Empirically Derived Indices of Biotic Integrity for Wetlands in Massachusetts and an Evaluation of their Utility for Assigning Coefficient of Conservatism Scores for FQA

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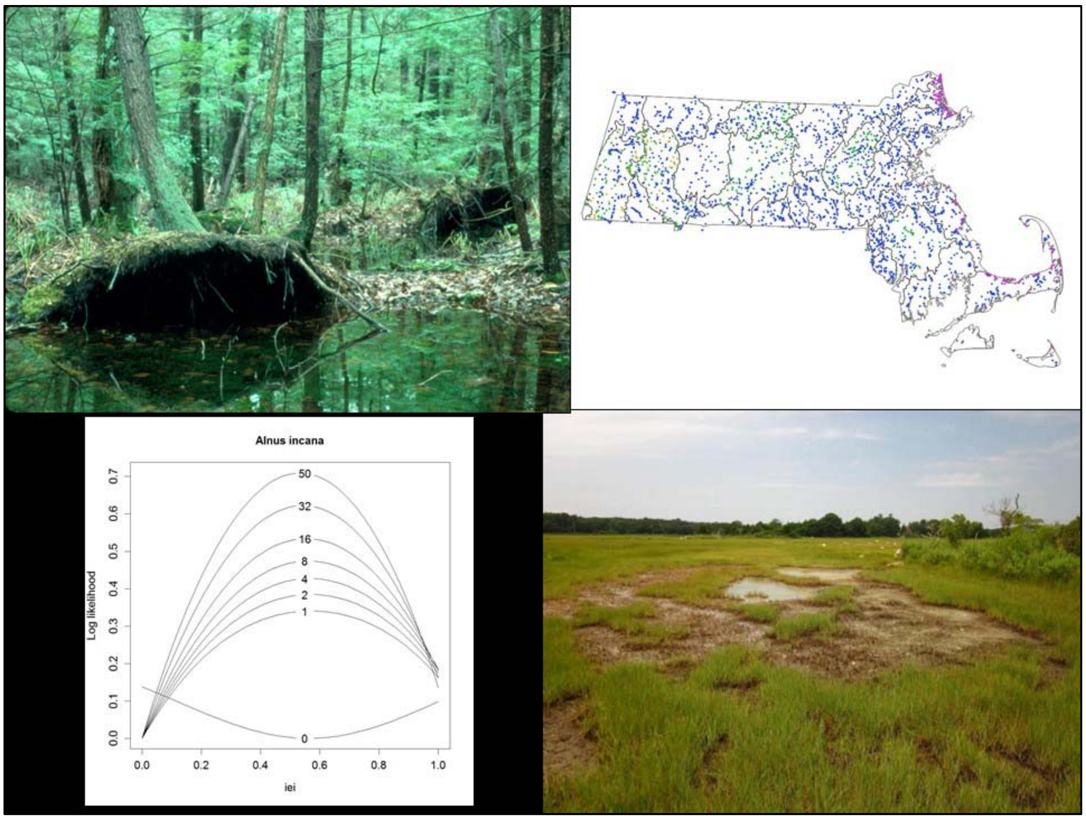

This report is the result of many years of field data collection, analyses and Indices of Biotic Integrity (IBI) development by the MA Office of Coastal Zone Management (CZM), MA Department of Environmental Protection (MassDEP) and University of Massachusetts Amherst (UMass Amherst). In this document, we report on the field data collection and IBI analyses conducted:

1. In the Taunton River Watershed as part of a FY2011 Wetlands Program Development Grant (WPDG) awarded by the U.S. EPA to MassDEP and UMass Amherst
2. In the Housatonic and Westfield River watersheds as part of a FY2013-2014 WPDG award by the U.S. EPA to UMass Amherst

IBI Analyses also included data from streams, salt marshes and forested wetlands collected/compiled in earlier WPDG projects as part of a comprehensive wetlands assessment and monitoring program for Massachusetts.

Abstract

For the past several years we have been using data collected in the field to compare the Indices of Ecological Integrity (IEI) calculated by CAPS with biological field data collected in streams, forested wetlands, salt marshes and, more recently, shrub swamps. Field data were collected in the Taunton River watershed in 2012 and the Housatonic and Westfield River watersheds in 2014-2015. IBI Analyses were conducted using these data as well as data from streams, salt marshes and forested wetlands collected/compiled in earlier WPDG projects. CAPS data on IEI (Index of Ecological Integrity) and the various metrics used in IEI models for streams, forested wetlands, shrub swamps and salt marshes used in our IBI analyses were from the 2015 CAPS analysis for Massachusetts. The 2015 CAPS analysis included new metrics, including three stream metrics (hydrological alteration, phosphorus loading and nitrogen loading) and one coastal metric (boat traffic intensity).

The CAPS IBI software has been updated with all of the new IBIs that met our random cross-validation threshold of concordance ≥ 0.5. These include eight IBIs for streams, eight for forested wetlands, and one IBI for shrub swamps. None of the salt marsh IBIs met the threshold for acceptance and thus the software does not currently cover this wetland type. In addition to the incorporation of new IBIs, the software is now equipped to generate charts/graphics to aid in the interpretation of IBI results.

We addressed three key issues of importance to FQA and other IBIs for assessing wetland condition. First, are the FQA CoC scores for MA consistent with empirical data on plant species abundance relative to stressor gradients? Second, how sensitive are IBIs to geographic variability in wetland plant ecology (i.e. the indicator value of plants)? Third, can IBIs (or CoC scores) developed in one wetland type be applied to other wetland types?

We examined the CoC scores developed for FQA in Massachusetts by comparing those scores with plant community data in our database for forested wetlands and shrub swamps. Comparing FQA CoC scores with our regression model results indicated relatively weak agreement (correlation coefficient of 0.382 for plants in forested wetlands and 0.211 for shrub swamps).

When we applied IBIs developed in central MA to forested wetlands in the Taunton watershed, we got poor results. This serves as a caution about applying IBIs outside of the geographic range of the training data. By expanding our sample size and the geographic scope for the training data we were able to create IBIs for forested wetlands that were robust for use in watersheds across Massachusetts. The IBIs performed best in the watersheds that were used to train the models. However, our analyses indicate that many of the IBIs are robust enough to be used in other watersheds, even though there is some drop-off in performance. These results validate concerns about the need for CoC scores that vary geographically (by state or by ecoregion).

Our analyses also addressed whether IBIs developed in one wetland type can be effectively applied in other wetland types. We found strong evidence to suggest that CoC scores for plants in one context (e.g. forested wetlands) are not sufficient for assessing those same plants in another context (e.g. shrub swamps). There are three lines of evidence to support this conclusion. 1) IBIs developed for forested wetlands performed poorly when applied to shrub swamps. 2) When applied to shrub swamps, IBIs developed for shrub swamps using a small number of sampling locations (n=70) generally out performed forested wetland IBIs that had been developed using data from hundreds of sites (n=388). 3) There was

relatively little agreement between empirically derived CoC scores for plants in forested wetlands and shrub swamps (correlation coefficient of 0.395).

Our results suggest that it may be possible to create a rapid assessment methodology that uses plants to assess wetlands condition for some wetland types (forested wetlands and shrub swamps). FQA is a framework that might meet the need for an affordable and reliable assessment method. However, our results suggest that more work needs to be done to test FQA and the assumptions that go into it. In particular, more attention needs to be paid to the assigning of CoC scores. The assumption that one CoC score will suffice for evaluating condition in all wetlands or ecosystems should be reconsidered.

Introduction

The Conservation Assessment and Prioritization System (CAPS) is a computer model and sophisticated approach to assessing the ecological integrity of ecosystems. It is being used as a level 1 assessment methodology as part of a comprehensive wetlands assessment and monitoring program for Massachusetts. Integrating landscape-based assessments (Level 1) and the site level assessments (Level 2/3) is at the core of the Massachusetts Monitoring and Assessment Program. The landscape-based assessment produces an Index of Ecological Integrity (IEI) as a means of scoring a wetland's context that is comparable to the Generalized Stressor Gradient. Site-based assessments produce Indices of Biological Integrity (IBIs) on the same scale as IEI and are comparable to the Biological Condition Gradient.

For the past several years we have been using data collected in the field to compare the Indices of Ecological Integrity (IEI) calculated by CAPS with biological field data collected in streams, forested wetlands, salt marshes and, more recently, shrub swamps. Our approach to creating IBIs and the results of analyses using data collected through 2011 were published in a 2013 report[1]. This document reports on development since that report and is based on field data collected from 2012 through 2015.

In this document, we report on the field data collection conducted:

1. In the Taunton River Watershed as part of a FY2011 Wetlands Program Development Grant (WPDG) awarded to MassDEP and UMass Amherst
2. In the Housatonic and Westfield River watersheds as part of a FY2013-2014 WPDG award to UMass Amherst

IBI Analyses were conducted using these data as well as data from streams, salt marshes and forested wetlands collected/compiled in earlier WPDG projects and reported in the 2013 report. In this report, we also examine the Massachusetts Coefficient of Conservatism scores developed for FQA and compare them to an analysis of vegetation data collected to date as part of the Massachusetts Wetlands Assessment and Monitoring Program.

[1] Empirically Derived Indices of Biotic Integrity for Forested Wetlands, Coastal Salt Marshes and Wadable Freshwater Streams in Massachusetts by K. McGarigal, E. Plunkett, J. Grand, B. Compton, T. Portante, K. Rolih, and S. Jackson. September 15, 2013. University of Massachusetts Amherst. Available at: http://umasscaps.org/pdf/CAPS%20IBI%20Report%20Sept%2015%202013%20Final.pdf.

Data Collection

Taunton River Watershed

In 2012, data were collected in 39 forested wetlands in the Taunton River watershed (Figure 1) as part of a project funded by a FY2011 WPDG awarded to MassDEP and UMass Amherst. Data were collected according to a Quality Assurance Project Plan (QAPP) and Standard Operating Procedures (SOP) approved by MassDEP and the U.S. Environmental Protection Agency (EPA), and included vascular plants, bryophytes, epiphytic macrolichens, algae (diatoms), and macroinvertebrates (including earthworms).

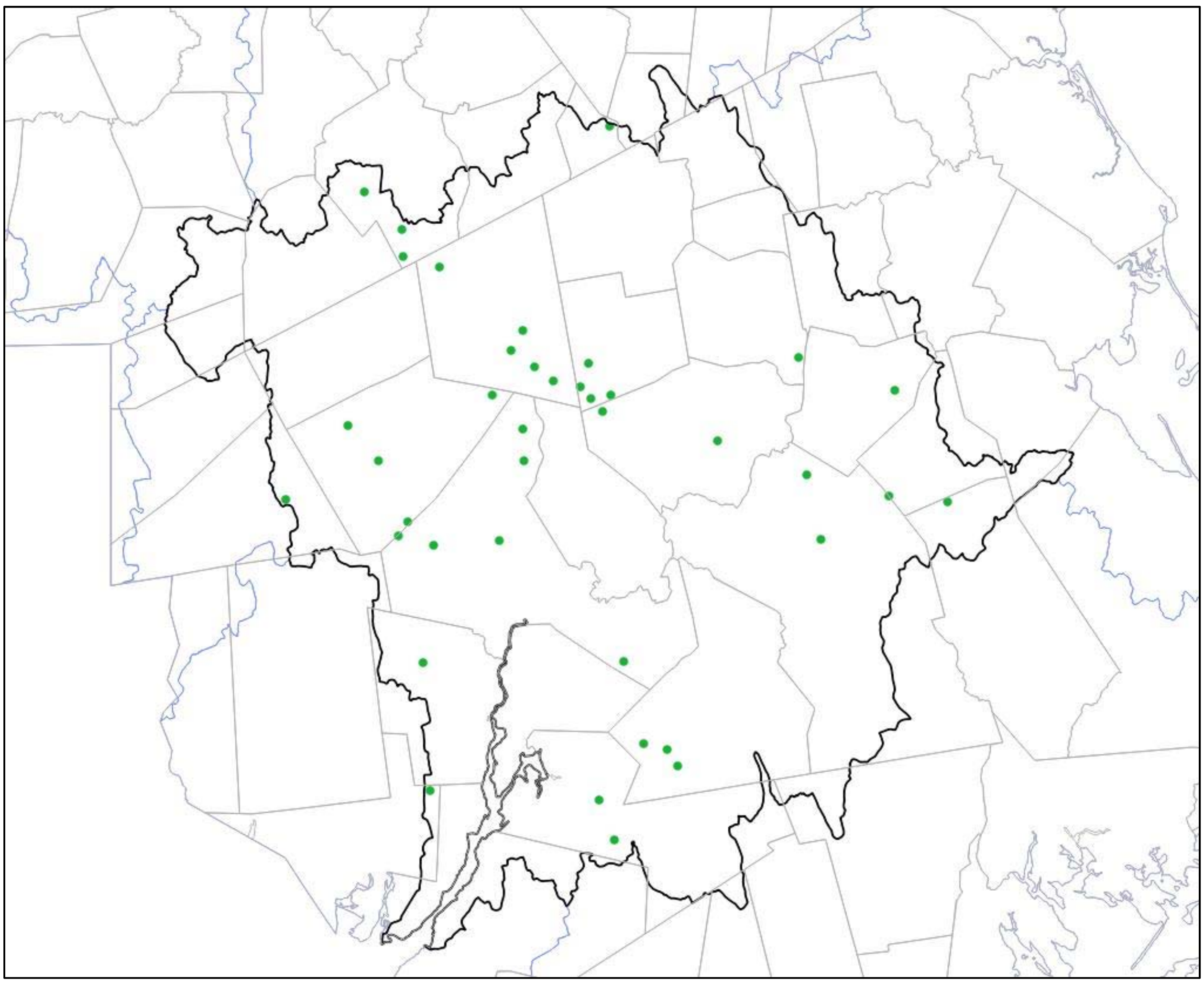

Figure 1. Locations of 39 forested wetland sampling sites in the Taunton River watershed, 2012.

Previous data collection and IBI analyses were conducted in watersheds in central Massachusetts (Chicopee, Concord and Miller's River watersheds). Expanding the IBI approach to include the Taunton River watershed – a coastal watershed – provided an opportunity to test the geographic robustness of the previously developed IBIs and to revise the IBIs to include data from this watershed.

Although data collection included a variety of taxa, our analyses of previously collected data (2013 report) indicated that vascular plant based IBIs performed nearly as well for forested wetlands as the best multi-taxa IBI we created. Given the expense and effort required to conduct extensive multi-taxa sampling we anticipated that future data collection would focus on taxa that were most useful for constructing informative IBIs and relatively easy/inexpensive to collect in the field. As a result, IBI analyses used only data for vascular plants and bryophytes.

Housatonic and Westfield River Watersheds

As part of a project funded by a FY2013-2014 WPDG awarded to UMass Amherst, vegetative communities were sampled in 197 forested and shrub swamp wetlands in 2014 and 2015 (Table 1 and Figure 2). Data were collected according to a Quality Assurance Project Plan (QAPP) and Standard Operating Procedures (SOP) approved by MassDEP and EPA. Originally, it was planned to sample vascular plants and bryophytes. However, after consultation with MassDEP and EPA it was decided to focus only on vascular plants. Previous analyses suggested that bryophytes only offered marginal added benefit to IBI performance and we decided that there was more to be gained by reallocating resources and increase the number wetlands sampled. Expansion of sampling sites to the westernmost boundary of Massachusetts provided an additional opportunity to test the geographic robustness of our IBIs.

Table 1. Numbers of forested wetlands and shrub swamps sampled in the Housatonic and Westfield River watersheds, 2014-2015.

	Forested Wetland	Shrub Swamp
Housatonic	55	35
Westfield	72	35
Total	127	70

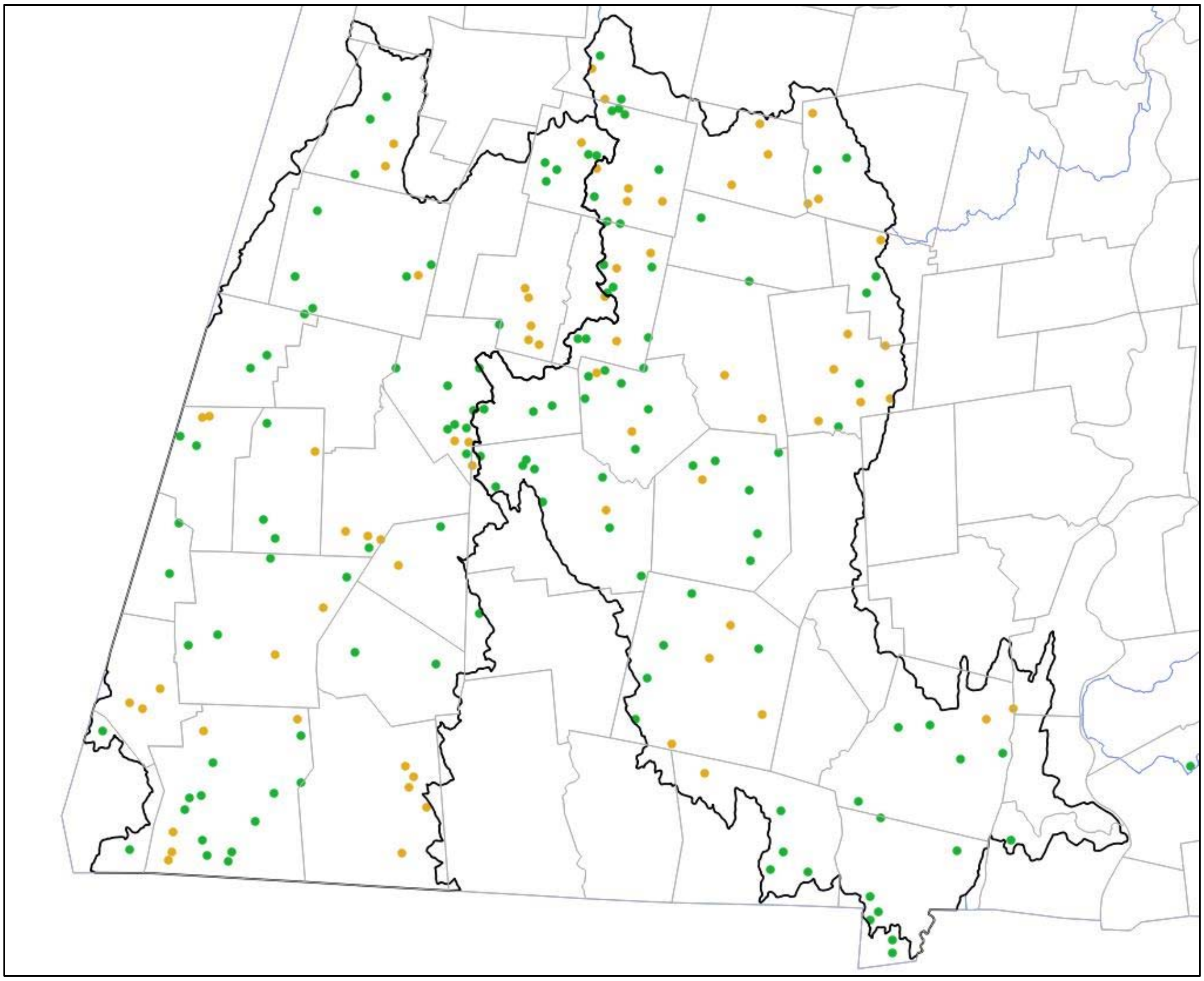

Figure 2. Locations of forested wetland (green) and shrub swamp (yellow) sampling sites in the Housatonic and Westfield River watersheds, 2014-2015.

2015 CAPS Analysis

CAPS data on IEI (Index of Ecological Integrity) and the various metrics used in IEI models for streams, forested wetlands, shrub swamps and salt marshes used in our IBI analyses were from the 2015 CAPS analysis for Massachusetts. Previous IBI analyses had used data from the 2011 CAPS analysis. The 2015 CAPS analysis included new metrics, including three stream metrics (hydrological alteration, phosphorus loading and nitrogen loading) and one coastal metric (boat traffic intensity).

IBI analysis

Our IBI analysis is an approach for detecting signals in biological data that correspond to stressors in, and characteristics of, the surrounding landscape. By identifying and characterizing biological signals, we then create models (IBIs) that can be used to predict the condition of wetlands based on the stressors affecting them. CAPS metrics are our way of quantifying the characteristics of landscapes and the stressors affecting wetlands. Biological signals might reflect the stressor gradient for a particular stressor (stressor metric) or landscape characteristic (resiliency metric), or may correspond with our Index of

Ecological Integrity (IEI), a composite metric that is consistent with the concept of a generalized stressor gradient. Thus, rather than creating a single IBI for each wetland system (stream, salt marsh, forested wetland, shrub swamp) we seek to create IBIs for IEI and for each stressor/resiliency metric included in the IEI models.

Analyses reported on this document include data collected through 2015, including 388 forested wetland, 70 shrub swamp, 175 salt marsh and 490 stream sampling locations (Table 2 and Figure 3).

Table 2. Numbers of sampling locations for streams, salt marshes, forested wetlands, and shrub swamps included in IBI analyses.

	Forested Wetland	Shrub Swamp	Salt Marsh	Streams
Chicopee Watershed	73			
Concord Watershed	75			
Miller's Watershed	74			
Taunton Watershed	39			
Housatonic Watershed	55	35		
Westfield Watershed	72	35		
Statewide			175	490
Total	388	70	175	490

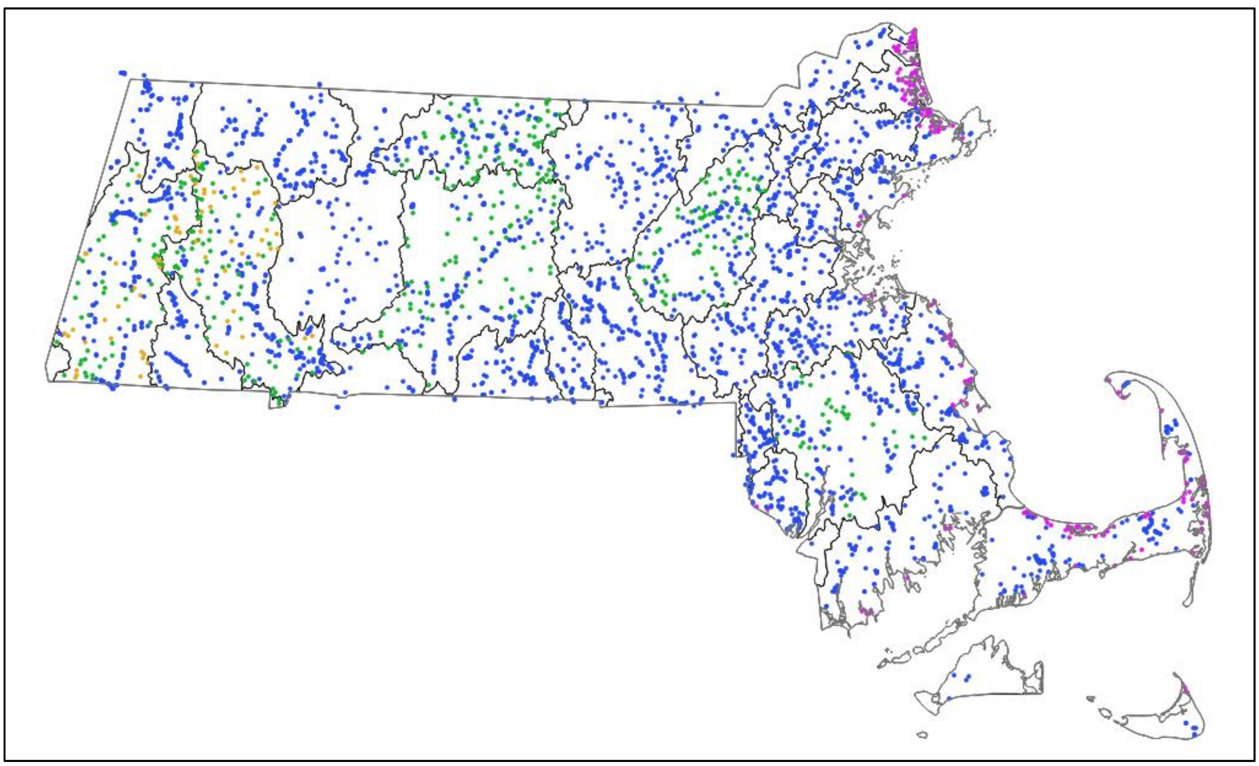

Figure 3. Locations of sampling sites for steams (blue), forested wetlands (green), shrub swamps (yellow) and salt marshes (magenta) included in IBI analyses.

General Approach

A detailed description of our IBI approach is presented in our 2013 report (McGarigal et al. 2013). What follows is a synopsis of that approach with details about modifications that we have made since the 2013 report.

Step 1. Taxonomic data summary

The first step involved summarizing the species abundance data at each site. For each site, we created counts of each taxon's abundance at each taxonomic level, including Species, Genus, Family, Order, Class and Phylum. This means that an individual in a sample identified to Species was counted again at the Genus level and, depending on the taxonomic group, the Family, Order, Class and Division/Phylum levels as well. If an individual was only identified to Order, then it was only counted at the Order or higher level. We treated the abundance of each taxon at each taxonomic level as a separate dependent variable in the regression models (described below), and treated abundance as a Binomial response with a trial size equal to the total specimen count and/or as an unbounded Poisson response (with an offset to account for sampling effort), as appropriate. As one of several measures to safeguard against model overfitting, given the generally large number of taxa relative to the number of sites, we dropped all taxa that were observed at fewer than 10 sites.

Step 2. Regression

The second step was to fit individual responses for each taxon. Specifically, we modeled the relationship between each taxon (dependent variable) and each stressor metric (independent variable) with two functional forms and eight error models (see 2013 report for details). See Figure 4 for examples.

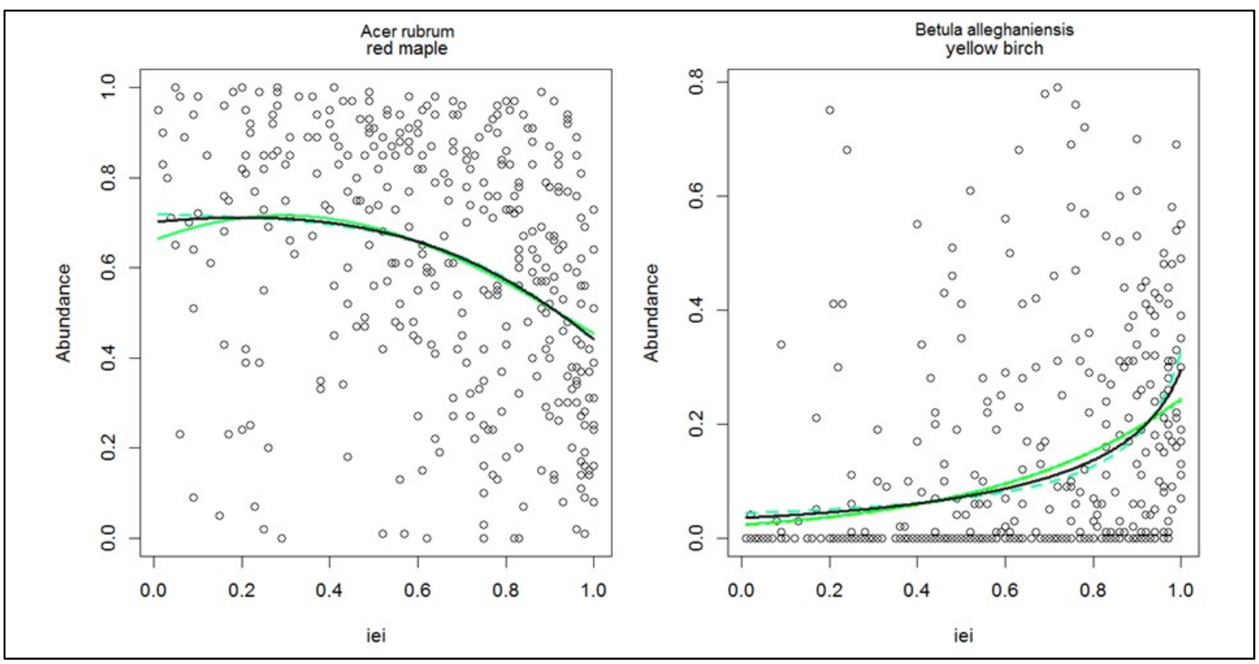

Figure 4. Examples of regression analysis for red maple (left) and yellow birch (right) in forested wetlands.

In a change from previous analyses (2013 report), we developed IBIs for raw and variously transformed metrics and chose the best one for each metric for inclusion in the IBI software. This was driven by a few metrics that had extremely skewed distributions that we felt could be substantially improved by transformation. We visually evaluated the distribution of every metric separately within each system to determine whether log or square root transformation improved the distribution of the observations and chose one of the transformations over the raw metric if it resulted in a substantially more even distribution of the metric over the range of the observations. We chose not to consider transformations for IEI because it is already quantile scaled by CAPS at the state level for all raster cells in the appropriate system. See Table 3 for an example of how transformation affects IBI concordance values for forested wetlands.

Table 3. Marginal concordance values with an alpha = 0.2 from random cross-validation for plants in forested wetlands with and without transformation of raw metric values.

Metric	Transformation	With Transformation	No Transformation	Difference
Aquatic connectedness	sqrt	0.312	0.260	0.052
Invasive plants	sqrt	0.502	0.498	0.004
Edge predators	sqrt	0.524	0.508	0.015
Microclimatic alterations	log	0.451	0.186	0.265
Habitat loss	sqrt	0.580	0.515	0.065
Mowing & plowing	sqrt	0.523	0.438	0.085
Road salt	sqrt	0.458	0.388	0.070
Road sediment	log	0.472	0.469	0.003
Traffic intensity	sqrt	0.446	0.387	0.060
Watershed habitat loss	sqrt	0.557	0.510	0.047
Invasive earthworms	sqrt	0.508	0.481	0.027

Step 3. Statistical Calibration

Calibration involves using the estimated parameters from the regression in step 2 and the observed value of the dependent variable, and estimating the value of the independent variable -- essentially, regression in reverse. Specifically, we used the fitted models from step 2 to predict the log-likelihood of different values of the stressor metric at each site based on the abundance of taxa. The result is a log-likelihood curve that indicates the relative probability of the stressor metric being any particular value given the observed abundance of the taxon at a particular site. We generated log-likelihood curves for each site from the 8-16 different statistical models and then averaged them based on the AIC weights to make a single log-likelihood curve for each site and taxon. See Figure 5 for examples.

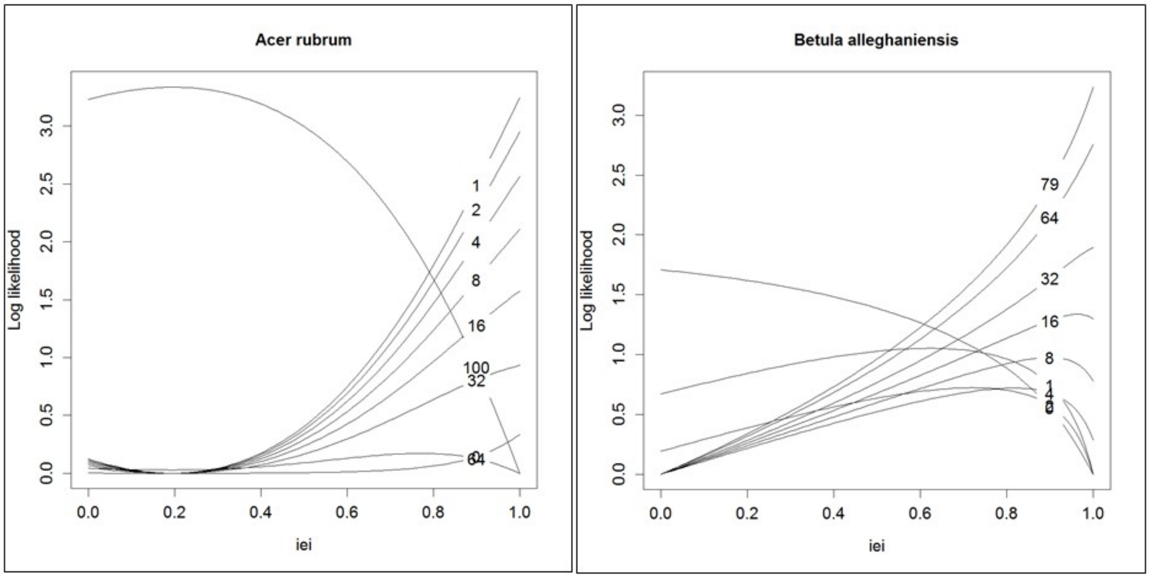

Figure 5. Examples of statistical calibration: log likelihood curves for red maple (left) and yellow birch (right) in forested wetlands. Numbers on the curves represent abundance (percent cover). Each line represents the log likelihood of the IEI values given the abundance of the species. By comparing the lines you can determine how the abundance of each species affects the log likelihood profile of the species.

Step 4. Taxa selection

The fourth step involved selecting the group of taxa that produce the most accurate predictions. Specifically, we added together the log-likelihood curves of individual taxa from step 3 to make a prediction for the site based on multiple taxa; the value of the stressor metric with the maximum log-likelihood was the predicted metric value for the site. Although the signal from individual taxa may be weak, the cumulative signal from evaluating the entire vegetative community can result in meaningful IBI predictions (Figure 6).

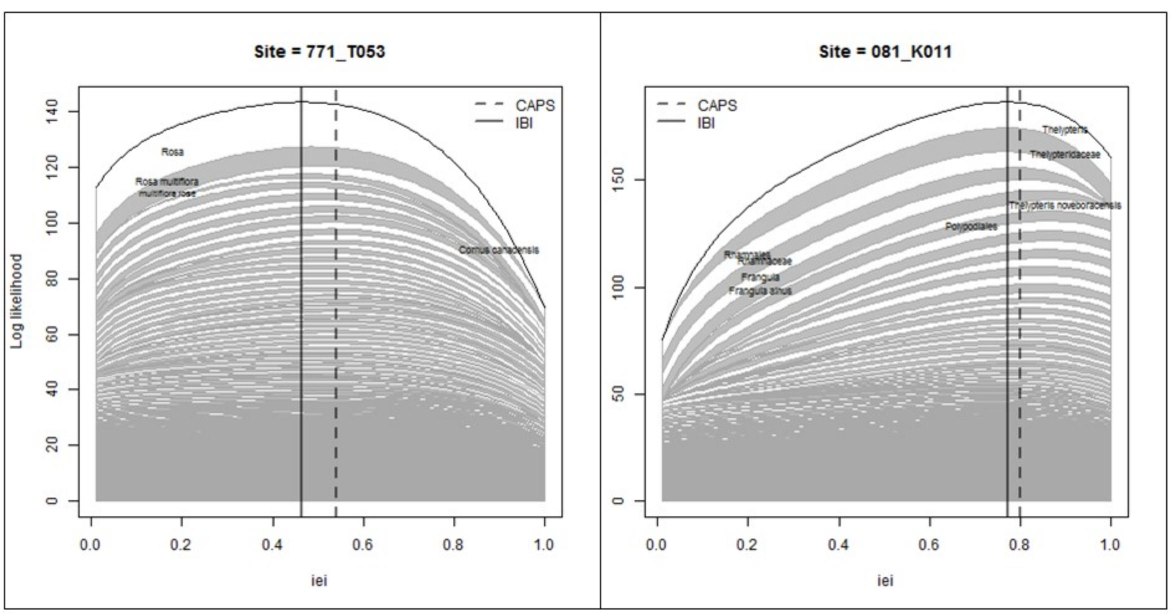

Figure 6. Forested wetland IBI predictions (solid line) of IEI (dashed line) for two sites.

In our 2013 analysis (McGarigal et al. 2013) we investigated two different procedure for selecting taxa: a stepwise method whereby taxa selection was “conditional” on previous selections, and a method based on the “marginal” (non-conditional) significance of each taxa. These two approaches were each used with three different alpha levels for inclusion: 0.05, 0.1 and 0.2. Based on the results of these analyses (Table 4) we chose the conditional alpha = 0.1 model as the best for use in our IBIs.

Table 4. Concordance of old (pre-Taunton) plant-based IBI's based on inner cross-validation. Previously this led us to believe that the conditional alpha of 0.10 was the best criterion.

	Criterion					
	Conditional Alpha			**Marginal Alpha**		
metric	**0.05**	**0.1**	**0.2**	**ma0.05**	**ma0.1**	**ma0.2**
aqconnect	0.76	0.79	0.79	0.63	0.63	0.63
badplants	0.76	0.79	0.79	0.63	0.62	0.62
connect	0.75	0.78	0.78	0.57	0.57	0.55
edgepred	0.73	0.78	0.77	0.57	0.57	0.55
edges	0.72	0.77	0.77	0.55	0.56	0.54
habloss	0.70	0.76	0.75	0.54	0.55	0.54
IEI	0.69	0.73	0.74	0.54	0.55	0.53
insults	0.68	0.73	0.73	0.51	0.54	0.51
nutrients	0.68	0.70	0.70	0.49	0.51	0.51
salt	0.68	0.69	0.66	0.44	0.48	0.46
sediment	0.63	0.66	0.66	0.41	0.45	0.46
sim	0.62	0.66	0.64	0.38	0.42	0.45
whabloss	0.62	0.66	0.51	0.30	0.26	0.34
worms	0.50	0.54	0.48	0.29	0.22	0.28
traffic	0.46	0.53	0.46	0.29	0.22	0.24
mean	**0.66**	**0.70**	**0.68**	**0.48**	**0.48**	**0.48**

However, when we applied the IBIs developed previously (without Taunton data) to the data from the Taunton River watershed, we got poor results. In **Error! Reference source not found.**, the predictions are from vascular plant IBIs built without data from the Taunton. Each column indicates a criterion used to select taxa to include in the IBI. The first three columns are conditional alphas where step selection proceeded until a taxon was not significantly better than the pseudo-taxa at the given alpha. “0.1”, a conditional alpha of 0.1 was our default. The marginal alpha criterion does not rely on step selection and simply includes all taxa that by themselves perform better than the pseudo-taxa at the given alpha. In the case of applying an IBI outside the extent of the training data, the marginal alpha performed much better than the conditional alpha. Based on these results we revised our taxa selection procedure to use the marginal alpha = 0.2 model.

Table 5. Concordance between vascular plant IBI predictions and CAPS metrics (and IEI) at sites in the Taunton.

	Criterion					
	Conditional Alpha			Marginal Alpha		
metric	**0.05**	**0.1**	**0.2**	**ma0.05**	**ma0.1**	**ma0.2**
aqconnect	-0.24	-0.19	-0.23	0.04	-0.03	-0.03
badplants	0.28	0.39	0.41	0.28	0.29	0.49
connect	-0.18	-0.06	-0.07	0.03	0.13	0.11
edgepred	0.32	0.48	0.34	0.41	0.56	0.59
edges	0.00	0.07	-0.08	-0.05	-0.01	-0.02
habloss	0.37	0.33	0.38	0.50	0.47	0.48
IEI	0.31	0.22	0.16	0.33	0.34	0.35
insults	0.04	0.03	-0.04	0.05	0.07	0.15
nutrients	0.10	-0.08	-0.06	0.10	0.15	0.16
salt	-0.18	-0.17	-0.16	0.08	0.03	0.02
sediment	-0.02	-0.03	0.00	0.03	0.08	0.05
sim	0.16	0.37	0.37	0.41	0.13	0.37
whabloss	-0.07	-0.07	-0.04	0.18	0.14	0.16
worms	0.18	0.37	0.22	0.44	0.48	0.49
traffic	0.20	0.03	0.01	0.31	0.07	0.03
mean	**0.08**	**0.11**	**0.08**	**0.21**	**0.19**	**0.23**

Step 5. Outer Cross-validation

When we looked across criteria, we found that on average using the marginal alpha of 0.2 worked best for extrapolating into the Taunton (Table 5). However, even with that criterion the mean concordance in the Taunton (0.23) was much lower than we had seen in the training data (0.48). We decided there were likely two reasons for this difference. 1. We were spatially extrapolating into a somewhat different ecological system. 2. Our (inner) cross-validated concordance in the training data was over estimating performance.

Previously our randomized testing in which we conducted the entire process on pseudo-species revealed that low concordances were achieved with pseudo-species alone. This showed that the inner cross-validation that was used to select species was not a true, independent estimate of performance. In this round, we decided to directly estimate performance by conducting the whole IBI fitting process in steps 1:4 within a four-fold, “outer” cross-validation. In this outer cross-validation, we divided the data in four groups, repeatedly conducted all of the prior steps on each combination of three groups, and then predicted the fourth group. Thus, the holdout data in this cross-validation was used to evaluate the entire IBI process.

We decided that to separate out the two factors causing concordance to drop in the Taunton we would perform a second, outer cross-validation in which we would divide the data into four groups, and repeatedly build models as before using three of the groups and apply them to the fourth group. We performed this outer cross-validation in two ways: 1. By assigning cross-validation groups randomly within each watershed (stratified by watershed) and 2. Using watershed as the group. In both cases, we expected to have no performance bias as we had previously seen with the inner cross-validation. In (1) we would accurately estimate the performance of the IBI when confronted with new data within the spatial extent of the training data. In (2) we would gain insight into the cost of extrapolating spatially into a new watershed and see how the watersheds differed (Table 6).

Table 6. Results of random and watershed cross-validation for vascular plant and bryophyte data in forested wetland using data collected through 2012 (Chicopee, Concord, Miller's and Taunton River watersheds). Values in bold exceed our threshold (concordance ≥ 0.5) for considering an IBI strong enough to be meaningful.

	concordance (marginal alpha = 0.2)		
metric	random groups	watershed groups	diff
iei	**0.57**	**0.52**	0.05
connect	**0.56**	**0.51**	0.04
habloss	**0.52**	0.49	0.03
edgepred	**0.51**	0.47	0.04
worms	**0.50**	0.46	0.04
badplants	0.50	0.43	0.06
sim	0.49	0.44	0.05
whabloss	0.46	0.48	-0.02
nutrients	0.44	0.44	0.00
sediment	0.39	0.40	-0.01
traffic	0.34	0.32	0.02
edges	0.33	0.22	0.11
aqconnect	0.32	0.24	0.07
salt	0.31	0.30	0.01
insults	0.25	0.20	0.06
Mean:	0.43	0.39	0.04

One side effect of this change is that our estimates of performance have decreased from prior estimates that used the inner cross-validation. Note when we applied the IBI’s to new data we used models fit to the entire dataset.

This outer cross-validation approach developed during our analysis of the Taunton data was then used on the full dataset, including data collected in 2014 and 2015 in the Housatonic and Westfield River watersheds. Only random cross-validation was used for salt marshes and streams (data not broken out by watershed) and shrub swamps (only two watersheds with a limited number of sites). Random and watershed cross-validation were both applied only to forested wetland sites (see Figure 7 for an example).

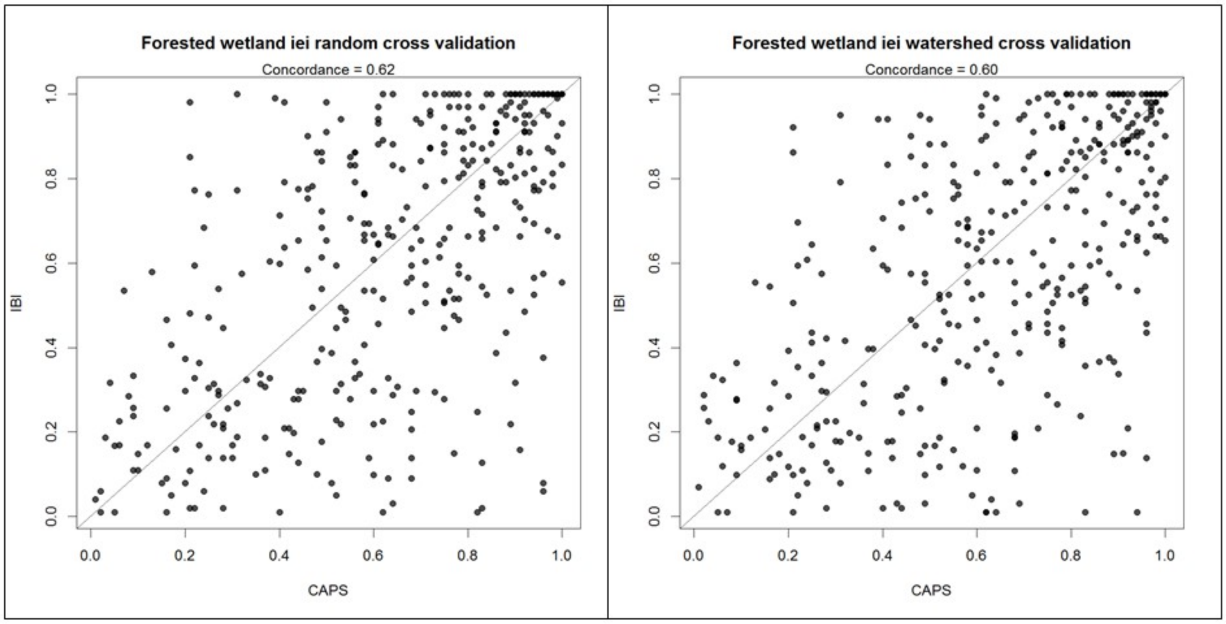

Figure 7. Outer cross-validation plots for IEI in forested wetlands for random cross-validation (left) and watershed cross-validation (right).

Results of IBI Analyses

Streams

We conducted IBI analyses for wadeable streams using MassDEP invertebrate sampling data for 490 sites throughout the state (Figure 8). These are the same data used for the analyses in the 2013 report. The current analyses were conducted with the procedural modifications described above and included three new stream metrics (flow alteration, phosphorus loading, and nitrogen loading) and CAPS data from the 2015 CAPS analysis for Massachusetts.

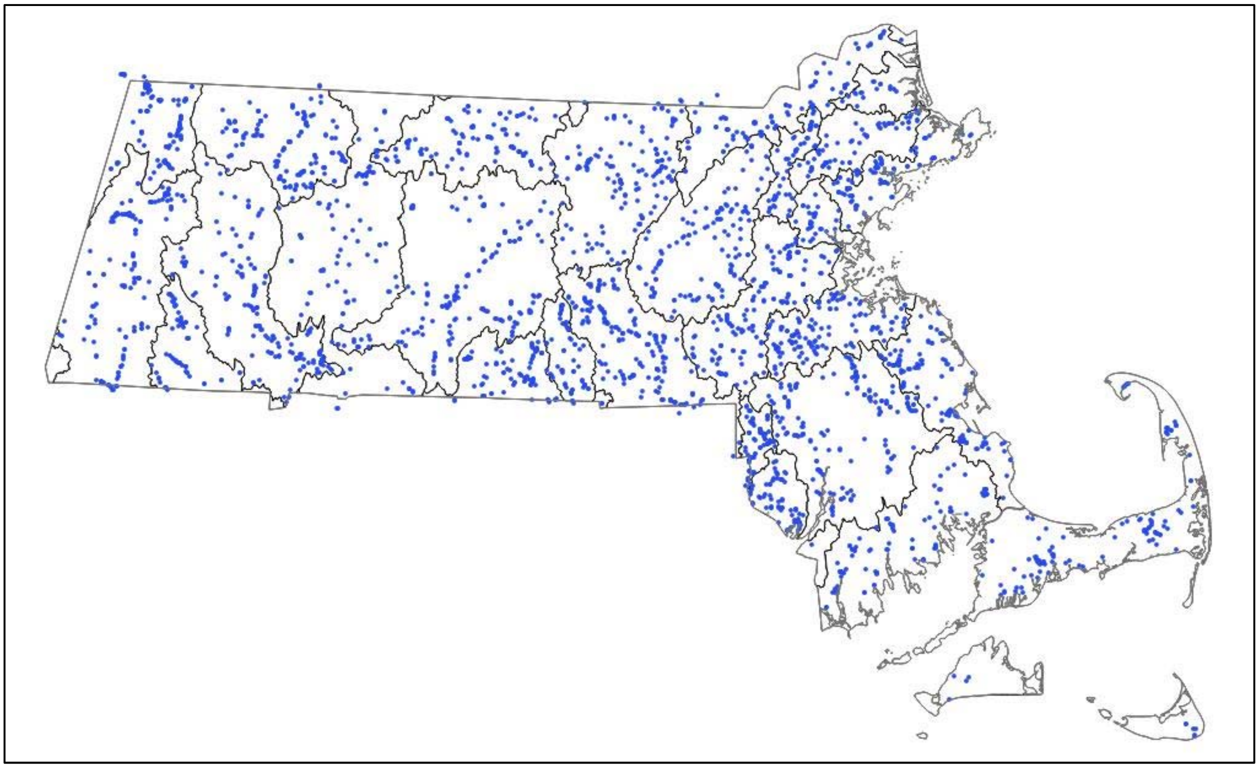

Figure 8. MassDEP stream sampling locations used for IBI analyses.

We were able to create meaningful stream IBIs for eight metrics, including IEI (Table 7). These eight IBIs were included in the CAPS IBI software.

Table 7. Concordance values for IBIs constructed for wadeable streams. "(sqrt)" signifies that the raw metric values were subject to square root transformation prior to IBI creation. Values in bold exceed our threshold (concordance ≥ 0.5) for considering an IBI strong enough to be meaningful.

Metric	ma0.2
Imperviousness (sqrt)	**0.791**
Watershed habitat loss (sqrt)	**0.741**
IEI	**0.730**
Road sediment	**0.724**
Hydrological alterations (sqrt)	**0.717**
Phosphorus loading	**0.692**
Traffic intensity (sqrt)	**0.646**
Habitat loss	**0.573**
Edge predators	0.437
Nitrogen loading	0.409
Aquatic connectedness (sqrt)	0.323
Dam intensity	0.308
Connectedness	0.258
Microclimatic alterations	0.229
Mowing & plowing (sqrt)	0.210

Forested Wetlands

IBIs for forested wetlands were constructed using plant sampling data from 388 sites in six watersheds (Figure 9). This represents a substantial increase in sample size (388 vs. 222 sites) from the 2013 analysis, due to the inclusion of data from the Taunton, Housatonic and Westfield River watersheds.

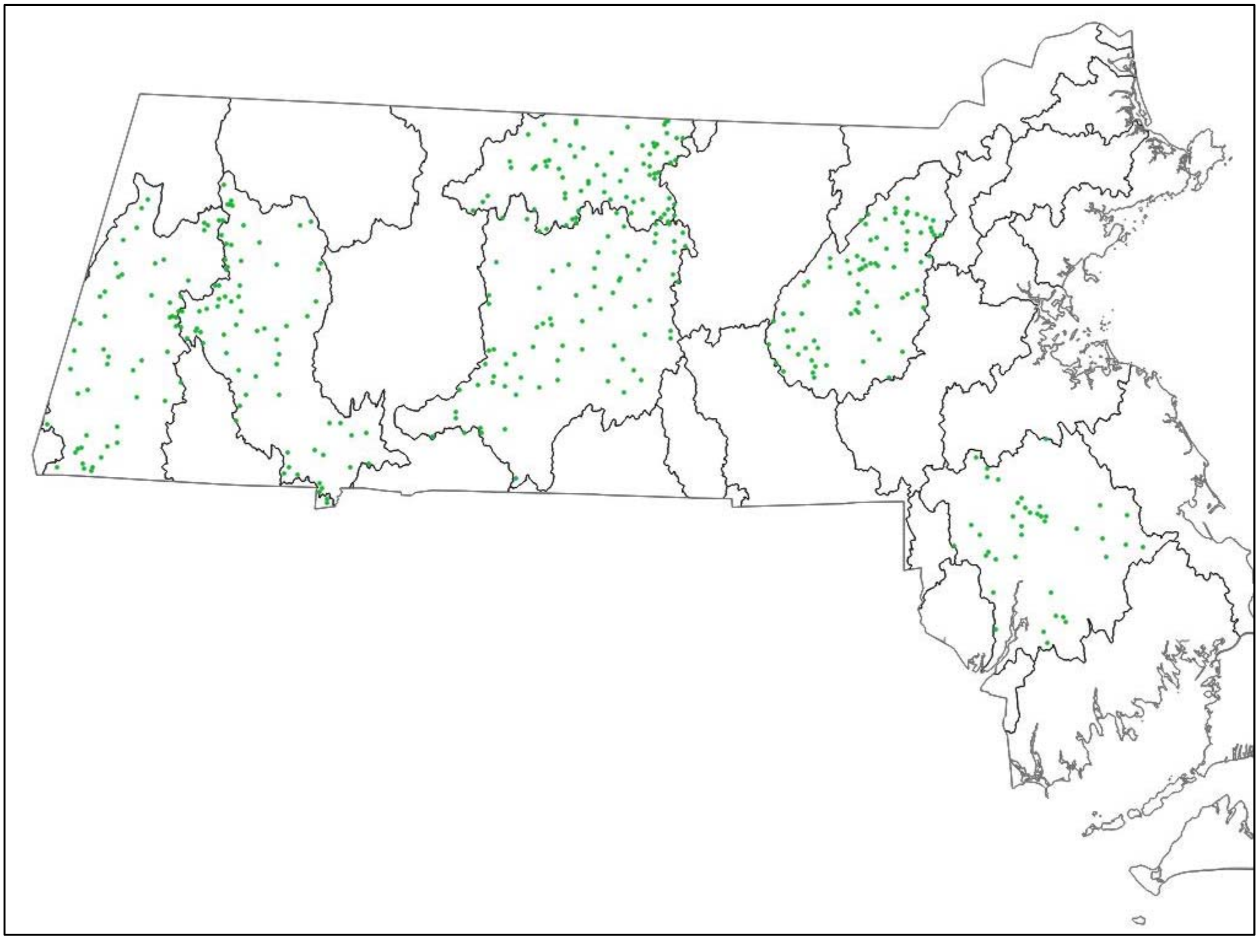

Figure 9. Forested wetland sampling locations used for IBI analyses.

Using random cross-validation, we concluded that forested wetland IBIs for eight metrics were strong enough to be meaningful (Table 8). This means that we have confidence that the IBIs will yield meaningful data when used within the same geographic range as the training data (six watersheds). These eight IBIs have been included in the CAPS IBI software.

The watershed cross-validation provides us some insight into the cost of extrapolating spatially into a new watershed. Five of the eight metrics deemed meaningful based on the random cross-validation remained meaningful under the watershed cross-validation. Three metrics fell below our threshold (mowing & plowing, invasive earthworms, and invasive plants) suggesting that caution should be used when applying these IBIs to data from other watersheds.

Table 8. Concordance values for IBIs constructed using plants for forested wetlands. "(sqrt)" signifies that the raw metric values were subject to square root transformation and "(log)" signifies log transformation prior to IBI creation. Concordance values are reported for both random cross-validation (4-way cross-validation mixing sites from all watersheds) and watershed cross-validation (sites from one watershed are predicted from IBIs constructed using data from the other five watersheds). Values in bold exceed our threshold (concordance ≥ 0.5) for considering an IBI strong enough to be meaningful.

Metric	Random	Watershed
Connectedness	**0.648**	**0.630**
IEI	**0.621**	**0.602**
Habitat loss (sqrt)	**0.580**	**0.527**
Watershed habitat loss (sqrt)	**0.557**	**0.557**
Edge predators (sqrt)	**0.524**	**0.508**
Mowing & Plowing (sqrt)	**0.523**	0.498
Invasive earthworms (sqrt)	**0.508**	0.482
Invasive plants (sqrt)	**0.502**	0.479
Similarity	0.477	0.436
Road sediment (log)	0.472	0.487
Road salt (sqrt)	0.458	0.430
Microclimatic alterations (log)	0.451	0.431
Traffic intensity (sqrt)	0.446	0.445
Aquatic connectedness (sqrt)	0.312	0.226

Shrub Swamps

Shrub swamp IBIs were constructed using data collected in 2014-2015 from 70 sites in the Housatonic and Westfield River watersheds (Figure 10). In addition, in order to test how robust IBIs constructed in one wetland type will be when applied to another, we applied our forested wetland IBIs to the data collected in these 70 shrub swamp sites.

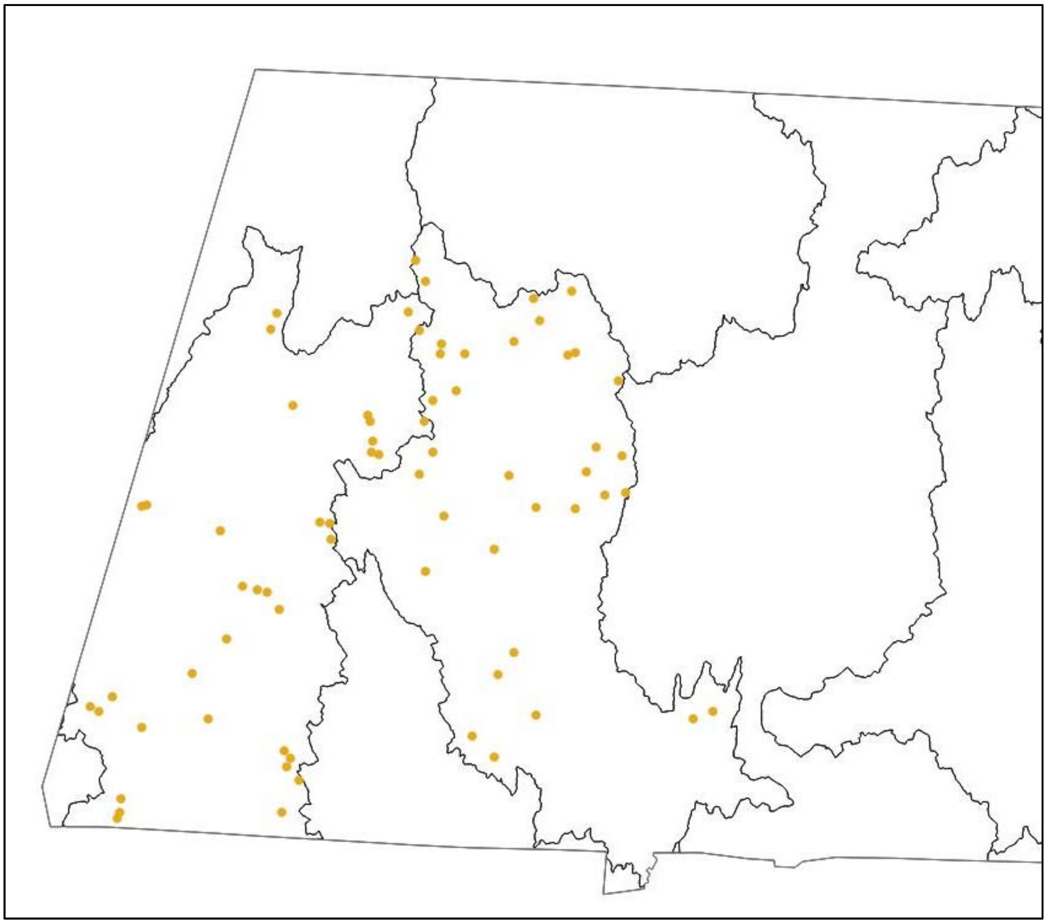

Figure 10. Shrub swamp sampling locations used for IBI analyses.

Of the 12 IBIs constructed for shrub swamp, only one (connectedness) had a concordance value strong enough to be considered meaningful (Table 9). This isn't all that surprising given the small sample size (70 sites).

We also applied the forested wetland IBIs to the shrub swamp sites and none of the eight IBIs exceeded our concordance threshold of 0.5 (Table 9). Further, for five of the eight metrics shrub swamp IBIs had higher concordance values than the forested wetland IBIs did when applied to shrub swamp data. This is especially remarkable given that there were only 70 shrub swamp sites and the cross-validation was based on IBIs constructed with data from only 53 sites (the other 17 having been held out for validation). Despite being based on data from 388 sites, many from the same watersheds as the shrub swamp sites, the forested wetland IBIs performed poorly when applied to shrub swamp data, especially compared to their performance when applied to forested wetland sites (Table 9).

Table 9. Concordance values for IBIs constructed using plants for a) forested wetland IBIs applied to forested wetlands, b) the forested wetland IBIs applied to shrub swamps, and c) shrub swamp IBIs applied to shrub swamps. "(sqrt)" signifies that the raw metric values were subject to square root transformation and "(log)" signifies log transformation prior to IBI creation. Values in bold exceed our threshold (concordance ≥ 0.5) for considering an IBI strong enough to be meaningful.

Metric	Forested Wetland IBI Applied to Forested Wetlands	Forested Wetland IBI Applied to Shrub Swamps	Shrub Swamp IBI Applied to Shrub Swamps
Connectedness	**0.648**	0.460	**0.642**
IEI	**0.621**	0.440	0.386
Habitat loss (sqrt)	**0.58**	0.384	0.411
Watershed habitat loss (sqrt)	**0.557**	0.425	0.252
Edge predators (sqrt)	**0.524**	0.385	0.467
Mowing & Plowing (sqrt)	**0.523**	0.238	0.390
Invasive earthworms (sqrt)	**0.508**		
Invasive plants (sqrt)	**0.502**		
Similarity	0.477	0.102	0.274
Road sediment (log)	0.472	0.262	0.130
Road salt (sqrt)	0.458		-0.076
Microclimatic alterations (log)	0.451		
Traffic intensity (sqrt)	0.446		0.281
Aquatic connectedness (sqrt)	0.312		0.230
Imperviousness (sqrt)			0.109

Salt Marshes

We used invertebrate and vegetation data from 175 salt marsh sites to construct IBIs (Figure 11Figure 11). Two analyses were run: one with invertebrates only and another that included plants and invertebrates.

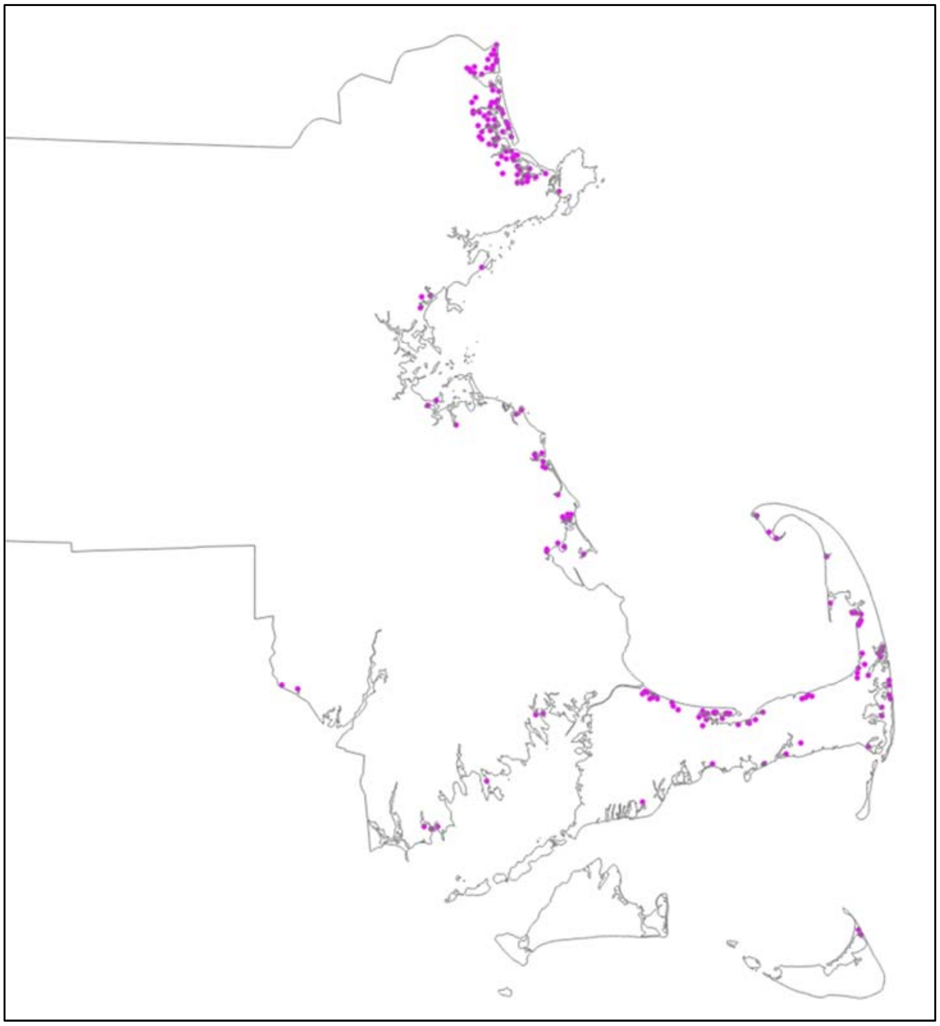

Figure 11. Locations of salt marsh sampling sites used in IBI analyses.

IBIs generally performed better when both invertebrates and vegetation were included. However, none of the IBIs we created met our standard for acceptance (Table 10).

Table 10. Random cross-validation concordance values for salt marsh invertebrate and invertebrate + plants IBIs. "(sqrt)" signifies that the raw metric values were subject to square root transformation and "(log)" signifies log transformation prior to IBI creation. None of the IBIs exceeded our threshold (concordance ≥ 0.5) for considering an IBI strong enough to be meaningful.

Metric	Invertebrates	Invertebrates & Plants
Hardened coastal structures (log)	0.316	0.328
Salt marsh ditching (sqrt)	0.205	0.265
IEI	0.196	0.254
Road sediment (log)	0.204	0.245
Habitat loss (sqrt)	0.183	0.242
Tidal restrictions (log)	0.023	0.233
Mowing & Plowing (log)	0.177	0.218
Traffic intensity (sqrt)	0.054	0.210
Road salt (log)	0.171	0.188
Feral predators (sqrt)	0.202	0.182
Connectedness	0.196	0.178
Edge predators (sqrt)	0.080	0.174
Similarity	0.063	0.169
Microclimatic alterations (log)	0.141	0.137
Watershed habitat loss (log)	0.106	0.112
Imperviousness (log)	0.065	0.101
Invasive plants (sqrt)	0.048	0.084
Boat traffic intensity (log)	-0.072	0.062

We have several possible explanations for why we have not yet been able to correlate CAPS metric scores with field indices of salt marsh condition.

1. Biological data collection has focused on the wrong taxa (plants and invertebrates). Perhaps other taxa (e.g. birds, fish) would be better indicators of salt marsh condition.
2. Methods for sampling invertebrates and vegetation in salt marshes were not sufficient/appropriate.
3. Given the low diversity of salt marsh plants and the tendency for large areas of salt marsh to be dominated by 2-3 species, perhaps species composition is the wrong metric for assessing vegetation. An alternative might be an assessment of plant health and productivity.
4. Given the low diversity of salt marsh plants, perhaps it would be more appropriate to use physical indicators (creek widening, creek bank instability, peat density, inappropriate high marsh flooding) to assess salt marsh condition.
5. The CAPS IEI model for salt marshes lacks metrics for important salt marsh stressors related to sediment dynamics, effects of increased nutrient loading on peat accretion, changes in marsh elevation relative to sea level rise, crab herbivory, and crab burrowing effects on peat density and stability.

Any, all, or various combinations of these factors may be affecting our ability to model ecological integrity or assess condition in the field for salt marshes. In our application to the FY2017-2018 WPDG we proposed to investigate alternative ways of assessing salt marshes focusing on physical indicators of marsh condition and plant stress/productivity (addressing explanations 3-5 above).

IBI Software

The complexity of our IBI approach and the resulting IBIs make it difficult to use them without access to the models and computer code used to implement them. To address this we created custom software to execute the IBIs on user provided data.

The CAPS IBI software has been updated with all of the new IBIs that met our random cross-validation threshold of concordance ≥ 0.5. These include eight IBIs for streams, eight for forested wetlands, and one IBI for shrub swamps. None of the salt marsh IBIs met the threshold for acceptance and thus the software does not currently cover this wetland type.

In addition to the incorporation of new IBIs, the software is now equipped to generate charts/graphics to aid in the interpretation of IBI results. The CAPS IBI software version 2.0 can be downloaded from https://sourceforge.net/projects/capsibi/files/.

CAPS IBIs and FQA

Many states in the northeastern U.S. are considering adoption of the Floristic Quality Assessment (FQA) as a site-level assessment methodology for evaluating wetland condition. FQA is a rapid assessment methodology that uses vegetation to produce a condition score for any ecosystem within the geographic area for which the FQA was developed. Previous CAPS IBI analyses (McGarigal et al. 2013) suggested that vegetation-based IBIs perform nearly as well in forested wetlands as intensive multi-taxa IBIs. This suggests that an assessment approach based solely on vegetation may be plausible, at least for forested wetlands.

FQA uses Coefficient of Conservatism (CoC) scores for plant species and any of a variety of formulas to generate a condition score (Floristic Quality Assessment Index – FQAI) for a site. Because adequate empirical data are generally lacking, CoC scores (ranging from zero to 10) are subjectively assigned based on best professional judgement. Plant species typically found in degraded areas are assigned low scores and species generally found in high quality sites are given high scores.

The data collected as part of our IBI development process and the analyses used to model taxa in relation to CAPS metrics, offers an opportunity to create empirically based CoC scores for use in FQA (Figure 12). We analyzed plant responses to the CAPS IEI gradient in forested wetlands to compare CoC scores as indicated by our IBI analyses with CoC scores subjectively assigned for Massachusetts as part of a regional FQA project.

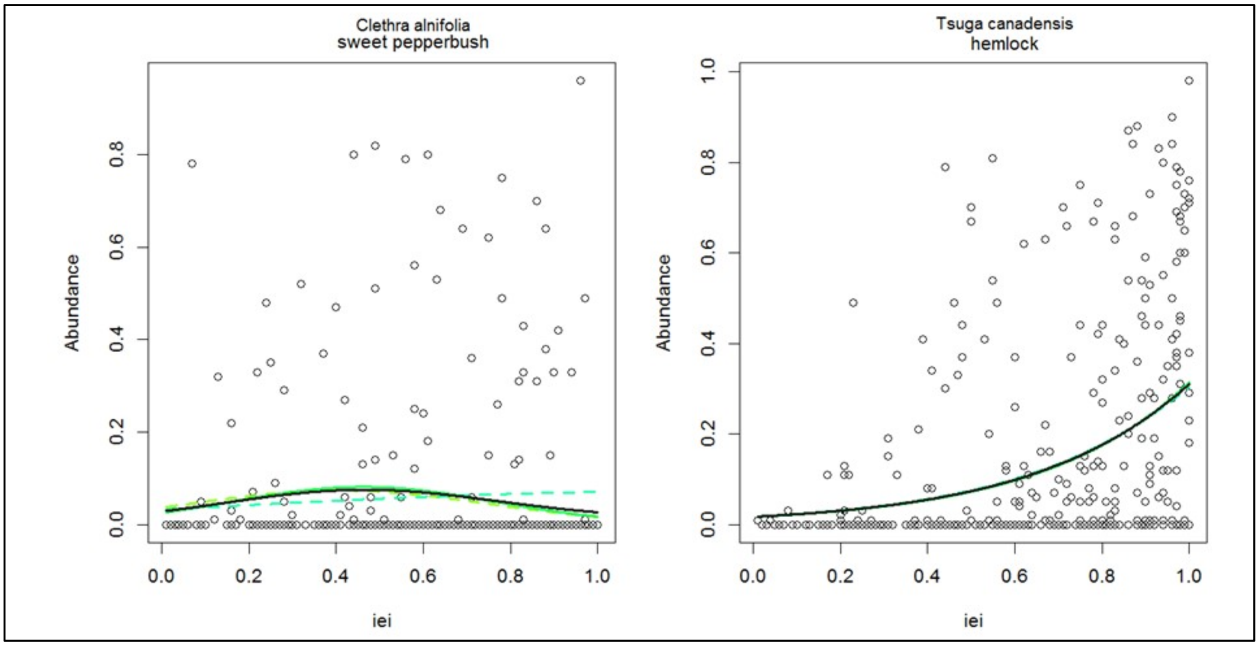

Figure 12. Regression analysis of sweet pepperbush (left) and eastern hemlock (right) in forested wetlands suggesting where they should probably fall on the Coefficient of Conservatism scale.

In order to address geographic variability of plant responses to stressor gradients, wetland scientists in the northeastern U.S. are developing regional CoC scores that vary geographically based on ecoregions. An issue that has not yet been addressed is whether CoC scores should vary from one ecosystem to another. Should the CoC scores for forested wetlands be the same as for upland forests, or shrub swamps, or salt marshes? To begin addressing this question, we compared CAPS-based CoC scores for forested wetlands with those for shrub swamps.

To derive CAPS CoC scores for plants we used the regression plots to identify the most likely score on the IEI gradient. We also calculated an upper and lower confidence interval to quantify the level of uncertainty associated with these values.

Comparison of MA FQA CoC Scores with CAPS Derived CoC Scores

A comparison of CAPS generated CoC scores with those on the MA FQA list shows relatively low correlation (Figure 13, correlation coefficient of 0.382). For detailed results, see Appendix A.

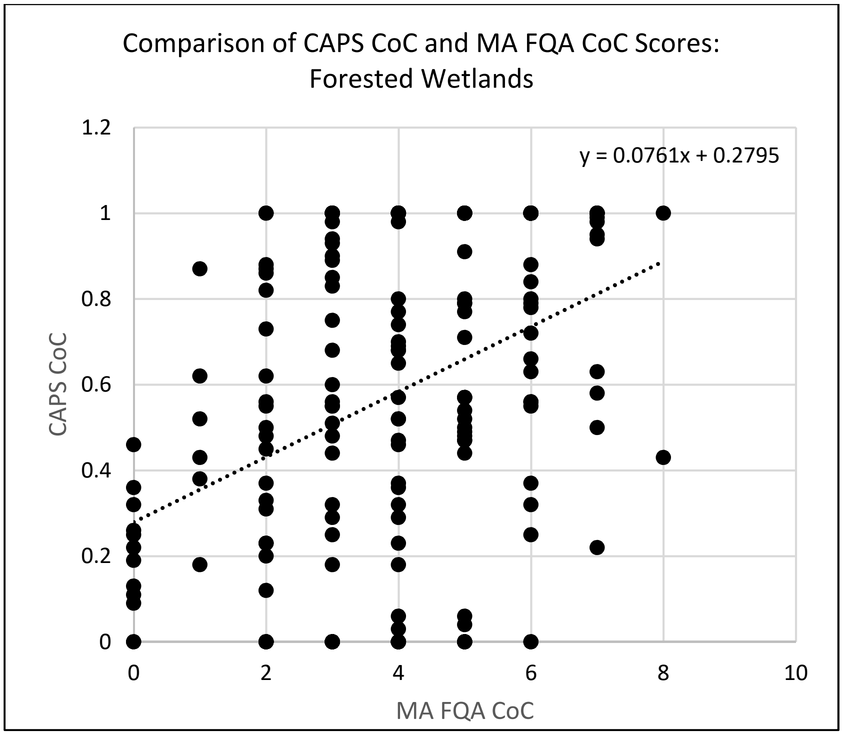

Figure 13. Comparison of CAPS CoC and MA FQA CoC scores for forested wetlands. The correlation coefficient was 0.382.

A comparison of scores for Shrub Swamps yielded similar results (Figure 14, correlation coefficient of 0.211). For detailed results, see Appendix B.

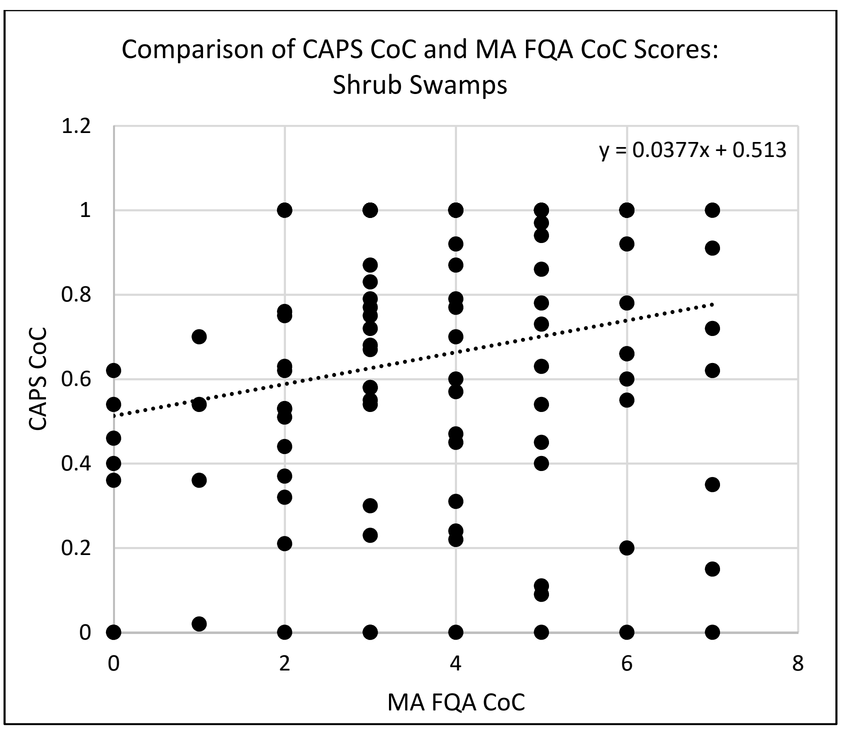

Figure 14. Comparison of CAPS CoC and MA FQA CoC scores for shrub swamps. The correlation coefficient was 0.211.

When we look at the confidence levels recorded for each MA FQA CoC we find that the vast majority of them were considered high confidence estimates (confidence score of 5 out of 5; Figure 15). The CAPS IBI analysis found that for most plants any signal corresponding to the IEI gradient was very weak; the range included between the upper, and lower confidence intervals were typically large. When we converted the confidence interval (1 – confidence interval) to create a scale that can be easily compared with the MA FQA confidence levels, and we see very different patterns in the confidence assigned to CoC scores under the two approachs. (Figure 15Figure 16 and 16).

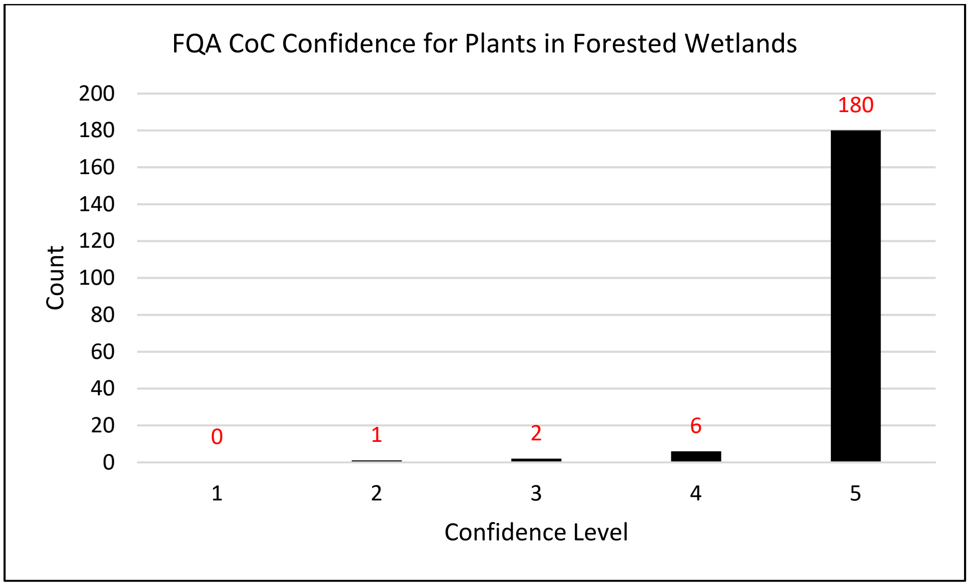

Figure 15. Distribution of confidence estimates for MA FQA CoC scores (1 = low confidence, 5 = high confidence).

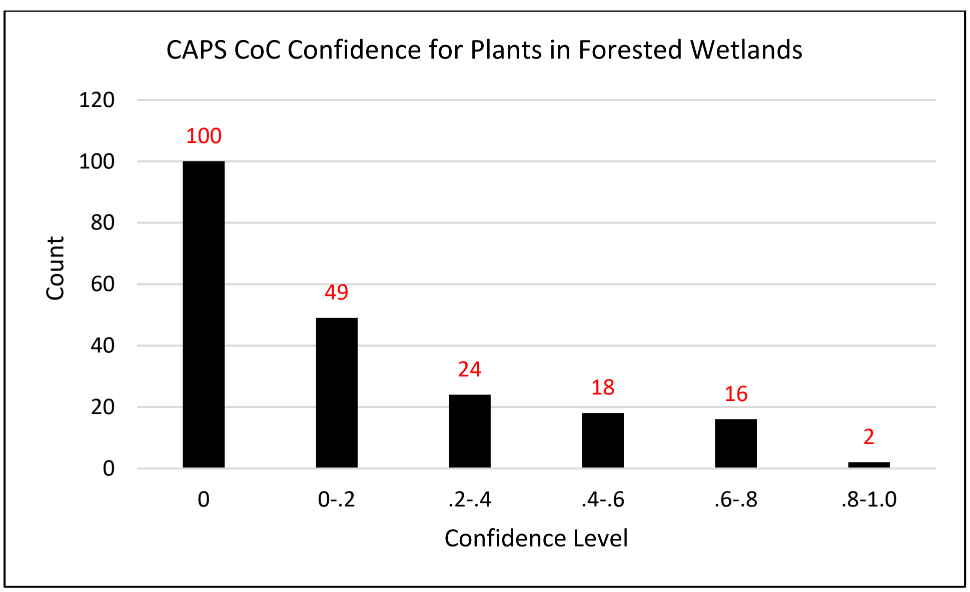

Figure 16. Distribution of confidence estimates for CAPS CoC scores based on forested wetland sites (0 = low confidence, 1 = high confidence). Confidence levels were created by subtracting the size of the confidence interval from one.

Forested Wetlands vs. Shrub Swamps

If the assumption that CoC scores hold no matter what ecosystem FQA is applied to was tested by comparing the CAPS derived CoC scores for forested wetland and for shrub swamp. If the assumption is true, then one would expect a high correlation between forested wetland and shrub swamp CoC scores. In fact, we found a relatively low level of correlation (Figure 17, correlation coefficient of 0.395). It appears, based on an analysis of empirical data from over 450 forested wetlands and shrub swamps, that FQA would be more effective if separate sets of CoC scores were used for these two wetland systems. For detailed results, see Appendix C.

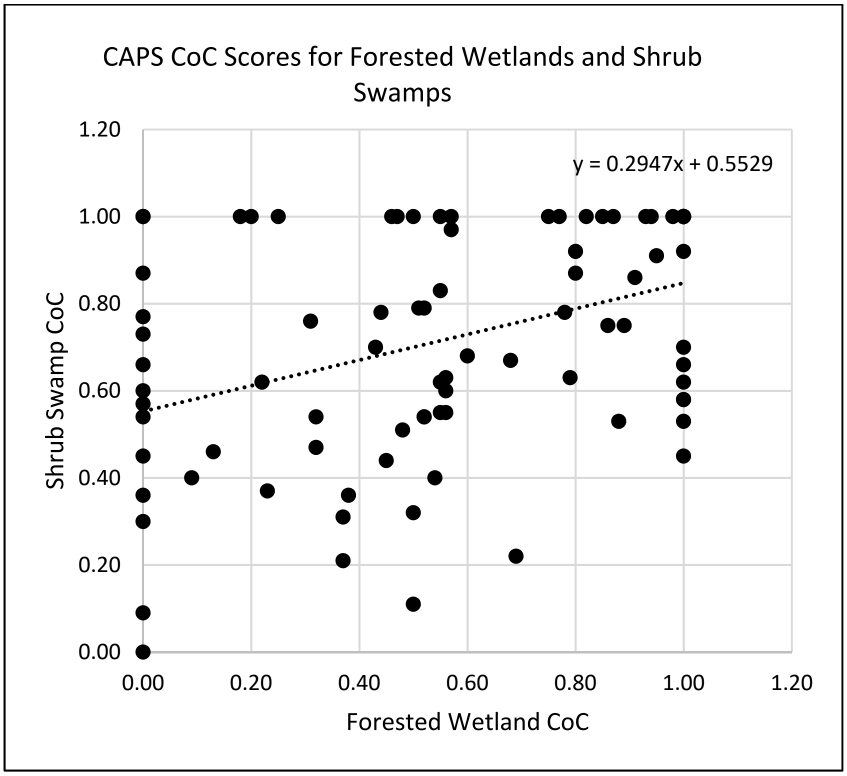

Figure 17. Comparison of CAPS derived CoC scores for forested wetlands and shrub swamps. The correlation coefficient was 0.395.

Implications for FQA

The Floristic Quality Assessment is a rapid assessment methodology based on vegetation, which often can be implemented without expensive diagnostics or specialized expertise. Thus, it is appealing as an approach for assessing the biological condition of ecosystems. EPA and state agencies have been working for years to develop efficient and effective methodologies for assessing wetland condition that are inexpensive enough that they can serve as the basis for comprehensive wetlands assessment and monitoring programs. Therefore, it is natural that states are looking at FQA and its potential for assessing wetland condition.

We have spent years developing plant-based IBIs for forested wetlands in Massachusetts. The process has been successful in developing a suite of robust IBIs that can be applied across most of the state, from coastal watersheds like the Taunton to the Housatonic and Westfield watersheds in the hills of western MA. We are just beginning our work on shrub swamp IBIs and have so far failed to develop effective IBIs for salt marshes using vegetation and invertebrates. We haven't even begun work for other wetland types.

Given the time and expense involved in developing empirically-based IBIs, there is good reason to investigate the use of rapid assessment methodologies like FQA, that are based primarily on best profession judgement. However, these methodologies should be tested using available field data and sophisticated analyses of landscape-based stressors, both individually (e.g. individual stressor metrics) and collectively (e.g. IEI -- Generalized Stressor Gradient).

Our earlier work with multi-taxa IBIs in forested wetlands provides a basis for hope that plant-based assessments can be effective for assessing wetland condition, at least for this wetland type. Continuing work on wetland IBIs has resulted in a dataset that contains detailed vegetation analyses for over 630 sampling locations (388 forested wetlands, 70 shrub swamps, and 175 salt marshes). This dataset provides an opportunity to better understand the relationship between plants and stressor gradients, and test some of the basic assumptions of FQA.

In this report, we address three key issues of importance to FQA and other IBIs (e.g. our empirically based IBIs) for assessing wetland condition. First, are the FQA CoC scores for MA consistent with empirical data on plant species abundance relative to stressor gradients? Second, how sensitive are IBIs to geographic variability in wetland plant ecology (i.e. the indicator value of plants)? Third, can IBIs (or CoC scores) developed in one wetland type be applied to other wetland types?

We examined the CoC scores developed for FQA in Massachusetts by comparing those scores with plant community data in our database for forested wetlands and shrub swamps. We treated CoC scores as predictions about the response of plants to stressor gradients. The 458 forested wetland and shrub swamp locations in our database are geographically diverse and were selected to represent the full range of CAPS IEI. Comparing FQA CoC scores with our regression model results indicated relatively weak agreement (correlation coefficient of 0.382 for plants in forested wetlands and 0.211 for shrub swamps). Although some plants may be strong indicators of low quality or high quality sites, our regression analyses indicate that for most plants, there is a very weak relationship with stressor gradients and most species had wide confidence intervals. It may be unrealistic to assign a single CoC score to species with weak associations with stressor gradients. The preponderance of large confidence intervals in our analysis contrasts with the large number of species whose FQA CoC scores were assigned high confidence levels.

When we applied IBIs developed in central MA to forested wetlands in the Taunton watershed, we got poor results. This serves as a caution about applying IBIs outside of the geographic range of the training data. By expanding our sample size and the geographic scope for the training data we were able to create IBIs for forested wetlands that were robust for use in watersheds across Massachusetts. The IBIs performed best in the watersheds that were used to train the models. However, our analyses indicate that many of the IBIs are robust enough to be used in other watersheds, even though there is some drop-off in performance. These results validate concerns about the need for CoC scores that vary geographically (by state or by ecoregion).

Our analyses also addressed whether IBIs developed in one wetland type can be effectively applied in other wetland types. We found strong evidence to suggest that CoC scores for plants in one context (e.g. forested wetlands) are not sufficient for assessing those same plants in another context (e.g. shrub swamps). There are three lines of evidence to support this conclusion.

1. IBIs developed for forested wetlands performed poorly when applied to shrub swamps.
2. When applied to shrub swamps, IBIs developed for shrub swamps using a small number of sampling locations (n=70) generally out performed forested wetland IBIs that had been developed using data from hundreds of sites (n=388).
3. There was relatively little agreement between empirically derived CoC scores for plants in forested wetlands and shrub swamps (correlation coefficient of 0.395).

Forested wetlands and shrub swamps are similar wetland types. One of the main differences is the amount of shading from canopy cover. Shrub swamps generally receive more sun in the understory and graminoids are not uncommon in these wetlands. Blue joint grass (*Calamagrostis Canadensis*) received an empirically derived CoC score of 0.47 in forested wetlands (meaning that the species is predicted to be most prevalent in sites with an IEI score around 0.47) and a score of 1.0 in shrub swamps. Tussock sedge (*Carex stricta*) had a CAPS CoC score of 0.25 in forested wetlands and 1.0 in shrub swamps (see Appendix C for other examples). One can only imagine the difference we would find in CoC scores for species when they occur in forested wetland versus salt marsh.

Our results suggest that it may be possible to create a rapid assessment methodology that uses plants to assess wetlands condition for some wetland types (forested wetlands and shrub swamps). FQA is a framework that might meet the need for an affordable and reliable assessment method. However, our results suggest that more work needs to be done to test FQA and the assumptions that go into it. In particular, more attention needs to be paid to the assigning of CoC scores. The assumption that one CoC score will suffice for evaluating condition in all wetlands or ecosystems should be reconsidered.

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Appendix A: Comparison of MA FQA CoC Scores with CAPS Derived CoC Scores for Forested Wetlands

CAPS CoC scores are on a scale of 0 to 1; MA FQA scores scale from 0 to 10. MA FQA CoC Confidence (1-5): 1 being the lowest degree of confidence and 5 being the greatest degree of confidence.

Forested Wetland Taxon	CAPS Most Likely CoC (IEI)	CAPS Lower CI	CAPS Upper CI	CI Range	MA FQA CoC Score	MA FQA CoC Confidence
Abies balsamea	1	0.62	1	0.38	7	5
Acer pensylvanicum	1	0.71	1	0.29	5	5
Acer rubrum	0.2	0	1	1	2	5
Acer saccharum	0	0	1	1	5	5
Acer spicatum	1	0.65	1	0.35	7	5
Ageratina altissima	0.62	0	1	1	2	5
Alnus incana	0.56	0	1	1	6	
Amphicarpaea bracteata	1	0	1	1	3	5
Anemone quinquefolia	0.79	0	1	1	6	5
Aralia nudicaulis	0.93	0	1	1	3	5
Arisaema triphyllum	0	0	1	1	4	5
Athyrium filix-femina	0	0	1	1	4	5
Berberis thunbergii	0.11	0	1	1	0	
Betula alleghaniensis	1	0.43	1	0.57	4	5
Betula lenta	0	0	1	1	4	5
Betula papyrifera	0.57	0	1	1	5	5
Betula populifolia	0.45	0	1	1	2	5
Bidens frondosa	0.12	0	0.77	0.77	2	5
Bidens tripartita	0.46	0	0.93	0.93	0	
Boehmeria cylindrica	0.03	0	0.82	0.82	4	5
Brachyelytrum erectum	1	0.35	1	0.65	6	5
Calamagrostis canadensis	0.47	0.02	1	0.98	4	5
Calla palustris	1	0.47	1	0.53	6	4
Caltha palustris	1	0	1	1	6	5
Carex bromoides	0.52	0	1	1	5	2
Carex crinita	0.29	0	0.85	0.85	3	5
Carex debilis	0	0	1	1	3	5
Carex disperma	1	0.95	1	0.05	6	5
Carex folliculata	0.91	0.1	1	0.9	5	5
Carex gracillima	0.6	0.09	1	0.91	3	5
Carex gynandra	1	0.49	1	0.51	4	5
Carex intumescens	0.75	0	1	1	3	5
Carex leptalea	1	0.29	1	0.71	7	3

Forested Wetland Taxon	CAPS Most Likely CoC (IEI)	CAPS Lower CI	CAPS Upper CI	CI Range	MA FQA CoC Score	MA FQA CoC Confidence
Carex lurida	0.82	0	1	1	2	5
Carex scabrata	1	0.5	1	0.5	4	5
Carex stipata	0	0	1	1	6	5
Carex stricta	0.25	0	0.88	0.88	3	5
Carex trisperma	1	0.63	1	0.37	5	5
Carpinus caroliniana	0.47	0.02	0.93	0.91	5	5
Carya cordiformis	0.57	0.23	0.91	0.68	4	5
Carya ovata	0.06	0	0.9	0.9	4	5
Celastrus orbiculatus	0.36	0	0.99	0.99	0	
Chamaecyparis thyoides	0.43	0	1	1	8	5
Chelone glabra	1	0	1	1	6	5
Chrysosplenium americanum	0.95	0	1	1	7	4
Cicuta maculata	0.06	0	1	1	5	5
Cinna latifolia	1	0	1	1	5	5
Circaea alpina	1	0.84	1	0.16	7	5
Circaea lutetiana	0	0	1	1	2	5
Clematis virginiana	0.68	0.05	1	0.95	3	5
Clethra alnifolia	0.47	0	1	1	5	5
Clintonia borealis	1	0.64	1	0.36	6	5
Coptis trifolia	1	0.34	1	0.66	6	5
Cornus alternifolia	0.36	0	1	1	4	5
Cornus amomum	0.32	0	0.81	0.81	4	5
Cornus canadensis	1	0.51	1	0.49	5	5
Cornus sericea	0.5	0.01	1	0.99	5	
Corylus americana	0	0	0.72	0.72	3	5
Corylus cornuta	0.68	0.06	1	0.94	4	5
Dalibarda repens	0.94	0.39	1	0.61	7	5
Dennstaedtia punctilobula	0.23	0	1	1	2	5
Deparia acrostichoides	1	0.31	1	0.69	6	5
Doellingeria umbellata	1	0	1	1	3	
Dryopteris carthusiana	0.37	0	1	1	6	5
Dryopteris clintoniana	0.99	0.07	1	0.93	7	4
Dryopteris cristata	0.5	0	1	1	7	5
Dryopteris intermedia	0.77	0.03	1	0.97	4	5
Epilobium ciliatum	1	0	1	1	4	5
Equisetum arvense	0.23	0	1	1	2	5
Equisetum sylvaticum	0.79	0.22	1	0.78	5	5
Eubotrys racemosa	0.84	0	0.97	0.97	6	5

Forested Wetland Taxon	CAPS Most Likely CoC (IEI)	CAPS Lower CI	CAPS Upper CI	CI Range	MA FQA CoC Score	MA FQA CoC Confidence
Eupatorium perfoliatum	0	0	0.85	0.85	4	5
Eurybia divaricata	1	0	1	1	3	5
Fagus grandifolia	0.98	0.07	1	0.93	4	5
Fragaria virginiana	0.56	0.01	1	0.99	2	5
Frangula alnus	0.22	0	0.93	0.93	0	
Fraxinus americana	0	0	1	1	4	5
Fraxinus nigra	1	0	1	1	7	5
Galium aparine	0.87	0	1	1	1	5
Galium asprellum	0.86	0.14	1	0.86	2	5
Galium palustre	0	0	1	1	6	5
Galium triflorum	0.48	0	1	1	5	5
Gaultheria hispidula	1	0.69	1	0.31	8	5
Gaultheria procumbens	0.7	0.28	1	0.72	4	5
Gaylussacia frondosa	0.49	0	1	1	5	5
Geranium maculatum	0	0	0.57	0.57	3	5
Geum canadense	0	0	1	1	2	5
Geum rivale	0.54	0	1	1	5	5
Glyceria melicaria	1	0.6	1	0.4	6	4
Glyceria striata	1	0.16	1	0.84	4	5
Hamamelis virginiana	1	0	1	1	4	5
Huperzia lucidula	1	0.73	1	0.27	6	5
Hydrocotyle americana	1	0	1	1	3	5
Ilex mucronata	1	0.78	1	0.22	6	5
Ilex verticillata	0.57	0	1	1	5	5
Impatiens capensis	0	0	1	1	3	5
Iris versicolor	1	0	1	1	4	5
Juncus effusus	1	0.63	1	0.37	2	5
Kalmia angustifolia	0.74	0.14	1	0.86	4	5
Kalmia latifolia	1	0.51	1	0.49	4	5
Larix laricina	0.66	0	1	1	6	5
Leersia oryzoides	0	0	1	1	4	5
Ligustrum vulgare	0.19	0	0.55	0.55	0	
Lilium canadense	0.63	0	1	1	6	5
Lindera benzoin	0	0	1	1	4	5
Lonicera canadensis	1	0.73	1	0.27	6	5
Lonicera morrowii	0.09	0	0.75	0.75	0	
Lycopodium hickeyi	0.77	0.51	1	0.49	5	5
Lycopodium obscurum	0.79	0	1	1	5	5
Lycopus uniflorus	1	0.65	1	0.35	4	5

Forested Wetland Taxon	CAPS Most Likely CoC (IEI)	CAPS Lower CI	CAPS Upper CI	CI Range	MA FQA CoC Score	MA FQA CoC Confidence
Lyonia ligustrina	0.55	0	1	1	6	5
Lysimachia ciliata	0.55	0	1	1	3	5
Lysimachia terrestris	0.89	0	1	1	3	5
Maianthemum canadense	0.98	0	1	1	3	5
Maianthemum racemosum	0	0	0.8	0.8	3	
Medeola virginiana	1	0.25	1	0.75	4	5
Mitchella repens	0.83	0	1	1	3	5
Monotropa uniflora	1	0.28	1	0.72	5	5
Nasturtium officinale	0	0	0.97	0.97	0	
Nyssa sylvatica	0.72	0	1	1	6	5
Oclemena acuminata	1	0.45	1	0.55	4	5
Onoclea sensibilis	0.37	0	1	1	2	5
Osmunda cinnamomea	0.85	0.05	1	0.95	3	5
Osmunda claytoniana	0	0	1	1	4	5
Osmunda regalis	0.57	0	1	1	5	5
Ostrya virginiana	0.04	0	1	1	5	5
Oxalis montana	1	0.75	1	0.25	6	5
Oxalis stricta	0	0	0.64	0.64	2	5
Packera aurea	0.8	0.26	1	0.74	4	5
Parthenocissus quinquefolia	0.18	0	1	1	1	5
Phegopteris connectilis	1	0.8	1	0.2	6	5
Photinia melanocarpa	0.52	0	1	1	4	5
Photinia pyrifolia	1	0	1	1	4	5
Physocarpus opulifolius	0.25	0	0.54	0.54	0	
Picea rubens	1	0.64	1	0.36	6	5
Pilea pumila	0	0	0.96	0.96	2	5
Pinus strobus	0.5	0	1	1	2	5
Platanthera clavellata	1	0.36	1	0.64	6	5
Polygonatum pubescens	0	0	1	1	4	5
Polygonum arifolium	0.52	0	1	1	4	5
Polygonum sagittatum	1	0.1	1	0.9	3	5
Polygonum virginianum	0.32	0	1	1	3	5
Polystichum acrostichoides	0.8	0	1	1	5	5
Populus grandidentata	0.44	0	0.9	0.9	3	5
Populus tremuloides	0.55	0.16	1	0.84	2	5
Potentilla simplex	0.52	0	1	1	1	5

Forested Wetland Taxon	CAPS Most Likely CoC (IEI)	CAPS Lower CI	CAPS Upper CI	CI Range	MA FQA CoC Score	MA FQA CoC Confidence
Prenanthes altissima	0.65	0.05	1	0.95	4	4
Prunella vulgaris	0.62	0	1	1	1	5
Prunus serotina	0.51	0.02	1	0.98	3	5
Prunus virginiana	0.55	0.04	1	0.96	3	5
Pteridium aquilinum	1	0.34	1	0.66	2	5
Pyrola elliptica	0.71	0.2	1	0.8	5	5
Quercus alba	0.23	0	0.89	0.89	4	5
Quercus bicolor	0.22	0	1	1	7	5
Quercus rubra	0	0	1	1	3	5
Ranunculus abortivus	0.68	0	1	1	4	5
Ranunculus hispidus	1	0.03	1	0.97	6	5
Ranunculus recurvatus	0.48	0	1	1	3	5
Rhamnus cathartica	0.32	0	0.82	0.82	0	
Rhododendron prinophyllum	1	0.71	1	0.29	5	5
Rhododendron viscosum	0.32	0	1	1	6	5
Rosa multiflora	0.13	0	0.88	0.88	0	
Rosa palustris	0	0	1	1	5	5
Rubus allegheniensis	0.33	0	1	1	2	5
Rubus hispidus	0.87	0	1	1	2	5
Rubus idaeus	0.43	0	1	1	1	5
Rubus pubescens	0.78	0.15	1	0.85	6	5
Sambucus canadensis	0	0	1	1	3	
Saxifraga pensylvanica	1	0.14	1	0.86	6	5
Scutellaria lateriflora	0.18	0	1	1	4	5
Smilax herbacea	0.18	0	0.83	0.83	3	5
Smilax rotundifolia	0.73	0	1	1	2	5
Solanum dulcamara	0	0	0.88	0.88	0	
Solidago gigantea	0.48	0.01	0.96	0.95	2	5
Solidago patula	0.56	0	1	1	6	5
Solidago rugosa	0.31	0	1	1	2	5
Sorbus americana	1	0.46	1	0.54	7	5
Symphyotrichum lateriflorum	0.88	0	1	1	2	
Symphyotrichum puniceum	0.69	0	1	1	4	
Symplocarpus foetidus	0	0	0.93	0.93	3	5
Taxus canadensis	0.98	0.09	1	0.91	7	5
Thalictrum pubescens	0.46	0	1	1	4	5

Forested Wetland Taxon	CAPS Most Likely CoC (IEI)	CAPS Lower CI	CAPS Upper CI	CI Range	MA FQA CoC Score	MA FQA CoC Confidence
Thelypteris noveboracensis	1	0	1	1	3	5
Thelypteris palustris	0	0	1	1	5	5
Thelypteris simulata	0.63	0.08	1	0.92	7	3
Tiarella cordifolia	1	0.35	1	0.65	7	5
Tilia americana	0	0	0.79	0.79	5	5
Toxicodendron radicans	0.38	0	1	1	1	5
Toxicodendron vernix	0.25	0	0.9	0.9	6	5
Triadenum virginicum	0.8	0.23	1	0.77	6	5
Trientalis borealis	1	0	1	1	4	5
Trillium undulatum	1	0.38	1	0.62	6	5
Tsuga canadensis	1	0.49	1	0.51	3	5
Ulmus americana	0	0	0.75	0.75	5	5
Uvularia sessilifolia	1	0	1	1	3	5
Vaccinium angustifolium	0.9	0.22	1	0.78	3	5
Vaccinium corymbosum	0.37	0	1	1	4	5
Vaccinium myrtilloides	0.88	0.5	1	0.5	6	5
Veratrum viride	1	0.5	1	0.5	5	5
Veronica officinalis	0.26	0	1	1	0	
Viburnum acerifolium	0.29	0	1	1	4	5
Viburnum dentatum	0.44	0	1	1	5	5
Viburnum lantanoides	1	0.62	1	0.38	6	5
Viburnum lentago	0	0	1	1	5	5
Viburnum nudum	0.94	0.2	1	0.8	3	
Viola cucullata	1	0.46	1	0.54	5	5
Vitis labrusca	0	0	0.74	0.74	2	5
Woodwardia virginica	0.58	0	1	1	7	4
Zizia aurea	0.56	0.27	0.85	0.58	3	5

Appendix B: Comparison of MA FQA CoC Scores with CAPS Derived CoC Scores for Shrub Swamps

CAPS CoC scores are on a scale of 0 to 1; MA FQA scores scale from 0 to 10. MA FQA CoC Confidence (1-5): 1 being the lowest degree of confidence and 5 being the greatest degree of confidence.

Forested Wetland Taxon	CAPS Most Likely CoC (IEI)	CAPS Lower CI	CAPS Upper CI	CI Range	MA FQA CoC Score	MA FQA CoC Confidence
Abies balsamea	1	0.39	1	0.61	7	5
Acer rubrum	1	0	1	1	2	5
Alnus incana	0.6	0.09	1	0.91	6	
Aralia nudicaulis	1	0.02	1	0.98	3	5
Arisaema triphyllum	0.77	0	1	1	4	5
Athyrium filix-femina	0.6	0.12	1	0.88	4	5
Betula alleghaniensis	1	0.03	1	0.97	4	5
Betula populifolia	0.44	0	1	1	2	5
Calamagrostis canadensis	1	0.48	1	0.52	4	5
Carex bromoides	0.54	0.05	1	0.95	5	2
Carex folliculata	0.86	0.69	1	0.31	5	5
Carex gracillima	0.68	0	1	1	3	5
Carex gynandra	0.92	0	1	1	4	5
Carex interior	0.35	0	1	1	7	4
Carex intumescens	1	0	1	1	3	5
Carex lacustris	1	0.23	1	0.77	6	5
Carex leptalea	0.62	0.12	1	0.88	7	3
Carex lurida	1	0	1	1	2	5
Carex projecta	1	0.03	1	0.97	5	3
Carex stipata	1	0.38	1	0.62	6	5
Carex stricta	1	0	1	1	3	5
Chelone glabra	1	0	1	1	6	5
Chrysosplenium americanum	0.91	0.54	1	0.46	7	4
Cicuta bulbifera	0	0	0.95	0.95	7	5
Clematis virginiana	0.67	0.23	1	0.77	3	5
Coptis trifolia	1	0.53	1	0.47	6	5
Cornus amomum	0.47	0	0.91	0.91	4	5
Cornus sericea	0.11	0	0.92	0.92	5	
Doellingeria umbellata	1	0	1	1	3	
Dryopteris cristata	1	0	1	1	7	5
Dryopteris intermedia	1	0.12	1	0.88	4	5

Forested Wetland Taxon	CAPS Most Likely CoC (IEI)	CAPS Lower CI	CAPS Upper CI	CI Range	MA FQA CoC Score	MA FQA CoC Confidence
Dulichium arundinaceum	1	0.81	1	0.19	6	5
Epilobium ciliatum	0.45	0	1	1	4	5
Equisetum arvense	0.37	0	1	1	2	5
Equisetum sylvaticum	0.63	0	1	1	5	5
Eupatorium perfoliatum	1	0	1	1	4	5
Euthamia graminifolia	0.77	0.16	1	0.84	3	5
Fragaria virginiana	0.63	0.26	1	0.74	2	5
Frangula alnus	0.62	0	1	1	0	
Fraxinus americana	0.57	0.24	0.96	0.72	4	5
Galium asprellum	0.75	0.07	1	0.93	2	5
Galium palustre	0.66	0.15	1	0.85	6	5
Galium tinctorium	0.94	0.05	1	0.95	5	3
Galium trifidum	0	0	1	1	6	4
Geum rivale	0.4	0	1	1	5	5
Glyceria canadensis	0	0	1	1	5	5
Glyceria melicaria	1	0.09	1	0.91	6	4
Glyceria striata	1	0	1	1	4	5
Hydrocotyle americana	0.58	0	1	1	3	5
Ilex verticillata	1	0	1	1	5	5
Impatiens capensis	0.3	0	1	1	3	5
Iris versicolor	1	0	1	1	4	5
Juncus effusus	0.53	0	1	1	2	5
Leersia oryzoides	0	0	1	1	4	5
Lonicera morrowii	0.4	0	0.91	0.91	0	
Lonicera villosa	0.72	0	1	1	7	3
Lycopus uniflorus	0.7	0	1	1	4	5
Lyonia ligustrina	1	0	1	1	6	5
Lysimachia ciliata	0.55	0.17	0.93	0.76	3	5
Lysimachia terrestris	0.75	0	1	1	3	5
Lythrum salicaria	0	0	0.77	0.77	0	
Maianthemum canadense	1	0	1	1	3	5
Mentha arvensis	0	0	1	1	0	
Onoclea sensibilis	0.21	0	1	1	2	5
Osmunda cinnamomea	1	0	1	1	3	5
Osmunda regalis	0.97	0.01	1	0.99	5	5
Packera aurea	0.87	0.06	1	0.94	4	5
Phalaris arundinacea	0.02	0	1	1	1	5
Picea rubens	1	0.4	1	0.6	6	5

Forested Wetland Taxon	CAPS Most Likely CoC (IEI)	CAPS Lower CI	CAPS Upper CI	CI Range	MA FQA CoC Score	MA FQA CoC Confidence
Pinus strobus	0.32	0	1	1	2	5
Poa palustris	0.72	0	1	1	3	5
Polygonum arifolium	0.79	0.26	1	0.74	4	5
Polygonum sagittatum	1	0	1	1	3	5
Populus tremuloides	0.62	0.11	1	0.89	2	5
Potentilla simplex	0.54	0.21	0.86	0.65	1	5
Prunus serotina	0.79	0.32	1	0.68	3	5
Prunus virginiana	0.83	0	1	1	3	5
Ranunculus hispidus	0.66	0.27	1	0.73	6	5
Rhamnus cathartica	0.54	0.14	0.94	0.8	0	
Rosa multiflora	0.46	0.13	0.84	0.71	0	
Rosa palustris	0.09	0	1	1	5	5
Rubus hispidus	1	0	1	1	2	5
Rubus idaeus	0.7	0	1	1	1	5
Rubus pubescens	0.78	0.26	1	0.74	6	5
Sagittaria latifolia	0.2	0	1	1	6	5
Salix bebbiana	0	0	0.88	0.88	2	5
Salix discolor	0.23	0	1	1	3	5
Salix sericea	0.24	0	1	1	4	4
Sambucus canadensis	0.87	0	1	1	3	
Scirpus cyperinus	0	0	0.94	0.94	3	5
Scutellaria galericulata	1	0	1	1	4	5
Scutellaria lateriflora	1	0	1	1	4	5
Solanum dulcamara	0.36	0	1	1	0	
Solidago gigantea	0.51	0.05	0.97	0.92	2	5
Solidago patula	0.55	0	1	1	6	5
Solidago rugosa	0.76	0.21	1	0.79	2	5
Sparganium americanum	0.15	0	1	1	7	4
Spiraea tomentosa	1	0.53	1	0.47	3	5
Symphyotrichum lateriflorum	0.53	0.11	0.98	0.87	2	
Symphyotrichum puniceum	0.22	0	1	1	4	
Symplocarpus foetidus	0.54	0	1	1	3	5
Thalictrum pubescens	1	0	1	1	4	5
Thelypteris noveboracensis	0.58	0	1	1	3	5
Thelypteris palustris	1	0	1	1	5	5
Toxicodendron radicans	0.36	0	1	1	1	5

Forested Wetland Taxon	CAPS Most Likely CoC (IEI)	CAPS Lower CI	CAPS Upper CI	CI Range	MA FQA CoC Score	MA FQA CoC Confidence
Triadenum virginicum	0.92	0.71	1	0.29	6	5
Tsuga canadensis	1	0.06	1	0.94	3	5
Typha latifolia	0	0	1	1	3	5
Ulmus americana	0.45	0.13	0.92	0.79	5	5
Vaccinium corymbosum	0.31	0	1	1	4	5
Viburnum dentatum	0.78	0	1	1	5	5
Viburnum lentago	0.73	0.17	1	0.83	5	5
Viburnum nudum	1	0	1	1	3	

Appendix C: Comparison of CAPS Derived CoC Scores for Forested Wetlands and Shrub Swamps

CAPS CoC scores are on a scale of 0 to 1; MA FQA scores scale from 0 to 10.

Taxon	Forested Wetland CAPS CoC	Shrub Swamp CAPS CoC	MA FQA CoC Score
Abies balsamea	1.00	1.00	7
Acer pensylvanicum	1.00		5
Acer rubrum	0.20	1.00	2
Acer saccharum	0.00		5
Acer spicatum	1.00		7
Ageratina altissima	0.62		2
Alnus incana	0.56	0.60	6
Amphicarpaea bracteata	1.00		3
Anemone quinquefolia	0.79		6
Aralia nudicaulis	0.93	1.00	3
Arisaema triphyllum	0.00	0.77	4
Athyrium filix-femina	0.00	0.60	4
Berberis thunbergii	0.11		0
Betula alleghaniensis	1.00	1.00	4
Betula lenta	0.00		4
Betula papyrifera	0.57		5
Betula populifolia	0.45	0.44	2
Bidens frondosa	0.12		2
Bidens tripartita	0.46		0
Boehmeria cylindrica	0.03		4
Brachyelytrum erectum	1.00		6
Calamagrostis canadensis	0.47	1.00	4
Calla palustris	1.00		6
Caltha palustris	1.00		6
Carex bromoides	0.52	0.54	5
Carex crinita	0.29		3
Carex debilis	0.00		3
Carex disperma	1.00		6
Carex folliculata	0.91	0.86	5
Carex gracillima	0.60	0.68	3
Carex gynandra	1.00	0.92	4
Carex interior		0.35	7
Carex intumescens	0.75	1.00	3
Carex lacustris		1.00	6
Carex leptalea	1.00	0.62	7

Taxon	Forested Wetland CAPS CoC	Shrub Swamp CAPS CoC	MA FQA CoC Score
Carex lurida	0.82	1.00	2
Carex projecta		1.00	5
Carex scabrata	1.00		4
Carex stipata	0.00	1.00	6
Carex stricta	0.25	1.00	3
Carex trisperma	1.00		5
Carpinus caroliniana	0.47		5
Carya cordiformis	0.57		4
Carya ovata	0.06		4
Celastrus orbiculatus	0.36		0
Chamaecyparis thyoides	0.43		8
Chelone glabra	1.00	1.00	6
Chrysosplenium americanum	0.95	0.91	7
Cicuta bulbifera		0.00	7
Cicuta maculata	0.06		5
Cinna latifolia	1.00		5
Circaea alpina	1.00		7
Circaea lutetiana	0.00		2
Clematis virginiana	0.68	0.67	3
Clethra alnifolia	0.47		5
Clintonia borealis	1.00		6
Coptis trifolia	1.00	1.00	6
Cornus alternifolia	0.36		4
Cornus amomum	0.32	0.47	4
Cornus canadensis	1.00		5
Cornus sericea	0.50	0.11	5
Corylus americana	0.00		3
Corylus cornuta	0.68		4
Dalibarda repens	0.94		7
Dennstaedtia punctilobula	0.23		2
Deparia acrostichoides	1.00		6
Doellingeria umbellata	1.00	1.00	3
Dryopteris carthusiana	0.37		6
Dryopteris clintoniana	0.99		7
Dryopteris cristata	0.50	1.00	7
Dryopteris intermedia	0.77	1.00	4
Dulichium arundinaceum		1.00	6
Epilobium ciliatum	1.00	0.45	4

Taxon	Forested Wetland CAPS CoC	Shrub Swamp CAPS CoC	MA FQA CoC Score
Equisetum arvense	0.23	0.37	2
Equisetum sylvaticum	0.79	0.63	5
Eubotrys racemosa	0.84		6
Eupatorium perfoliatum	0.00	1.00	4
Eurybia divaricata	1.00		3
Euthamia graminifolia		0.77	3
Fagus grandifolia	0.98		4
Fragaria virginiana	0.56	0.63	2
Frangula alnus	0.22	0.62	0
Fraxinus americana	0.00	0.57	4
Fraxinus nigra	1.00		7
Galium aparine	0.87		1
Galium asprellum	0.86	0.75	2
Galium palustre	0.00	0.66	6
Galium tinctorium		0.94	5
Galium trifidum		0.00	6
Galium triflorum	0.48		5
Gaultheria hispidula	1.00		8
Gaultheria procumbens	0.70		4
Gaylussacia frondosa	0.49		5
Geranium maculatum	0.00		3
Geum canadense	0.00		2
Geum rivale	0.54	0.40	5
Glyceria canadensis		0.00	5
Glyceria melicaria	1.00	1.00	6
Glyceria striata	1.00	1.00	4
Hamamelis virginiana	1.00		4
Huperzia lucidula	1.00		6
Hydrocotyle americana	1.00	0.58	3
Ilex mucronata	1.00		6
Ilex verticillata	0.57	1.00	5
Impatiens capensis	0.00	0.30	3
Iris versicolor	1.00	1.00	4
Juncus effusus	1.00	0.53	2
Kalmia angustifolia	0.74		4
Kalmia latifolia	1.00		4
Larix laricina	0.66		6
Leersia oryzoides	0.00	0.00	4
Ligustrum vulgare	0.19		0

Taxon	Forested Wetland CAPS CoC	Shrub Swamp CAPS CoC	MA FQA CoC Score
Lilium canadense	0.63		6
Lindera benzoin	0.00		4
Lonicera canadensis	1.00		6
Lonicera morrowii	0.09	0.40	0
Lonicera villosa		0.72	7
Lycopodium hickeyi	0.77		5
Lycopodium obscurum	0.79		5
Lycopus uniflorus	1.00	0.70	4
Lyonia ligustrina	0.55	1.00	6
Lysimachia ciliata	0.55	0.55	3
Lysimachia terrestris	0.89	0.75	3
Lythrum salicaria		0.00	0
Maianthemum canadense	0.98	1.00	3
Maianthemum racemosum	0.00		3
Medeola virginiana	1.00		4
Mentha arvensis		0.00	0
Mitchella repens	0.83		3
Monotropa uniflora	1.00		5
Nasturtium officinale	0.00		0
Nyssa sylvatica	0.72		6
Oclemena acuminata	1.00		4
Onoclea sensibilis	0.37	0.21	2
Osmunda cinnamomea	0.85	1.00	3
Osmunda claytoniana	0.00		4
Osmunda regalis	0.57	0.97	5
Ostrya virginiana	0.04		5
Oxalis montana	1.00		6
Oxalis stricta	0.00		2
Packera aurea	0.80	0.87	4
Parthenocissus quinquefolia	0.18		1
Phalaris arundinacea		0.02	1
Phegopteris connectilis	1.00		6
Photinia melanocarpa	0.52		4
Photinia pyrifolia	1.00		4
Physocarpus opulifolius	0.25		0
Picea rubens	1.00	1.00	6
Pilea pumila	0.00		2
Pinus strobus	0.50	0.32	2

Taxon	Forested Wetland CAPS CoC	Shrub Swamp CAPS CoC	MA FQA CoC Score
Platanthera clavellata	1.00		6
Poa palustris		0.72	3
Polygonatum pubescens	0.00		4
Polygonum arifolium	0.52	0.79	4
Polygonum sagittatum	1.00	1.00	3
Polygonum virginianum	0.32		3
Polystichum acrostichoides	0.80		5
Populus grandidentata	0.44		3
Populus tremuloides	0.55	0.62	2
Potentilla simplex	0.52	0.54	1
Prenanthes altissima	0.65		4
Prunella vulgaris	0.62		1
Prunus serotina	0.51	0.79	3
Prunus virginiana	0.55	0.83	3
Pteridium aquilinum	1.00		2
Pyrola elliptica	0.71		5
Quercus alba	0.23		4
Quercus bicolor	0.22		7
Quercus rubra	0.00		3
Ranunculus abortivus	0.68		4
Ranunculus hispidus	1.00	0.66	6
Ranunculus recurvatus	0.48		3
Rhamnus cathartica	0.32	0.54	0
Rhododendron prinophyllum	1.00		5
Rhododendron viscosum	0.32		6
Rosa multiflora	0.13	0.46	0
Rosa palustris	0.00	0.09	5
Rubus allegheniensis	0.33		2
Rubus hispidus	0.87	1.00	2
Rubus idaeus	0.43	0.70	1
Rubus pubescens	0.78	0.78	6
Sagittaria latifolia		0.20	6
Salix bebbiana		0.00	2
Salix discolor		0.23	3
Salix sericea		0.24	4
Sambucus canadensis	0.00	0.87	3
Saxifraga pensylvanica	1.00		6
Scirpus cyperinus		0.00	3

Taxon	Forested Wetland CAPS CoC	Shrub Swamp CAPS CoC	MA FQA CoC Score
Scutellaria galericulata		1.00	4
Scutellaria lateriflora	0.18	1.00	4
Smilax herbacea	0.18		3
Smilax rotundifolia	0.73		2
Solanum dulcamara	0.00	0.36	0
Solidago gigantea	0.48	0.51	2
Solidago patula	0.56	0.55	6
Solidago rugosa	0.31	0.76	2
Sorbus americana	1.00		7
Sparganium americanum		0.15	7
Spiraea tomentosa		1.00	3
Symphyotrichum lateriflorum	0.88	0.53	2
Symphyotrichum puniceum	0.69	0.22	4
Symplocarpus foetidus	0.00	0.54	3
Taxus canadensis	0.98		7
Thalictrum pubescens	0.46	1.00	4
Thelypteris noveboracensis	1.00	0.58	3
Thelypteris palustris	0.00	1.00	5
Thelypteris simulata	0.63		7
Tiarella cordifolia	1.00		7
Tilia americana	0.00		5
Toxicodendron radicans	0.38	0.36	1
Toxicodendron vernix	0.25		6
Triadenum virginicum	0.80	0.92	6
Trientalis borealis	1.00		4
Trillium undulatum	1.00		6
Tsuga canadensis	1.00	1.00	3
Typha latifolia		0.00	3
Ulmus americana	0.00	0.45	5
Uvularia sessilifolia	1.00		3
Vaccinium angustifolium	0.90		3
Vaccinium corymbosum	0.37	0.31	4
Vaccinium myrtilloides	0.88		6
Veratrum viride	1.00		5
Veronica officinalis	0.26		0
Viburnum acerifolium	0.29		4
Viburnum dentatum	0.44	0.78	5

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Viburnum lantanoides	1.00		6
Viburnum lentago	0.00	0.73	5
Viburnum nudum	0.94	1.00	3
Viola cucullata	1.00		5
Vitis labrusca	0.00		2
Woodwardia virginica	0.58		7
Zizia aurea	0.56		3