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

Phase I Report for 2007

Development of a wetland Rapid Assessment Method (RAM) and field validation of the Conservation Assessment and Prioritization System (CAPS)

Landscape Ecology Program, Department of Natural Resources Conservation, University of Massachusetts Amherst

Kevin McGarigal, Associate Professor, Department of Natural Resources Conservation. University of Massachusetts, Amherst, MA 01003. Phone: (413) 577-0655; email: mcgarigalk@nrc.umass.edu

Theresa Portante, Graduate Research Assistant, Department of Natural Resources Conservation. University of Massachusetts, Amherst, MA 01003. Email: tportant@nrc.umass.edu

Scott D. Jackson, Program Director, UMass Extension Natural Resources and Environmental Conservation Program. University of Massachusetts, Amherst, MA 01003. Phone: (413) 545-4743; email: sjackson@umext.umass.edu

Bradley W. Compton, Research Associate, Department of Natural Resources Conservation. University of Massachusetts, Amherst, MA 01003. Phone: (413) 577-2179; email: bcompton@nrc.umass.edu

Kasey Rolih, Research Associate, Department of Natural Resources Conservation. University of Massachusetts, Amherst, MA 01003. Phone: (413) 577-2179; email: krolih@nrc.umass.edu

Introduction

During the summer of 2007 a pilot study was conducted to develop a draft RAM for freshwater wetlands in MA as part of Phase I in the development of a comprehensive wetland monitoring and assessment strategy for Massachusetts. The specific goal of this work was to develop a Rapid Assessment Methodology (RAM) to assess freshwater wetland condition and to validate the Conservation Assessment & Prioritization System (CAPS). MassDEP intends to use CAPS, together with a RAM and Intensive Site Assessment, to help guide policy, regulation and management actions.

As defined by the EPA (April 2006) a rapid assessment:

> *…uses relatively simple metrics for collecting data at specific wetland sites. These methods should provide a single rating or score that shows where a wetland falls on the*

continuum ranging from full ecological integrity (or least impacted condition) to highly degraded (poor condition).

The specific objectives of this phase of the project included:

- Identification of condition variables suitable for use as part of a Rapid Assessment Method (RAM) for Massachusetts in association with CAPS-based landscape scale wetland assessment;
- Development of a draft RAM; and the
- Development of a QAPP for RAM testing.

After review of several state wetland RAM's we compiled a list of local stressors that are commonly incorporated into metrics to score wetland condition in addition to stressors that are of concern in MA, particularly in the regulated 100-foot buffer zone. In addition to surveying the wetland for the presence of local stressors we collected data on wetland characteristics. Wetland characterization was subsequently simplified after a few sites because of the time it took in the field to complete.

The study was conducted in the Westfield River watershed (Fig. 1). The Westfield River runs from the Berkshire Hills until its confluence at the Connecticut River in Agawam, draining about 516 square miles (1,290 km^2) of southwestern MA.

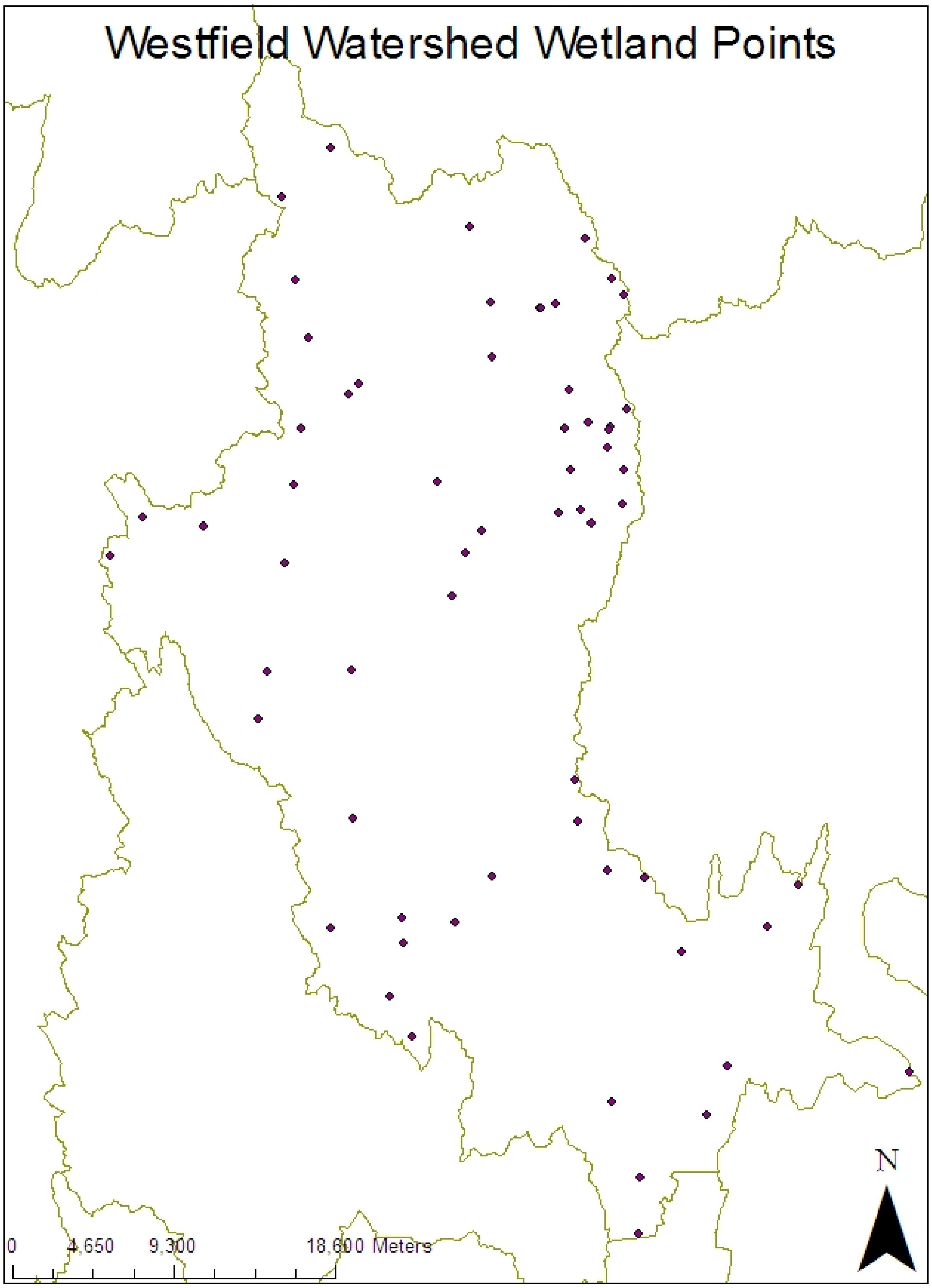

Figure 1. Location of wetland points surveyed in the Westfield watershed during Phase I.

A Quality Assurance Project Plan (QAPP) for development of a comprehensive wetlands monitoring and assessment program was written and approved by EPA and MassDEP. As part of the QAPP development process we developed Standard Operating Procedures (SOPs) for this phase of the program.

Methods

Sampling occurred between July 1, and September 30. Forested (FOWET) and Shrub/scrub (SS) wetlands in the Westfield River watershed were identified using the MassDEP Wetlands Mapping data (1:12,000 based on photography from 1993 and 1999). Sample locations were randomly stratified across six equal wetland size classes and 10 gradients of ecological integrity from the CAPS assessment of 2005. Field plots maintained a minimum separation of 500m. GPS navigation was used to locate each wetland plot.

Assessment Area

From the central plot point two circular plots were established to define the Assessment Area (AA) (Fig. 2). If the central plot point coordinates fell outside the targeted wetland, we moved the central plot point into the wetland to the nearest location 20m from the wetland edge. Sample plot 1 (AA1) had a radius of 30m and was used to characterize the wetland. Wetland characterization only included those areas of AA1 that matched the target wetland type (FOWET or SS). Sample plot 2 (AA2) had a radius of 50m and was used to assess the condition of the wetland. All areas of wetland that fell within AA2 were assessed for condition regardless of wetland type. Four transects ran at 0^o, 90^o, 180^o, and 270^o compass bearings from the central plot point.

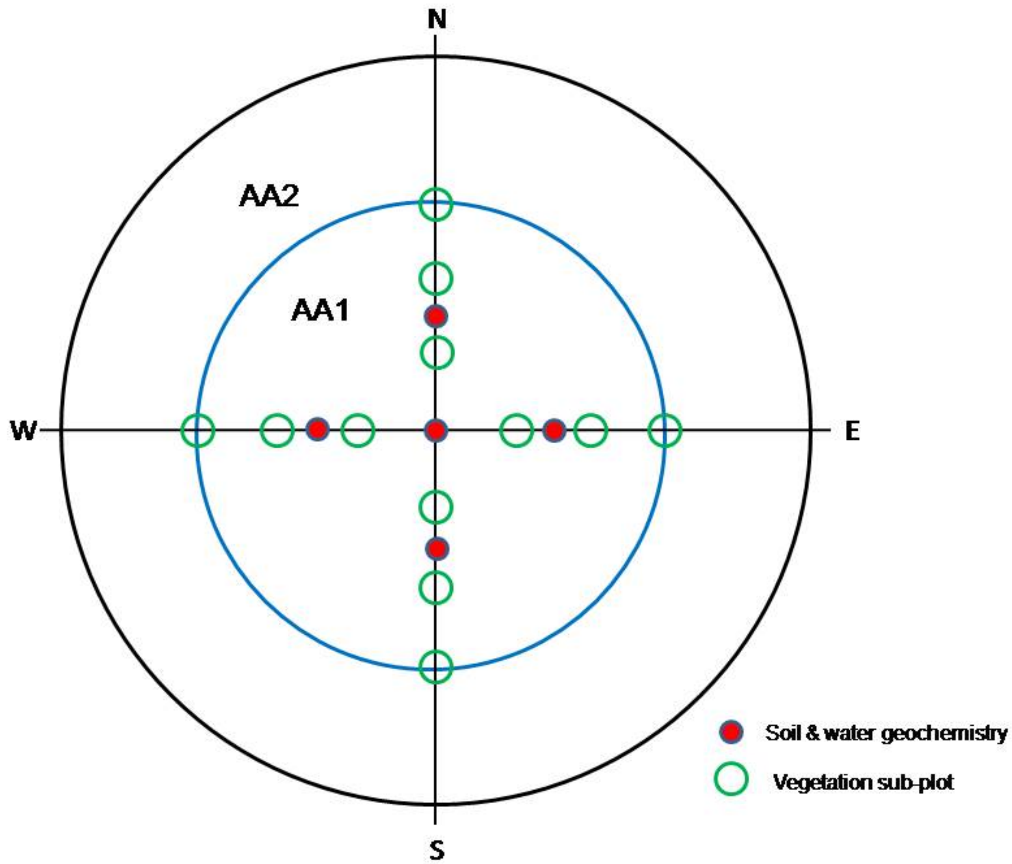

Figure 2. Assessment Area plot diagram. The inner circle (AA1) had a 30m radius; outer plot (AA2) radius was 50m. Transects were run in cardinal directions.

Assessment of stressors

At the start of the season we were characterizing the wetland within the 30m radius plot. Characterization included using the HGM (Brinson, 1993) and the Cowardin classification (Cowardin et al., 1978) systems, and by additional characteristics of hydrology, vegetative structure, soil, and topography. Detailed hydrologic, soil, and topographic characterization were dropped after 20 sites because of the required time to complete on site. We instead focused on surveying the presence of stressors on the site and simplified the characterization component to a course description of the dominant plant communities and general hydrologic descriptors. Condition indicators included altered hydrology, altered plant community, altered soils, water pollution, and human disturbance in sample plot 2 (AA2).

The 30.5m (100 ft) buffer zone was assessed for condition using indicators of altered plant community, altered soils, and human disturbance. Buffers zones were only evaluated if they were within 100m of the wetland edge. The buffer zone was divided into 3 zones: Inner 7.5m, Middle 7.5m, and Outer 15m. Conditions within the buffer zone were accessed for a distance of 25m on each side (50m total) of each 50m transect that intersected the wetland boundary (but without double sampling in buffer zone areas that overlap). If the nearest wetland boundary was >50m but less than 100m from the plot center point, then 100m of buffer zone was assessed centered on the point nearest AA2. If the distance to the wetland edge was >100m from the central plot point the buffer zone was not assessed because any buffer disturbance would be less likely to have had an impact on the assessment area from such a distance. Aerial photos (2005, 1:5000) were used to help determine the closest wetland edge to the central plot point.

Indicators of altered hydrology

Indicators of altered hydrology included the presence of water control structures (dam, weir, culvert, fill, ditching, channelization, beaver dam, storm water inputs) upstream, downstream, and within AA2. These were used to assess the hydrologic condition of the AA2. Observations were made along the four transects within AA1 and AA2. For any channels encountered within the AA2 we walked 100m up and down gradient to survey indicators of altered hydrology with the potential to impact the assessment area.

Indicators of altered plant community

Invasive species richness and percent cover, evidence of mowing and/or burning were surveyed as indicators of plant community condition. Invasive species included species that have been identified by the Massachusetts Invasive Plant Advisory Group as "invasive", likely invasive", or "potentially invasive" (http://www.massnrc.org/MIPAG/index.htm).

Four 50m transects were walked from plot center in each plot and an additional 20 minutes were spent walking the rest of the plot to make visual observations of evidence of mowing, burning, or timber harvesting, making a note as to whether it was vegetative management as part of a ecological restoration project. The percent of the AA that was affected was noted using the following categories: <10%, 10-50%, 50-90%, >90%. Percent cover of invasive species was taken along the 50m transect line using the line intercept method.

Indicators of altered soils

Along the 50m transects, observations of altered soils were taken. Indicators of altered soils included filling, plowing, grading, grazing, dredging, sedimentation, and vehicle use. The percent of the AA that was affected was noted using the following categories: <10%, 10-50%, 50-90%, >90%.

Indicators of degraded water quality

Visual observations were made along transects of any obvious spills, or direct point or nonpoint source discharge from agricultural operations, septic or sewage treatment systems, or storm water. The percent of the AA that was affected was indicated using the following categories: <10%, 10-50%, 50-90%, >90%.

Indicators of human disturbance

Visual observations of evidence of motorized or non-motorized vehicle use, presence of trash/litter, garbage dumping, and organic dumping were made within the AA along each transect. Indicators of human disturbance included walking trails, horse trails, logging roads, ATV trails, old cart paths, and roads. The percent of the AA that was affected by human disturbance was indicated using the following categories: <10%, 10-50%, 50-90%, >90%.

Indicators of buffer zone disturbance

Each buffer zone (inner, middle, and outer) was assessed to 1) determine the percent (none, <10%, 10-50%, 50-90%, >90%) that was mowed turf, hay/pasture, row crop, impervious, subject to vegetation management, or natural, 2) was affected by trash/litter, garbage (indicate historic/recent), and/or leaf/brush dumping, 3) the number of point and non-point source discharges 4) evidence of erosion and sedimentation, and 5) the number of structures present in the following categories: Agricultural, Residential, Commercial, and Industrial.

Results

Fifty seven wetlands (26 FOWET and 31 SS) were surveyed for indicators (stressors) of wetland condition. Data were analyzed for the presence of stressors at each site and the % occurrence for all points.

Among the categories of human disturbances found within the wetland, indicators of motorized/non-motorized vehicle were present at 7% of the sites (Table 1). Other indicators (Table 2) were present at 35%. Hydrologic stressors in the AA were present at 12% of sites (Table 3). Hydrologic stressors were present along channels 100m up or down-gradient of AA at 25% of sites (Table 4).

Stressors were present in the inner buffer zone at 53% (Table 5), the middle zone at 51% (Table 6), and the outer buffer zone at 49% of the sites (Table 7). Vegetation management had the highest occurrence (includes both recent and historic) for all zones. One residential structure was present in the middle buffer zone at 2% of the sites, and occurred at 9% of sites in the outer buffer zone. Only one structure, an old child’s fort, was present at one site in the inner buffer zone.

Invasive species were present at 44% of sites. Six species of invasive plants were present at the sites (Table 8). *Rosa multiflora* (Multiflora rose) had the highest percent occurrence among all sites.

Table 1 Indicators of motorized/non-motorized vehicles present within the AA present at 7% of sites

Stressor	# of sites present	% occurrence
Dirt road	3	5
ATV trail	2	4
Old cart path	1	2
Walking trail	1	2

Table 2 Other indicators of disturbance present at 35% of sites

Stressor	# of sites present	% occurrence
Trash/litter	12	21
Garbage dumping	6	11
Evidence of mowing	3	5
Hay/pasture	2	4

Table 3 Hydrologic stressors within the AA present at 12% of sites

Stressor	# of sites present	% occurrence
Culvert	5	9%
Road (dirt/paved)	2	4%
Fill	2	4%
Channelization	2	4%
Ditching	1	2%
Storm water inputs	1	2%

Table 4 Hydrologic stressors present at 25% of sites along channels 100m up or down-gradient of AA

Stressor	# of sites present	% occurrence
Culvert	9	16
Fill (road/railroad)	4	7
Channelization	1	2
Storm water inputs	1	2

Table 5 Inner buffer zone stressors present at 53% of sites

Stressor	# of Sites	% Occurrence
Subject to vegetation management	20 8 (historic)	35
Trash/litter	12	21
Garbage dump	6	11
Mowed turf	5	8
Logging road	3	5
Dirt road	3	5

Cart path	2	4
Leaf/brush	2	4
Railroad tracks	1	2

Table 6 Middle buffer zone stressors present at 51% of sites

Stressor	# of Sites	% Occurrence
Subject to vegetation management	20 6 (historic)	35
Trash/litter	13	23
Garbage dump	5	8
Leaf/brush	5	8
Mowed turf	4	7
Logging road	3	5
Dirt road	2	4
ATV trail	1	2
Railroad tracks	1	2

Table 7 Outer buffer zone stressors present at 49% of sites

Stressor	# of Sites	% Occurrence
Subject to vegetation management	13 3 (historic)	22
Trash/litter	9	16
Mowed turf	8	14
Impervious	6	11
Hay/pasture	4	7
Garbage dumping	4	7
Leaf/brush	4	7
ATV trail	1	2
Dirt road	1	2
Railroad tracks	1	2

Table 8 Invasive species present at 44% of sites

Species	# of sites present	% Occurrence
Rosa multiflora (Multiflora rose)	11	34
Phalaris arundinacea (Reed canary grass)	10	31
Berberis thunbergii (Japanese barberry)	9	28
Lonicera morrowi (Morrow's honeysuckle)	8	25
Celastrus orbiculatus (Oriental bittersweet)	7	22

Frangula alnus (Glossy buckthorn)	7	22

Discussion

The results of our review of other states' wetland assessment and monitoring work and our first field season has provided a greater appreciation of the challenges of developing a credible RAM and establishing valid relationships between landscape-based assessments and condition assessments conducted in the field. Of primary concern is heavy reliance on stressors in existing RAMs and the general uncertainty around the relationships between stressors and wetland condition.

If a RAM is primarily composed of condition metrics then it would provide a strong basis for testing predictions from landscape-based ecological assessments. However, to the extent that a RAM is based on the assessment of site-based stressors rather than condition then, much like the landscape-based assessment, it only serves to make predictions about the ecological condition of a wetland. As such it cannot be used to test or validate the landscape-based predictions because there are many landscape-scale stressors that cannot be assessed by site-based field assessments (e.g. development intensity, road intensity, similarity, connectedness, dams, road crossings). In as much as the RAM may be able to identify local stressors that cannot be accurately predicted from landscape-scale assessment (e.g. direct storm water discharges, ditching, chemical spill or dumping) it can serve as a complement to landscape-based assessments.

It is important to recognize that the predictions made by stressor-based RAMs will be significantly different than predictions made by landscape-based assessments. For example, RAM-based predictions of condition will not be able to account for the role of patch size, edge effects, associations with surrounding habitats, or connectedness that would be expected to strongly influence biotic communities over time.

Ideally we should seek to develop a RAM (or RAMs if necessary to accurately address the full range of wetland types) that is based on valid condition metrics (IBIs) rather than stressor metrics. These RAMs would be expected to correlate strongly with landscape-based predictions provided that the level 1 assessment is based on known relationships between landscape-scale stressors and ecological condition. Such a RAM could then be credibly used to identify wetlands whose ecological condition falls outside the predicted range given its landscape context (degraded wetlands).

We propose to postpone the development of a freshwater wetland RAM until we 1) develop IBIs that will allow us to assess ecological condition in the field and 2) determine the relationships between stressors and ecological condition that will result in credible predictions based on landscape-level assessments.

Proposed new approach for the next phase of work

Recognizing that there are others out there focusing on understanding the relationship between site-based stressors and condition and the development of RAMs, we propose to focus on understanding the relationships between landscape-based stressors and ecological condition.

Landscape-based assessment is our particular strength and probably the most significant contribution we can make to the community of agency and academic scientists working on wetlands assessment and monitoring. Although others (e.g., Ohio) are investigating the relationships between landscape metrics and condition, their landscape-based assessments lack the sophistication and rigor that CAPS can provide. For example, Ohio uses a single landscape-base metric (Landscape Disturbance Index) that lacks any distance-weighting function. CAPS uses up to 21 landscape-based metrics, many of which contain sophisticated distance-weighting functions.

Much (but not all) of the existing work done in other states has focused on emergent wetlands (and salt marshes in Massachusetts). Therefore, we propose to focus our work initially in forested wetlands. Forested wetlands make up the vast majority of wetlands in Massachusetts and are the most difficult to model using aquatic-based metrics (e.g., water quality, aquatic invertebrates). Because they typically lack permanent standing water, forested wetlands are more integrated into the surrounding terrestrial landscape (e.g., they can be viewed ecologically as both wetlands and forests). Therefore, it is necessary not only to look at how the surrounding landscape can negatively affect the physical-chemical characteristics of wetlands, but how the landscape can support components of the wetland biota that may be shared between wetland and terrestrial systems.

Due to the uncertainty surrounding the choice of effective indicators of ecological condition in forested wetlands, we propose to evaluate various taxonomic groups for their potential to yield IBIs for assessing condition. These include lichens, algae, vascular plants, bryophytes, and invertebrates (terrestrial as well as aquatic). The IBIs will be used to create a Site-Level Assessment Methodology (SLAM) for forested wetlands that can be used to understand the relationship between ecological condition and various stressor metrics. Note, SLAMs differ from RAMs in that they may be more intensive than rapid assessments in order to be rigorous enough to test and calibrate landscape-based stressor metrics. Once we have tested and modified (as necessary) the landscape-based assessment methodology (CAPS) then we will be positioned to use the work being done by others and the SLAMs produced by our work to optionally develop one or more RAMs. RAMs based on condition metrics rather than stressor metrics will then be able to fulfill our original expectations of identifying relationships between landscape-based assessments (CAPS scores) and conditions on the ground (RAM-scores).

We propose that the next phase of work focus on the following two objectives.

1. Identify indicators of wetland condition. Identify taxa that are good indicators of wetland condition because they demonstrate a dose-related response to stressors. This, in of itself, will provide useful information about how some organisms respond to various stressors. Some organisms might be strongly correlated with overall conditions/integrity (as represented by IEI scores). Others might show a strong correlation with one or a few stressors but not with overall IEI.
2. Calibrate CAPS metrics. Those taxa that demonstrate correlations with specific stressors will be used to calibrate the stressor metrics used in CAPS. The combination of these relationships as well any relationships we find between taxa and overall condition will be used to adjust the CAPS IEI models.

Because they rely heavily on the assessment of stressors rather than indicators of wetland condition (or only a subset of condition indicators) Level 1 and Level 2 assessments should be calibrated using empirical data. The models used in CAPS as well as the scoring algorithms used in RAMs are only best guesses if they are not based on empirically derived relationships between stressors and condition.

In other wetland systems (emergent wetlands, rivers/streams, coastal salt marshes) intensive studies have provided some of the information needed to create and calibrate RAMs. However, developing scoring algorithms for those RAMs continues to be a challenge because we generally don't have empirical data of sufficient resolution to derive dose-dependent relationships between stressors and condition, or because empirical data are not available for all stressors.

By in large empirical data on the relationships between stressors and condition are almost entirely lacking for forested wetlands. As a result we lack IBIs or the data necessary to develop IBIs for these wetlands. We intend to conduct intensive studies of wetland condition at a sufficiently large number of sites to characterize the relationships between stressors and conditions in forested wetlands. With these data in hand we expect to be able to develop IBIs for forested wetlands and use these to calibrate the CAPS metrics and models. Ultimately, these data will also be useful for developing a RAM for forested wetlands.

The best indicators of forested wetland condition will be taxa that are:

- Widespread in forested wetlands
- Reasonably common in forested wetlands
- Not specialized to particular conditions or micro-habitats that are not common to most/all forested wetlands
- Good indicators of wetland condition (demonstrate dose-dependent responses to stressors)
- Practical to sample

Thus far, no one seems to be able to point us to particular taxa that meet these criteria. In addition we have concerns about whether certain taxa (algae, aquatic macro-invertebrates) used for other wetland types will be useful for assessing condition in forested wetlands.

One additional consideration is that some taxa groups might demonstrate a strong relationship with overall condition while others might be correlated with only one or perhaps a few stressor metrics. To calibrate CAPS we would like to identify indicators of condition that are correlated with <u>specific metrics</u> that contribute to overall condition.

For these reasons, we feel that it is necessary to cast our net as broadly as possible while prospecting for IBI candidates.

The assessment of vascular plants and bryophytes is relatively straight-forward and are not significantly different from techniques for assessing these biotic elements in other wetlands.

However, some of the techniques developed for other wetlands have been difficult to adapt for forested wetlands.

Epiphytic macro-lichens and earthworms are components of the biological community in forested wetlands that are not present in emergent and salt marsh wetlands. Therefore we have adapted techniques used in the characterization of forest communities for use in the forested wetlands SOP.

Because emergent marsh and riverine systems have relatively long hydroperiods the invertebrate communities in those wetlands are predominately aquatic. The relatively short hydroperiods of forested wetlands along with non-aquatic elements of these ecosystems (e.g. mounds, tree canopies) means that we would expect aquatic invertebrates to be only one element of macro-invertebrate communities. We have struggled to develop sampling protocols that can efficiently sample both aquatic and terrestrial invertebrates.

Techniques for sampling aquatic invertebrates are well-developed for other wetlands. Some of these techniques (funnel traps, sweep netting) are generally not suitable for use in forested wetlands because areas of standing water are often too small and shallow. We have decided to use the stovepipe sampling method along with emergence traps to sampling aquatic invertebrates. We believe that these techniques are likely to yield good results in forested wetlands that contain suitable standing water. However, there is concern that if a significant number of our forested wetland sites lack standing water or have very short hydroperiods our aquatic invertebrate samples will be too variable (independent of condition) and not useful for developing IBIs.

Concerns about the usefulness of aquatic invertebrates as indictors of wetland condition in forested wetlands means that it is important that we also try to sample terrestrial invertebrates. In addition, terrestrial invertebrates might show greater sensitivity (relative to aquatic invertebrates) to landscape-based resiliency metrics such as similarity and connectedness. Unfortunately, some of the techniques for sampling terrestrial invertebrates are impractical to use. For example fogging trees with pesticides and catching the invertebrates as they fall is not easy to use in wetland communities. Sticky traps are very difficult to work with and professional entomologists here at UMass have abandoned the technique because it is just too difficult to extract the invertebrates without damaging them. Light traps are expensive, heavy, and tend to yield overwhelming numbers of moths that are very difficult to identify. Pit trapping is the only technique that we have found that appears to be a practical method for sampling terrestrial invertebrates within the limits of our budget and study design.

We believe that algae may be a promising taxa group for use in condition assessment. Some of the sampling techniques for algae are suitable for use in forested wetlands (water grab samples; sediment samples) but only if there is sufficient standing water in the wetland plot. Other techniques (e.g. sampling submerged vegetation for epiphytic algae and sampling submerged woody debris) are not practical to use in forested wetlands with limited standing water and little or no submerged vegetation.

We considered sampling vertebrates in forested wetlands but these were not included in the SOP for the following reasons.

- Amphibian and reptile communities are not sufficiently diverse to yield meaningful IBIs. Too few species are typical of forested wetlands. Those that are tend to be dependent on vernal pool habitat (the four-toed salamander being a notable exception). The time and effort required to adequately sample for some of these species are beyond the scope of what can reasonably be done given the limitation of budget and study design.
- There are no mammals that are characteristic of forested wetlands. Several species are likely to utilize forested wetlands but also utilize a variety of other habitats as well. Use of forested wetlands by some species (e.g. mink, otter, water shrew, bog lemmings) is likely to be dependent on the presence of appropriate wetland or open water habitats nearby. Small mammals (voles, shrews, star-nosed mole) might yield meaningful results but the effort necessary to adequately sample these taxa are not practical for our study.
- It is possible that a study of birds could yield useful results. Because some birds demonstrate area-sensitively they may be responsive to the resiliency metrics (similarity and connectedness) as well as landscape-based stressor metrics. They can reasonably be sampled by trained observers monitoring bird songs and calls. However, only a handful of species are characteristic of forest wetland communities (veery, northern waterthrush, Canada warbler). Given limitations of budget and time we chose not to include birds in the current draft of the Site-Level Assessment Method (SLAM). We are open to adding this component should additional resources become available.

Conclusion

Metrics used in other state's RAMs are very simple and highly subjective. Most of the metrics were entirely or in part, stressor-based. Apart from noting the presence or absence of stressors we found it difficult to assess these indicators in the field. It is particularly difficult to assess the severity of impacts and the proportion of the wetland affected by each particular stressor. Further it was unclear to what extend we should be focused on historic impacts and past land use (past logging, old ditches, 100-year old dams, previous clearing for agriculture followed by 80 years of re-forestation).

Compounding our uncertainty about how to assess these metrics in the field was a lack of knowledge about how these stressors relate to wetland condition. For example, does the fact that we found a white 5-gallon bucket in a wetland mean that it is degraded?

RAMs based on stressor metrics are not suitable for calibrating or validating assessments made by landscape-based approaches such as CAPS. Given that both RAMs and landscape-based assessments are estimates or predictions about wetland condition, RAMs may indeed be inferior to Level 1 assessments because they cannot realistically account for landscape-scale stressors. Landscape-based assessments offer other advantages such as comprehensive coverage (all wetlands within a given area are assessed) and a wider range of applications such as alternatives analysis, mitigation planning, and establishing priorities for ecological restoration.

At this time it appears that rather than devote any more time to RAM development more can be accomplished in Massachusetts by focusing on the development of IBIs and Site-Level Assessment Methods that can be used characterize wetland condition. These can then be used to calibrate the CAPS metrics and eventually validate the results of CAPS landscape-based models.