Use of a Continuous Aquatic Life Use (CALU) Approach to Evaluate Wetland Mitigation Sites in Massachusetts

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Acknowledgements

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Executive Summary

This project represents the first attempt at using the Continuous Aquatic Life Use (CALU) approach to evaluate wetland condition. Five replacement wetlands constructed as part of variance-permitted projects were evaluated using the Site Level Assessment Method (SLAM) for forested wetlands. All five sites fell within expected ranges for ecological integrity, although the Hanson replacement area was borderline low for ecological integrity and unacceptably low for two of three metrics. The Indices of Biological Integrity (IBIs) applied to these five sites were all vegetation-based IBIs. Results from a related study focused on the success of wetlands replacement projects suggested that wetland seed mixes and nursery stock could potentially be providing a distorted picture of the condition of created wetlands. Further research is needed to determine whether, given the influence that seed mixes and nursery stock have on vegetative communities, it is appropriate to use plant-based IBIs to evaluate created wetlands. It is possible that we will find that while vegetation-only IBIs are appropriate for evaluating natural wetlands, multi-taxa IBIs are needed in order to get an accurate assessment of the condition of created wetlands.

Introduction

As part of a larger project to evaluate wetland replacement as a form of mitigation for wetland loss in Massachusetts we collected detailed vegetation data for replacement wetlands that were permitted through the variance process of the Massachusetts Wetlands Protection Act regulations (310 CMR 10.05(10)) and applied Indices of Biological Integrity (IBIs) to test a Continuous Aquatic Life Use (CALU) approach for developing wetland water quality standards. Variances can be requested for projects with an overriding public interest, no alternative, and wetlands alterations that cannot meet performance standards. The goals of this evaluation were to determine: 1) if the replacement areas are on a "trajectory" to become forested wetlands and if so, 2) if they are within an expected range of variability for IBIs included in the CALU wetlands assessment methodology. The CALU approach is described in Development and Use of Aquatic Life Use Standards for Wetlands in Massachusetts (Jackson et al., 2011). Excerpts from that report are included as part of this report.

The Biological Condition Gradient

The Biological Condition Gradient (BCG) was developed to provide a conceptual basis for understanding biological condition and developing numeric criteria for aquatic life use. The BCG is a comprehensive model that describes the relationship between biological condition and stressors in the surrounding environment along a disturbance gradient. EPA has suggested that states consider designating Tiers corresponding to various levels of biological condition based on the BCG model. This is referred to as the Tiered Aquatic Life Use (TALU) approach.

In Massachusetts, we have characterized the disturbance gradient with a sophisticated modeling approach, the Conservation Assessment and Prioritization System (CAPS). The output of CAPS is an Index of Ecological Integrity (IEI). Ecological integrity is defined as the "the long-term capability of the ecological community to sustain its composition, structure and function and thus also its resiliency to stress." Neither BCG nor Ecological Integrity can be directly determined in the field.

In order to develop narrative and/or numeric criteria for biological condition to be used in assessing attainment goals for fish, other aquatic life and wildlife, it is necessary to use indices of biological integrity (IBIs). Indices of Biological Integrity are metrics used to quantify changes in biological communities in response to adverse human activity and can serve as indicators of particular stressors acting on a wetland or water body or as a composite score for biological condition. In order to implement the TALU approach it is first necessary to develop one or more IBIs for assessing biological condition. Presumably the aquatic life use Tiers would be based on IBI scores and would correspond to either water quality Classes or Qualifiers. Tying TALU to water quality Classes or Qualifiers is necessary because the biological condition of Waters is likely to be constrained by the amount of development (and associated stressors) in the surrounding landscape or watershed unless significant restoration measures are implemented. Wetlands or water bodies that occur within highly developed landscapes are likely to be limited in how good they can be from a biological perspective. The use of Classes or Qualifiers allows for the setting of numeric criteria (IBI scores) that are attainable for wetlands and water bodies in different landscape contexts.

From TALU to CALU

The Biological Condition Gradient model depicts a theoretical relationship between biological condition on the vertical axis and a Generalized Stressor Gradient on the horizontal axis (Figure 1). CAPS is a tool that can be used to approximate the Generalized Stressor Gradient (GSG) used in the Biological Condition Gradient model for wetlands and water bodies. The results of the CAPS assessment are scores for every undeveloped cell in the landscape along a continuous gradient (Index of Ecological Integrity – IEI) ranging from 0-1. High IEI scores (approaching 1.0) are indicative of communities that are relatively free from stressors. In our approach the GSG is simply the opposite of the Index of Ecological Integrity (GSG = 1 - IEI) (Figure 2).

CAPS provides an approach to the establishment of numeric criteria for aquatic life use that is consistent with TALU but eliminates the need to develop tiers. We call this new approach CALU for Continuous Aquatic Life Use standards. Because both IEI and IBI yield scores that are continuous throughout their range it is not necessary to create Tiers or Classes for wetlands and water bodies in order to have meaningful criteria for aquatic life use.

The CALU approach is based on the relationship between IEI (representing the constraints on biological condition due to the nature of the surrounding landscape) and IBI, which represents the actual condition of a site based on assessments conducted in the field (figure 3). By defining an expected range of variability around this relationship it is possible to create numeric criteria for biological condition (a range of acceptable IBI scores) based on each site's particular landscape context (IEI score).

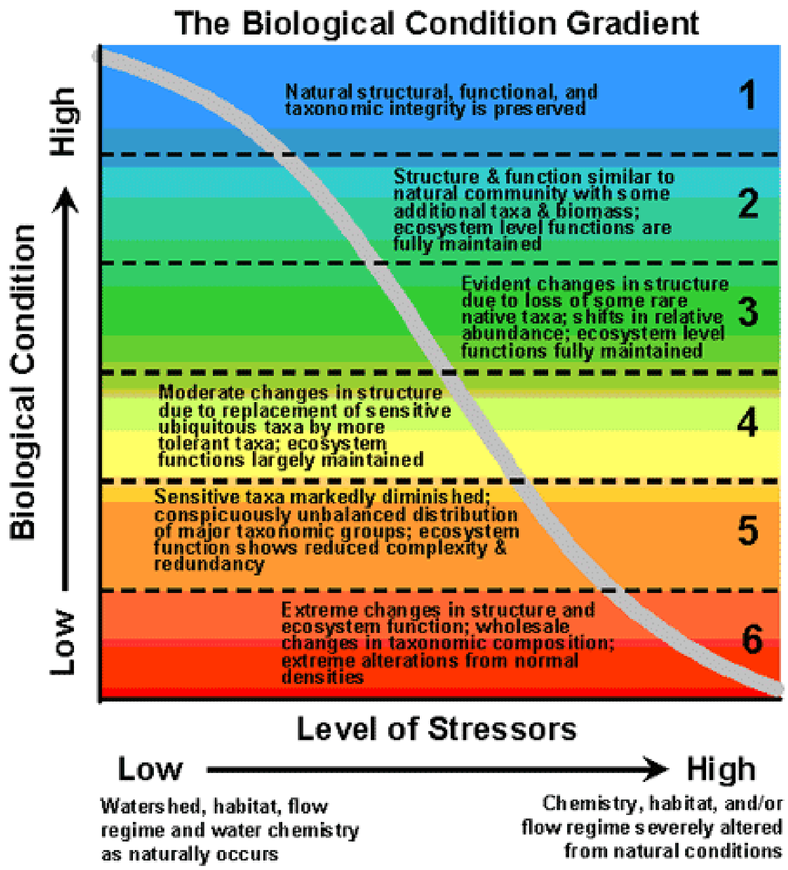

Figure 1. Theoretical Relationship between biological condition and a generalized stressor gradient as part of the Biological Condition Gradient model.

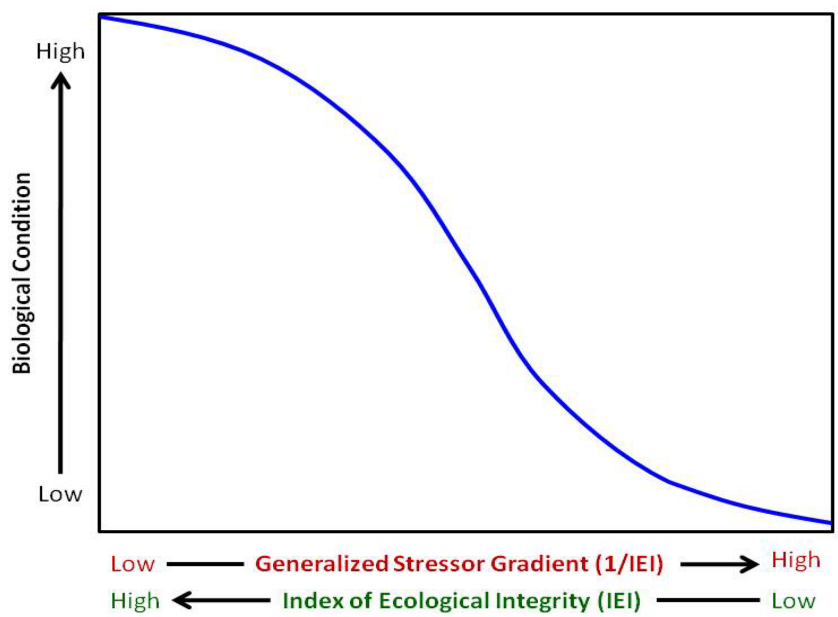

Figure 2. CAPS IEI is the opposite of the Generalized Stressor Gradient. Ecological Integrity scores are positively correlated with biological condition.

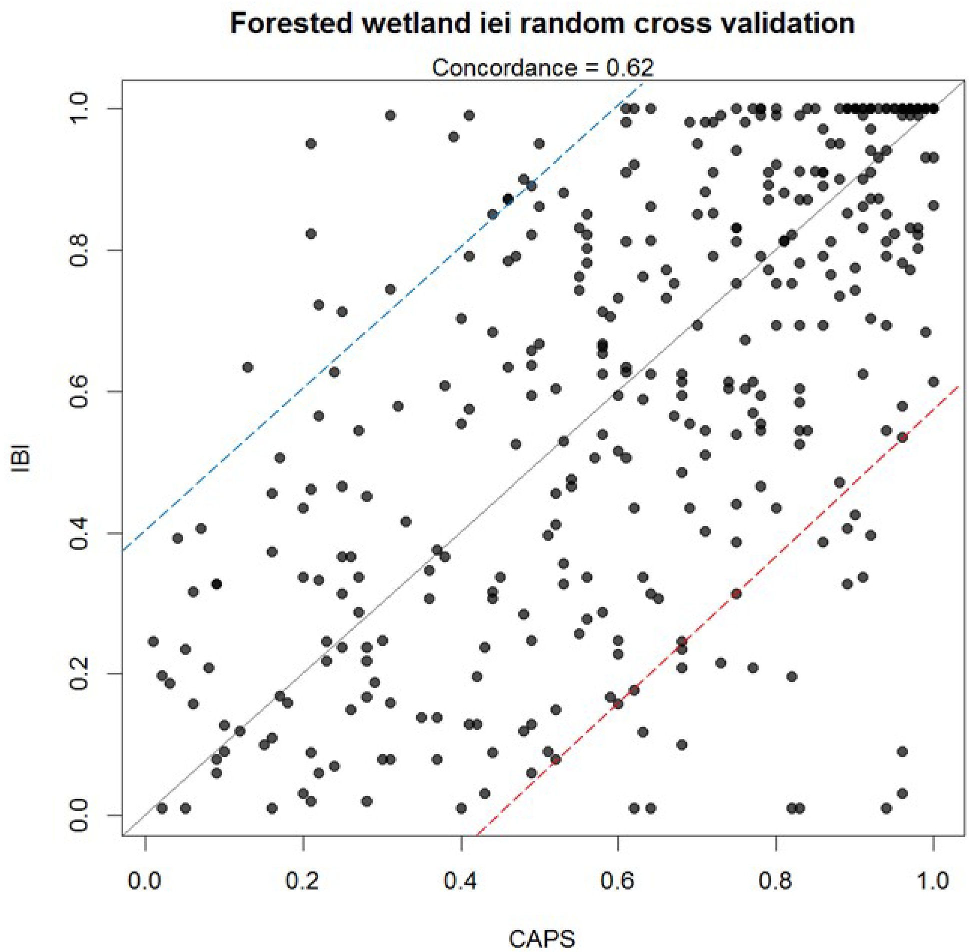

Figure 3. Using the relationship between IEI and IBI scores to define an expected range of variability for wetland biological condition.

The CALU approach provides a rigorous and quantitative system for establishing criteria for aquatic life use that avoids undesirable effects from cutting up a continuous environmental gradient into discrete Classes or Tiers. A site's biological condition relative to its landscape context can be assessed by noting its position relative to the lines on figure 3. Sites between the dotted lines (expected range of variability) would be considered to meet standards. Sites that are above the highest dotted line would exceed expectations. Those falling below the lowest dotted line would be flagged as potentially degraded. Improvement at a site can be measured using CALU by documenting upward movement over time of a site relative to the solid diagonal line.

Methods

Site investigations were conducted to assess five forested wetland replacement areas to determine if they are on a trajectory to become forested and if they fall within the expected range of variability.

Reconnaissance and Site Selection

Sites were selected by reviewing Variance project files to determine whether forested wetland replacement sites were proposed and approved, and if sufficient time has passed for them to have been built. Once sites were identified, reconnaissance was conducted to confirm that they had been built (if not already known) and to ensure that the replacement area, if not yet forested, was at least on a "trajectory" to become forested with wetland plant species. For a site to be on a trajectory to become forested, they would have to meet the following criteria.

- If recently built they must have woody vegetation (saplings) planted.
- If a site was more than a year or two old, the site must be succeeding to at least a tall shrub and sapling community, if not yet forested.
- The site could not be stressed, that is, would not be used if all planted woody vegetation had failed, if vegetation on the site was characteristic of an emergent wetland system, or if the site was dry (not a wetland) or a deep water habitat.

A total of 17 sites were initially considered, including 16 Variance project replacement areas and 1 private development/non-variance project. Of the 17 sites, four were dismissed because they were not forested or not on a trajectory to be forested, three were dismissed for compliance reasons, two were under construction or otherwise difficult to sample, and three were dismissed for other reasons. The five that were selected are described in Table 1 as follows:

Table 1: Wetland Replacement Areas assessed for Biological Condition.

Variance Issuance Date	**Location**	**Size of Replacement Area (square feet)**	**Est. Year Built (Age at time of Sampling)**
1/26/2001	Chelmsford	68,825	2007 (5 yrs)
1993	South Weymouth	58,369	1994 (18 yrs)
12/31/94	Hanson	72,000	1996 (16 yrs)
11/8/2002	West Hingham	52,628 (includes ½ acre Forested wetland)	2006 (6 yrs)
3/15/2002	Franklin	45,470	2003-4 (8-9 yrs)

Site Assessments

The five (5) forested replacement sites were assessed using the Conservation Assessment and Prioritization System (CAPS) Site Level Assessment (SLAM) protocol (Portante et al., 2009). This methodology establishes a standard set of procedures for identifying and quantifying vascular plants, epiphytic macrolichens, algae, macroinvertebrates and other taxa to assess forested wetland condition.

Data Analysis

For the forested wetland replacement areas where the SLAM was conducted, the data were used to determine if those areas were meeting expectations for biological condition. An evaluation of the landscape context (CAPS Index of Ecological Integrity (IEI) score) was used to establish a target for the site, and Index of Biological Integrity (IBI) values were calculated based on the SLAM data collected. The two values were plotted against each other to assess biological success of the replacement site as further described below.

Landscape Level 1 Assessment: CAPS is a landscape level model (McGarigal et al., 2008) that predicts ecological integrity based on GIS-derived metrics representing stressors on the landscape (e.g. habitat loss, buffer zone impacts, road traffic intensity, non-native invasive plants) or resiliency (i.e. connectedness, aquatic connectedness and similarity). One of the outputs of CAPS is an Index of Ecological Integrity (IEI), a weighted combination of metric outputs yielding a score ranging from 0 to 1 for each 30 m^2 point on the landscape, with 0 being the lowest and 1 the highest. The CAPS IEI values approximate the generalized stressor gradient used in the 'Biological Condition Gradient' model for waters.

Level 3 Site Level Assessment Method (SLAM): The SLAM is our approach for detailed site-level (level 3) assessments of forested wetlands. Appendix A contains the Standard Operating Procedures for the forested wetland SLAM from our approved Quality Assurance Project Plan (QAPP). Field data collection for this project followed these protocols.

Index of Biological Integrity (IBI) Our approach for assessment of biological condition of the forested wetland replacement areas is based on the relationship between the CAPS IEI (i.e. constraints on biological condition from the surrounding landscape) and the IBI (i.e. actual condition of a site based on field assessments) (Jackson et al., 2011). Development of IBI's for forested wetlands has been ongoing for several years by UMass Amherst (McGarigal et al., 2013). Researchers used CAPS IEI and individual metric grids to look for, and quantify, relationships between IEI/metric scores and biotic communities in forested wetlands to create IBIs from those data.

Based on field data from the study sites, the biological condition relative to its landscape context was assessed relative to the lines on the Continuous Aquatic Life Use (CALU) as shown in figure 3. Sites that fall between the dotted lines (expected range of variability) were considered to meet standards; those falling above the highest dotted line would exceed standards; and sites falling below the lowest dotted line would be flagged as not meeting standards.

Results

Index of Ecological Integrity (IEI)

The IBI for ecological integrity was developed based on CAPS Index of Ecological Integrity (IEI scores). Under normal conditions it would be expected that the IBI score would be very close to the IEI score for a particular site. All five of the replacement wetlands for variance projects had IBI scores for ecological integrity (IEI) that fell within the expected range of variability, although the Hanson site was very near the lower bound of the expected range (Figure 4).

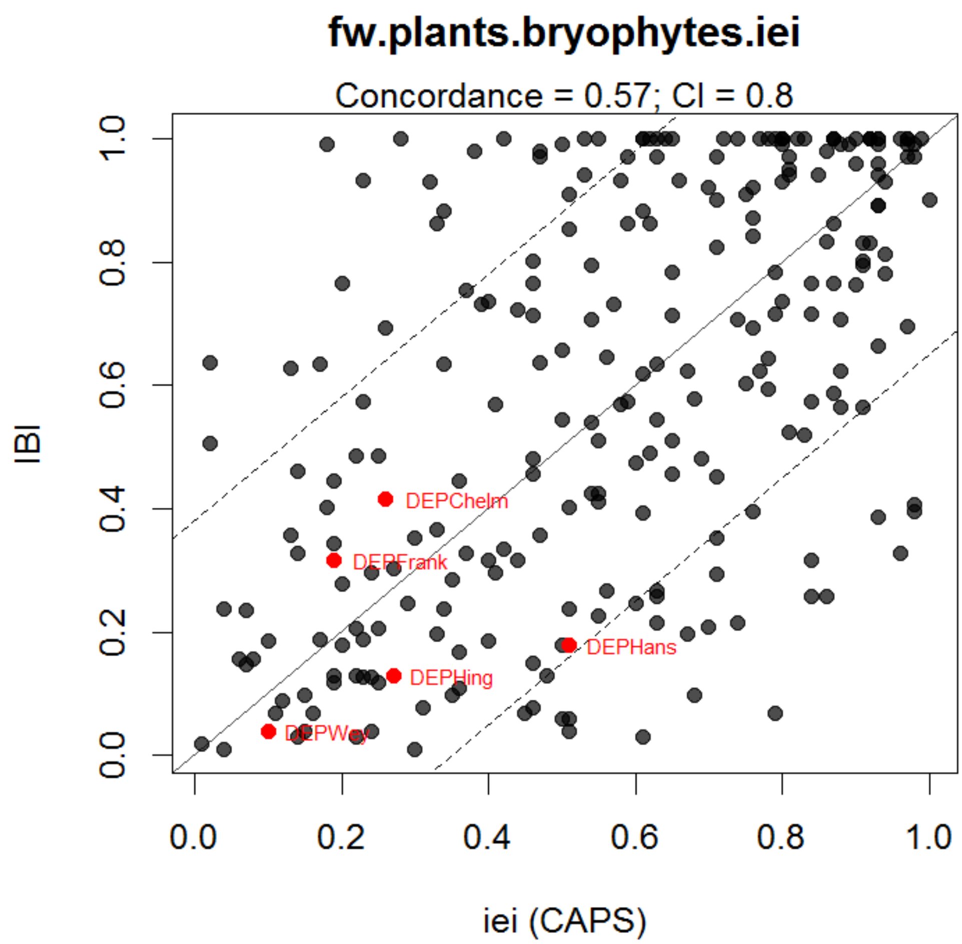

Figure 4: Continuous Aquatic Life Use (CALU) plot for ecological integrity. Red dots represent replacement wetlands; black dots are sites used to create the IBI. The dashed lines represent the expected range of variability.

Hanson

The Hanson replacement wetland had IBI scores that were quite low, although they were just within the range of expected variability for ecological integrity (Figure 4). Figure 5 is the Hanson IBI plot for ecological integrity showing the plant taxa that had the most influence in determining the IBI score.

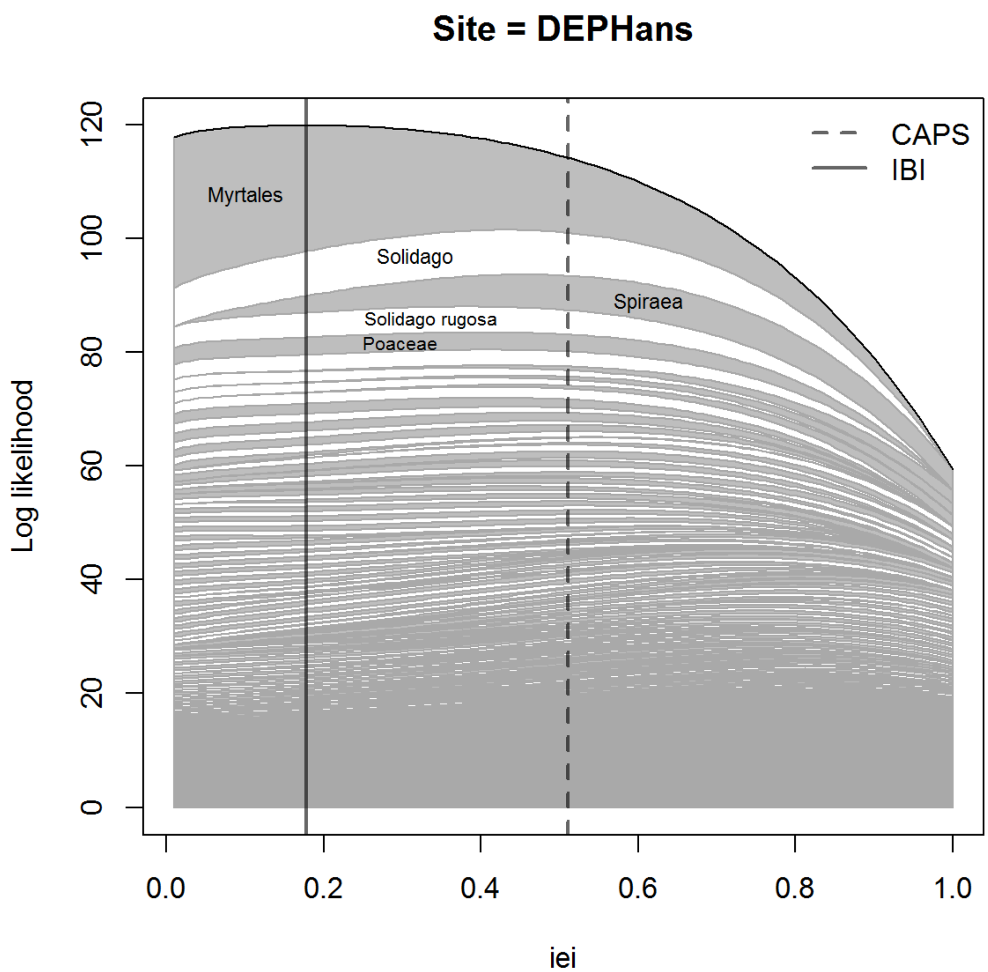

Figure 5: IBI plot for ecological integrity at the Hanson site. Width of each band is proportional to its influence in determining the IBI score. Labels are located at the point in the IEI range most indicative for that taxon.

The most influential taxa include the following, in order of importance. Taxa can influence IBI scores by their presence (or high abundance) or absence (or low abundance). Numbers in parentheses are percent cover values for each taxon. Indented taxa are the species or other taxonomic levels that make up the taxon included in the IBI. A species may contribute individually and/or as part of a higher taxonomic group.

Myrtales: Order
- Genus *Epilobium* (<1%)
- *Ludwigia palustris* (1%)
- *Lythrum salicaria* (29%)

Solidago: Genus (goldenrod)
S. latissimifolia (5%)
S. rugosa (4%)
Spiraea: Genus
S. alba (1%)
S. tomentosa (13%)
Solidago rugosa (4%)
Poaceae: Family (grasses; 10%)

The presence of plants in the order Myrtales and, in particular, purple loosestrife, contributed significantly to the low IBI score for the Hanson site.

South Weymouth

The IBI score for the South Weymouth site was quite low but so was its IEI score (Figures 4 & 6). As a result the IBI score was very close to what was expected based on its landscape context.

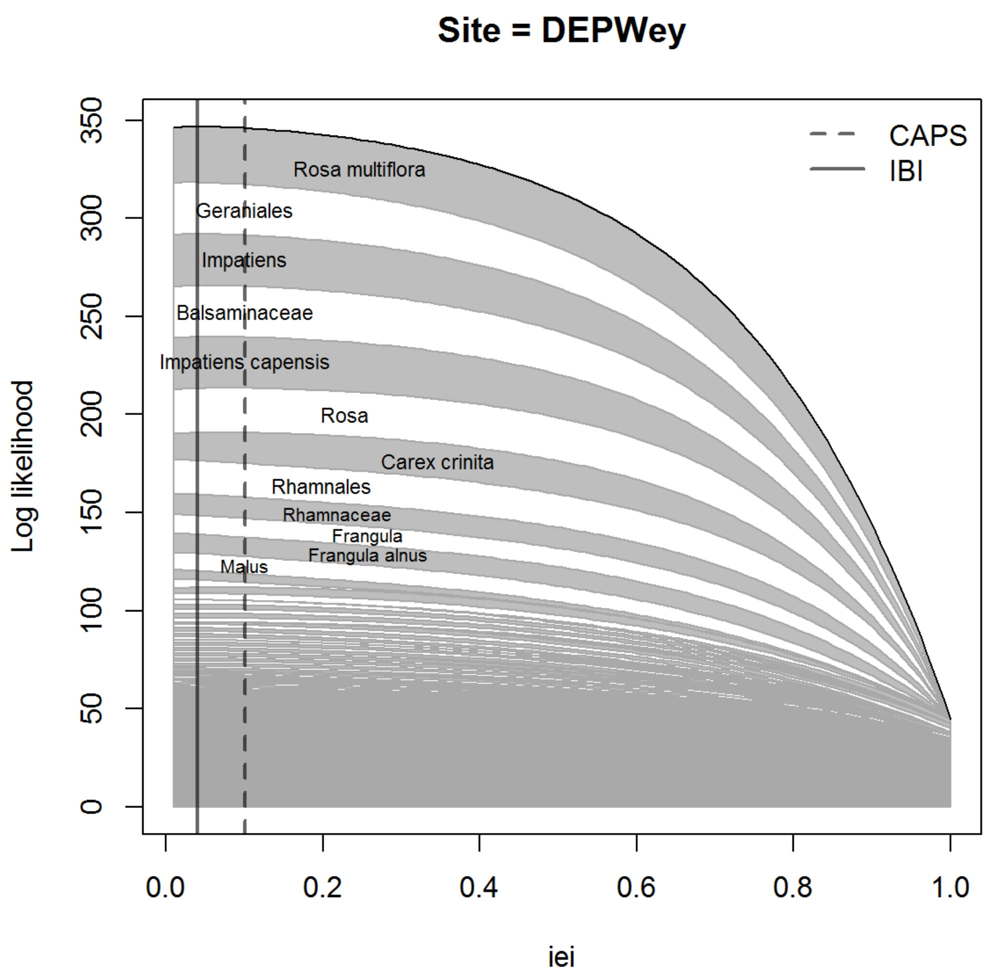

Figure 6: IBI plot for ecological integrity at the South Weymouth site. Width of each band is proportional to its influence in determining the IBI score. Labels are located at the point in the IEI range most indicative for that taxon.

The most influential taxa include the following, in order of importance.

- *Rosa multiflora* (20%)
- Geraniales: Order
    - *Impatiens capensis* (34%)
    - *Oxalis stricta* (1%)
- *Impatiens*: Genus (34%)
- Balsaminaceae: Family that includes Impatiens (34%)
- *Impatiens capensis* (34%)
- *Rosa*: Genus (20%)
- *Carex crinita* (4%)
- Rhamnales: Order that includes the buckthorns (76%)
- Rhamnaceae: family that includes buckthorns (76%)
- *Frangula*: Genus that includes glossy buckthorn (76%)
- *Frangula alnus* (glossy buckthorn; 76%)
- *Malus:* Genus (7%)

Multiflora rose (*Rosa multiflora*) and glossy buckthorn (*Frangula alnus*) were largely responsible for the low IBI score for ecological integrity at the South Weymouth site.

Chelmsford

The Chelmsford site had an IBI score that was a little better than expected from its landscape context (Figures 4 & 7).

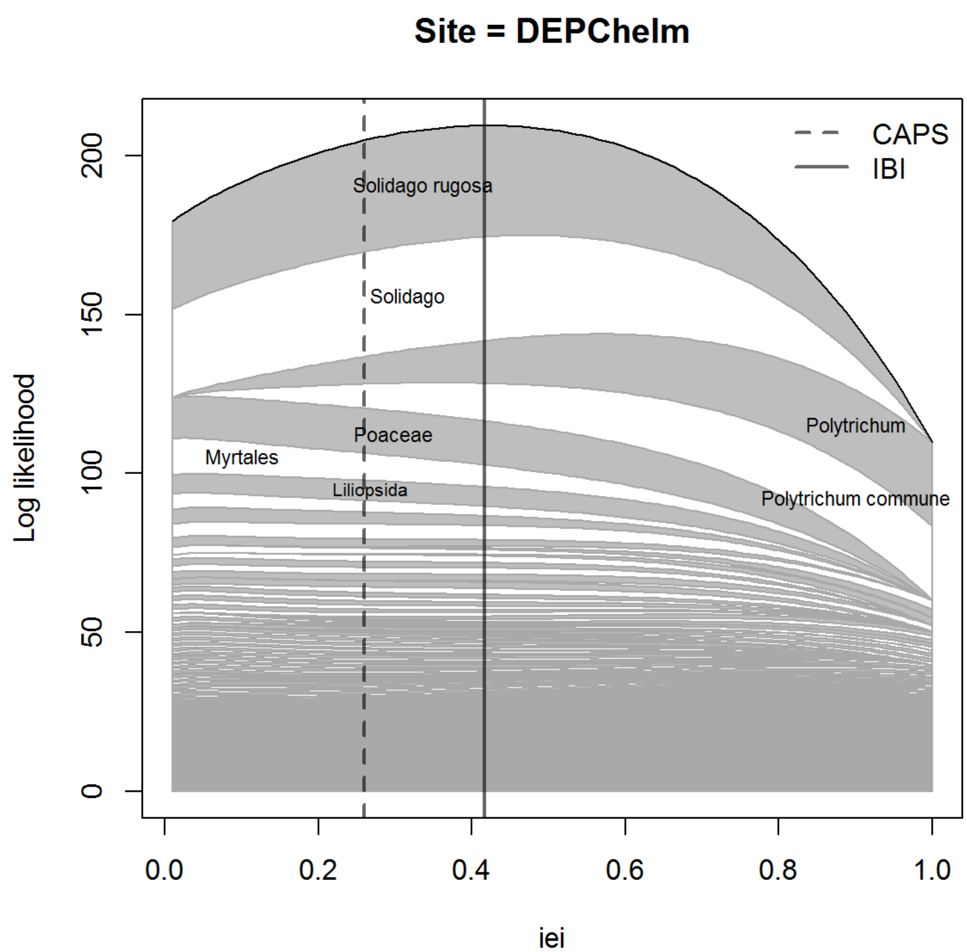

Figure 7: IBI plot for ecological integrity at the Chelmsford site. Width of each band is proportional to its influence in determining the IBI score. Labels are located at the point in the IEI range most indicative for that taxon.

The most influential taxa include the following, in order of importance.

Solidago rugosa (29%)
Solidago: Genus (goldenrod)
- *S. canadensis* (4%)
- *S. gigantea* (3%)
- *S. nemoralis* (3%)
- *S. rugosa* (29%)

Polytrichum: genus (bryophyte)
- *P. commune* (40%)
- *P. juniperinum* (<1%)

Polytrichum commune (bryophyte; 40%)
Poaceae: Family (grasses; 8 species; 39%)
Myrtales: Order that includes
- *Lythrum salicaria* (13%)
- *Oenothera biennis* (<1%)

Liliopsida: Class (grasses, sedges, cattails; 15 species)

An abundant bryophyte (*Polytrichum commune*) was largely responsible for the high IBI score for ecological integrity relative to landscape context at the Chelmsford site.

West Hingham

The IBI score for ecological integrity for the West Hingham was very close to what was predicted based on CAPS Index of Ecological Integrity (IEI) scores (Figures 4 & 8).

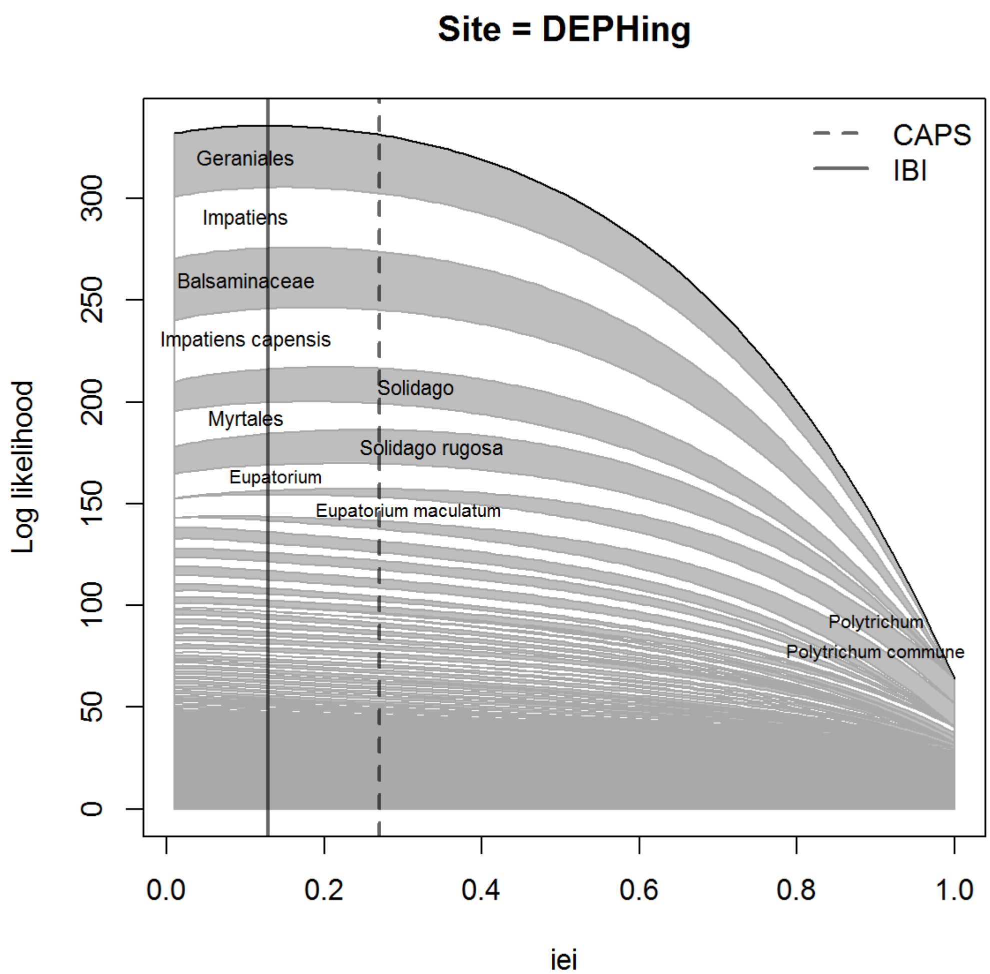

Figure 8: IBI plot for ecological integrity at the West Hingham site. Width of each band is proportional to its influence in determining the IBI score. Labels are located at the point in the IEI range most indicative for that taxon.

The most influential taxa include the following, in order of importance.

- Geraniales: Order
    - *Impatiens capensis* (39%)
    - *Oxalis stricta* (2%)
- *Impatiens*: Genus (39%)
- Balsaminaceae: Family that includes Impatiens (34%)
- *Impatiens capensis* (39%)
- *Solidago*: Genus (goldenrod)
    - *S. canadensis* (4%)
    - *S. gigantea* (1%)
    - *S. nemoralis* (1%)
    - *S. rugosa* (14%)
- Myrtales: Order that includes
    - Genus *Epilobium* (1%)
    - *Ludwigia palustris* (2%)
    - *Lythrum salicaria* (18%)
- *Solidago rugosa* (14%)
- *Eupatorium*: genus
    - *E. maculatum* (12%)
    - *E. perfoliatum* (<1%)
- *Polytrichum*: genus (bryophyte)
    - *Polytrichum commune* (19%)
- *Eupatorium maculatum* (12%)
- *Polytrichum commune* (19%)

Jewelweed (*Impatiens capensis*) and purple loosestrife (*Lythrum salicaria*) were particularly important plants contributing to a low IBI score for ecological integrity relative to landscape context for the Hingham site.

Franklin

The IBI score for ecological integrity was a little higher at the Franklin site than expected given its landscape context (Figures 4 & 9).

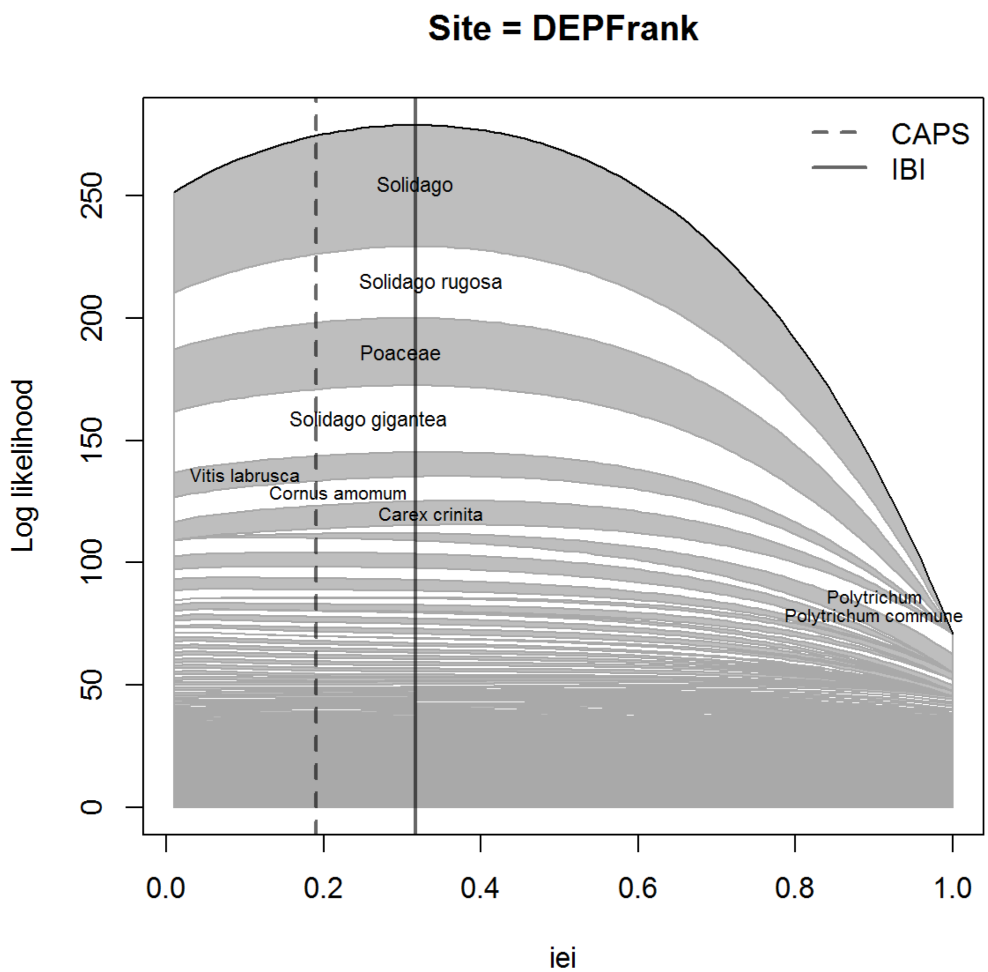

Figure 9: IBI plot for ecological integrity at the Franklin site. Width of each band is proportional to its influence in determining the IBI score. Labels are located at the point in the IEI range most indicative for that taxon.

The most influential taxa include the following, in order of importance.

- *Solidago*: Genus (goldenrod)
  - *S. altissima* (10%)
  - *S. canadensis* (3%)
  - *S. gigantea* (17%)
  - *S. junceea* (5%)
  - *S. rugosa* (24%)
- *Solidago rugosa* (24%)
- Poaceae: Family (grasses)
  - *Calamagrostis Canadensis* (17%)

Dichanthelium clandestinum (5%)
Phleum pretense (<1%)
Poaceae (54%)
Solidago gigantean (17%)
Atrichum: genus (bryophyte; 90%)
Vitis labrusca (6%)
Cornus amomum (7%)
Carex crinita (2%)
Polytrichum: genus (bryophyte)
P. commune (11%)
P. juniperinum (<1%)
Polytrichum commune (11%)

Various goldenrods (*Solidago spp.*) and the bryophyte *Polytrichum commune* were of particular importance contributing to an IBI score that was higher than expected.

Stressor Metrics

In addition to ecological integrity (IEI), IBIs for two stressor metrics (habitat loss and edge predators) and one resiliency metric (connectedness) were applied to the vegetation data from the five variance replacement areas (Figures 10 and 11). The IBI plots for these metrics are included in Appendix B.

Hanson

IBI scores for the Hanson replacement area fell within the expected range of variability for only one metric (connectedness) and the score was near the lower limit for acceptability. IBI scores were below (habitat loss) and well below (edge predators) the expected range of variability for the other two metrics.

South Weymouth

Two of the three metric IBI scores (connectedness and habitat loss) for the South Weymouth replacement area were lower than expected but within the expected range for those metrics. Only for the edge predator metric was the IBI score below the expected range of variability.

Chelmsford

IBI scores for two metrics (connectedness and habitat loss) were above expectations with scores above the 90^{th} percentile. The score for the other metric (edge predators) was below the expected range of variability.

West Hingham

The West Hingham replacement area had IBI scores that fell within expected ranges for all three metrics.

Franklin

IBI scores for two of the metrics (connectedness and edge predators) fell within expected ranges for the Franklin replacement area. The IBI score for habitat loss was higher than expected (above the 90^{th} percentile).

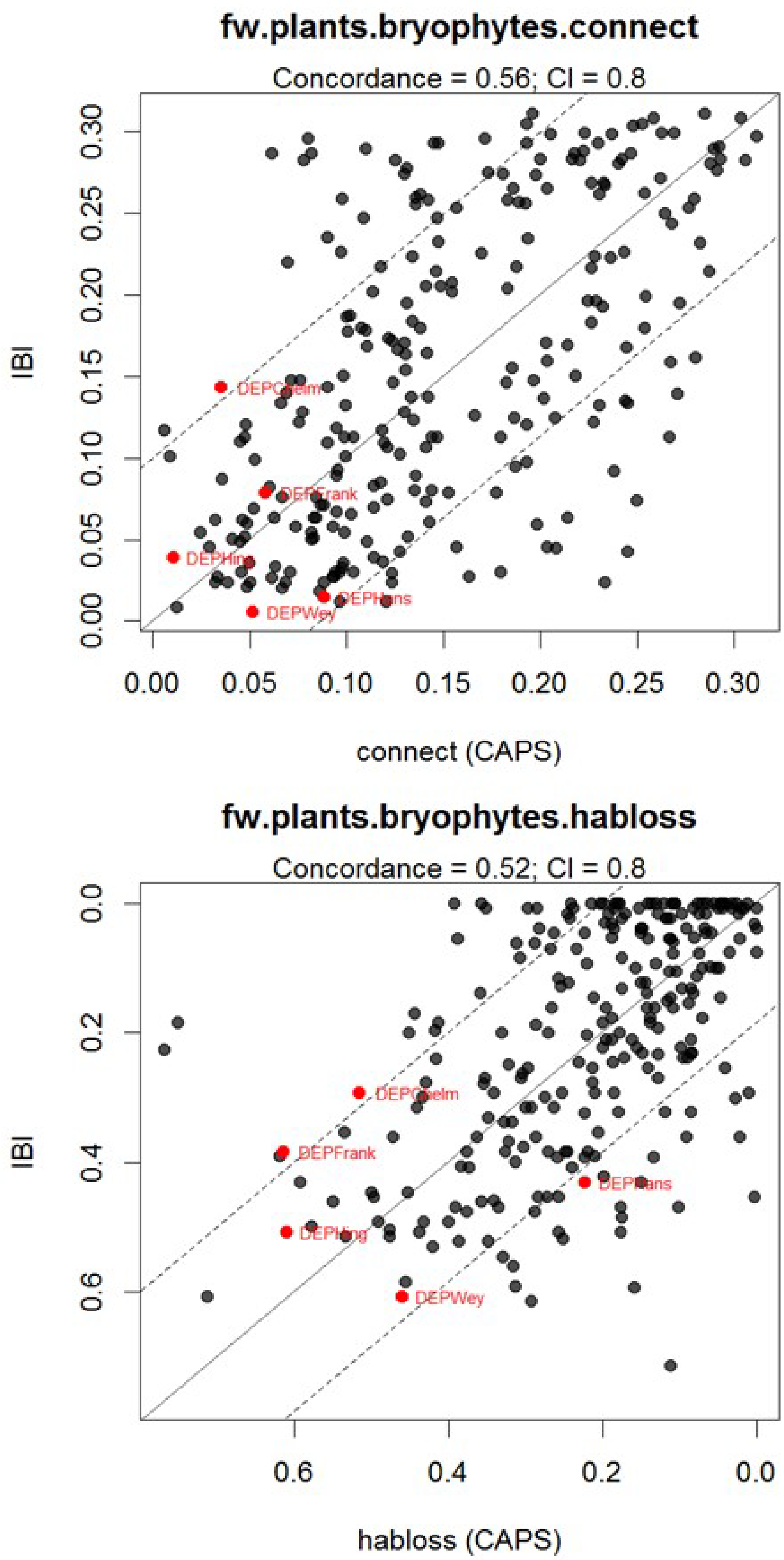

Figure 10: CALU plots for connectedness and habitat loss. Red dots represent replacement wetlands; black dots are sites used to create the IBIs.

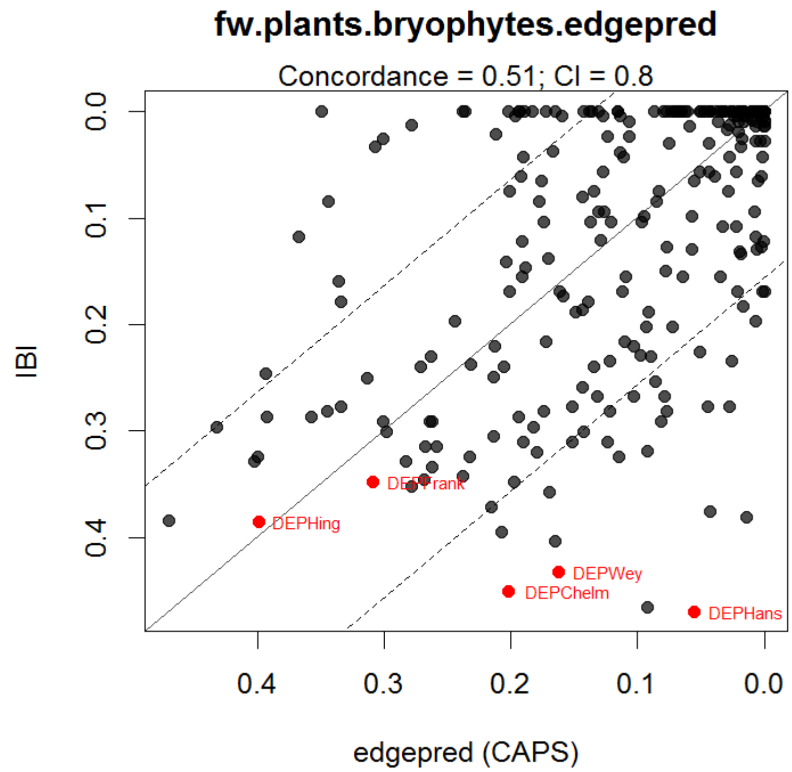

Figure 11: CALU plots for edge predators. Red dots represent replacement wetlands; black dots are sites used to create the IBI's.

Discussion

This project represents the first attempt at using the CALU approach to evaluate wetland condition. Five replacement wetlands constructed as part of variance-permitted projects were evaluated using the Site Level Assessment Method (SLAM) for forested wetlands. The five sites were chosen because the replacement wetlands were intended to eventually become forested wetlands and each showed progress toward reaching that goal.

All five sites fell within expected ranges for ecological integrity, although the Hanson replacement area was borderline low for ecological integrity and unacceptably low for two of the three metrics evaluated. This was unexpected because the Hanson site appeared to be a relatively high quality wetland (relative to other wetland creation sites). The presence of purple loosestrife (*Lythrum salicaria*), a species indicative of low IEI sites, depressed the IBI score for ecological integrity below what would be expected based on landscape position alone.

The Chelmsford replacement area had an IBI score for ecological integrity that was a little higher than expected and IBI scores for two of three metrics that were much higher than expected based on landscape context. *Polytrichum commune,* a bryophyte species indicative of high IEI sites, is largely responsible for the high IBI scores. It raises the question of whether the presence of this species in the Chelmsford replacement area could be an artifact of re-vegetation efforts after construction.

The IBIs applied to these five sites were all vegetation-based IBIs. Preliminary development work suggested that vegetation-based IBIs performed almost as well as complicated multi-taxa IBIs (including diatoms, lichens, and macroinvertebrates) that were much more expensive to implement (McGarigal et al., 2013). However, results from a related study focused on the success of wetlands replacement projects (Jackson et al., 2018) suggested that wetland seed mixes and nursery stock could potentially be providing a distorted picture of the condition of created wetlands. It is possible that as these replacement areas age the vegetation communities will change to a mix of plants better suited to the ecological conditions of the site. As this happens it will be interesting to see if IBI scores decline at these five sites, and particularly for the high-scoring Chelmsford replacement area.

Further research is needed to determine whether, given the influence that seed mixes and nursery stock have on vegetative communities, it is appropriate to use plant-based IBIs to evaluate created wetlands. Data on diatoms, lichens, and macroinvertebrates were collected at these five sites. It would be interesting to update the multi-taxa IBIs with data already collected from the Taunton River watershed and apply them to these replacement wetlands. It's possible that we will find that while vegetation-only IBIs are appropriate for evaluating natural wetlands, multi-taxa IBIs are needed in order to get an accurate assessment of the condition of created wetlands.

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Appendix A

Development of a Comprehensive State Monitoring and Assessment Program for Wetlands in Massachusetts

Appendix H[1]

Revised December 30, 2009

Standard Operating Procedures: Assessment of Wetland Communities

Phase 2c: 2009

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[1] **This appendix is part of the larger QAPP for Wetland Monitoring and Assessment and was incorporated into the Mitigation Study QAPP.**

Standard Operating Procedures: Assessment of Wetland Communities

1. Scope and Application

This SOP establishes a standard set of procedures to be followed for data collection toward the development of a Site Level Assessment Method (SLAM) for MA freshwater forested wetlands and to validate/calibrate the Conservation Assessment and Prioritization System (CAPS) as a mechanism for a landscape level analysis (Level 1) of ecological integrity. This project will focus on assessment of wetland biological community condition in forested wetlands.

Described below are the procedures that will be followed in collecting data on algae, macroinvertebrates, vascular plants, bryophytes, epiphytic macrolichens and habitat characterization (e.g. water chemistry, hydroperiod, etc.) to serve as a basis for development of a SLAM, which will incorporate the use of Indices of Biological Integrity, for freshwater forested wetlands.

2. Summary

This SOP is applicable for freshwater deciduous/coniferous forested wetlands that have the hydrogeomorphic (HGM) classification of a slope or flat throughout Massachusetts (hereafter referred to as forested wetland). Data collection for phase 2c will focus on forested wetland communities in the Miller's and Concord (Sudbury-Assabet-Concord) Watersheds, however this SOP can be applied to all forested wetland communities. Sampling sites will be selected via a stratified random process. Field data collection will involve sampling of several biotic communities to determine if 1) there is a dose-dependent response in various attributes of the biological community to stressors within the landscape and 2) to validate/calibrate the ecological integrity metrics that are utilized in the CAPS model. Characterization of the wetland and assessment of its biological condition will be conducted in the field by assessing habitat, algae, macroinvertebrates, vascular plants, bryophytes, epiphytic macrolichens and habitat characterization.

3. Safety Considerations

- Fieldwork will not be conducted during heavy rain events or unsafe conditions such as electrical storms or high wind events. Practice "safety first".
- If there is no safe access to a plot point, the field sampling will not be conducted for that site.
- Private property will be respected using the following guidelines.
    - If property is in close proximity to buildings or other heavily used areas, landowner permission will be sought
    - Posted property will not be accessed without permission of the landowner
    - Otherwise, sampling will proceed without any special effort to gain landowner permission

- If asked to leave private property by the landowner, samplers will discontinue work and leave.

- Each field technician will carry a personal first aid kit and a wilderness first aid guide
- Field personnel will not access sites alone without the instruction of a field manager
- No chemicals (other than ethanol) will be handled by personnel in the field

4. Sample Collection, Preservation, and Handling

Macroinvertebrates collected using the stovepipe sampler will be preserved in 95% ethyl alcohol solution. 70% ethanol will be used to preserve macroinvertebrates collected in the emergence traps. Macroinvertebrates collected in the pitfall traps will be preserved initially in a 50:50 propylene glycol/water solution and a drop of dishwashing liquid soap. The samples will be rinsed with tap water in the lab and transferred to a 70% ethyl alcohol solution. Samples will be labeled with the plot ID, date, surveyor, and collection method. They will be sorted and identified to order in the lab. Samples will be preserved and held in the lab until resources are available to identify the macroinvertbrates to genus and species (if possible).

Earthworms will be collected into 70% isopropyl alcohol and kept cool until transfer to the lab for permanent preservation in 10% formalin. Samples will be labeled in the field with plot ID, data, and name of surveyor. Transfer of worms into formalin will occur in a fume hood using safety glasses and gloves. Worms will remain in formalin for at least 24 hours before being permanently stored in 70% isopropyl alcohol. Tentative species IDs and counts may be made in the field. Official counts and IDs will be made in the lab using a dissecting microscope. Earthworm species identifications will follow Schwert (1990) and Reynolds (1977).

Algae will be collected and labeled with the plot ID, date, surveyor, and collection method. Algae samples will be preserved with M3 fixative (Potassium Iodide, Iodine (optional), glacial acetic acid, formalin) and stored until resources are available to identify them to genus and species.

Vascular plant, bryophyte and lichen collections will be limited to species that cannot be identified in the field. For species that cannot be positively identified in the field samples will be collected for lab identification and photographed for digital preservation. Taxonomic identification at the species level (preferred) or genus level (if species identification is not possible) will be achieved in the laboratory through the use of field guides, technical keys, and reference to regional herbaria housed at research universities such as UMass. Samples will be labeled in the field with the plant ID (e.g., “unknown sedge #1”) site location, date, and person who collected the sample, and assigned a code in the laboratory for use in digital preservation.

5. Equipment/Apparatus

Before leaving for the field the Field Manager will confirm the following equipment is available:

Backpack sprayer
Beaker
Bleach solution (1/2 cup bleach per gallon tap water)
Clipboard
Compasses
Cooler with ice
Data sheets
Deionized water
Digital camera w/extra batteries
Dip net, small, 500 micron mesh
Dishwashing soap solution Emergence traps
Ethanol (95%, 70%)
Field notebook
Flagging
Forceps
GPS (Global Positioning System)
Hand lens
Hanna ph/conductivity meter
Hip chain
HOBO Pendant Temperature/Light Data Logger
iButtons
Isopropyl alcohol
Labels for algae samples
Labels for earthworm samples
Labels for macroinvertebrate samples
Labels for vascular plant, bryophyte & lichen samples
Lids, closed
Liquid dish soap or hand soap (phosphate-free and biodegradable)
Location maps
Meter stick
Meter tape
M3 preservative
Nalgene bottle (500ml)
Palm Tungsten E2 Handheld (PDA)
Pencils
Permanent markers
pH/CON 10 pH/Conductivity/C° Meter
Plastic collecting bags
Plastic cups
Plastic containers (32 oz and 16 oz)

Plastic amber bottles (100 ml-250 ml)
PVC pipe (2 ½" diameter)
Rite-in-rain paper and pen
Scissors or jack knife
Screens
Stakes
String
Soil auger
SOP
Spoonulet
Squirt bottle
Standard solutions for calibration of pH/Conductivity/Temp meter
Stovepipe sampler
Tap water
Trowel or bulb planter
Turkey baster (large Pipette)
Vials
Water/detergent solution
White bowl

6. Reagents

Bleach solution (1/2 cup bleach per gallon tap water)
Deionized water
Ethanol
Formalin solution (10%) *
Glacial acetic acid *
Isopropyl alcohol
Liquid dish soap or hand soap (phosphate-free and biodegradable)
Potassium Iodide *
Propylene glycol/water solution
Standard solutions for calibration of pH/Conductivity/Temp meter
Tap water
* M3 solution

7. Calibration & Training

Equipment calibration procedures for the GPS units, Oakton pH/CON 10 pH/Conductivity/C^o Meter, Hanna portable ph/EC/TDS/Temperature Meter, Thermocron ibutton, and HOBO Pendant Temperature/Light Logger will be done according to the manufacturers' recommendations. See section 2.6 of the QAPP for details.

Field crew members will have sufficient previous training and experience to reliably conduct field data collection or they will receive training from the UMass QA Manager and/or other project scientists with relevant expertise. The QA Manager will ensure that all field crew members receive specific training on macroinvertebrate sample sorting and identification (to order), plant identification, and delineation of a Bordering Vegetated Wetland.

All Field Managers and Field Scientists will receive training from the QA Manager on appropriate QA/QC procedures.

8.0 Procedures

Sampling will occur between May 11 and September 30, to ensure adequate assessment of the targeted wetland biotic communities. Forested wetlands in the Millers and Concord Watersheds will be identified using the MassDEP Wetlands Mapping data (1:12,000 based on photography from 1993 and 1999).

Sample locations will be randomly stratified across deciles of buffer zone insults (one of the landscape metrics used in CAPS) and deciles of ecological integrity (results from CAPS analysis) from the CAPS assessment of 2009. This will create 100 buffer zone insults x IEI bins. Up to five random points that fall within deciduous or mixed forested wetlands (as depicted in MassDEP wetlands; 1:12,000 based on photography from 1993 and 1999) will be selected for each bin. Samples within 100 m of a fourth order or larger stream will be excluded to avoid areas that might potentially be floodplain forests. All points will be separated by at least 500 meters. The 150 (75 in each watershed) sampling plots will be selected randomly from among the 100 bins. Within each bin, potential plots are ordered. If a plot needs to be dropped, the next-higher plot in the same bin will be used. Note that some bins will have fewer than five points or may be entirely empty because some combinations of IEI and wetland buffer insults are rare or absent in the landscape.

A random identifier will be assigned to each bin to obscure the IEI/wetland buffer insults class that each bin represents. Field personnel will not have access to the original classes, thus sampling will be blind with respect to CAPS predictions.

Plots will be compared to aerial photographs (1:5000, 2005 Color Orthophotos available from MassGIS) and GIS data for hydrography (MassGIS, 2005), Potential Vernal Pools (NHESP, 2000) and Certified Vernal Pools (NHESP, 2008). Plots that fall within 30 m of potential or certified vernal pools, dominated by conifers, or fall within 30 m of a 3rd order stream or greater will be dropped. Areas in close proximity to vernal pools and larger (> 2nd order) streams will be dropped to avoid sampling invertebrates too close to areas characterized by longer hydroperiods than our target wetland community. Likewise, areas dominated by conifers will be avoided because they do not match the target wetland community (freshwater deciduous/coniferous forested wetlands that have the hydrogeomorphic (HGM) classification of a slope or flat).

GPS navigation will be used to locate each wetland plot. GPS precision must be 10 m or less and the navigator will stop and establish the plot once the distance to plot center is 0m. In the case of GPS interference from tree-canopy or atmospheric effects two procedures may be followed. The first is to wait 10 minutes for satellite reception to improve. If a dense forest canopy appears to be the problem use triangulation to locate the plot. We will approach the plot from three different locations where the canopy is mainly deciduous. Using compass and distance measurements provided by the GPS (precision must be 10 m or less), the plot will be located.

It will not be necessary to hit the plot exactly (since it's randomly selected) it just needs to be selected without bias. However, a reasonably precise GPS point is needed of where the plot actually ends up. The strategy is (1) do the best we can when locating the plot and (2) take a precise location (precision ≤ 10 m RMS) once the plot has been established. Field workers will be on the plot for 2-3 hours and will be able to keep trying until they get good GPS coverage.

8.1 Establishing Sampling Area

A 30 m radius plot will be used to sample the wetland point (Figure 1). A reserved 5 m radius area will be established in the center of the plot. Eight 25 m transects will be run from plot center at 0^{o}, 45^{o}, 90^{o}, 135^{o}, 180^{o}, 225^{o}, 270^{o}, and 315^{o} compass bearings. Vascular plants and bryophytes will be surveyed on transects run at, 45^{o},135^{o},225^{o}, and 315^{o}. Plant transects (transects 2, 4, 6, 8) and bryophyte plots will be denoted to prevent trampling, by flagging the transects and marking them on the Plot Information A form (Appendix L). The plot will be subdivided into 4 quarters, A-D.. They will be established in a clockwise direction beginning with transect 1 (Quarter A between the N and E transect, etc.)

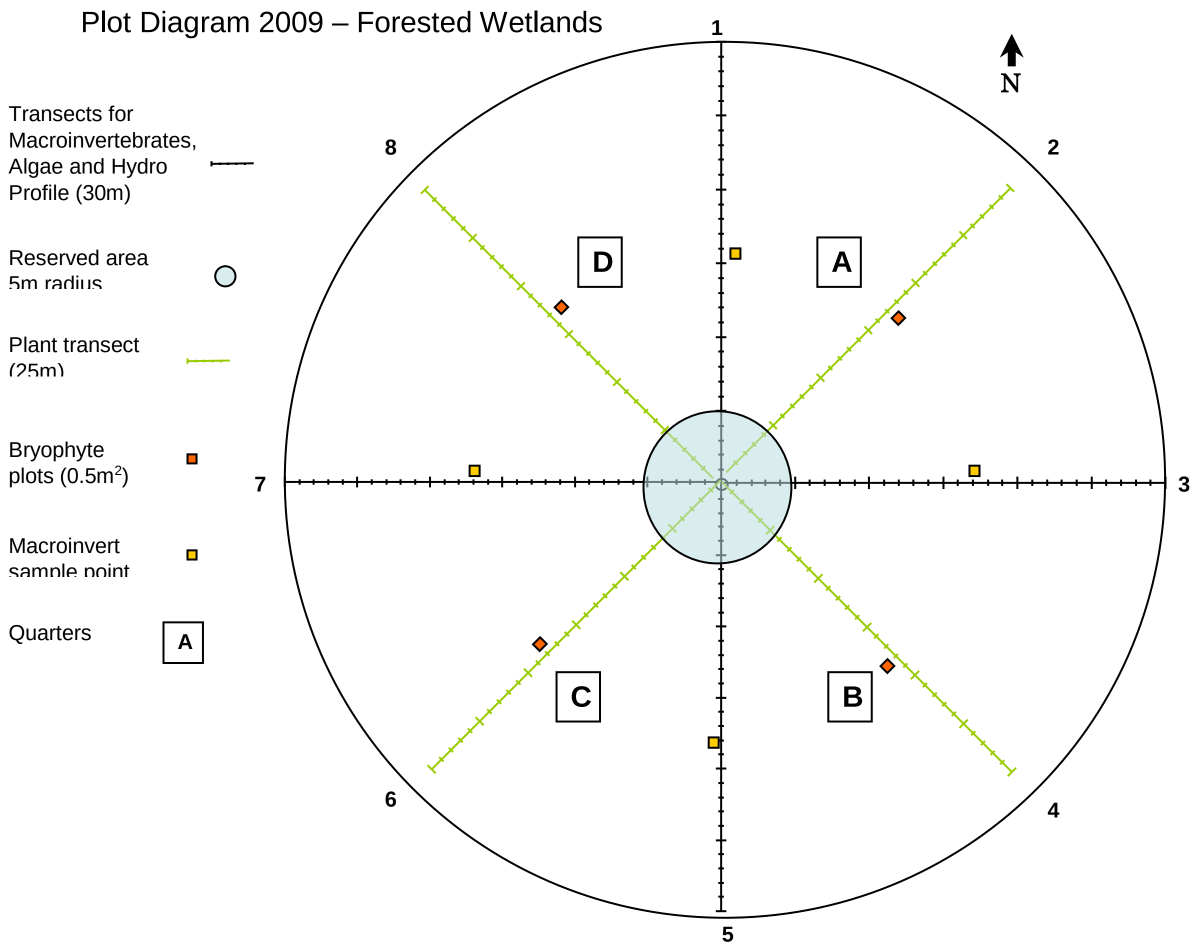


Figure 1.

Diagram of sampling area. Eight 25 m transects run at 0°, 45 °, 90°, 135 °, 180°, 225 °, 270°, and 315 ° compass bearings. The location for all samples (algae, water chemistry, etc.) will be noted on the plot diagram.

A sampling point will be moved if any of the following conditions are encountered.

- The dominant tree cover in the plot area is <30% as determined by visual estimation
- Any transect length is <15 m, as may occur in narrow wetlands (e.g. fingerlike projections, narrow bands of wetland along streams)
- Plot area is inundated due to beaver dams
- Point falls within 30 m of a mapped 3rd order stream (or larger)

The sampling point will be moved to the nearest location that does not violate the previously stated conditions, but no greater than 30 m away. If a suitable sampling point cannot be found within 30m of the original point the site will be dropped and another sampling point from the same bin selected.

8.2 Overview of Wetland Biotic Community and Habitat Assessment

Each point will be sampled for algae, macroinvertebrates, vascular plants, bryophytes and epiphytic macrolichens. Samples will be taken within a 30 m radius plot. Samples will be analyzed to determine if the attributes of the biotic communities show a dose-dependent response to anthropogenic stressors in the landscape as measured by CAPS metrics. In addition a habitat assessment will be conducted to characterize the assessment area. A detailed description of the plot (includes hydrology, anthropogenic disturbance, etc.) will be recorded in a field notebook by each surveyor. Data will be recorded with a PDA and paper forms. Tungsten E2 Handheld PDAs will be used to record vegetation, bryophyte and lichen data in the field. Paper data sheets will also be completed to serve as backups. Data from the PDAs will be downloaded to the master database on a daily basis.

8.2.1 Habitat Assessment

(a) Topographic complexity

Topographic complexity will be determined to assist in the characterization of the wetland. Each odd numbered transect will be walked to observe and record variations in slope/elevation.

From the center point of the plot walk four 30 m transects and count the number of micro-topographic depressions ("pits") at least 1 m^2 in size encountered along each transect. Counts will be recorded on a data sheet Topographic Complexity form (Appendix L) Depressions will only be counted if they are sufficiently obvious that they could be recognized even if groundcover vegetation is dense. If a pit is divided along the transect line by a mound it will be counted as two separate pits. A mound is defined as ≥ 15cm in height relative to the base of a pit and has the development of soil. Vegetation (e.g. tussock sedge) will not count as a mound. Topographic complexity will be expressed as the number of micro-topographic depressions per 100 m of transect length.

(b) Hydrology

Hydroperiod

A HOBO Pendant temperature/light data logger will be placed in the water for the duration of the study period (about 4 months) to determine the relative hydroperiod of the wetland surface water. The HOBO will record temperature at two hour intervals.

Place the data logger in a location within the plot that is judged by the field manager likely to remain inundated longest whether or not there is any standing water at the time. Place the logger inside a plastic white container to protect it from direct sunlight. Holes will be drilled into the sides of the cup to allow water to flow through. The cup will be held flush to the surface of the ground with a plant stake with a metal ring at the top to keep the cup from moving. Label the container with the serial number of the HOBO. Measure the depth of the water where the HOBO is placed at each plot visit (7 measurements) and record on the Hydrological Characterization form (Appendix L).

An ibutton will be hung against the North side of the closest tree to the location of the HOBO. The ibutton will record ambient air temperature every two hours in sync with the HOBO. The ibutton will also be protected by direct sunlight with a white plastic container and holes will be drilled to allow air passage. Label the container with the serial number of the ibutton.

Record the placement location and the serial number of the loggers on the Plot Information A form. Collect data loggers upon the completion of the biotic community assessment.

The temperature data from the loggers will be uploaded following procedures according the manufacturer's instructions (See QAPP Appendix J). The temperature data will be used to determine the relative hydroperiod (i.e. the duration of the sampling period).The coefficient of variation (CV) in temperature for each 24 hour period will be calculated for both the ambient air temperature (AAT) and water temperature (WT). The assumption is the ratio of AAT(CV)/WT(CV) will approach 1 as the depth of the water decreases. This will be verified with the recorded water depth of the HOBO location (recorded at 7 dates throughout the sampling period). This relationship will be used to estimate the depth of water for each day based on the temperature data. This data will be used to characterize the relative hydroperiod of surface water for each plot (method to be determined).

Hydologic Profile/Characterization

A hydrologic profile along odd numbered transects will be taken using a point intercept method each time a site is visited (e.g. trap deployment, trap collection, etc.) The profile will be used to characterize the surface hydrology during the field season.

At the first site visit, odd numbered transects will be flagged every 5m. At each 5m point intercept along the transect, the presence of saturated soil, surface water (>2.5cm), or dry surface will be recorded on the Hydrologic Characterization form. The percent cover of each category will be determined for each visit and for the duration of the field season.

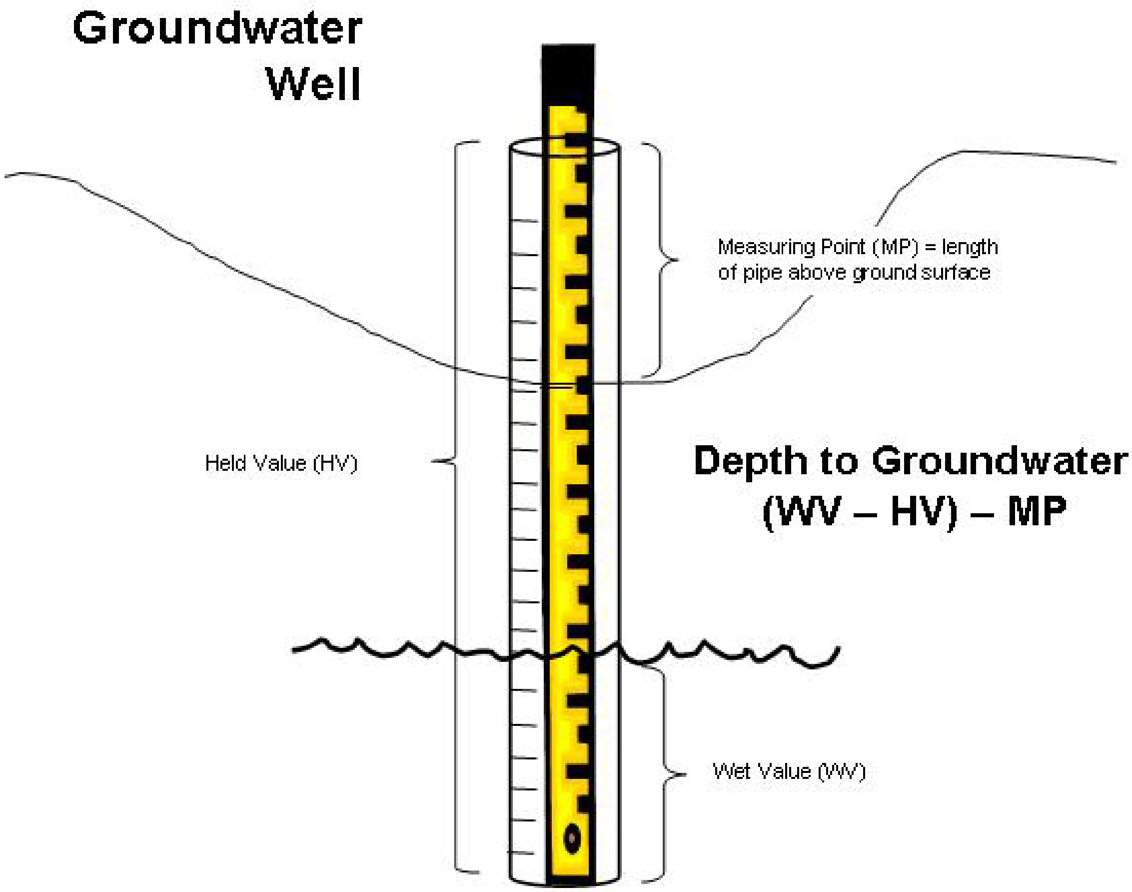
Hydrologic features such as a single channel or braided stream channel that is located in the plot will be described (direction of flow, etc.) and recorded on the Plot Information A form.

Groundwater

Groundwater will be monitored using shallow groundwater monitoring wells to determine the fluctuation in the water table throughout the field season. Readings will only be taken 6 or 7 times and will not be monitored daily. This information will provide information to characterize the influence of groundwater to the wetland point.

A PVC pipe, 1.2 m in length and 6.35 cm in diameter, will be installed to monitor groundwater (Fig. 2). A single pipe will be installed at the lowest point in the wetland, based on topography and depth of surface water. This will be determined after setting up the hydrologic profile transects and walking around the plot. The hole for the pipe will be dug using a soil auger. 0.90 m will be placed below the surface. Slits will be cut every 4.8 cm along the length of the pipe on each side through about a quarter of the pipe. The slits will allow the passage of water while preventing the soil from entering the pipe. The bottom of the pipe will be capped with a water tight seal. A 4.8 cm diameter cap will cover the top of the pipe for ease of removal to take water measurements. A meter stick lined with chalk will be used to measure the depth to groundwater. First determine the measuring point (MP) by measuring the length of the pipe above the surface. Insert the meter stick lined with chalk above the well and record when it crosses into the pipe (held value). Remove the stick and note where the chalk is wet (wet value). To determine the depth to groundwater first subtract the wet value from the held value to determine the water level below MP. Then subtract MP to determine the level below the land surface. (*/personal correspondence/*, R. S. Socolow, USGS) Measurements will be taken each time the site is visited. The data will be recorded on Hydro Profile form.

Figure 2. Groundwater well measurements.



(c) Water geochemistry

Conductivity, temperature and pH will be measured for surface water (if present) using a portable pH/Conductivity meter at 4 locations in the plot.

Take readings from surface water closest to the midpoint of each of the odd numbered transects running in cardinal directions (location of algae samples). If there is no standing water present along a transect move in a clockwise direction to find the closest area with standing water. If there is no standing water present within the quarter plot keep moving clockwise until readings are collected from four locations within the plot. The minimum distance between readings must be 3 m. Take a reading from any major stream channel in the plot if present. Note on the Plot Information A form the transects and/or quarters from which readings were taken. Record pH, conductivity, and temperature on the Plot Information B form.

(d) Human disturbance

Visual observations of human disturbance to the wetland will be noted. Surveyors will note the following activities in the field notebook, describing the type and extent of each disturbance.

Walk the four odd numbered transects running in cardinal directions and record in the field notebook the type and extent of disturbance for each of the following.

- Water control structures (culvert, dam, weir, storm water input, fill (road/railroad), ditching, channelization, beaver dam, and other human activity affecting the hydrology of the site
- Soil disturbance (filling, plowing, grading, grazing, dredging, sedimentation, vehicle use.
- Obvious spills.
- Direct point or nonpoint source discharge from agricultural operations, septic or sewage treatment systems, or storm water affecting water quality of the site
- Walking trails, horse trails, logging roads, ATV trails, old cart paths, and roads (excluding wildlife trails)
- Evidence of mowing, burning, or timber harvesting.
- Presence of trash/litter.
- Presence of garbage dumping.

Also record any of these indicators of disturbance when encountered while implementing other elements of the SOP.

(e) Soils

A soil pit will be used to characterize the soil for each plot.

Select a location for the soil pit within 5 m of the groundwater well and 1 m distant from tree stems, animal holes, or other disturbances. Using a spade dig a soil pit 12 inches in diameter to a minimum depth of 16 inches; increase depth if more information is needed to characterize the soil. Dig a second soil pit for plots lacking uniform topography, where a change in the soil may be present. Conduct work only when the light allows for accurate color classification of the soil and its features.

Remove a clean slice of soil from the soil pit. If saturated conditions prevent a pit from being dug use an auger to sample the soil and collect the necessary data. Turn the auger no more than 4 times so that the core is not mixed and an accurate profile can be documented. Repeat this step until the profile reaches a depth of at least 16 inches.

Record on the Soils data form a description of the soil profile, including soil horizons, redoximorphic features and the associated colors. A Munsell Soil Color Chart (Munsell 2000) will be used as a guideline when describing the color and redoximorphic features of the soil pit. Soil Taxonomy, tenth edition (USDA 2006) will be used to define the soil horizons. Document on the data form additional information useful for classification, such as hydric indicators (USDA 2002), texture, depth to groundwater, stoniness, and slope. This information will be analyzed in order to classify the soil using Keys to Soil Taxonomy, tenth edition.

8.2.2 Protocols for Sampling Biotic Communities

8.2.2.1 Algae

Algae will be sampled as a indicator of water quality, community composition, and ecosystem health. Algae are an integral component to the wetland community and are a primary food source to many macroinvertebrates. Samples will be collected in June before water draw down occurs. Four samples, each 50 ml, will be collected from each microhabitat within the wetland (benthic, including leaf litter and surface sediments, and surface water) for a total of 12 samples per site. Algae samples will be preserved in M3 fixative (Potassium Iodide, Iodine (optional), glacial acetic acid, 25% formalin). One ml of M3 will be added per 50 ml sample. All algae samples will be recorded on the algae sample login form before storage in the lab. Protocols for sampling algae were adapted from Danielson, 2006, Hawkins et al., 2003, and Vermont DEP, 2003.

(a) Benthic algae

Leaf litter samples will be collected. Leaf litter will be collected from areas within the plot with surface water present. In the absence of surface water, leaf litter will be collected from wet depressions.

Collect leaf litter from areas of standing water closest to the midpoint of odd numbered transects If there is no standing water present along a transect move in a clockwise direction to find the closest suitable sampling location within the quarter plot. If standing water is lacking within a quarter plot collect leaves from a wet depression closest to the midpoint of the transect. If there are no suitable locations (surface water or wet depressions) present within a quarter keep moving through the plot until four samples have been collected. The minimum distance that samples must be spaced is 3 m. Note on the Plot Information A form the transects and/or quarters from which samples were taken and a description of the sampling location. Record the depth of the surface water if present on the Plot Information B form.

From each sampling location collect red maple leaves to cover the bottom of a small bowl (10.5 cm^2). Scrape the leaf surfaces using a metal spoonulet to scrape off the algae. If red maple leaves are not available collect other deciduous leaves of similar size and make a note of the species used. Rinse each leaf with DI water after scraping. Collect all scrapings from the small bowl into a 50 ml vial. Keep rinsing the pan with DI water until there is 50ml in the vial. Add 1ml of M3 per 50ml of benthic leaf scrapings for preservation.

Clean the pan and spoonula with tap water after sampling.

(b) Water grab sample (adapted from ME DEP)

Water samples will be collected to sample algae**.**

Take samples from surface water closest to the midpoint of the four odd numbered transects. If there is no standing water present along a transect move in a clockwise direction to find the closest suitable sampling location. If there is no suitable location present within the quarter plot keep moving clockwise until samples are collected from four locations within the plot. The minimum distance between samples must be 3 m. Note on the Plot Information A form the transects and/or quarters from which samples were taken. Record the depth of the surface water on the Plot Information B form

Use a clean and dry 50 ml vial to collect sample. Submerge the water sampler to collect the surface water taking care to minimize the collection of organic material**.** Water samples will not be collected in areas where the leaf litter must be depressed in order to collect a sample. Add 1ml of M3 per 50ml of the water sample for preservation. Repeat for each transect.

(c) Surface substrate sampling

Surface substrate samples will be collected to sample algae.

Using a turkey baster (large pipette) collect a 50 ml sample of the surface substrate from areas with surface water at the same location as leaf samples (see (a) above). To collect the sample, stick the end of the baster into the substrate and suck up a sample from the surface. If necessary, loosen up the substrate by moving around the tip of the baster before taking a sample. Pour the 50 ml sample into a 50 ml vial. Add 1ml of M3 per 50ml of the water sample for preservation. Note on the Plot Information A form the transects and/or quarters from which samples were taken. Repeat for each transect. Record the depth of the surface water if present on the Plot Information B form.

Clean the turkey baster with deionized water after sampling.

8.2.2.2 Macroinvertebrates

Macroinvertebrates are will be sampled as an indicator of water quality and community composition, and ecosystem health. Macroinvertebrates will be sampled from June-August. Stovepipe sampler and emergence traps will be used in June; pitfall traps to collect epigeal macroinvertebrates and soil pits to collect earthworms will be conducted from July-August.

(a) Earthworms

Earthworms will be sampled in forested wetlands from August through November using a combination of liquid extraction and midden counts (Lawrence and Bowers 2002, Hale et al 2005):

For midden counts place 1m^2 sampling frame on soil surface at 15m along each odd-numbered transect and count number of middens inside the frame.

Establish one earthworm sampling plots at the most suitable location (not standing water) within the assessment area. Place sampling frame (11' diameter or 613 cm^2) on top of soil and carefully remove any vegetation from within frame. Collect any earthworms found on soil surface or in vegetation and place in small plastic sampling tray with lid. Count number of juveniles, adults, and middens within the plot. Push sampling frame into soil. Pour ½ gallon liquid mustard solution into sample area and begin collecting worms as they surface. Wait three minutes before pouring remaining ½ gallon into soil. Liquid extraction sampling time for each plot is 10 minutes.

Earthworms encountered during the excavation pit traps or soil pits will be collected and preserved.

Kill all worms in 70% isopropyl alcohol. Place worms into alcohol-filled vial labeled with plot ID, subplot ID, and date, and collector's name. Keep earthworms cool until transfer into 10% formalin solution for permanent preservation at the end of the field day.

(b) Aquatic macroinvertebrates: Stovepipe sampler (adapted from ME DEP)

Macroinvertebrates will be collected using a stovepipe sampler (5 gallon plastic bucket with the bottom cut off). Collections will be made in two locations dispersed within the plot where surface water and/or wet depressions are present.

Samples will be taken from two locations within the plot where surface water is most suitable for sampling based on water depth and areal extent of inundation. If surface water is not present within the plot, sample in locations (depressions) with the wettest substrate. If possible locate the sampling locations in diagonal quarters of the plot (e.g. quarters 1 & 3 or quarters 2 & 4). If suitable sampling conditions are not present in diagonal quarters try to use sampling locations in each of two adjacent quarters. If necessary place both sampling locations in the same quarter. The minimum distance between samples must be 3 m. Note on the Plot Information A form the transects and/or quarters from which samples were taken.

At each sampling location place the stovepipe sampler firmly into the substrate (few cm deep) and hold it in place. Agitate the water in the sampler for 10 seconds to dislodge organisms from the substrate and vegetation. If surface water (>1.27 cm) is present take five sweeps within the sampler with a 500 micron mesh hand net (10.5x12.5 cm). After each sweep, transfer all material into a 32 oz collecting jar. Inspect the net, remove any clinging organisms and add them to the sample. The jar should only be filled halfway with sample material and additional jars may be used if necessary. Fill container with 95% ethanol. Record depth of surface water on the Plot Information B form.

For wet depressions (with little or no standing water) collect three, one-hand leaf litter grab samples from within the stovepipe. Distribute grabs evenly throughout the stovepipe area. Preserve the sample the same as for the dipnet samples. Record on the Plot Information B form. Label containers with site ID, date of collection, surveyor ID, and description of microhabitat. Samples will be strained and preserved with fresh ethanol within four months of collection. Containers will be stored in the lab for up to five years until they are processed.

(c) Insects: Emergence Traps

Four emergence traps per plot will be set and collected after 7 days. Emergence traps will be set on the water surface or on the surface of the soil in the wettest depressions in the absence of surface water. Site selection for trap placement will follow the protocol previously described for benthic algae, but will be placed 1m apart from areas that were disturbed while sampling for algae or using the stovepipe sampler**.**

Set emergence traps in areas of standing water closest to the midpoint of each transect. If there is no standing water present along a transect move in a clockwise direction to find the closest suitable sampling location within the quarter plot. If standing water is lacking within a quarter plot set the trap in a wet depression closest to the midpoint of the transect. If there are no suitable locations (surface water or wet depressions) present within a quarter keep moving through the plot until four trap locations are selected. The minimum distance that samples must be spaced is 3 m. Note on the Plot Information A form the transects and/or quarters where emergence traps are set.

Fill a jar (with funnel top) with 70% ethanol and place it upside down at the top of the emergence trap to collect emerging insects. Tie the traps with string to nearby vegetation or with stakes to prevent drifting. Make sure that there is enough slack in the string to ensure the trap will stay flush with the water surface if draw down or flooding occurs. Upon collection of the traps replace the jar lids with fully enclosed lids and add ethanol as needed. Samples will be kept separately. Label jars with site ID, start and end date of collection, surveyor ID, and description of microhabitat. If surface water is present record the depth at the time of placement and collection on the Emergence Trap Log form (Appendix L). In addition, record the setter and collector ID, microhabitat, condition of the trap, and the amount of ethanol in the jar when collected. Jars will be stored in the lab for up to five years until processed.

(d) Epigeal macroinvertebrates

Pitfall traps will be set out in July to collect epigeal macroinvertebrates. Traps will be 16 oz clear cups placed in the ground with the top of the cup flush with the ground surface. Cups will be filled with ~150ml of a 50:50 propylene glycol/water solution and a drop of dishwashing soap. A small screen made of hardware cloth (1x1 cm squares) will be placed inside the cups to prevent small vertebrates from entering the killing solution. A plastic plate held up with small stakes will be placed over the pitfall trap to serve as a roof.

Place eight pitfall traps, 2 on each transect at 10 and 15m. Place traps in areas where the chance of flooding by surface water (avoid pits) is reduced. Collect the contents of pitfall traps after 7 days. If the trap is >1/2 full of water it will be discarded. Each trap will be collected separately in a small container. Record the setter and collector ID, microhabitat, amount of water in the trap, and the condition on the Pitfall Trap Log (Appendix L). The samples will be rinsed with tap water in the lab (to remove the soap) and 70% ethanol will be added. Label jars with site ID and start and end date of collection. Samples will be stored for up to five years in the lab until they are processed.

8.2.2.3 Vascular plants

Vascular plant data will be collected as an indicator of community composition and species diversity (proportion of native to invasive), will contribute to the understanding of the status of species of conservation concern (rare, endangered, or invasive), and provide useful information on potential threats to natural systems. Invasive plants named as such in this assessment are those currently regulated by the Commonwealth of Massachusetts (Somers et al 2006). Data collection will occur throughout the field season, June – September 2008.

a. Estimate species abundance of all vascular plants in a 30 m radius plot using a point intercept method. Estimate percent cover as the proportion of the line directly intercepted by each species by vertical projection on four 25 m transects (excluding reserved area) placed in the four directions (even numbered transects). Tally each plant species that touches the transect line or is intercepted by a vertical projection from forest floor to canopy every 1m along the transect. Record tallies every 5 m to ensure an accurate count.
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%. Record data on the vascular plant data form.
c. Estimate basal area using a wedge prism (10 or 15-factor). Stand near plot center, hold prism over plot center, view trees through prism at breast height (1.4 m) and tally trees, moving in a full circle starting north. List the species of each tallied tree.
d. Assign a forested landcover class according to MassWildlife Landcover Mapping Decision Rules (March 1996) and a natural community type according to the Massachusetts Natural Heritage & Endangered Species Program (Swain & Kearsley 1999).

e. Collect unknown species for lab identification under dissecting scope. Place each species in a separate collecting bag labeled with plant ID (e.g., "Unknown #1, etc.), plot ID and date. Take digital photographs on site as needed. List PhotoID # next to unknown plant ID on the vascular plant form.

f. Refer to resources on regional flora if necessary (Gleason & Cronquist 1991, Magee & Ahles 1999). Assistance from the herbaria and staff at the UMass herbarium will be requested as needed.

8.2.2.4 Epiphytic macrolichens

Epiphytic macrolichen data will be collected as an indicator of forest health, community composition, and species diversity.

Stand at center of established 30 m radius plot. Starting due north, use a 10 or 15-factor prism to select trees for lichen sampling. Identify and estimate percent cover for macro-lichens on all trees and shrubs with a diameter at breast height (dbh) of four inches or greater. Estimate percent cover on the trunk in the area between from base of tree up to 2m from base. On the Epiphytic Macrolichens form number and list each tree, record the tree species and dbh, and list macrolichen species present. Estimate percent cover for each macro-lichen species using the following cover classes: 0.1=<1%, 1=1-5%, 2=6-25%, 3=26-50%, 4=50-75%, 5=>75%.

Collect samples as needed into paper herbarium packets labeled with plot ID, date, collector, and sample number. Mark any samples collected with a "V" for voucher on the data sheet next to its tentative name or as "Unknown #1, Unknown #2, " etc. Nomeclature will follow (Esslinger 2007).

8.2.2.5 Bryophytes

Bryophytes have important roles in mineral cycling, water dynamics (some species may hold 10 times their weight in water), regulation of microclimate, and provide food and habitat to a host of invertebrates. Many are sensitive to human disturbance including forest management, and bryophytes may comprise a major component of the biomass and net productivity in wetland systems. Ground-dwelling moss and liverwort data will be collected on 4-0.5 m^2 plots located in representative areas along the vascular plant sampling transects.

Estimate percent cover for each bryophyte species in each quadrat using the following cover classes: 0.1=<1%, 1=1-5%, 2=6-25%, 3=26-50%, 4=50-75%, 5=>75%. Follow quadrat sampling with a 20-minute walk around the plot and list additional species not found in quadrats; species documented during the walk around will be assign a percent cover of 0.01%. Collect a voucher specimen in herbarium packets for each species found across all study plots. Nomenclature for mosses follows Anderson (1990) and Anderson et al (1990), for liverworts follows Schuster (1974).

8.7 Protocol for Decontamination of Field Equipment

Inspect all equipment for debris before leaving a site. Dispose of debris in a trash bag or on dry, high ground. When possible, leave equipment to air dry and inspect to remove any remaining plant fragments. Spray equipment with a bleach solution, scrub, and rinse with tap water to remove any additional debris. Clean the pH/conductivity meter according to manufacturer's recommendations.

9. Quality Control

Compliance with procedures in this SOP will be maintained through monthly internal reviews. Personnel will conduct periodic self-checks by comparing their results with similarly trained personnel working on the project. See sections 2.5 and 2.6 of the QAPP for details about QA/QC measures.

10. Interferences

Inclement weather (heavy rain) may interfere with our ability to collect representative data on a variety of parameters. Severe weather may delay field data collection due to safety concerns. Access may be a challenging aspect of data collection in more developed areas of the study area. Posted property or sites that are too difficult to access or unsafe to sample will be replaced with alternative sites from the same stratified sampling bin.

11. Preventative Maintenance

Field equipment will be inspected by the UMass Field Manager each day before going out to collect field data. At the field site equipment will be tested prior to data collection to ensure that it is working properly. Equipment will be subject to regular maintenance as needed and as recommended by the manufacturer. GPS accuracy will be assessed once a month by a check of any units used in the field with a known location. See section 2.6 of the QAPP for more detail.

11. Corrective Actions

Data quality control ensures high quality data, however we are prepared to re-measure any plots within the same season or period of monitoring which contain data anomalies. Any plots that contain anomalous data that cannot be resolved will be removed from the data set.

12. Waste Minimization and Pollution Prevention

Care will be taken to avoid transport of vegetation and soil to other sites. This will be done by thorough cleaning and inspection of all equipment and clothing prior to departure from a site. Invasive plant samples will be disposed of in a way to avoid accidental release into the environment.

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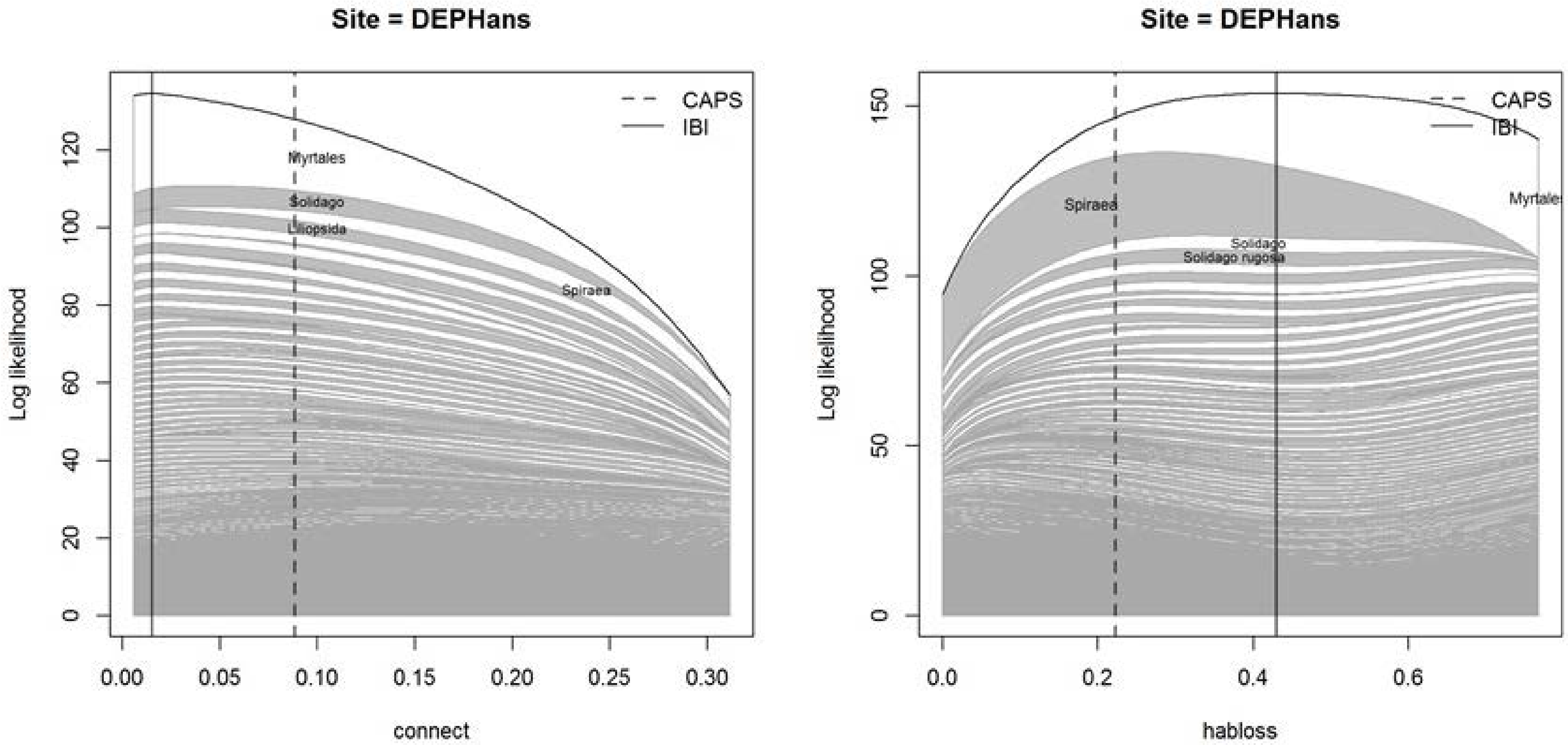
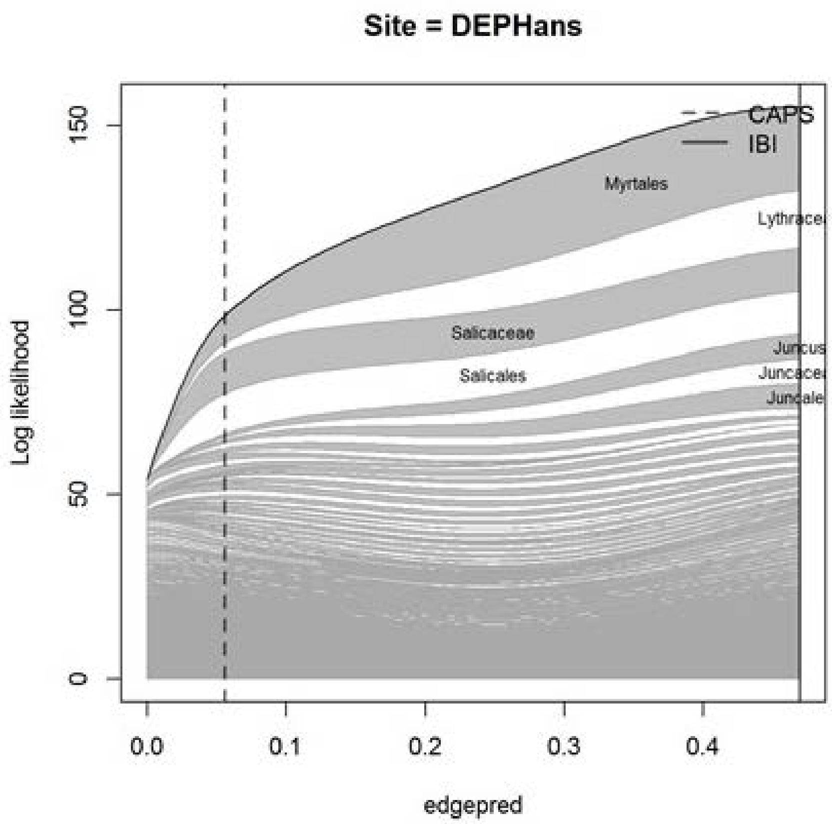
Appendix B

Metric IBI Plots for Variance Project Replacement Areas

IBI plots for four CAPS metrics (connectedness, habitat loss, earthworms, edge predators) at the five variance project wetland replacement sites. Width of each band is proportional to its influence in determining the IBI score. Labels are located at the point in the IEI range most indicative for that taxon.

Hanson

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IBI
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Salicaceae
Salicales
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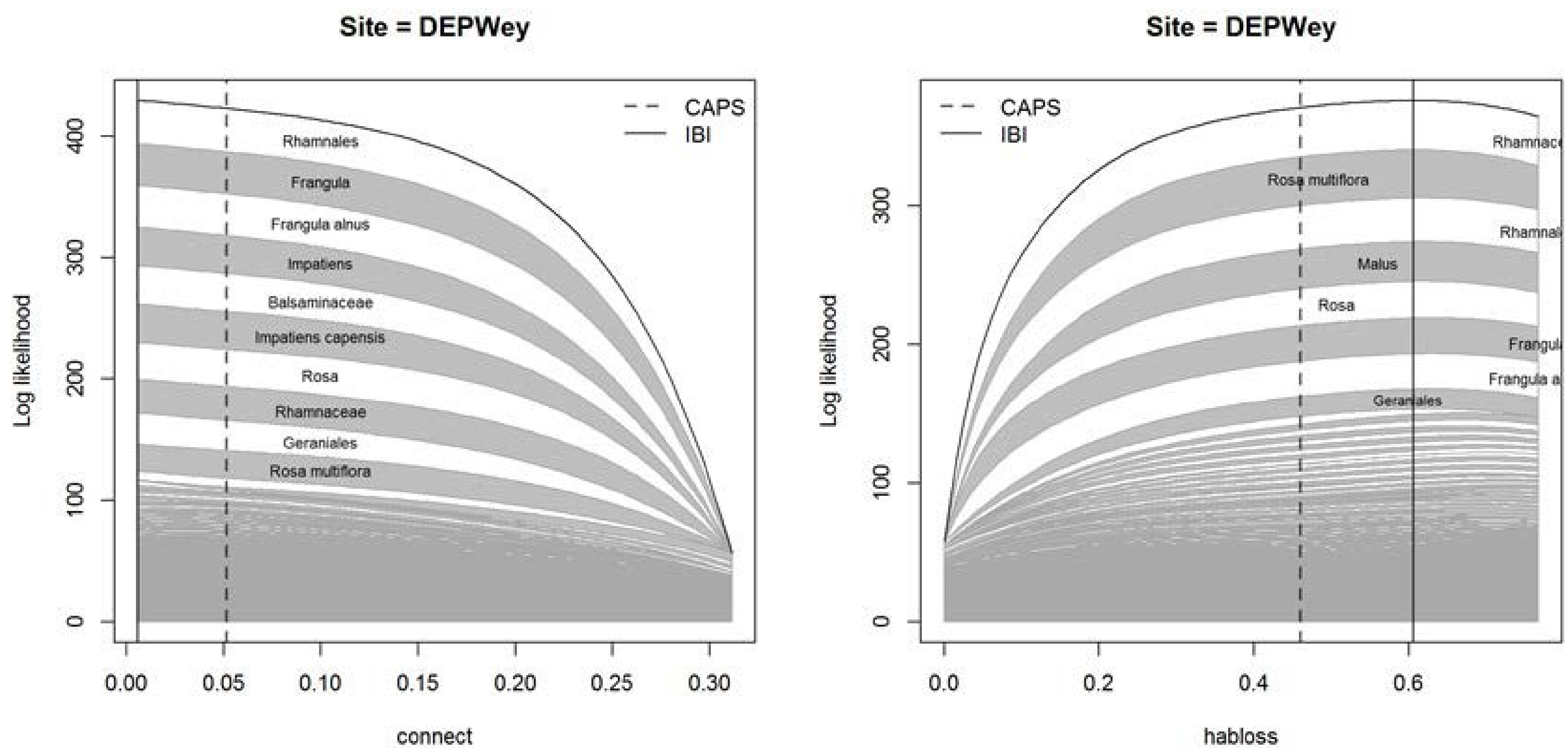
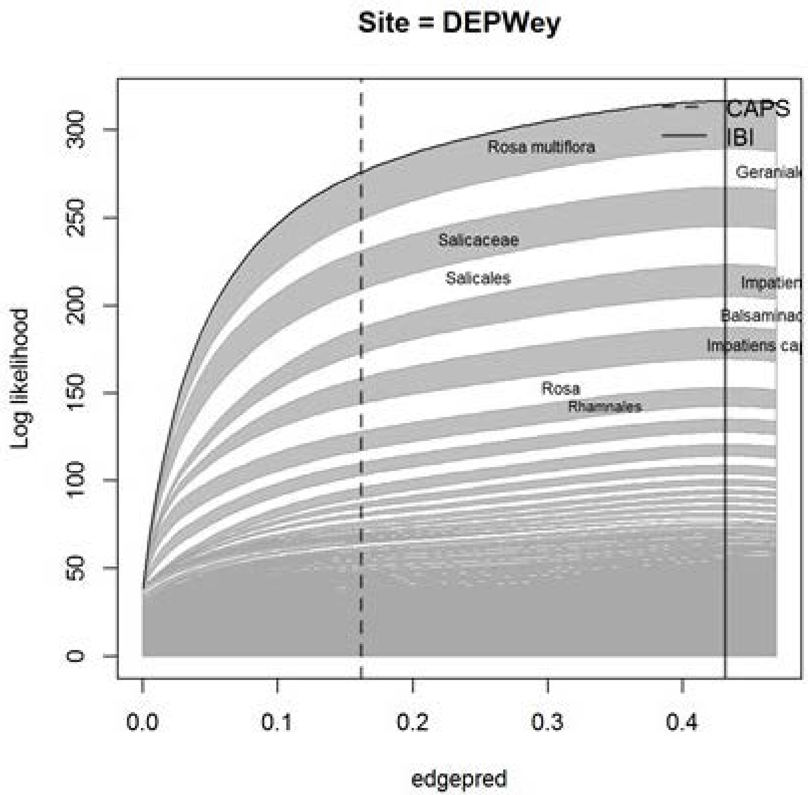
0.4
edgepred

South Weymouth

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IBI
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Geranial
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Impatien
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Impatiens ca
Rosa
Rhamnales
Log likelihood
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200
250
300
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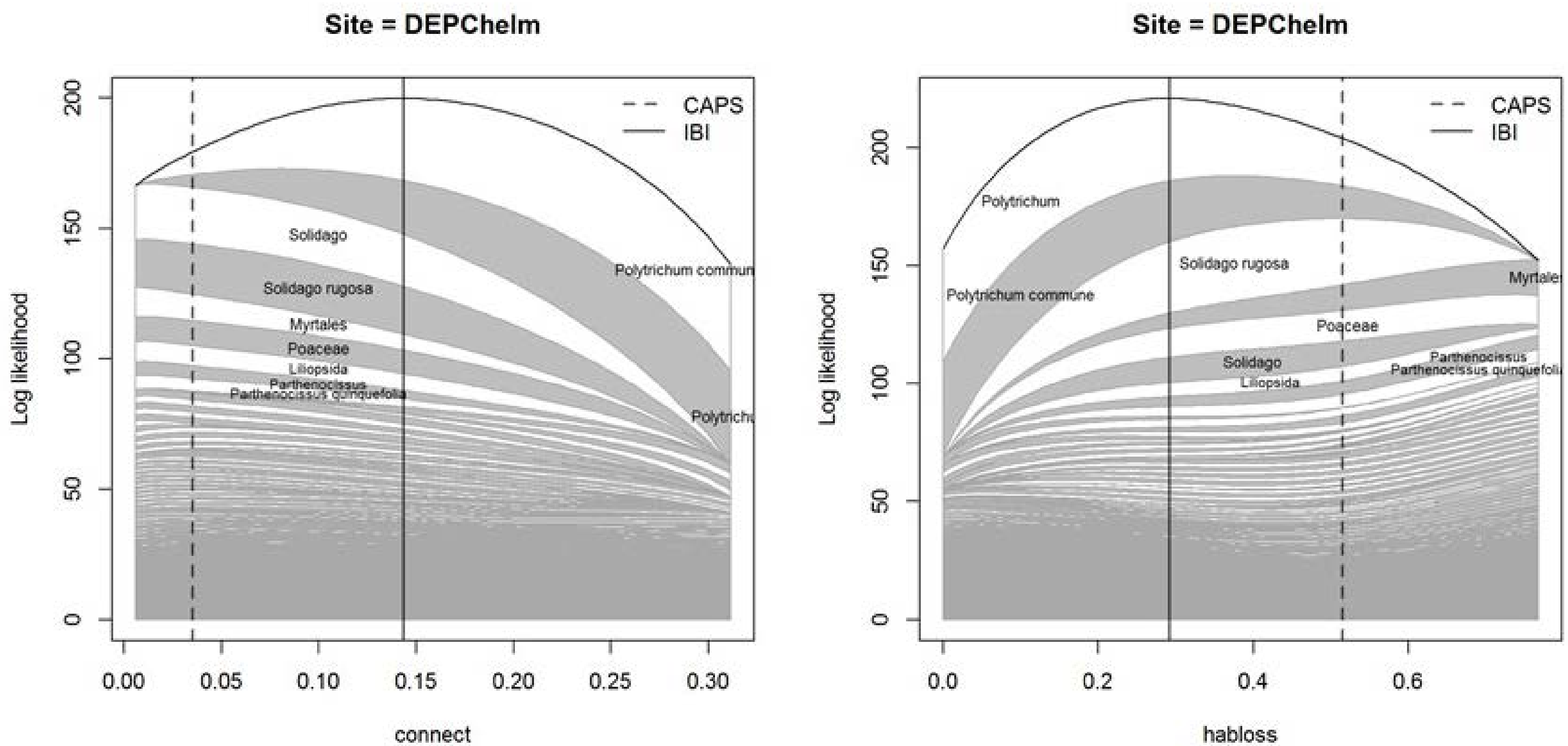
0.1
0.2
0.3
0.4
edgepred

Chelmsford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IBI
Log likelihood
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Myrtales
Poaceae
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Parthenocissus
Parthenocissus quinquefolia
Polytrichum commun
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0.05
0.10
0.15
0.20
0.25
0.30
connect
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CAPS
IBI
Log likelihood
0
50
100
150
200
Polytrichum
Polytrichum commune
Solidago rugosa
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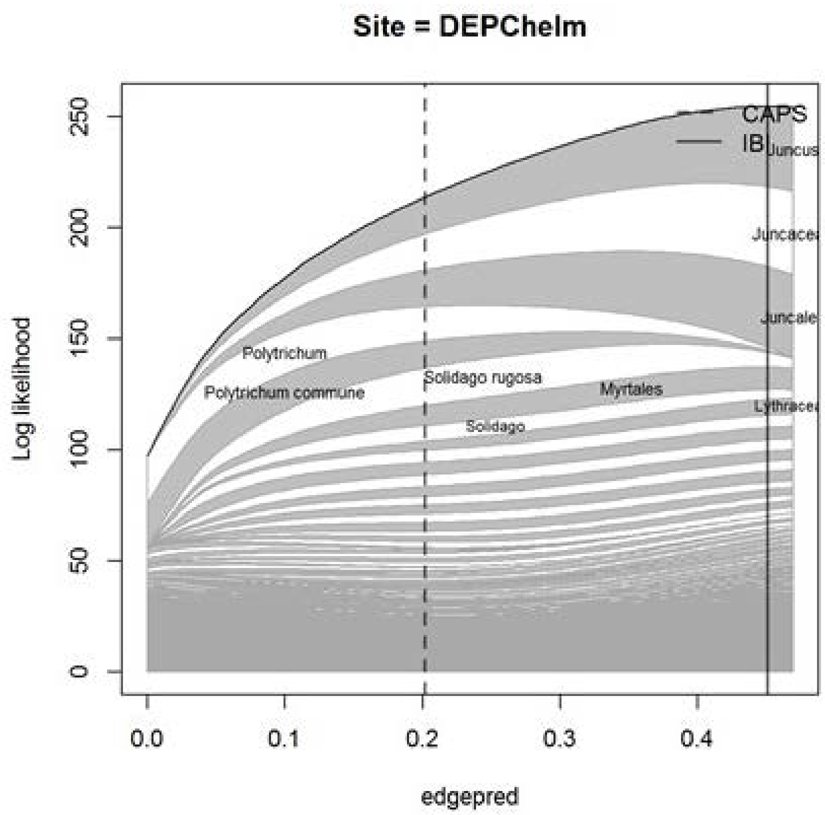
habloss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Juncus
Juncace
Juncale
Polytrichum
Polytrichum commune
Solidago rugosa
Myrtales
Lythrace
Solidago
Log likelihood
edgepred
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0.4
0
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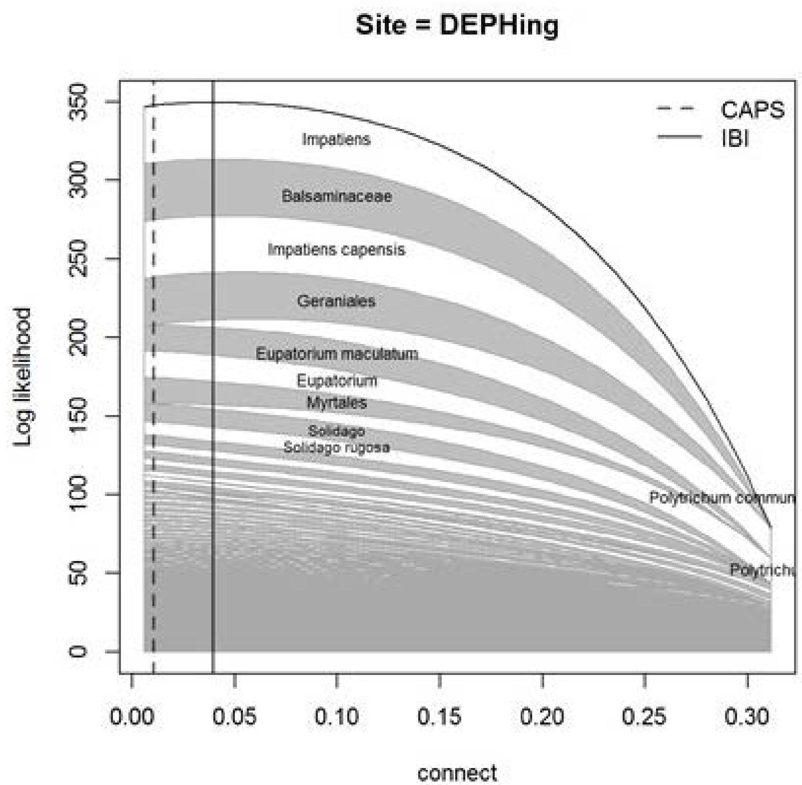
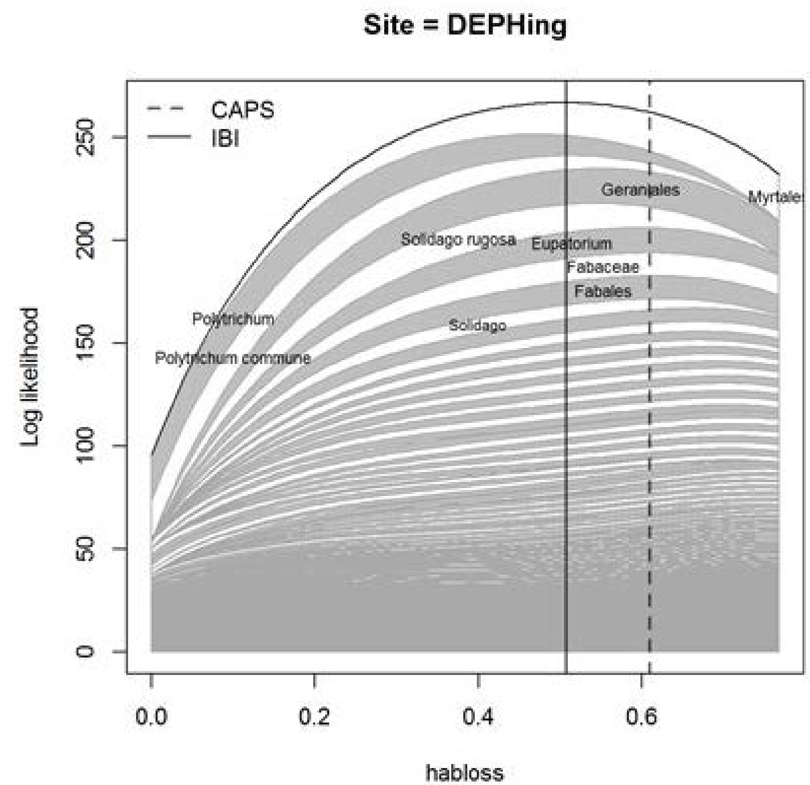
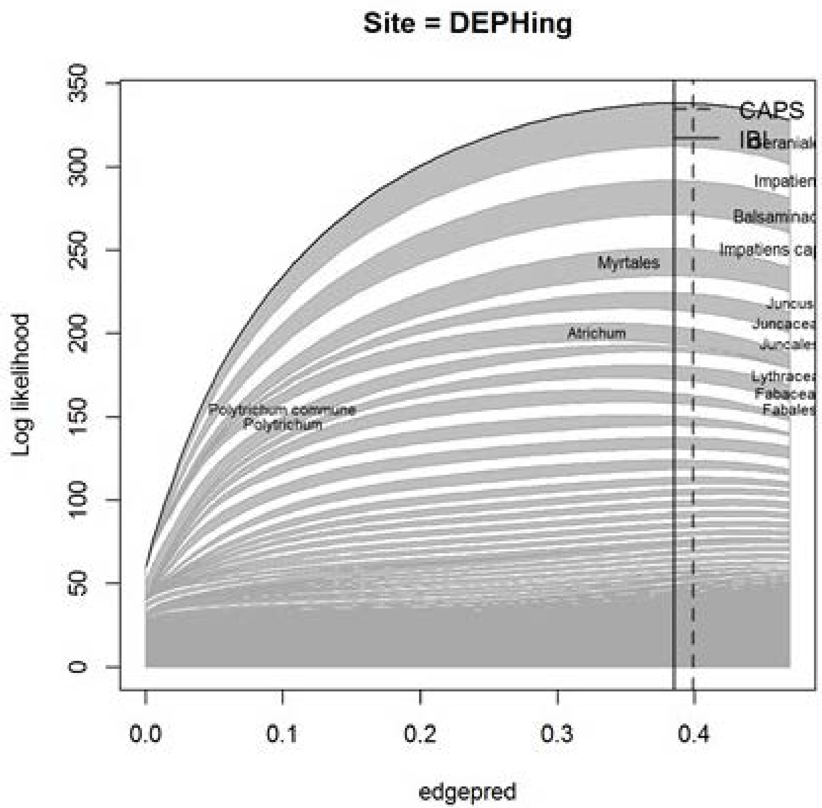
100
150
200
250

West Hingham



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CAPS
IBI
Impatien
Balsaminac
Impatiens ca
Myrtales
Atrichum
Juncus
Juncacea
Juncales
Lythracea
Fabacea
Fabales
Polytrichum commune
Polytrichum
Log likelihood
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100
150
200
250
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350
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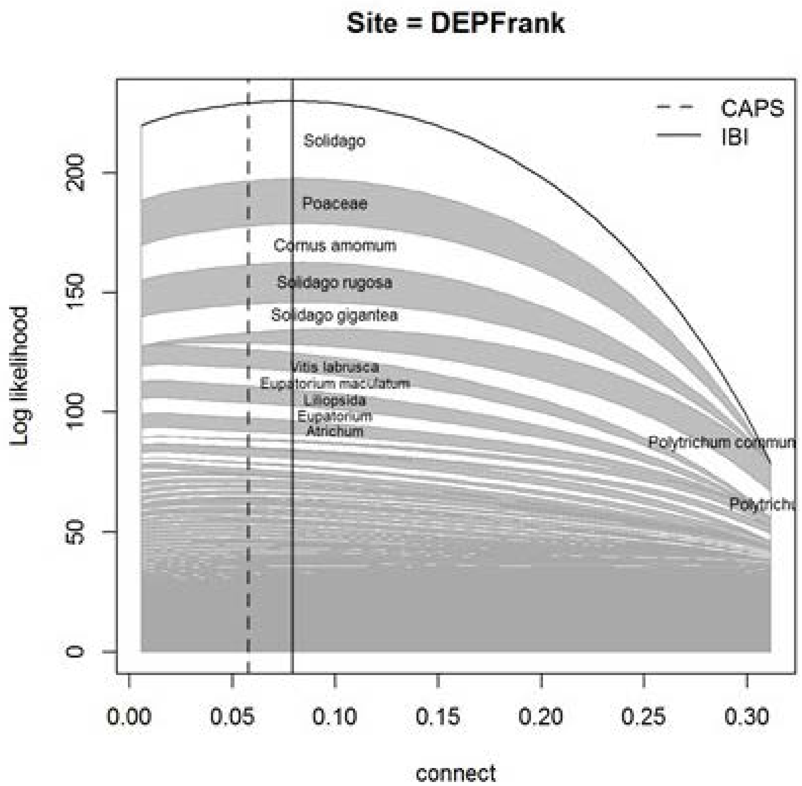
0.1
0.2
0.3
0.4
edgepred

Franklin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CAPS
IBI
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Poaceae
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Solidago rugosa
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Vitis labrusca
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Eupatorium
Atrichum
Log likelihood
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0
50
100
150
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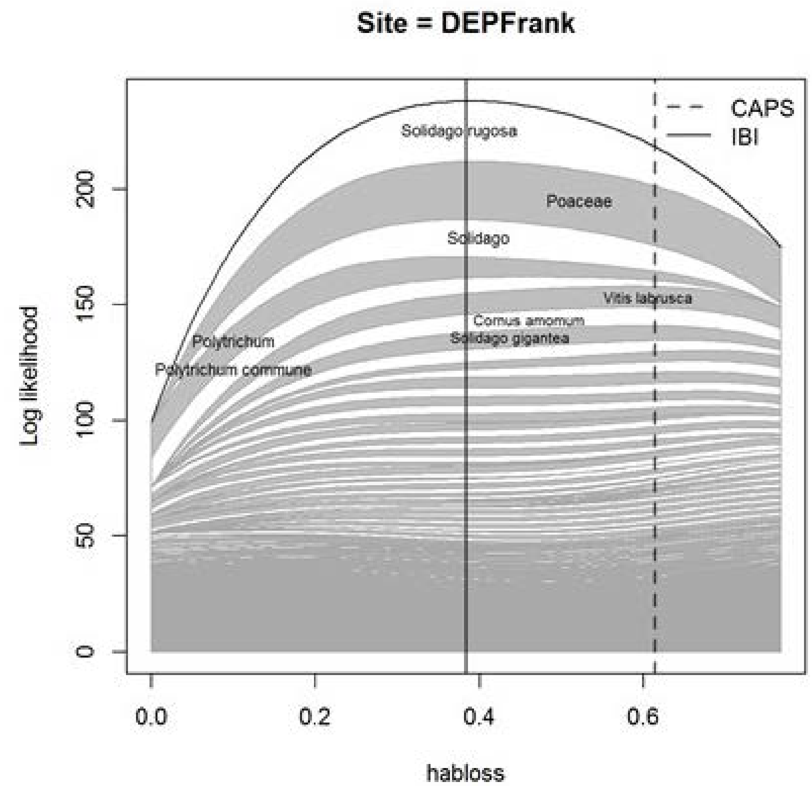
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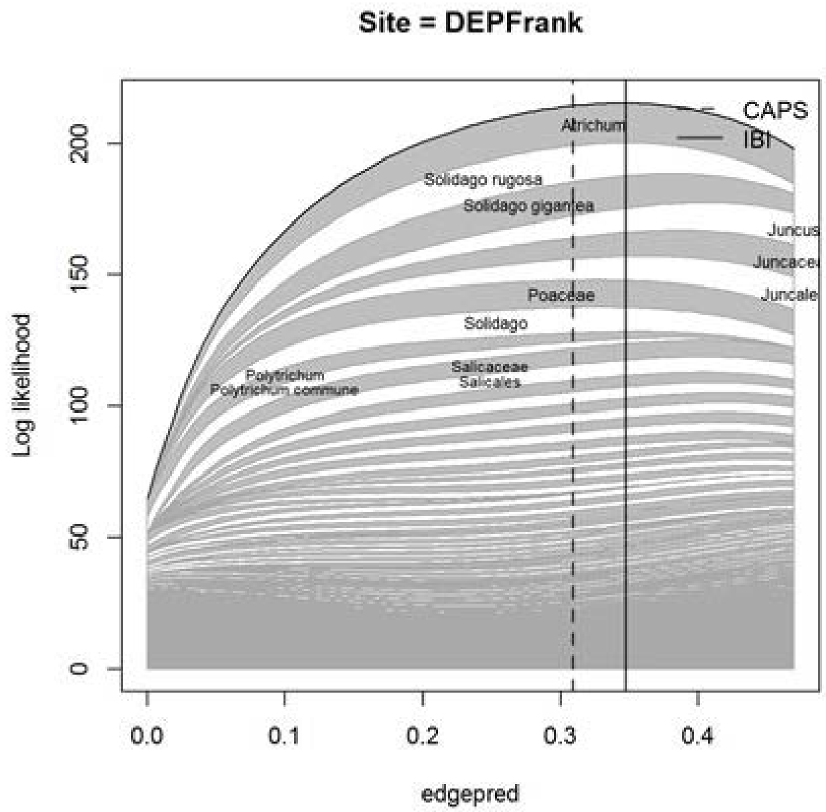
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Poaceae
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Salicaceae
Salicales
Log likelihood
0
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edgepred