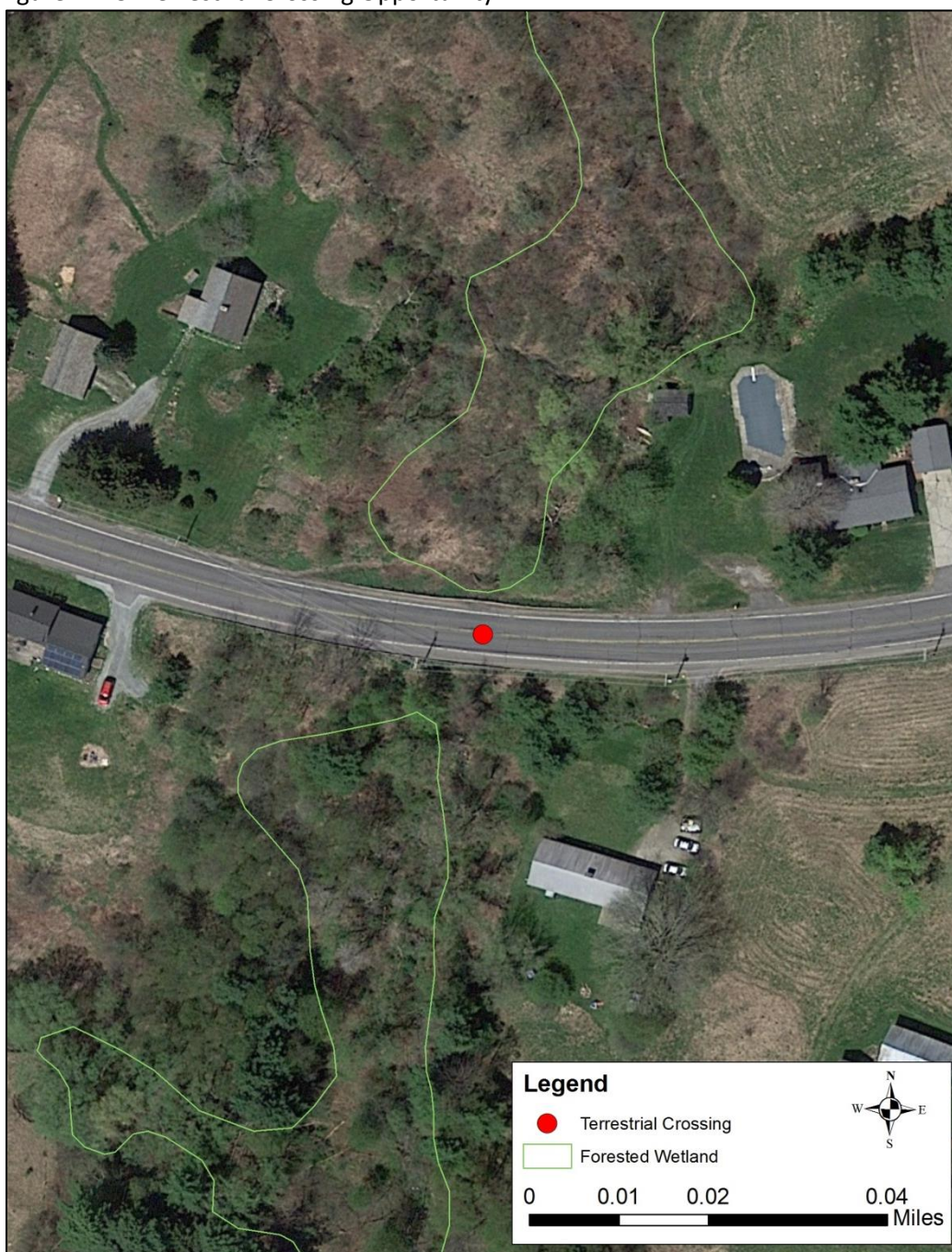
The photo above is an example of a location identified by Critical linkages where terrestrial connections could be installed.Creating a crossing under the road here would potentially reconnect the two wetland habitats, which has been been fragmented by the road.

In addition to restoring habitat connections under roadways, 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 such as clearing, fill or development that has been abandoned. Information on funding sources may be available

through the Massachusetts Ecological Restoration Program or other non-profit organizations.

2) Avoid New Fragmentation

Another way to reduce the ecological impacts of fragmentation and traffic is to avoid new impacts when possible, minimize them when unavoidable, and mitigate for impacts that cannot be avoided or minimized. As a general rule, the Massachusetts Wetlands Protection Act regulations prohibit the destruction or impairment of vegetated wetlands (310 CMR 10.55(4)(a)).   However, 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 2017, a total of 54 new roadways/driveways across wetlands or waters were approved.[9]

To ensure that forested wetland condition in the Western Basin do not continue to be impacted, and 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 and otherwise meeting the Massachusetts Stream Crossing Standards;[10] 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

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[9] While this represents only 0.01% of the total 5522 filings between January 1 and December 31, 2017; it also means that 54 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, 25 new crossings are limited projects where the issuing authority may waive standards, and 29 are not limited projects and should meet standards.

[10] 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://streamcontinuity.org/pdf_files/MA%20Crossing%20Stds%203-1-11%20corrected%203-8-12.pdf

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"[11]. Where streams are being crossed, culverts should be designed appropriately.

2.3   Similarity

Another of the top five causes of ecological stress to forested wetlands in the Western Basin is loss of similarity. Similarity is also a resiliency metric, and addresses the capacity of the ecosystem to recover from anthropogenic perturbations. Similarity addresses 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 (*Figure 2.3-1*), bats, insects, 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: Heron Rookery

Birds, such as heron, depend on the similarity of the landscape to determine suitable habitat and safe areas to land.

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

To address the ecological stress caused by loss of similarity that is impacting forested wetlands in the Western Basin, undeveloped buffer zones surrounding forested wetlands should 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 (*Lithobates sylvaticus*), which breed in wetlands but spend much of the year in uplands; Blanding's Turtles (*Emydoidea blandingii*) which spend much of the year in wetlands but nests in uplands,[12] 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.

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[12] https://www.mass.gov/files/documents/2016/08/tl/emydoidea-blandingii.pdf

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 another major cause of stress to forested wetlands in the Western Basin. The CAPS model assesses the pervasiveness of non-native invasive vascular plant species[13] 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. 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).[14]

A major component of the assessment of the Western Basin was site sampling on 20 forested wetland areas within the Western Basin. The sampling primarily involved documentation of plant communities. That sampling is discussed in detail in Section 3.3 of this report. The plant community assessments identified invasive plant species present on 17 of the 20 sites. Each site documented plant species at 100 points; therefore any invasive plant could be documented up to 2000 times.

The largest number of invasive plants encountered was in the Housatonic Watershed. Of these, Japanese barberry (*Berberis thunbergii*) was encountered 94 times, and is the 18th most common plant encountered in the Western Basin (*Figure 2.4-1*). The other invasive species encountered in the Housatonic Watershed are Morrow's honeysuckle (*Lonicera morrowii*), Oriental bittersweet (*Celastrus orbiculatus*), common buckthorn (*Rhamnus cathartica*), multiflora rose (*Rosa multiflora*), creeping Jenny (*Lysimachia nummularia*), winged burning bush (*Euonymus alatus*), and garlic mustard (*Alliaria petiolata)*.

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[13] 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. 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.
[14] 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/)

The second largest number of invasive plant encountered was in the Hudson Watershed. Of these, garlic mustard (*Alliaria petiolata*), multiflora rose (*Rosa Multiflora*), Morrow's honeysuckle (*Lonicera morrowii*), and common buckthorn (*Rhamnus cathartica*) were encountered the most. Other invasive plants encountered include creeping Jenny (*Lysimachia nummularia*), bishop's goutweed (*Aegopodium podagraria*), Oriental bittersweet (*Celastrus orbiculatus*), and glossy buckthorn (*Frangula alnus*).

The most abundant invasive plant species encountered in the Westfield Watershed were glossy buckthorn (*Frangula alnus*), and Oriental bittersweet (*Celastrus orbiculatus*). Other invasive plant species encountered were Japanese knotweed (*Polygonum cuspidatum*), multiflora rose (*Rosa Multiflora*), bishop's goutweed (*Aegopodium podagraria*), and Japanese barberry (*Berberis thunbergii*).

Invasive plant species were encountered the least the Deerfield Watershed. The invasive plant species encountered include bishop's goutweed (*Aegopodium podagraria*), multiflora rose (*Rosa Multiflora*), Japanese barberry (*Berberis thunbergii*), and reed canary-grass (*Phalaris arundinacea*).

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 IPANE to map, inventory, and track the location of invasive species;

- Encourage recreational boaters to participate in decontamination measures, such as removal of all plant material from hulls, propellers, and washing down all parts of the boat prior to entering another waterbody;

- Practice decontamination and disinfection of field equipment measures when leaving a wetland area. This involves removing all plant particles from clothing and rinsing rubber boots and equipment with a mild bleach solution prior to a final rinse down in order to minimize the risk of spreading invasive plant seeds or propagules as well as minimizing the risk of spreading amphibian pathogens such as Chytridiomycosis or Ranavirus.

Figure 2.4-1: Western Basin: Common Plants Encountered
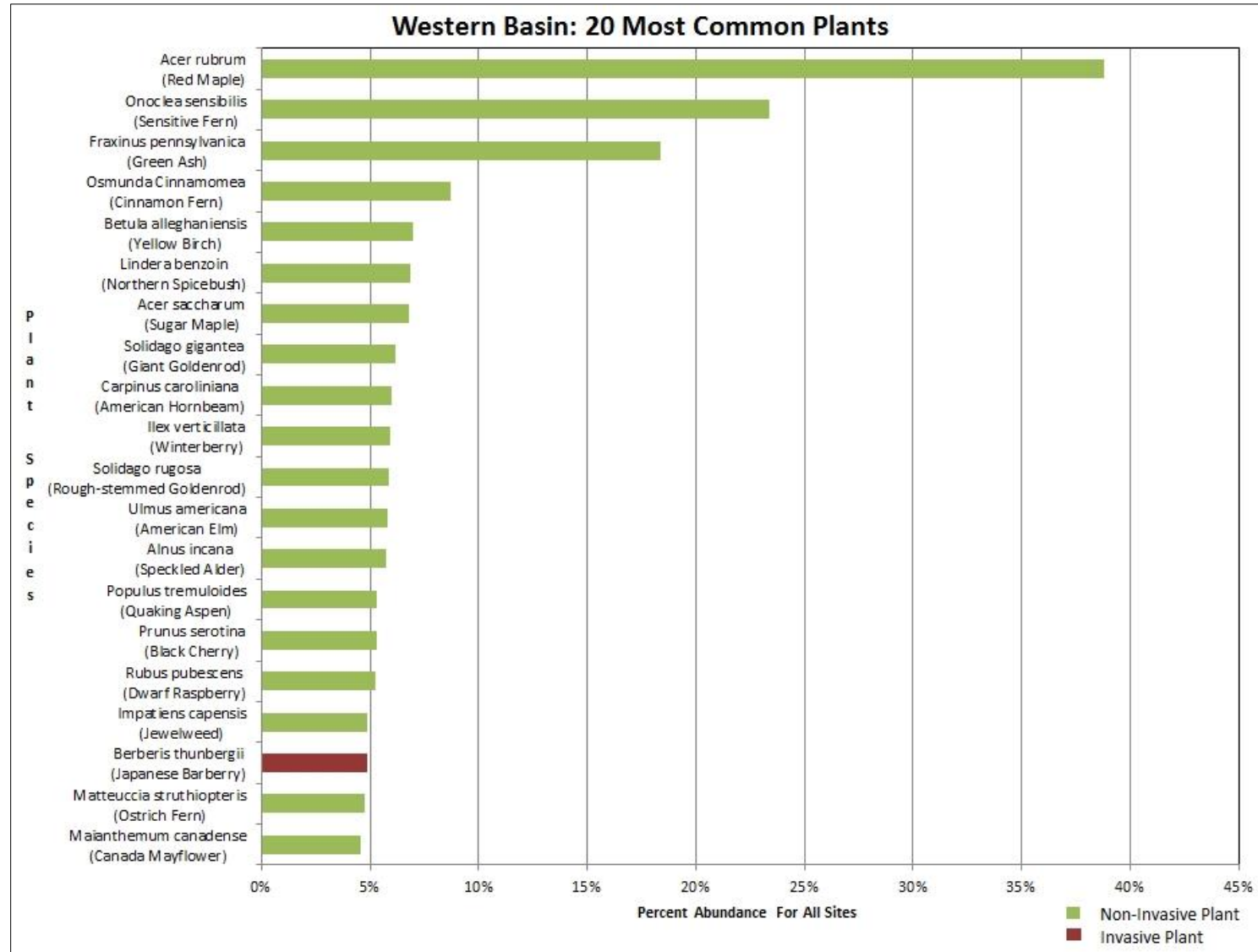
The most common plants encountered during the sampling of the Western Basin are shown in the graph above. The plants tallied for each site were summed together then divided by the total number of sample points(X/2000) to determine the relative abundance of each species.

Figure 2.4-2: Western Basin: Invasive Plants Encountered


Western Basin: Invasive Plants Encountered
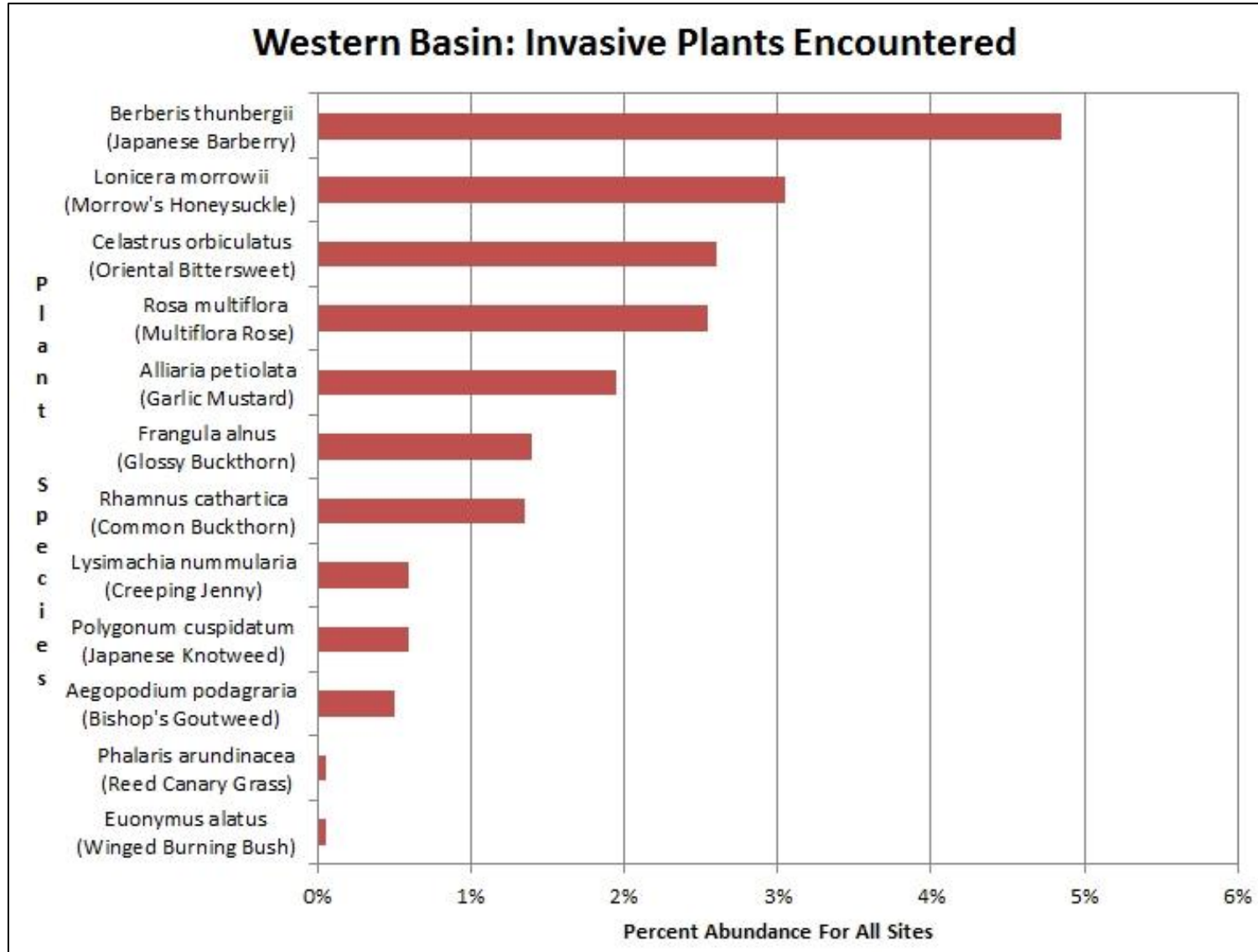
The invasive plants encountered during the sampling of the Western Basin are shown in the graphs above. The plants tallied for each site were summed together then divided by the total number of sample points(X/2000) to determine the relative abundance of each species.

Figure 2.4-3: Western Basin: Sites with Invasive Plants
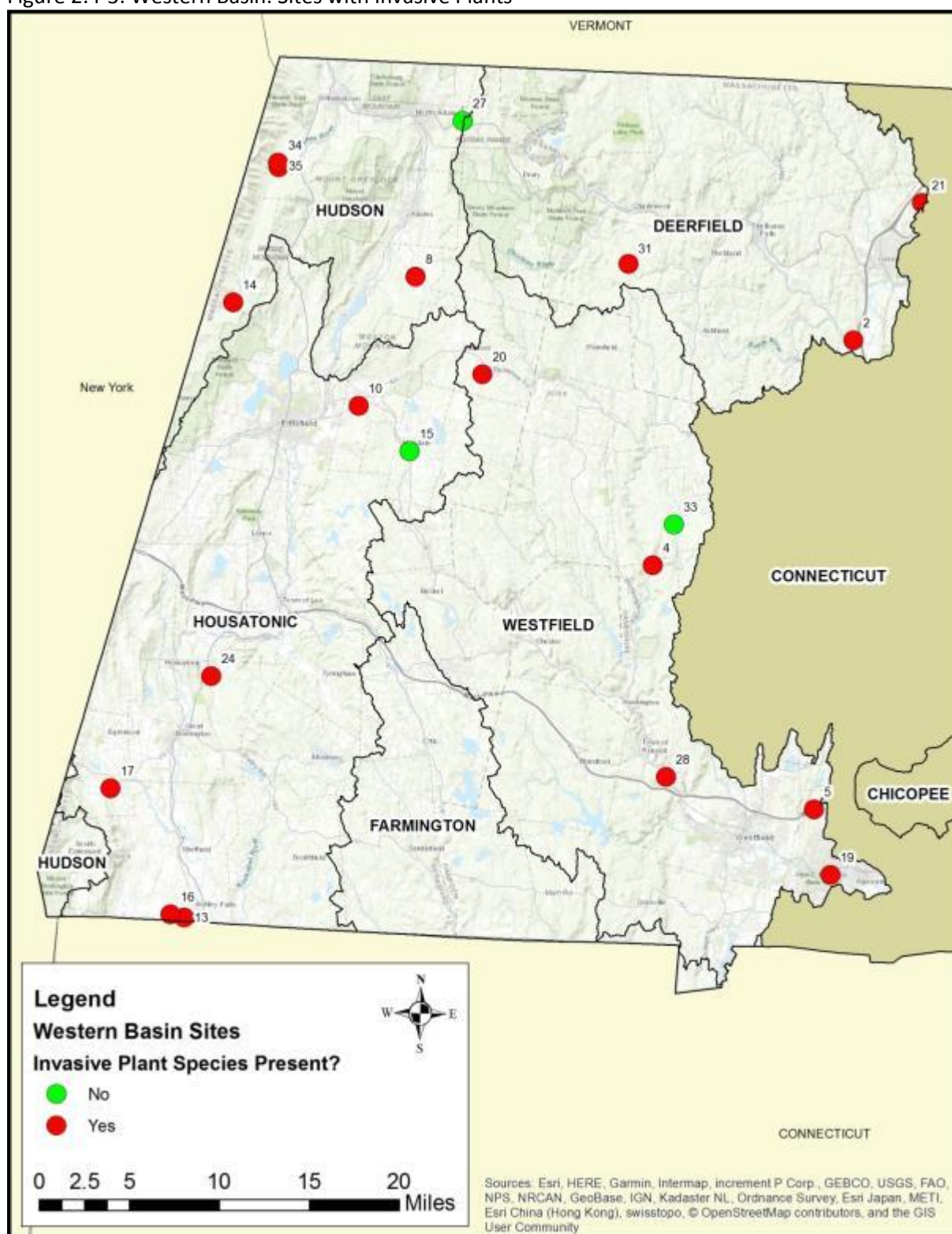
Shown in the maps above are the site locations where invasive plants were found. Invasive plants are more likely to be found in the more developed areas of the watershed

2.5   Habitat Loss

Land use change is a major driver in habitat fragmentation (breaking apart a larger habitat into several smaller pieces), [15] which results in loss of habitat as well as reduction of biodiversity. Impacts to intact ecosystems from land uses such as urban development, agriculture, highways, and dams generally reduce or degrade suitable ecosystem habitat for plants and animals to survive and flourish. Habitat loss is one of the top five stressors impacting the Western Basin (see *Figure 2.1-2*).

The habitat loss metric measures the intensity of habitat loss caused by anthropogenic development in the area surrounding each cell on the natural 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 based 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. Large expanses of undisturbed land provide intact habitat for a wide variety of species, and make the ecosystem more resilient to anthropogenic incursion. [16] As development occurs around the edges, wildlife still has refuge to retreat into. Small patches of undeveloped land on the other hand, are more susceptible to land use change and heavy development since the natural landscape has less interior to provide refuge. That makes them less resilient. Available and sustainable habitat contributes to the long term health and integrity of the ecosystem as a whole.

Similar to the Critical Linkages Project referenced above, one solution discussed in the literature is to create wildlife corridors that link separate habitat zones making it easier for wildlife to move freely from one patch of habitat to another without injury. [17] The corridors can include crossing structures, discussed above; otherwise, highways, railways, and other development create obstacles to migration.

One of the most effective ways 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*. 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-Amherst website[18] *Figures 2.5-1*, is an example of the maps that are available.

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

[16] Bartlett, L. J., Newbold, T., Purves, D.W., Tittensor, D.P., Harfoot, M.B., *Synergistic impacts of habitat loss and fragmentation   on model ecosystems,* 2016.DOI: 10.1098/rspb.2016.1027

[17] 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.

[18] http://www.umasscaps.org/data_maps/massdep-maps.html

Figure 2.5-1: Habitat Map for the Town of Pittsfield, MA
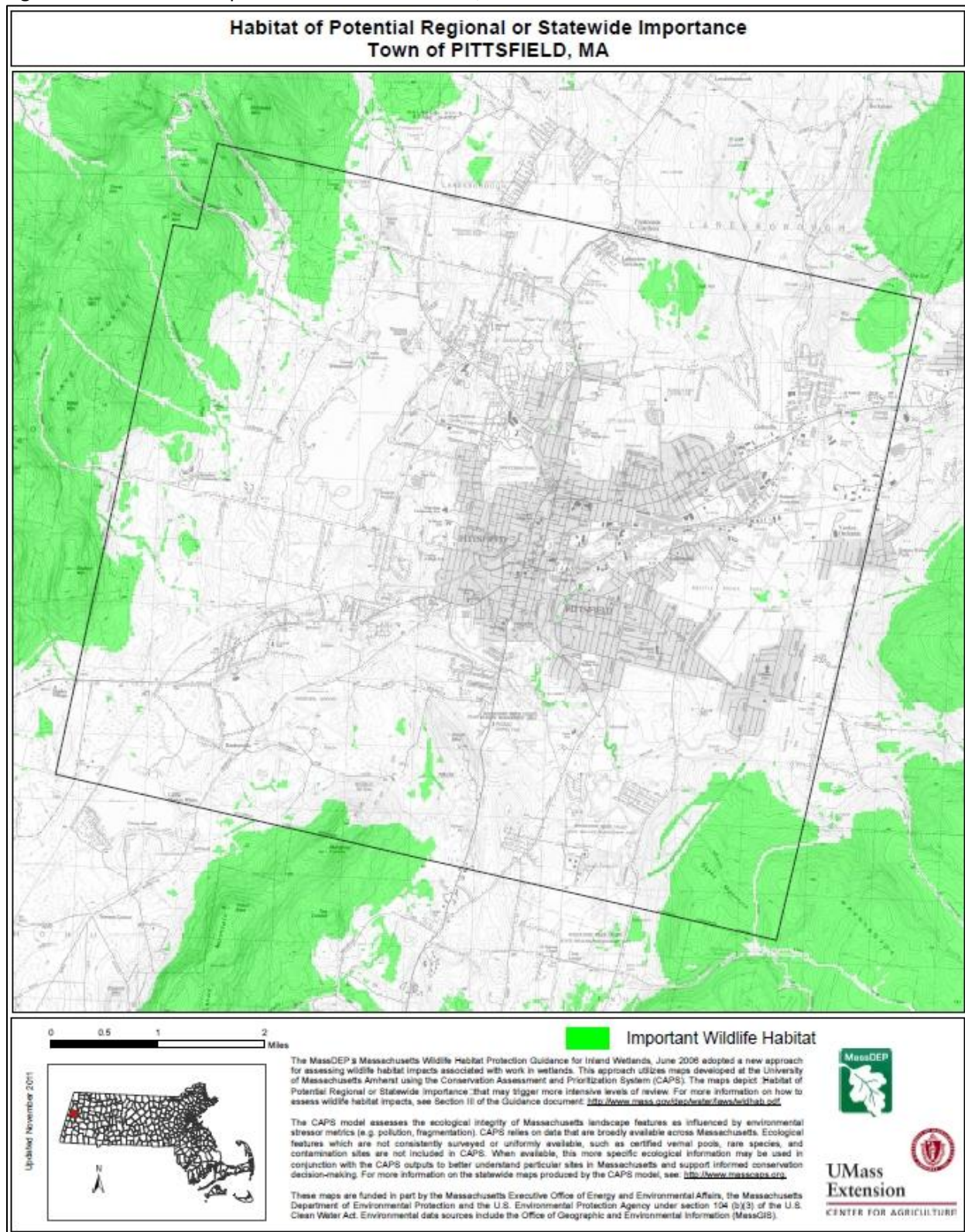
Maps depicting 'Habitat of Potential Regional or Statewide Importance' (example shown above) display polygons (in green) that represent the top 40% IEI from CAPS. The polygons represent potential candidates for preservation of important wildlife habitat, and should be investigated where habitat loss is a major cause of degradation.

3.0   Western Basin Study Watersheds: Site Level Analysis

3.1   Indices of Biological Integrity

The onsite component of this study involved application of an empirically-based assessment method using IBI's for forested wetlands within the Western Basin. 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 388 forested wetland sites across a range of stressor gradients in three different watersheds across the state.[19] The IBI's were then developed based on statistical analysis that identified relationships between specific taxa or groups of taxa and specific stressor or resiliency metrics, as well as the IEI.

The analysis of the IBI data for forested wetlands indicated that they 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[20] 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. Seven metrics showed a strong enough statistical correlation to be deemed reliable, based on vascular plant data collected for each site. Those seven metrics are:

- Loss of Connectedness – the degree to which wetland systems are fragmented.
- Habitat Loss – the degree to which habitat has been lost to anthropogenic uses.
- Edge Predators – the degree to which mesopredators[21] are unchecked and impacting the wetland.
- Watershed Habitat Loss – the degree to which habitat has been lost to development or anthropogenic uses in the neighborhood upstream
- Mowing & Plowing – the degree to which agriculture may be impacting the wetland system.
- Invasive Plants – the degree to which invasive plants may be impacting the wetland system.
- Invasive Worms – The degree to which invasive earthworms may be impacting the wetland system.

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[19] 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

[20] 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.

[21] 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.

3.2 Continuous Aquatic Life Use

The 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). 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 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.

3.3 Site Selection and Sampling Procedure

Site Selection

In 2017, MassDEP sampled a total of 20 deciduous dominated (<30% conifer cover) forested wetland sites in the Western Basin. The Western Basin was selected in accordance with the MassDEP 5-year basin cycle for water quality sampling and reporting pursuant to the CWA. Using a probabilistic sampling approach, MassDEP randomly selected 20 deciduous dominated forested wetlands with a state-wide IEI value between 0.4 and 0.7 within the Western Reporting Basin. Wetlands with an IEI between 0.4 and 0.7 were chosen because this mid-range of values allows for the identification of wetland sites that exceed or fail to meet expectations. A probabilistic approach was chosen because it increases the spatial extent of wetlands being sampled and reduces bias. This randomized sampling of a defined target population provides data to allow us to apply the IBIs within the CALU to gain an understanding of wetland condition. The goal of our study is to document the ecological integrity of forested wetlands in order to assess the wetland health within Massachusetts and better understand some of the secondary impacts that are affecting wetland health.

Sampling Procedure

Data was collected on presence of vascular plants, and physical alterations. 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 3.3-1* for an example of the plot.

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%.

Figure 3.3-1: Sample Vegetation and Physical Alteration Plot Set-up
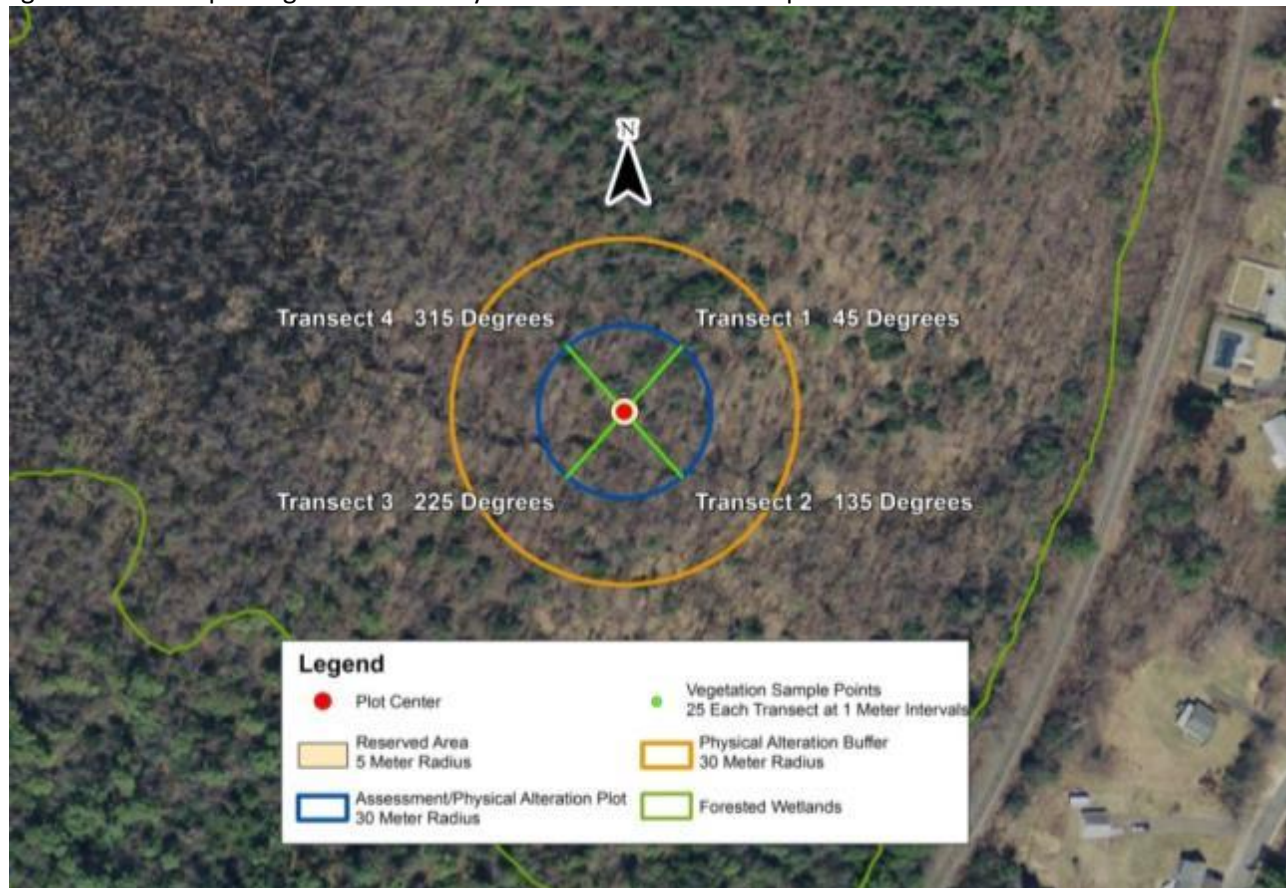
Typical Plot set up in a forested wetland. Plant species are tallied in the four ordinal directions. The Physical Alteration plot includes the entire assessment plot, and a 30 meter buffer outside of the assessment plot.

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 reconfigured in accordance with the approved Quality Assurance Project Plan (QAPP). [22] 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. A five meter 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, e.g. when a *Carex sp*. without an inflorescence was encountered. All plants were identified in accordance with the United States Department of Agriculture (USDA) Plants Database nomenclature.[23]

Physical Alteration data collection was incorporated to assess the degree of physical stressors that were affecting the survey plot, but which may not have been evident or identified on any GIS data layer. Physical

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[22] http://www.mass.gov/eea/agencies/massdep/water/watersheds/quality-assurance-project-plans-qapps.html
[23] http://plants.usda.gov/java/

Alterations documented may be the result of natural occurrences (e.g. storm damage or beaver activity) or anthropogenic activities (e.g. ditching, vegetation removal). The Physical Alteration Data collected is located in Appendix E. The method for documentation of the physical alteration was:

a. Data is tracked in an excel spreadsheet and populated in the appropriate cells using a ruggedized field tablet computer (Trimble Yuma 2). A value of 0 to 4 must be entered in each cell in order to confirm the investigator reviewed that parameter. That value of 0 to 4 pertains to the percent of alteration on the site, determined using percent cover charts:

   0 = No disturbance present

   1 = 1-24% of the plot is impacted

   2 = 25-49% of the plot is impacted

   3 = 50-74% of the plot is impacted

   4 = 75-100% of the plot is impacted

b. The investigators walked through the vegetation sample plot and the physical alteration buffer plot (see *Figure 3.3-1*) and documented the presence and extent of the physical alterations observed on the Physical Alterations Form.

c. In cases where the physical alteration could not be documented in the field (i.e. when residential property was adjacent to the assessment area) it is determined via aerial photography, and the cell was colored light blue to denote this.

3.4   Site Data Results

The focus of the Western Basin study was to sample 20 randomly selected sites to determine if the wetlands meet the expected IEI score, which is a surrogate for, or prediction of, wetland condition or health – for the site and the landscape around the site. The results of the assessments are depicted in *Figure 3.4-1* and *3.4-2*. Of the 20 sites sampled, 6 failed to meet expectations, 1 site exceeded expectations, and 13 sites met expectations of the IEI. As explained above, it is expected that most sites would fall within the "meets" range. When a site fails to meet expectations it suggests that there is something different about the site. That difference could be a stressor that the model underestimates or a stressor that the model failed to identify. In those cases further investigation is warranted in order to attempt to identify and assess the stressors, as the site is likely not meeting expectation for more than one reason. The further investigation includes: reviewing the CAPS metric calculations to see what the IBI is identifying as a stressor relationship, reviewing physical alteration notes, reviewing aerial photographs, and revisiting the sites that did not meet expectations.

Two watersheds in the Western Basin had the 6 sites that *failed to meet expectations*: the Housatonic and Westfield Watersheds. Further investigation revealed that 4 of 6 sites are located in areas that appear to be subject to frequent flooding from both natural and anthropogenic causes. Those wetlands had low IBI scores, which indicate that the sediment laden waters may be impacting wetland biological condition (i.e. plants); however the wetlands' functional values of flood storage, sediment reduction and groundwater recharge appear to be intact. Two wetlands sites did *not meet expectations* (one of which also was subject to frequent flooding), which may be due to historical agricultural land use that likely resulted in the introduction of invasive plant species. Invasive plant species, such as Japanese barberry (*Berberis thunbergii*), appear to be stressing the ecological community by outperforming the native vegetation, affecting the site condition by

reducing biodiversity. One of the sites that *failed to meet expectations* could possibly be related to a major interstate highway within close proximity and / or a clearing of forest upstream in the watershed.

With multiple stressors present in the vicinity of a site that does *not meet expectations* it is difficult to determine which stressor is the primary cause. In fact, the IBI score simply means that the biotic community exhibits structure in relation to the stressor metric. Given their landscape position, and the fact that the sites are still an intact forested wetland, the site likely continues to provide some of the services and values one would expect from a forested wetland, such as pollution attenuation, sediment control, storm damage prevention and flood control.

Figure 3.4-1: *CALU Graph for all Western Basin Sites*
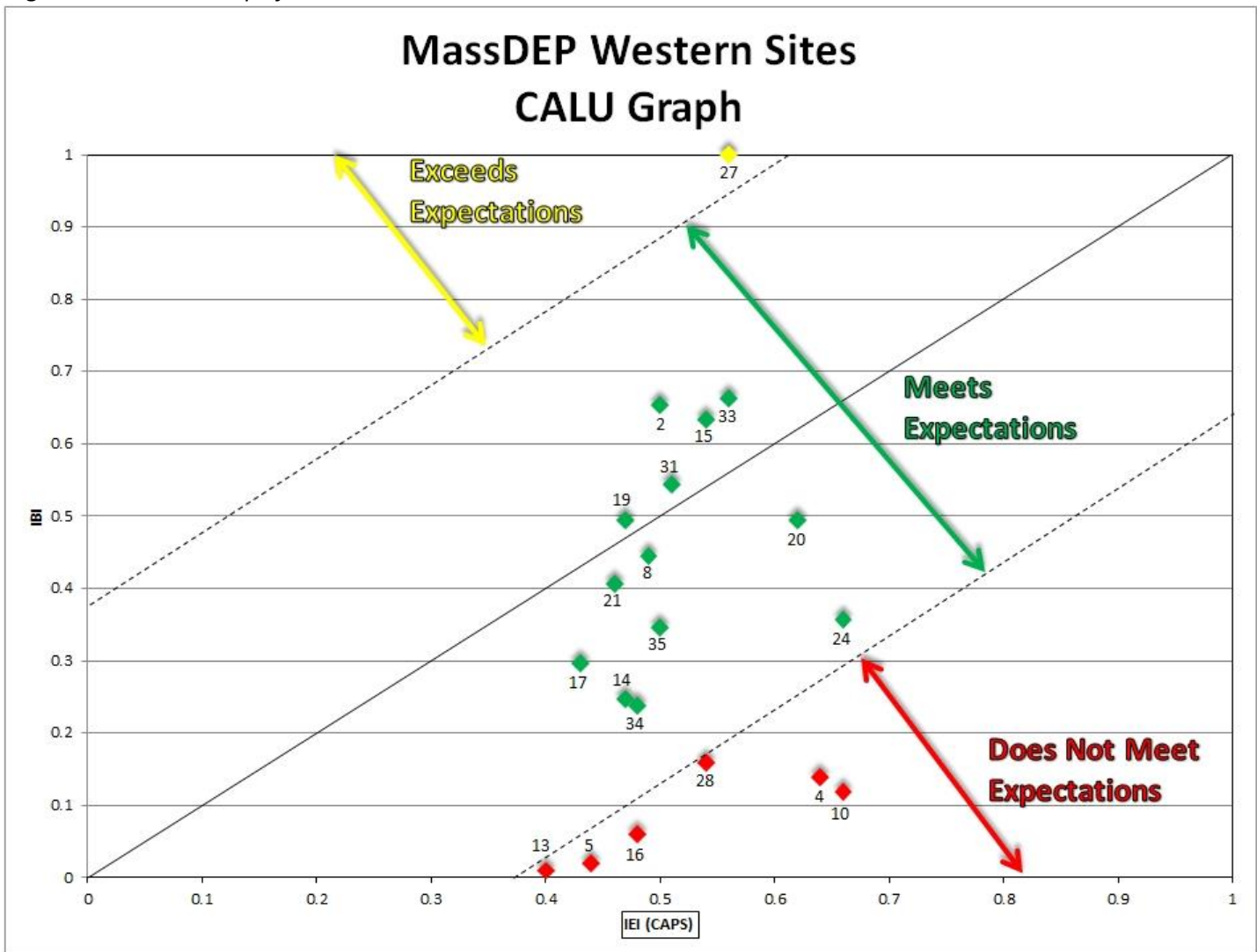
The CALU model is the basis for determining whether sites sampled in the Western Study Watersheds meet expectations, or whether they exceed or fail expectation. The CALU assessment shows that 13 sites (green diamonds) are within the two dashed lines and thus, "Meet" expectations. Six (6) of the sites "fail" to meet expectation (red triangles) because they fall below the range between the dotted lines and one(1) site "exceeds" expectations (yellow square) because it had a higher IBI than the range predicted

Figure 3.4-2: Western Basin CALU Results
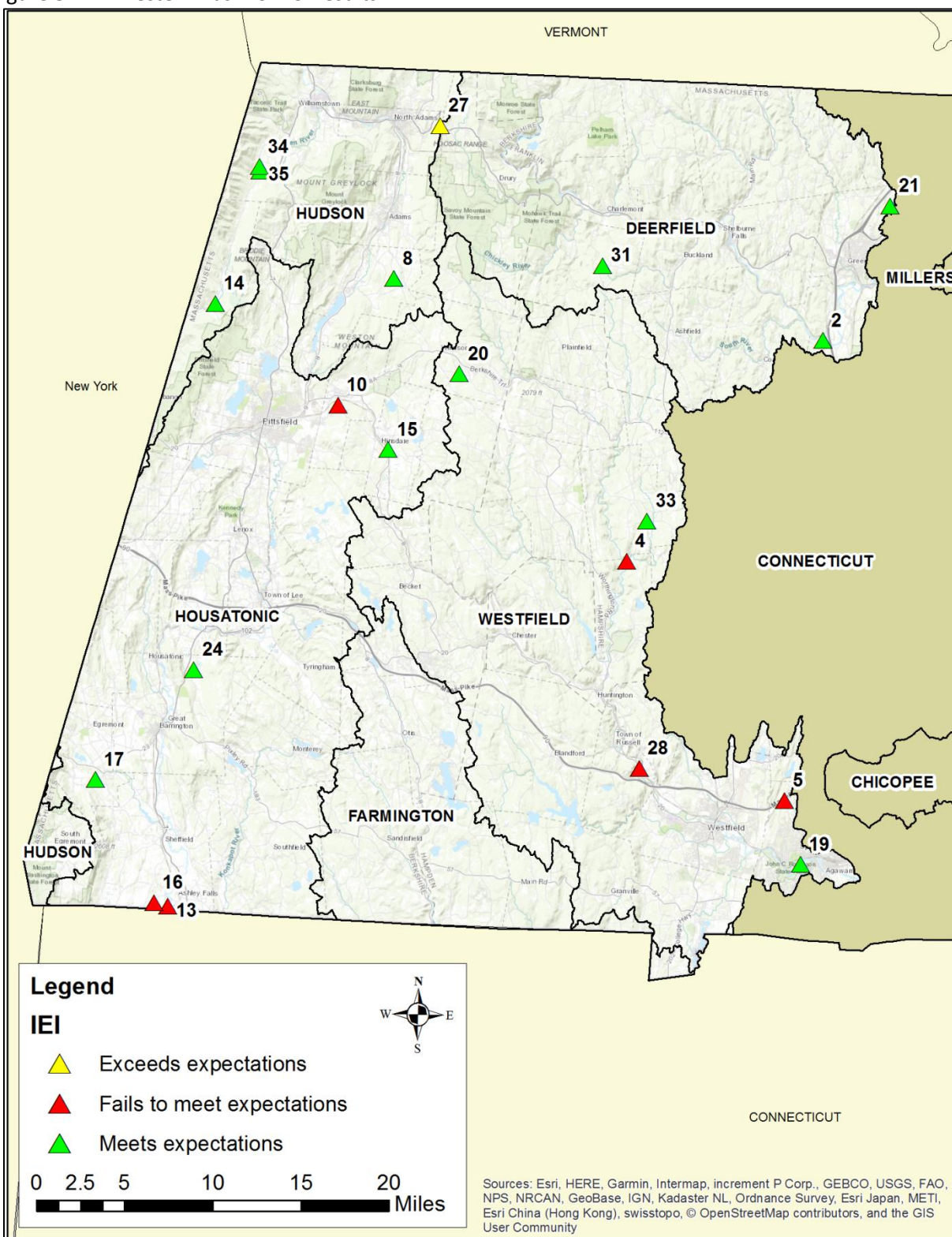
The map above shows the CALU results for each site in the Western Basin. The sites that did not meet expectations fell within two watersheds: the Housatonic and Westfield Watersheds. Due to the random selection of sites the Farmington Watershed was not sampled.

Westfield Watershed – Sites 4, 5 and 28:

The following is a discussion of each site that failed to meet expectations. Three sites located in the Westfield Watershed fell below the range of their expected IEI scores. The table in *Figure 3.4-3* compares the scoring between the model and field results for the sites that did *not meet expectations*. The following are detailed analyses of each of these sites.

Figure 3.4-3: Westfield Watershed Comparative Table of IEI and IBI Scores

Site	IEI Score (Target)	IBI Score (Actual)
Site 4	0.64	0.1387
Site 5	0.44	0.0199
Site 28	0.54	0.1585

The plants encountered at these sites are located in Appendix B, and the *plant community plots (*see example, *Figure 3.4-4*) in this section depict the key plant species that are affecting the CALU Assessment. The CAPS model predicted value is displayed 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 labels 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 of that plant. Plants with a label to the left of the IEI line will draw the IBI down from the predicted IEI; plants to the right would increase the IBI.

Westfield Watershed, Site 4:

Figure 3.4-4: Site 4 Plant Community Plot
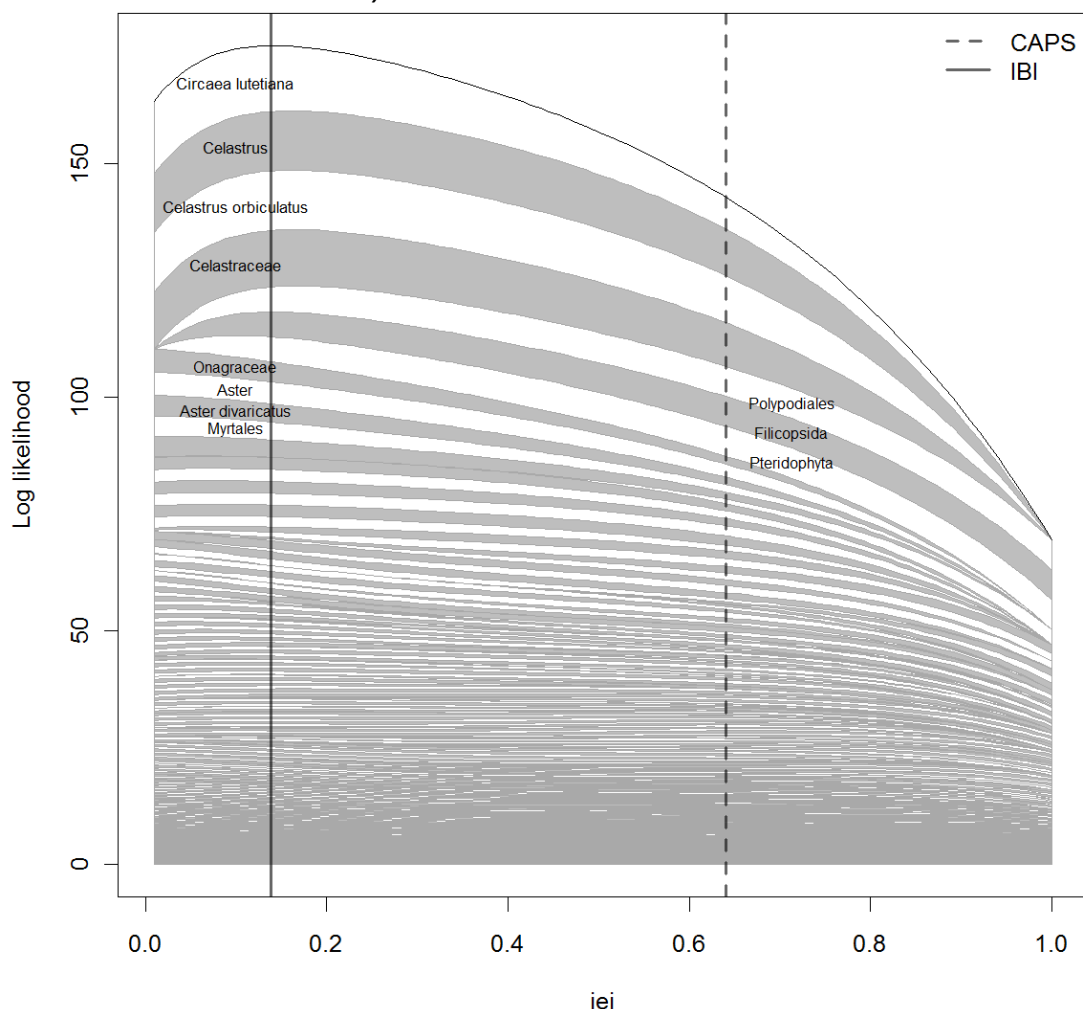
The site 4 plant community is influenced by Circaea lutetiana (enchanter's nightshade); Celastrus orbiculatus (Oriental bittersweet); and Aster divaricatus (white wood aster), which are species indicative of low IEI sites.

Site 4 is located on the inside of a Westfield River meander, which has a slower water velocity and is where sediment from the river would naturally be deposited.[24] This site is within a FEMA mapped 100-year floodplain of the Westfield River. Approximately 4 miles downstream from the site is the Knightsville Dam; according to the U.S. Army Corps of Engineers the flood storage of the dam extends about six miles upstream.[25] The vegetative community is mapped by MassWildlife's Natural Heritage & Endangered Species Program (MNHESP) as a High-terrace Floodplain Forest.[26] [27] According to the IBI Plant Community Plot (*Figure 3.4-4*), the enchanter's

[24] Dodds, W. K., & Whiles, M. R. (2010). *Freshwater ecology: concepts and environmental applications of limnology* (2nd ed.). London: Academic.
[25] http://www.nae.usace.army.mil/Missions/Civil-Works/Flood-Risk-Management/Massachusetts/Knightville/
[26] https://www.mass.gov/files/documents/2016/08/wh/high-terrace-floodplain-forest.pdf
[27] https://www.mass.gov/service-details/natural-heritage-gis-resources

nightshade (*Circaea lutetiana*), Oriental bittersweet (*Celastrus orbiculatus*), and whitewood aster (*Aster divaricatus*) present on site are indicative of low IEI scoring sites. On site, the investigators noted evidence of flood events on the whole site and most of the buffer, while storm damage and trash were present in low frequency of occurrence (see Appendix E: Physical Alteration Data). The Site did not meet the targeted score for the following metrics: Connectedness, Edge Predators, Habitat Loss, and Invasive Earthworms.

Figure 3.4-5: Westfield Watershed – Site 4 CALU Results
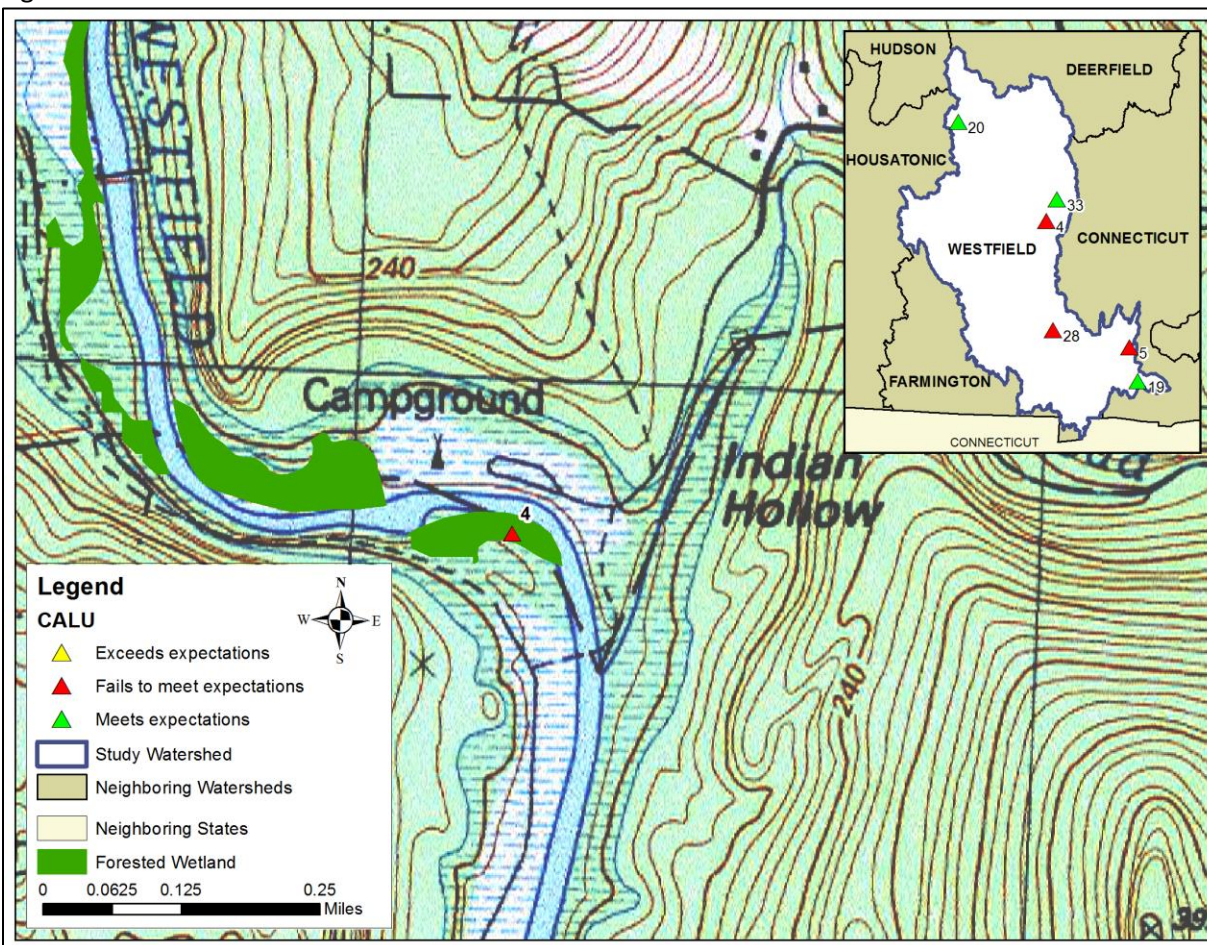
The locus map above shows the approximate location of site four. The graphic in the upper right corner shows the approximate locations of the sampled sites in the Westfield Watershed, and the assessment of forested wetland condition for each site according to the CALU framework.

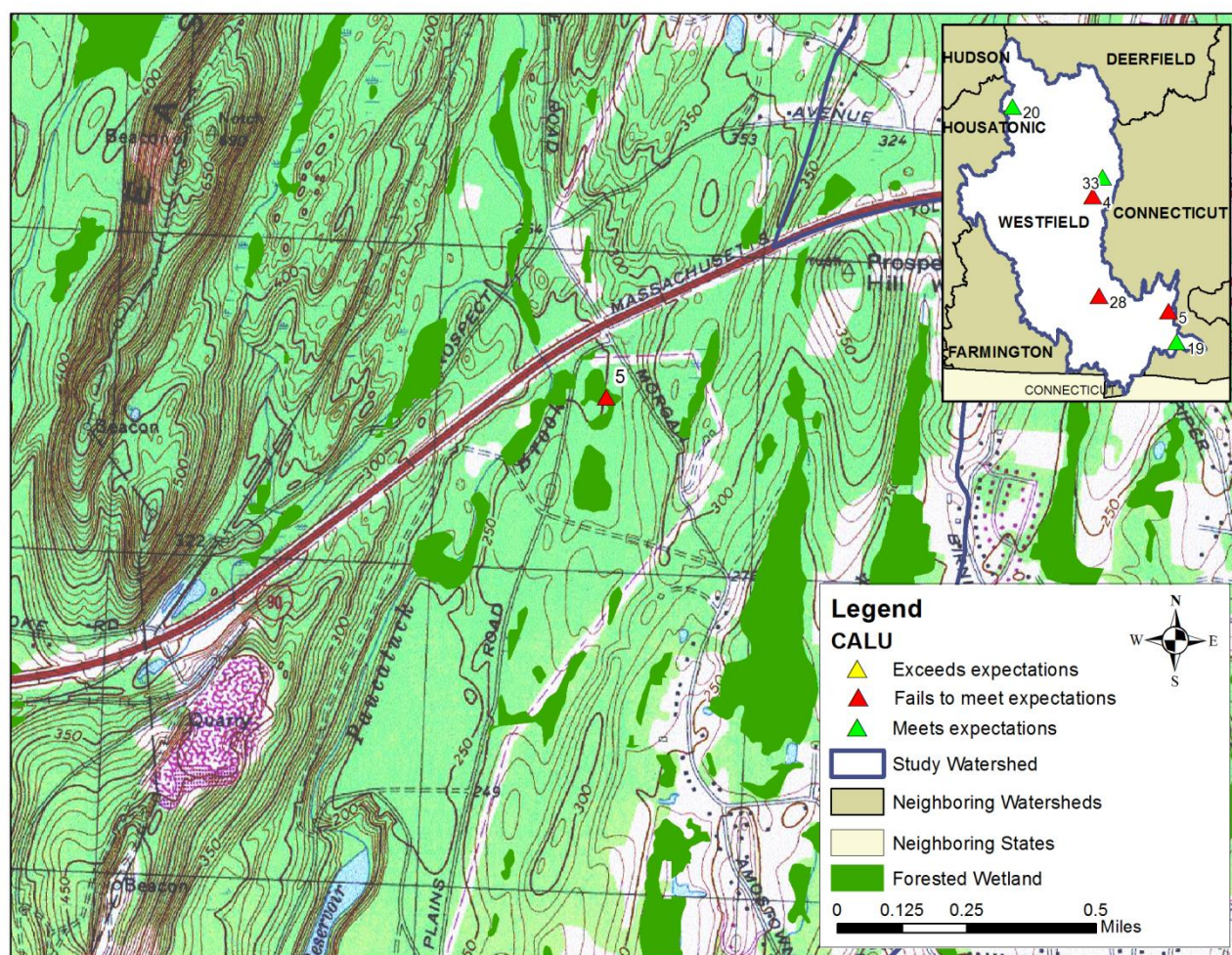Westfield Watershed, Site 5:

Figure 3.4-6: Site 5 Plant Community Plot
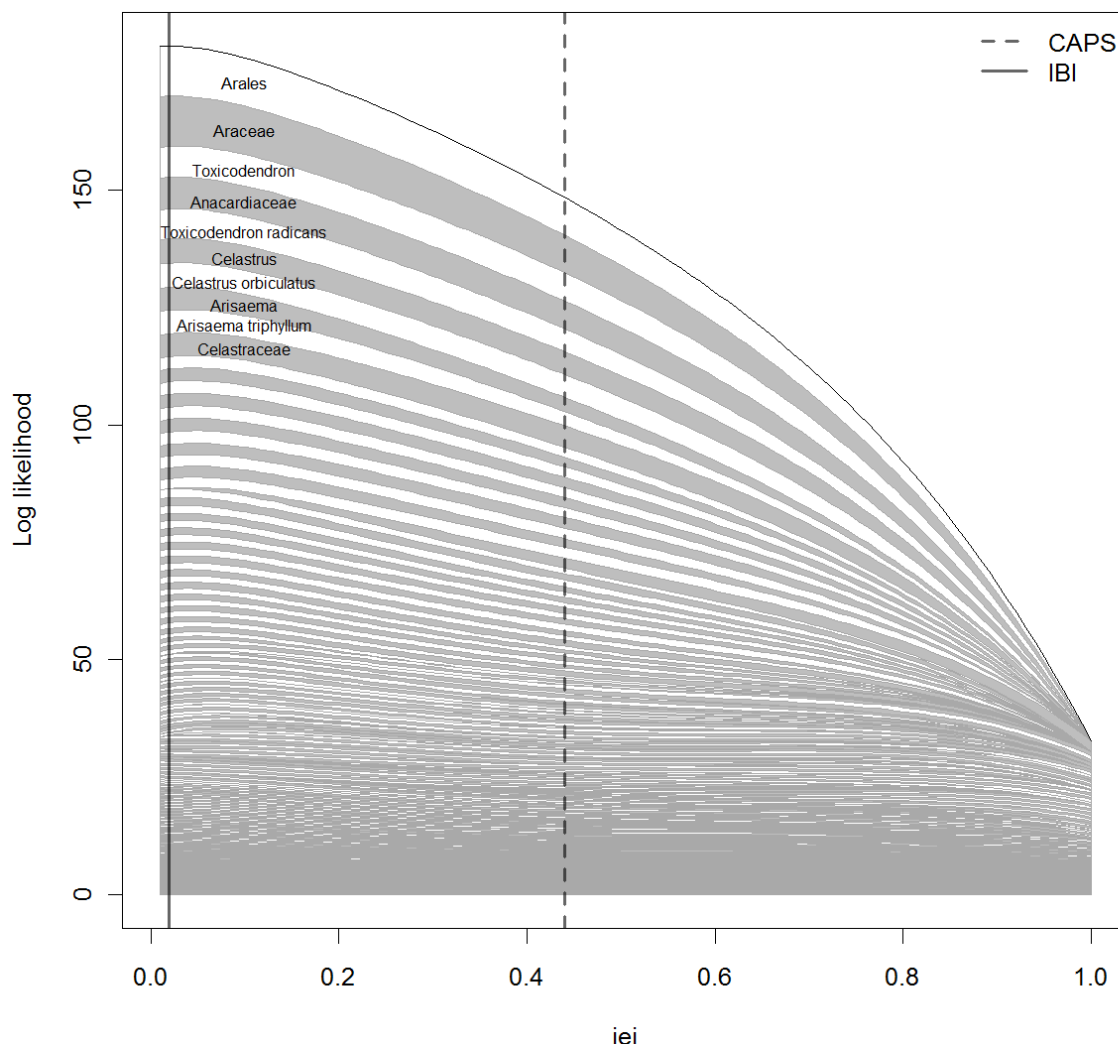
Site 5's plant community was influenced by Arisaema triphyllum (Jack-in-the-pulpit); Toxicodendron radicans (poison Ivy); and Celastrus orbiculatus (Oriental bittersweet), which are species indicative of low IEI sites.

Site 5 is located about a tenth of a mile from Massachusetts Turnpike (i.e., Interstate 90), located just outside of the FEMA mapped floodplain for Paucatuck Brook. Paucatuck Brook connects Bearhole Reservoir and Ashley Pond. IBI Plant Community Plot (*Figure 3.4-6*) identified plants on site that are indicative of lower IEI scoring sites such as: Jack-in-the-pulpit (*Arisaema triphylum*), poison ivy (*Toxicodendron radicans)*, and Oriental bittersweet (*C. orbiculatus*). While on site, the investigators identified minor occurrences of storm damage and ATV use. The site did not meet expectations for the CAPS IBI metrics: Edge Predators, Habitat Loss, Mowing and Plowing, Watershed Habitat Loss, and Invasive Earthworms.

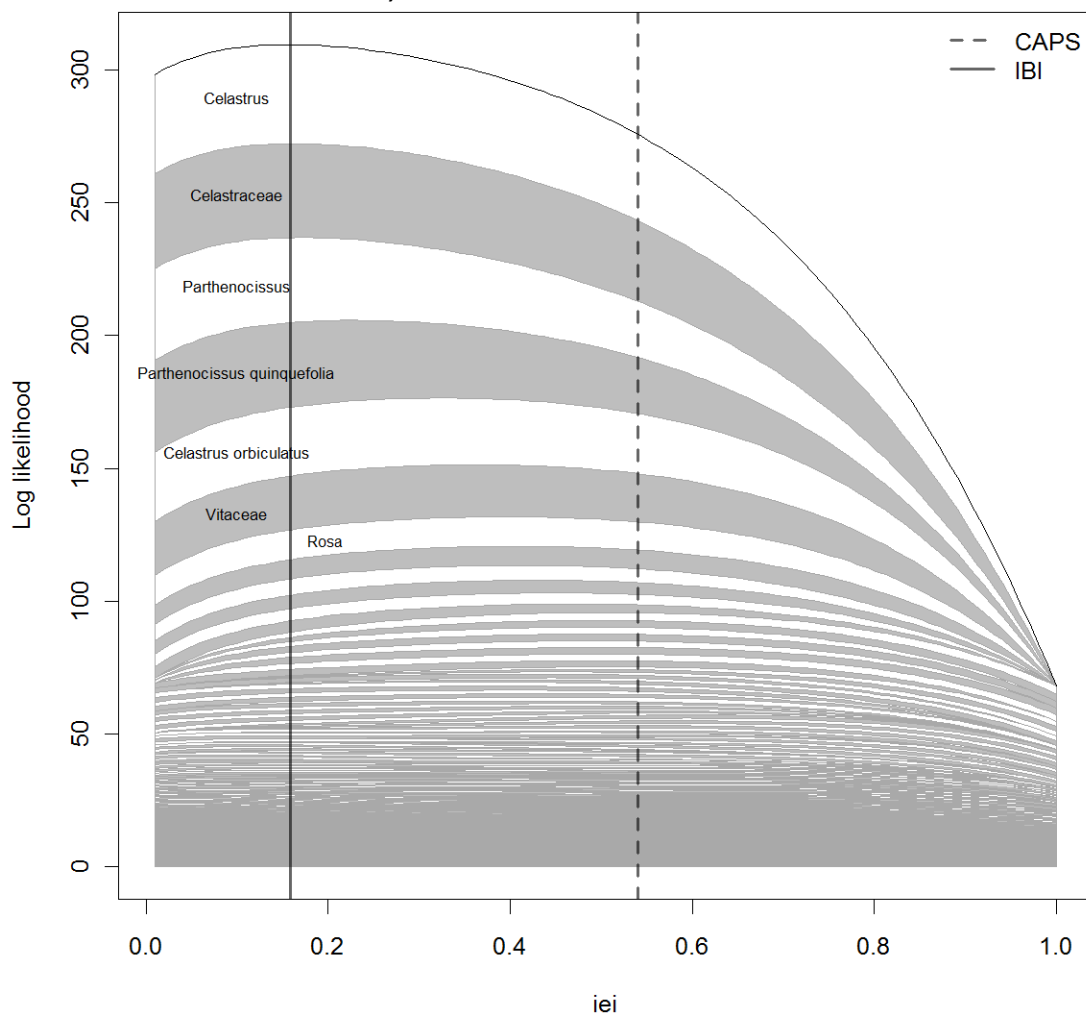Figure 3.4-7: Westfield Watershed – Site 5 CALU Results

The graphic shows the approximate locations of the sampled sites in the Westfield Watershed, and the assessment of forested wetland condition for each site according to the CALU model.
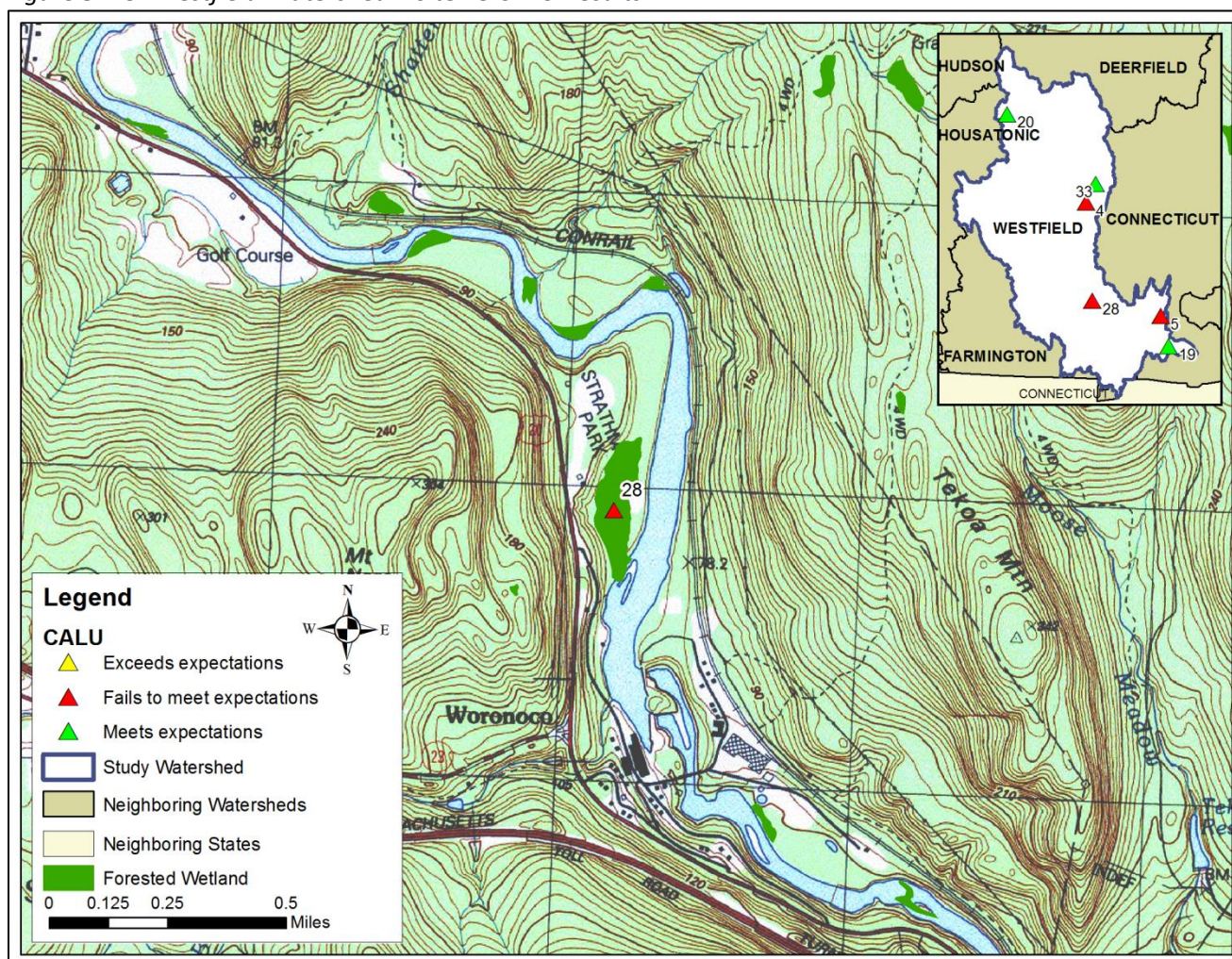
Westfield Watershed, Site 28:

Figure 3.4-8: Site 28 Plant Community Plot

The plant community of site 28 is influenced by the presence of Celastrus orbiculatus (Oriental bittersweet); Parthenocissus quinquefolia (Virginia creeper); and Rosa multiflora (Multiflora Rose) which are species indicative of low IEI sites.

Site 28 is located along the Westfield River. The site is less than a half mile upstream from the Woronoco Mill dams, which are used for hydroelectric power. The site is 2.25 miles downstream from the Westfield Paper Company dam that is also used for hydroelectric generation. Both dam systems are actively maintained. The site is located within a FEMA mapped 100-year floodplain. The Strathmore Park (Community Groundwater) Well operated by the Town of Russell is located within the buffer of the site. Paths have been cleared around the site to provide access to the well. The site did not meet the target IBI scores for the CAPS metrics: Invasive Plants, Edge Predators, Habitat Loss, Mowing and Plowing, Watershed Habitat Loss, and Invasive Earthworms. The IBI score is influenced by the presence of Oriental bittersweet (*C. orbiculatus*), Virginia creeper (*Parthenocissus quinquefolia*), and multiflora rose (*Rosa multiflora*) shown in the site's Plant Community Plot (*Figure 3.4-10*).

Figure 3.4-9: Westfield Watershed – Site 28 CALU Results

The graphic shows the approximate locations of the sampled sites in the Westfield Watershed, and the assessment of forested wetland condition for each site according to the CALU model.

Housatonic Watershed: Sites 10, 13 and 16

Three sites located in the Housatonic Watershed fell below the range of their expected IEI Scores. The following are detailed analyses of each of these sites.

Figure 3.4-10: Housatonic Watershed Comparative Table of IEI and IBI Scores

Site	IEI Score (Target)	IBI Score (Actual)
Site 10	0.66	0.1189
Site 13	0.4	0.01
Site 16	0.48	0.0595

Housatonic Watershed, Site 10:

Figure 3.4-11: Site 10 Plant Community Plot
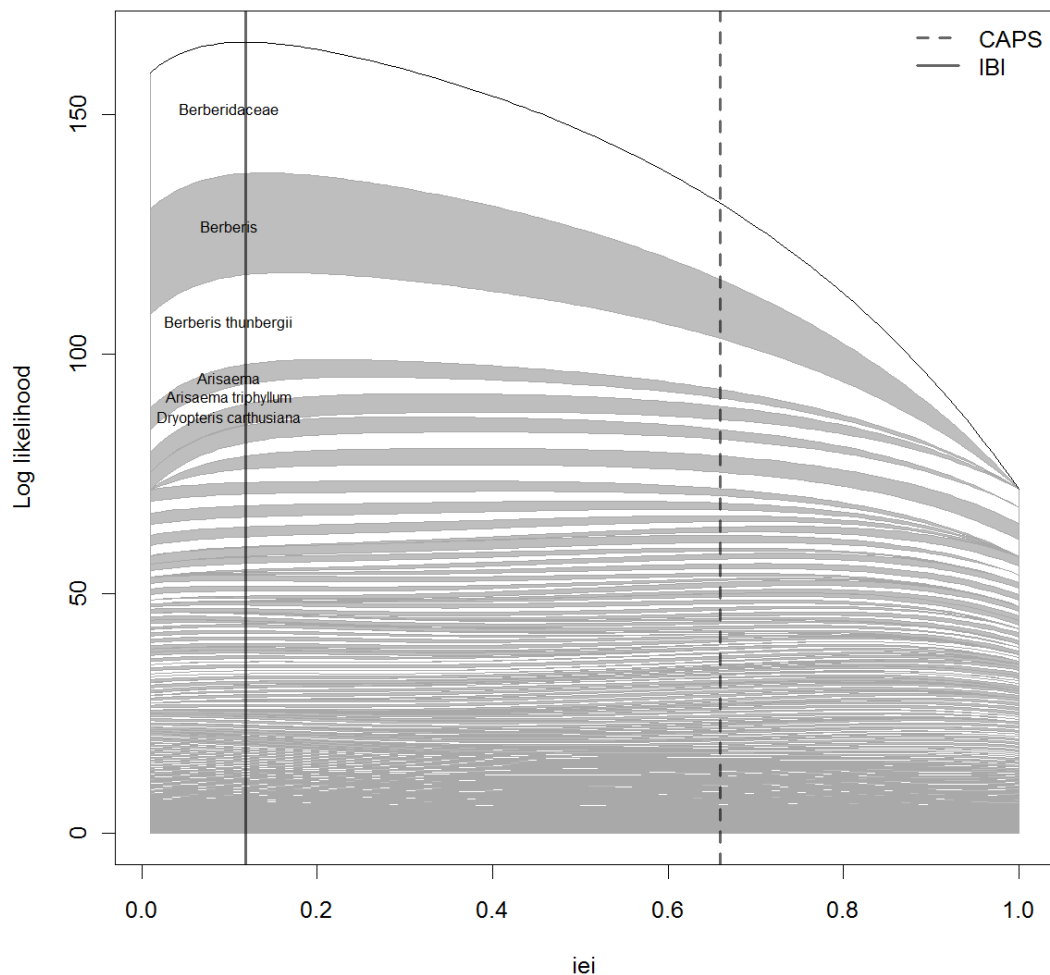
The plant community of Site 10 is influenced by the presence of Berberis thunbergii (Japanese barberry); Arisaema triphyllum (Jack-in-the-Pulpit); and dryopteris carthusiana (Spinulose Wood Fern), which are indicative of sites with low IEI. The site did not meet expectations for the Invasive Plants, Mowing and Plowing, Watershed Habitat Loss, and Invasive Earthworms metrics.

While in the field at site 10, the investigators noted a power-line cut starting at the eastern boundary of the site. The power-line cut is a form of vegetation clearing that is actively managed to allow for access to maintain the power-line when necessary. Review of historical topographic maps[28] show that the power-line cut has been present along the site as early as the 1940's. The site investigators also observed numerous birds on site, hiking trails within the wetland buffer and stone walls outside of the wetland buffer.

The site did not meet the target IBI scores for the CAPS metrics: Invasive Plants, Mowing and Plowing, Watershed Habitat Loss, and Invasive Earthworms. The wetland had 60 percent relative abundance of the listed invasive species Japanese barberry (*Berberis thunbergii*), which

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[28] http://historicalmaps.arcgis.com/usgs/

the IBI Plant Community Plot (*Figure 3.4-13*) identified as the biggest influence on the IBI score of this site. It is uncertain of what introduced the Japanese barberry on the site. A study of what makes habitats susceptible to Japanese barberry invasion found that post-introduction land use (20th century land use) along with nutrient-rich and less acidic soils influence the prone to invasion.[29] The land use of the site during the early 20th century is unknown, but the large stone walls may be indicative of an abandoned pasture.[30] The vegetation clearing along the powerline cut could also potentially impact the ecological condition of the site by allowing additional sunlight to enter the site and/or wildlife, such as birds, dispersing seeds in the wetland or on the edge of the wetland.

Figure 3.4-12: Housatonic Watershed – Site 10 CALU Results
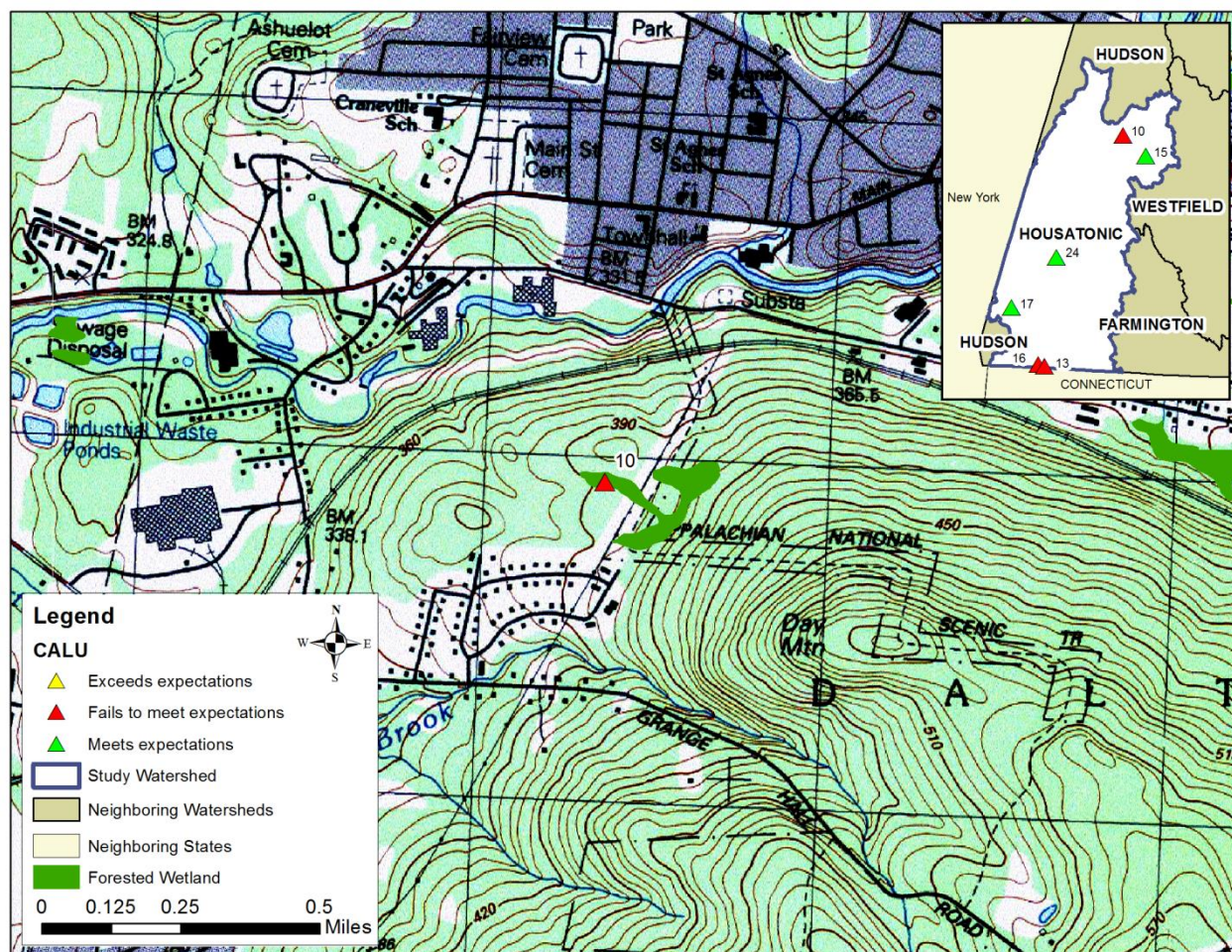
The graphic shows the approximate locations of the sampled sites in the Housatonic Watershed, and the assessment of forested wetland condition for each site according to the CALU model.
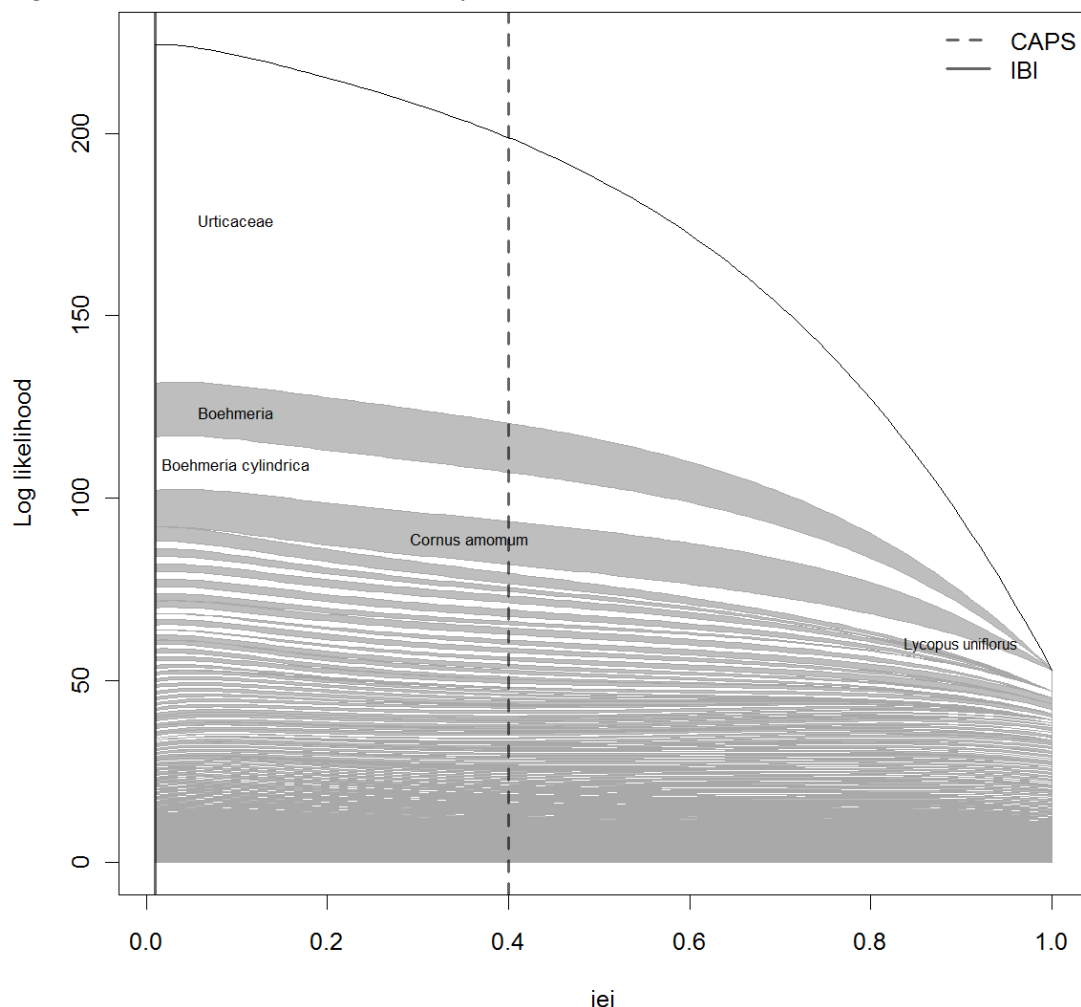
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[29] http://harvardforest.fas.harvard.edu/sites/harvardforest.fas.harvard.edu/files/publications/pdfs/DeGasperis_Ecology_2007.pdf

[30] Wessels, T. (2010). *Forest forensics: A field guide to reading the forested landscape*. Woodstock, VT: Countryman Press.

Housatonic Watershed, Site 13:

Figure 3.4-13: Site 13 Plant Community Plot

The plant community of Site 13 is influenced by Boehmeria cylindrical (False Nettle), which is indicative of low IEI sites. The site did not meet the expectations for Edge Predators, Habitat Loss, Watershed Habitat Loss, and Invasive Earthworms metrics.
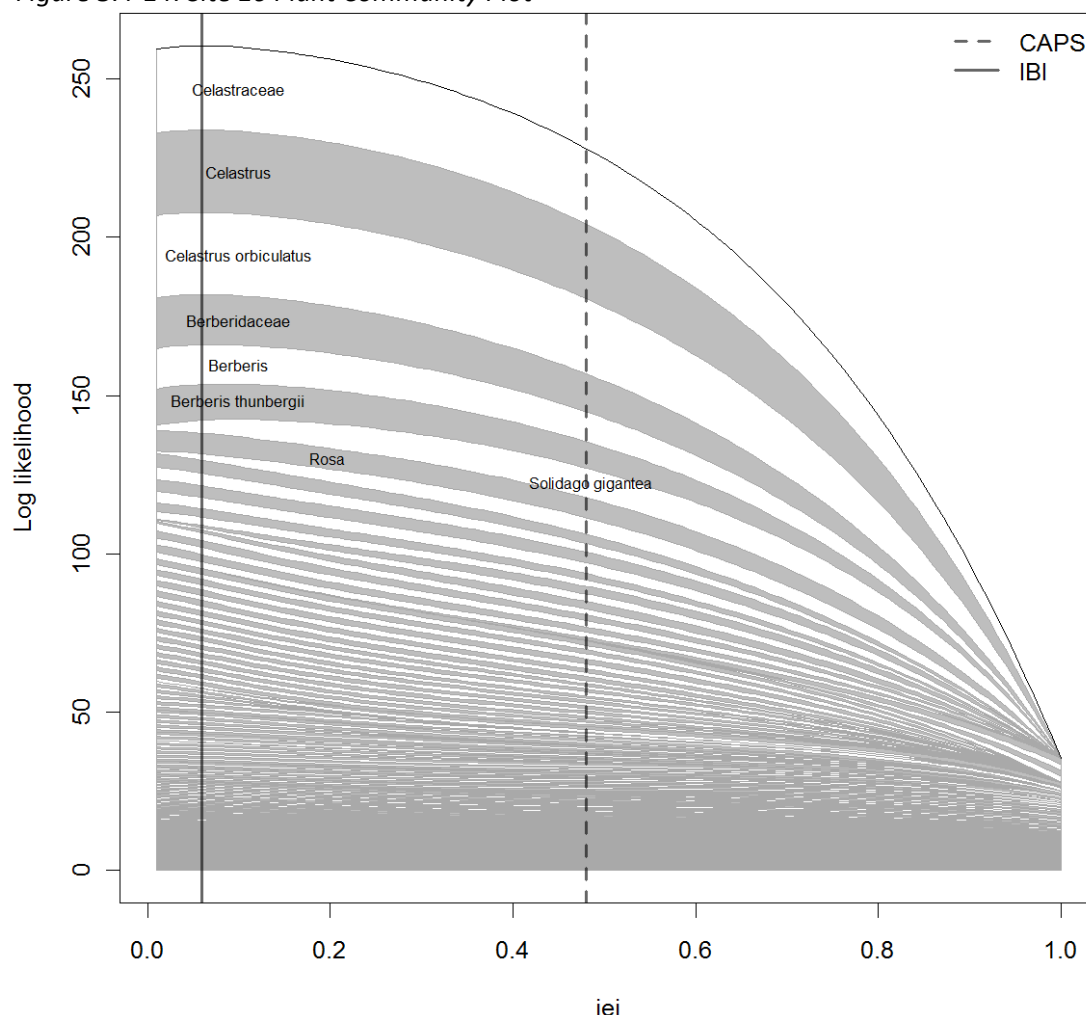
While in the field at site 13, the investigators observed that the site was impacted by flooding of the Housatonic River. The site is located within the 100-year floodplain of the Housatonic River. Trees on site had water marks from flood waters and the vegetative community is mapped by the Massachusetts Natural Heritage and Endangered Species Program (MNHESP) as a Major-River Floodplain Forest.[31] [32] The site was dominated by wood nettle (*Laportea canadensis*) with a relative abundance of 68 percent, and is in the same nettle family (*Urticaceae*) as false nettle (*Boehmeria cylindrica*) which is CAPS found to be indicative of low IEI sites (*Figure 3.4-15*). The site did not meet the target CAPS IBI metrics for Edge Predators, Habitat Loss, Watershed Habitat Loss, and Invasive Earthworms.

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[31] https://www.mass.gov/files/documents/2016/08/wk/major-river-floodplain-forest.pdf
[32] https://www.mass.gov/service-details/natural-heritage-gis-resources
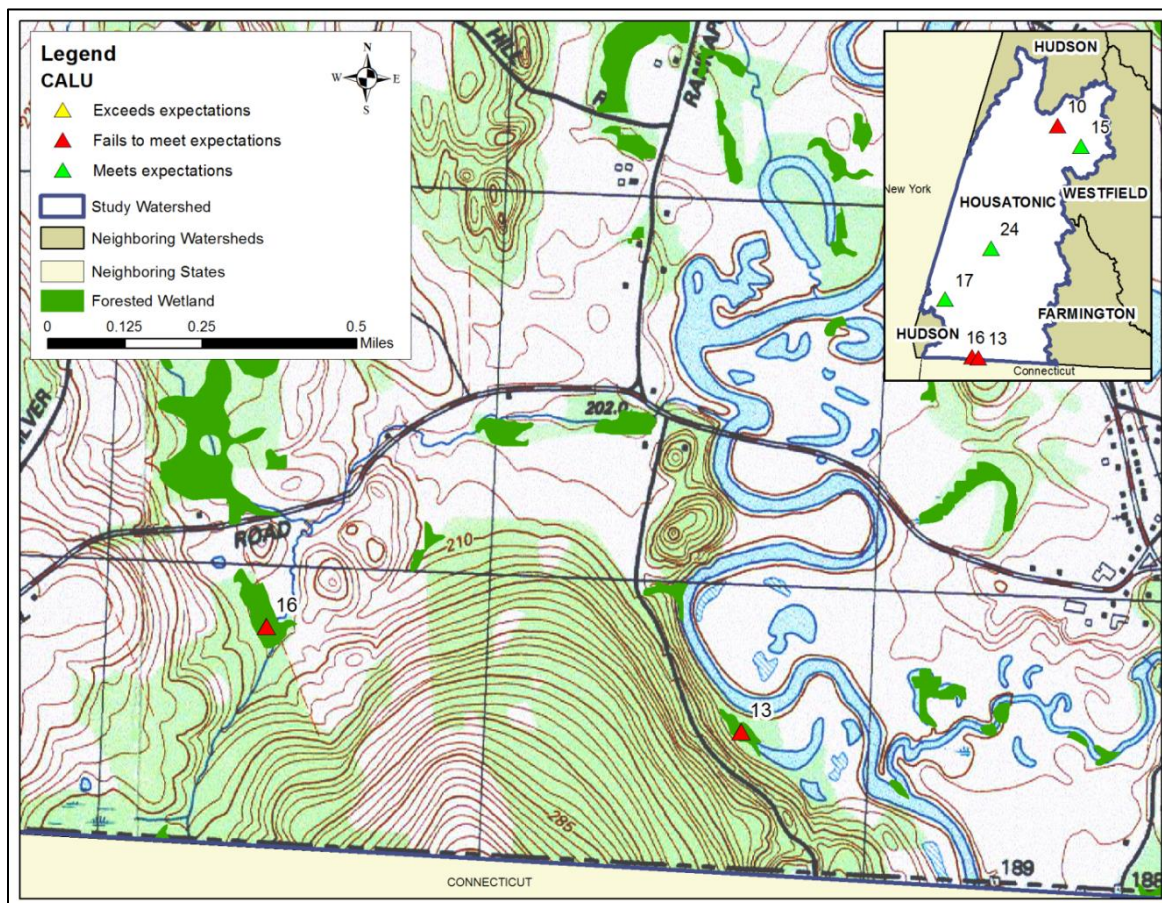
Housatonic Watershed, Site 16:

Figure 3.4-14: Site 16 Plant Community Plot

The plant community of site 16 is influenced by the presence of Celastrus orbiculatus (Oriental bittersweet)
and Berberis thunbergii (Japanese barberry), which are species indicative of low IEI sites. The Site did not meet
the targeted score for the following metrics: Invasive Plants, Edge Predators, Habitat Loss, Watershed Habitat
Loss, and Invasive Earthworms.

While in the field at site 16, the investigators noted that the site had an open canopy to the
east of the site within the buffer. The Site did not meet the targeted score for the following
metrics: Invasive Plants, Edge Predators, Habitat Loss, Watershed Habitat Loss, and Invasive
Earthworms. According to the plant community plot (*Figure 3.4-16*) the IBI score is mostly
influenced on the presence of Oriental bittersweet (*Celastrus orbiculatus*) and Japanese
barberry (*Berberis thunbergii*). The site had a 34 percent relative abundance of Japanese
barberry and 14 percent relative abundance of Oriental bittersweet. The land use of the
surrounding area is used as agriculture, and a review of historical aerial imagery has shown that
the site appears to have been used for agriculture since at least the beginning of the 20th
century. The site is also located on a Federal Emergency Management Agency (FEMA) mapped
100-year floodplain.

*Figure 3.4-15: Housatonic Watershed – Sites 13 and 16 CALU Results*

The graphic shows the approximate locations of the sampled sites in the Housatonic Watershed, and the assessment of forested wetland condition for each site according to the CALU model.

Physical Alteration Data Analysis:

After conducting the vegetation survey, the investigators walked through the vegetation sample plot and a 30 meter buffer plot to document the presence and extent of the physical alterations observed on the site. The *Physical Alteration* Data collected is located in Appendix E.

The chart in *Figure 3.4-18* shows the frequency of the different types of physical alteration that were encountered (beaver activity, ATV use, etc.). The most common physical alteration observed on the sites was storm damage, flood events, and trash/litter. The chart in *Figure 3.4-19* shows to degree of combined impact from physical alteration for each site. Four of the sites that failed to meet expectations are within mapped floodplains. Site 14 is just outside of the mapped floodplain, but there was evidence of flooding during the on-site investigation such as drift material and sedimentation. Interestingly, the site with the most diverse types of physical alteration was site 27, which received an IBI score of 1.0 (which is the highest score possible). The physical alteration consisted of road, foot path, and trash and debris. However, the extent of the physical alteration was limited to the buffer area outside of the wetland sample plot so while it was varied, it was not extensive

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Figure 3.4-16: Occurrences of Physical Alteration by Type
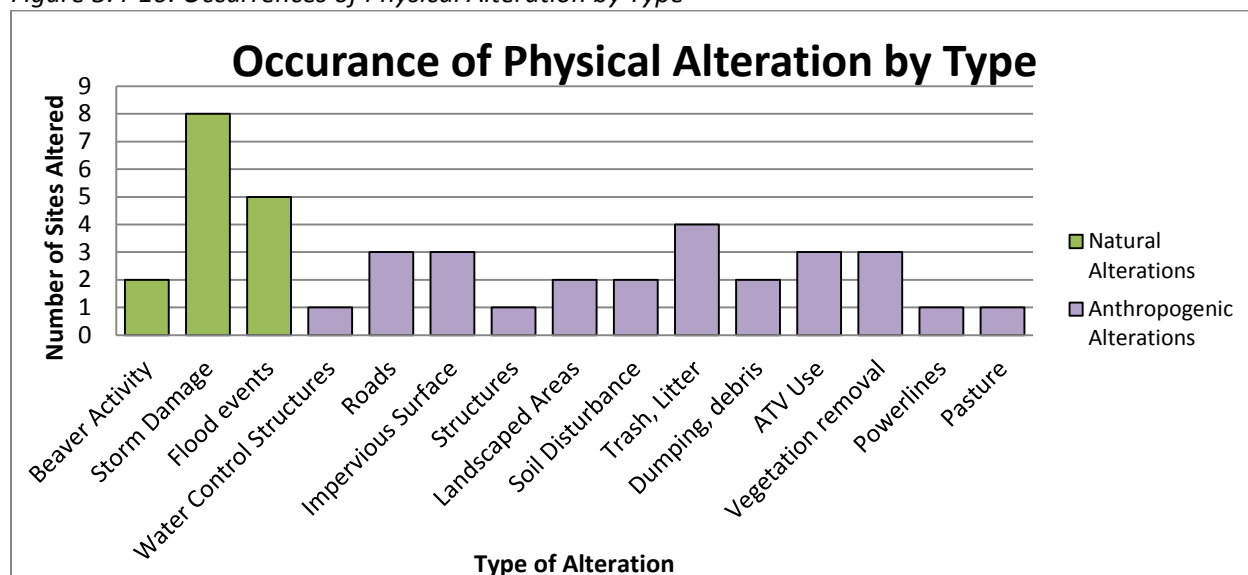
All but four sites experience some form of physical alteration. The type and number of sites it was found to occur in is depicted in the graphic above. Note that physical alteration can be a result of natural (green) or anthropogenic (purple) occurrences.

Figure 3.4-17: Degree of Physical Alteration by Sites
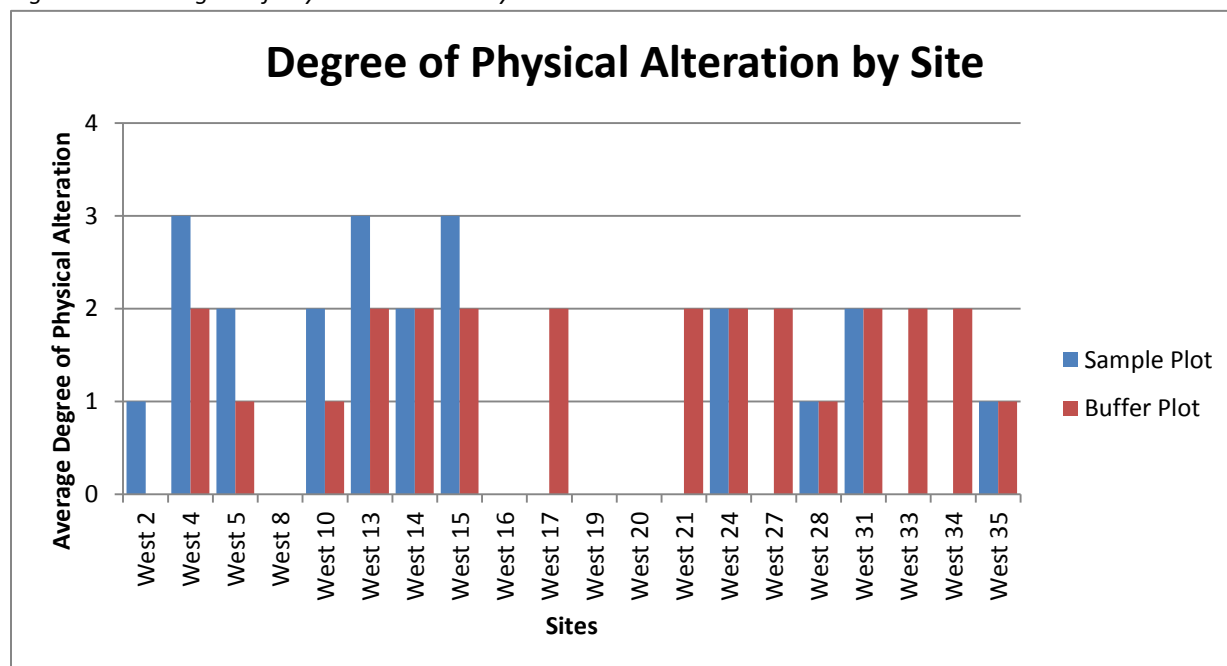

Figure 3.4-19 depicts degree of Physical Alterations at each site in both the Sample Plot (blue) and Buffer Plot (red). At each site, Physical Alteration types (see Figure 3.4-18) were documented using a scale of 0-4 to measure the degree: 0 = Physical Alteration not present, 1 = 0-25%, 2 = 26-50%, 3 = 51 − 75%, and 4 = 76 − 100%. The different physical alterations were combined and averaged for both plots.

One of the most common physical alteration metrics tracked is storm damage. In August 2011, the remnants of Hurricane Irene, the seventh costliest hurricane in United States history,[33] hit Western Massachusetts. In Western Massachusetts it is referred to as tropical storm Irene. Before Irene's arrival the soil was already saturated due to prior rain events, thus when Irene dropped between 3 to 10 inches of precipitation (it varied by location in the watershed) it quickly created erosion and flooding conditions. The stream gage at one USGS stream gage stations along the Deerfield River increased from 5 to almost 24 feet in less than four hours.[34] Irene resulted in impacts throughout the reporting Basin such as erosion of river banks, landslides, downed trees, and damage to infrastructure.[35] While conducting site work, the field investigators noted that many features depicted on older aerial photographs were no longer present. They appeared to have been altered or washed away by the floodwaters. Many wetlands throughout the Western Basin may have experienced direct or indirect impacts from Irene or other intense storms. The physical alteration tallied on-site for the *natural storm damage* and *flooding* categories are displayed spatially in the graphic below. Despite its overall impact in the reporting basin, six years after Tropical Storm Irene the physical alteration of the sample sites from the event doesn't show a strong relationship to the path of the Tropical Storm Irene. However, it is possible the precipitation from the event may have contributed to higher floodwaters downstream at sites 4, 13, and 14, which are located along major rivers, but it is not possible to know for certain. Physical alterations for these sites were documented as heavily impacted by flooding.
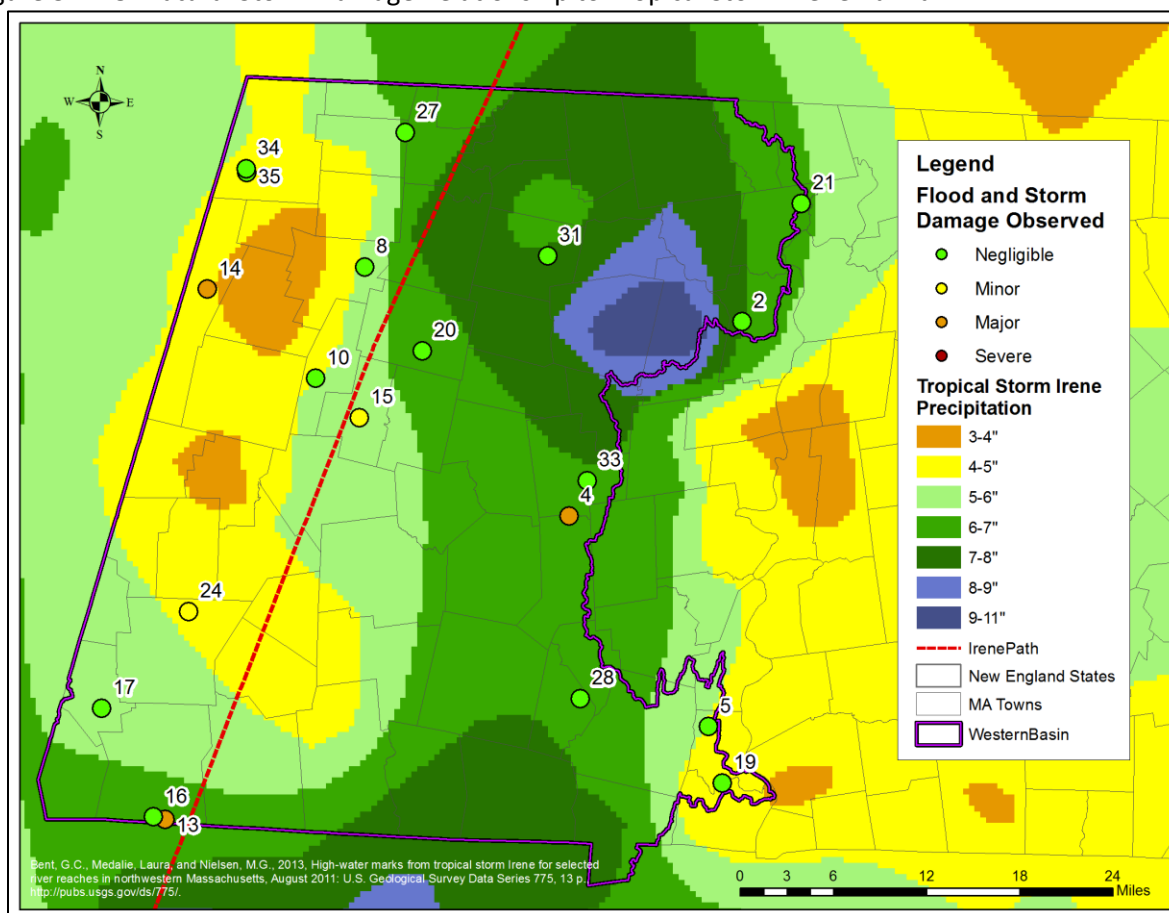
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[33] Costliest U.S. Hurricanes | Weather Underground
[34] https://pubs.usgs.gov/ds/775/pdf/ds775_report_508.pdf
[35] http://www.geo.umass.edu/stategeologist/Products/reports/Landslide2_web.pdf?_ga=2.269190066.212902233 5.1510256303-2061715205.1468856285

Figure 3.4-18: Natural Storm Damage Relationship to Tropical Storm Irene Rainfall[36]

The natural storm damage and flooding impacts are based on the total percentage of the site that appears to be impacted by physical alteration events. 0-24% is Negligible, 25-49% is Minor, 50-74% is Major, and 75-100% is Severe.

4.0   CONCLUSIONS

The study of the Western Basin is the fourth MassDEP wetland monitoring and assessment study undertaken using recently developed tools including CAPS, SLAM's, forested wetland IBI's and CALU. Throughout this process strengths and weaknesses have been identified in the approach. The CALU results highlight the strength of the CAPS model to flag a site that has undergone stress, but the model is sometimes unable to pinpoint the exact cause of the stress when multiple culprits may exist, or that stressor is not included in the model. Therefore, it is necessary for investigators to revisit a site or conduct further investigation to evaluate why the site had not met expectations. Overall, the CALU analysis has demonstrated that the forested wetland IBI's appear to be accurately predicting wetland condition in most cases, The CAPS

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[36] Bent, G.C., Medalie, Laura, and Nielsen, M.G., 2013, High-water marks from tropical storm Irene for selected river reaches in northwestern Massachusetts, August 2011: U.S. Geological Survey Data Series 775, 13 p., http://pubs.usgs.gov/ds/775/

model is undergoing continued development to further strengthen its ability to confidently assess stressors and better assist the MassDEP with wetland monitoring and assessment. In addition, the CAPS model is also proving to be an effective tool to assist in prioritizing potential restoration and preservation sites. Opportunities for restoration that would improve wetland condition have been discussed in this report and include improving terrestrial connectedness by installing terrestrial crossings to mitigate the impact of high intensity traffic; and eradication of invasive species. To offset the adverse effects of habitat loss, potential high quality habitat should be investigated, protected and/or considered for preservation using the *Habitat of Potential Regional and Statewide Importance* maps.

The CALU analysis of the randomly selected plots indicated that 6 of 20 sites in the Western Basin failed to meet expectations. Analyses of the failed sites found that 4 of 6 sites were located in a flood plain and upstream of a dam. Additionally, 2 of 3 failed sites assessed in the Central Basin in 2016 [37] were also located in floodplains and upstream of dams. While this is an extremely small number of sites where this has been observed, future analyses will be reviewed for similar patterns. Two sites that failed to meet expectations (one of which was also included in the flood plain numbers) were dominated by Japanese barberry (*Berberis thunbergii*), a non-native invasive species, which disturbs the native community by shading out the forest understory. In one case, a site that failed to meet expectations was located in close proximity to a major interstate highway, and also had forest clearing observed upstream from the site.

Documenting *physical alterations*, in additional to the index of biological integrity, provides a more comprehensive approach to assessing wetland condition. By documenting direct evidence of physical alteration, stressors that may not be readily apparent in a GIS based landscape level analysis can be assessed. Physical alteration data provided further information in understanding all stressors that are impacting the forested wetlands.

While it is understood that a certain number of sites, due to model error alone, could naturally fall out of the normal range of variability, it is important to attempt to discern when it is due to model error and when it is due to a stressor that has either not been identified or perhaps underestimated by the model. Incorporating *physical alteration* observations, along with a more detailed analysis when a site fails to meet expectations, are the tools used to assist in that determination.

MassDEP continues to apply and advance its monitoring and assessment program. This study has been an important step in testing the tools that have been developed, and understanding what the results tell us and do not tell us. To summarize, the data supports the findings that:

1. Not all physical disturbances that impact ecological communities are anthropogenic (e.g. storm damage and floodplains)

2. Potential secondary impact may be occurring from the influence of dams and flooding.

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[37] https://www.mass.gov/lists/wetlands-monitoring-and-assessment-final-reports-and-data

3. IBI data alone cannot determine which stressor is most significant when multiple stressors are present; this may require revisits to sites that fail to meet expectations, because they always will fail to meet the expectations of a few metrics.

4. Some causes of degradation cannot be identified and may be due to model error, or may be due to causes that are difficult to discern, such as contamination.

As the MassDEP monitoring and assessment effort evolves, the strengths and weakness of its approach are better understood. The MassDEP will continue to utilize the study findings to inform regulatory, policy and/or guidance development as well as identify opportunities to improve wetland condition through protection, restoration and preservation.