

Pilot wetland condition assessment of palustrine emergent marshes in the Upper Hudson River watershed



New York Natural Heritage Program

A Partnership between The Nature Conservancy and the NYS Department of Environmental Conservation

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marsh in the Upper Hudson River watershed**

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A report prepared by the

New York Natural Heritage Program

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for the

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I. INTRODUCTION

New York State does not currently conduct statewide comprehensive monitoring for wetland quality and condition, although the importance of wetlands and their health is well understood. Wetlands are critical in flood and storm water control; surface and groundwater exchange; erosion control; nutrient cycling and food chain support; recreation; and as habitat for fish, shellfish, other wildlife, and wetland plants. The catastrophic flood events over much of eastern New York in 2011 make clear the importance of our wetlands, especially in connection to surface waters. Rigorous, ongoing monitoring of the condition of these wetlands is therefore critical to the conservation of many of the state's environmental resources, and especially for understanding baseline condition and change in wetland condition over time.

This wetland condition assessment effort establishes wetland surveys within the basins that are being sampled in the Division of Water's Rotating Integrated Basin Studies (RIBS) network. One target wetland type (palustrine emergent marsh) was chosen to maximize our ability to calibrate metrics. In 2012, we targeted wetlands in the Upper Hudson River basin. Condition was assessed following the EPA's three-tiered approach: Level 1, a remote landscape assessment; Level 2, a rapid field survey evaluating ecological integrity and stressors; and Level 3, a quantitative description of vegetation.

1. Background

The New York State Department of Environmental Conservation (NYSDEC) recognizes the vital importance of wetlands to the health of the New York's environment through various Wetland Program projects, including ongoing mapping efforts and attempts to measure net gains or losses of wetlands. Despite this, "New York State has not yet integrated wetlands into existing surface water monitoring programs, nor undertaken efforts to monitor the biological, physical, and chemical integrity of wetlands" (New York State Department of Environmental Conservation 2010). This project complements the ongoing regulatory wetland mapping carried out by the Division of Fish, Wildlife, and Marine Resources by developing and enacting a protocol for evaluating the health and quality of the state's wetlands. It also complements an effort currently underway for wetlands along the Lake Ontario shoreline by The New York Natural Heritage Program (EPA GLRI grant # GL00E00842-0), through the collection of consistent metrics across sites (e.g., Floristic Quality Index and presence, cover, and diversity of invasive species). This pilot study sampled different wetland types than those being sampled for the Lake Ontario project, and thus expanded the overall pool of wetlands being evaluated. Similarly, in the Adirondacks, the Adirondack Park Agency has complete wetland maps and is beginning a pilot citizen-science wetland monitoring program (Agreement: CD-972080-00).

2. Objectives

The objective of this pilot monitoring project is to assess how to apply the approach taken by the statewide ambient water quality program into wetlands, while building on the work in New York conducted as part of the EPA National Wetland Condition Assessment (NWCA). To do this, the New York Natural Heritage Program (NYNHP) piloted wetland condition assessment protocols that follow the EPA's three-tiered approach. We explored whether the NWCA protocol was

appropriate as the basis for a state monitoring program, and we were informed by Level 1, 2, and 3 methods that have been developed nationally and locally (Mack 2001, U.S. Environmental Protection Agency 2006, 2011, Faber-Langendoen *et al.* 2009, Lemly *et al.* 2011, Walz and Domber 2011, Lemly and Gilligan 2012) to create a strategy for an ongoing wetland condition monitoring effort here in New York.

We aimed to apply the broader approach of the statewide ambient water quality program into wetlands, and monitoring sites were selected within the framework of the rotating basins approach followed by the NYSDEC DOW's flowing waters, lakes, and groundwater monitoring programs (Figure 1). Of the basins that the Division of Water sampled in 2012, in consultation with DOW and DEC's Freshwater Wetlands Program in the Division of Fish, Wildlife and Marine Resources (DFWMR), we selected the Upper Hudson. We sampled during the middle of the growing season, in July and August.

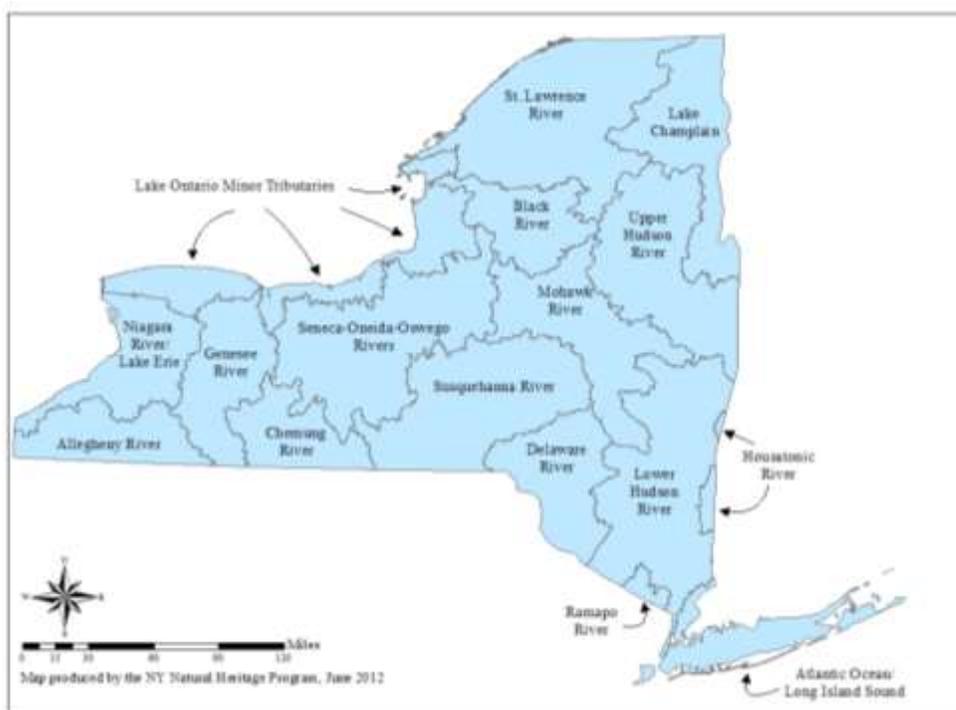


Figure 1. NYSDEC DOW watersheds used to guide freshwater monitoring and assessment.

Because our primary goal is to pilot assessment methods at Levels 1, 2, and 3, and because we had a limited field sample size ($n=18$ for Level 2, $n=14$ for level 3), we selected one wetland type to maximize the strength of our analyses. Both Ecological Integrity Assessment (EIA; Level 2) metrics and Floristic Quality Assessment (FQA; Level 3) indices are typically calibrated to natural community type (Andreas *et al.* 2004, Faber-Langendoen *et al.* 2012), so our approach of selecting sites of a common community type across a landscape condition gradient allows us to explore the range of variation within a type, maximize our sample size, and calibrate metrics for this type.

II. METHODS

1. Quality Assurance Plan

Following the EPA's guidelines (U.S. Environmental Protection Agency 2012), we began by developing a detailed project plan to describe our approach to data collection, analysis, and storage in the context of specifying measurable standards for quality control throughout the project's lifecycle (NYNHP and NYSDEC 2012). This Quality Assurance Project Plan (QAPP) was completed by NYNHP and approved by NYSDEC, an EPA-delegated state for quality assurance approval. We conducted periodic informal audits to ensure procedural compliance with the QAPP, and we calculated metrics to assess accuracy, precision, completeness, comparability, and representativeness. These findings are presented in the quality assurance and quality control (QA/QC) results section of this report.

2. Methods Development

Arguably our most important preliminary task was to review existing wetland condition assessment protocols with an eye towards selecting methods that could form the basis of a statewide monitoring program. Our intention was that this pilot project would allow us to determine whether our chosen methods were appropriate and what refinements would be needed as we moved forward. The NWCA methods followed the "three-level framework" (Fennessy *et al.* 2007) and we decided to follow suit, since, in addition to being a federal standard, this approach is being adopted by state programs (e.g., U.S. Environmental Protection Agency 2006, Lemly *et al.* 2011, Maine Wetland Interagency Team 2011). We next explored our options for data collection at each level, outlined here and discussed in detail in subsequent sections.

Our Level 1 method followed Comer and Hak's (2012) Landscape Condition Assessment because it seemed like an elegant integration of relevant landscape-level stressors. We wanted to move beyond NWCA's desktop evaluation of the buffer around each assessment area towards a semi-quantitative model of landscape condition.

The NWCA study included a Level 2 Rapid Assessment Method (USA-RAM), but because scoring for the metrics was still in development, we decided not to use it. Instead, we turned to another RAM, a wetland-specific Ecological Integrity Assessment (EIA) protocol developed by NatureServe for the EPA (Faber-Langendoen *et al.* 2012), with some modifications (California Wetlands Monitoring Workgroup (CWMW) 2012, Lemly and Gilligan 2012). Because the metrics and scoring for the EIA have been tested nationwide and have been repeatedly refined, we felt confident that the approach would be a solid starting point for us.

Level 3 data collection for the NWCA was quite intense; it required teams of four and encompassed algae and water chemistry (collecting and processing multiple samples), soils (digging numerous soil pits and bagging samples for lab analysis), and vegetation (documenting composition within nested plots). We decided to significantly scale that approach back to something that could be accomplished by a two-person team. Because we did not have the resources to process water or soil samples and because we have extensive vegetation sampling experience, we opted to focus our intense sampling on plant communities. We felt that the nested



plot sampling design would, again, be too time intense, so we followed a subplot approach that has been piloted in other states and that is derived from traditional relevé plot work (Peet *et al.* 1998, Walz and Domber 2011, Lemly and Gilligan 2012). Essentially, we collected detailed data in four subplots instead of sampling five plots with nested corners.

Analytical procedures for each level of sampling were available, which drove our selection process; those procedures are detailed in a subsequent section.

3. Site Selection and Level 1 Landscape Analysis

Prior to sampling, we determined our target population for study. We chose from naturally-occurring vegetated wetlands classified as palustrine emergent, scrub-shrub, and forested in the Upper Hudson River watershed that are located on conservation lands and are ‘connected to’ (within 10 m of) surface waters. The sample frame consisted of Adirondack Park Agency (APA) and National Wetlands Inventory (NWI) polygons of the target type, with adjacent polygons of same Cowardin class merged. We set our minimum polygon size to 2 acres to accommodate an assessment area of 1.2 acres (a 40 m radius around a sample point).

Within the Upper Hudson watershed, wetland delineations have been developed by the Adirondack Park Agency (for the Northern Appalachian / Acadian ecoregion) and the U.S. Fish and Wildlife Service’s National Wetlands Inventory (for the Lower New England / Northern Piedmont ecoregion). In selecting one wetland type to focus on, we evaluated the distribution and abundance of all wetlands in the watershed that were connected to surface waters and located on protected lands. First, we selected those that intersected “conservation” lands (Kinal 2012), minimizing our need to gain formal access permission. To link our findings to those of the DOW’s monitoring program, we wanted to ensure that our sites had a hydrologic connection to surface water, so we discarded wetlands that were further than 10 m from the National Hydrography Dataset’s flowline and waterbody features. A total of 11,257 polygons met those initial criteria, and Figure 2 shows the distribution of this first set. Not surprisingly, the vast majority of sites were in the Northern Appalachian / Acadian ecoregion on protected lands within the boundary of the Adirondack Park.

We next merged adjacent polygons of the same Cowardin class and extracted three types for evaluation: palustrine emergent marsh (PEM), palustrine forested (PFO), and palustrine shrub-scrub (PSS). We eliminated polygons that were less than 2 acres in size, deeming them too small to comfortably accommodate our 1.2 acre assessment area. We were left with 677 PEM polygons, 2102 PFOs, and 1616 PSS sites. In consultation with DOW and the freshwater wetlands program of DFWMR we mutually agreed that PEM was the most appropriate system to target for this pilot study. Our sample frame of 677 palustrine emergent wetlands is depicted in Figure 3.

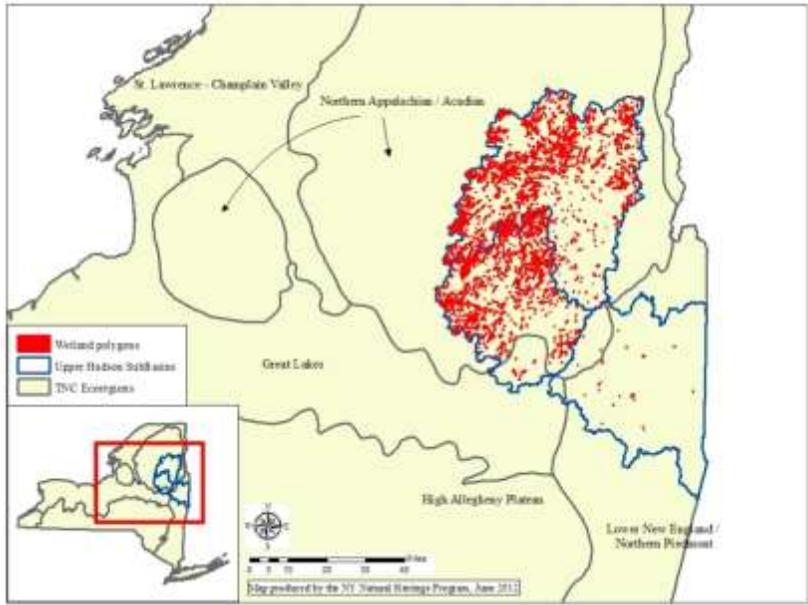


Figure 2. Pool of all wetlands on conservation lands and connected to surface waters in the Upper Hudson River watershed.

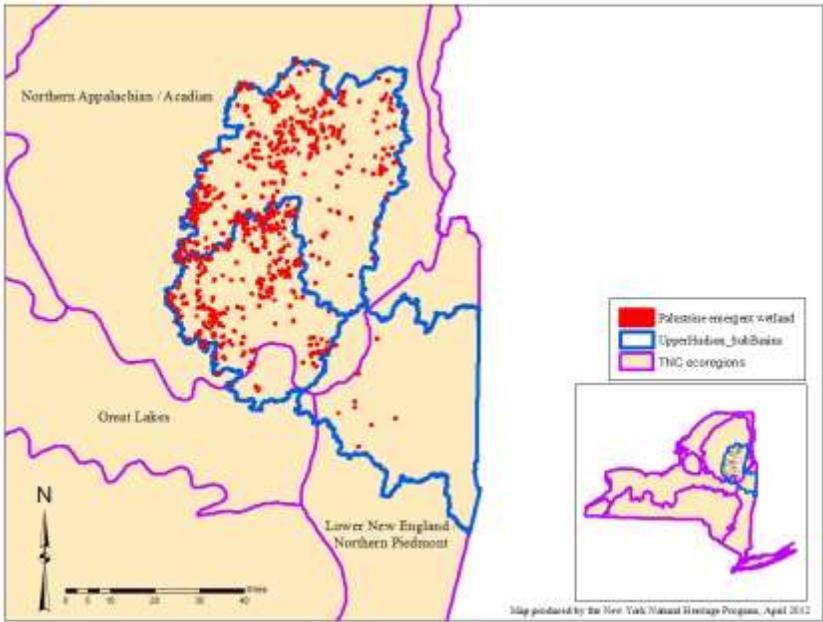


Figure 3. Our sample frame, palustrine emergent wetland polygons on conservation lands and connected to surface waters in the Upper Hudson River basin.

We wanted to use a landscape-scale (Level 1) parameter to stratify our sample frame before randomly selecting twenty point locations for field sampling. We developed a statewide, coarse-scale Landscape Condition Assessment (LCA) that integrated anthropogenic stressors into overall landscape condition scores to provide an estimate of ecological stress. Our inputs included a variety of roads layers, from dirt roads to primary highways, electrical and gas transmission

corridors, development classes, and some representation of managed/modified land cover (Table 1). The model, a weighted algorithm, included a weighted impact score for each stressor and a linear decay effect that lessened the influence of the stressor as distance from it increased. Methodology, including variable weights and decay distances, followed Comer and Hak (2012). The LCA scores were calculated statewide at the 30x30 m pixel scale, and were applied to each wetland polygon in our sample frame as the average of the contained pixels. Statewide, pixel scores ranged from 0.05 in the most ‘stressed’ locations to 1.0 in areas with no stressors. Using Jenks natural breaks classification (Jenks 1967), these statewide scores were binned into meaningful categories to represent levels of stress, from low (including none) to high. As Figure 4 shows, our study area was in a relatively low-stress region of the state because of its intersection with the Adirondack Park.

Table 1. Input themes, impact scores, and decay distances for Landscape Condition model.

Input theme	Impact score	Presumed relative stress	Decay score	Impact decays to zero (m)
<i>Transportation</i>				
Vehicle trails, 4-wheel drive	0.7	Low	0.5	200
Local and neighborhood roads	0.5	Medium	0.5	200
Secondary and connecting roads	0.2	High	0.2	500
Primary highways, limited access	0.05	Very High	0.1	1000
Primary highways, w/o limited access	0.05	Very High	0.05	2000
<i>Urban and Industrial Development</i>				
Low intensity development	0.6	Medium	0.5	200
Medium intensity development	0.5	Medium	0.5	200
High intensity development	0.05	Very High	0.05	2000
<i>Utility Corridors</i>				
Electric transmission corridor	0.5	Medium	0.9	100
Natural Gas corridor	0.5	Medium	0.9	100
<i>Land Use-Land Cover</i>				
Pasture	0.9	Very Low	1	0
Open spaces	0.5	Medium	0.5	200
Cultivated land (REMOVED)	0.3	High	0.5	200

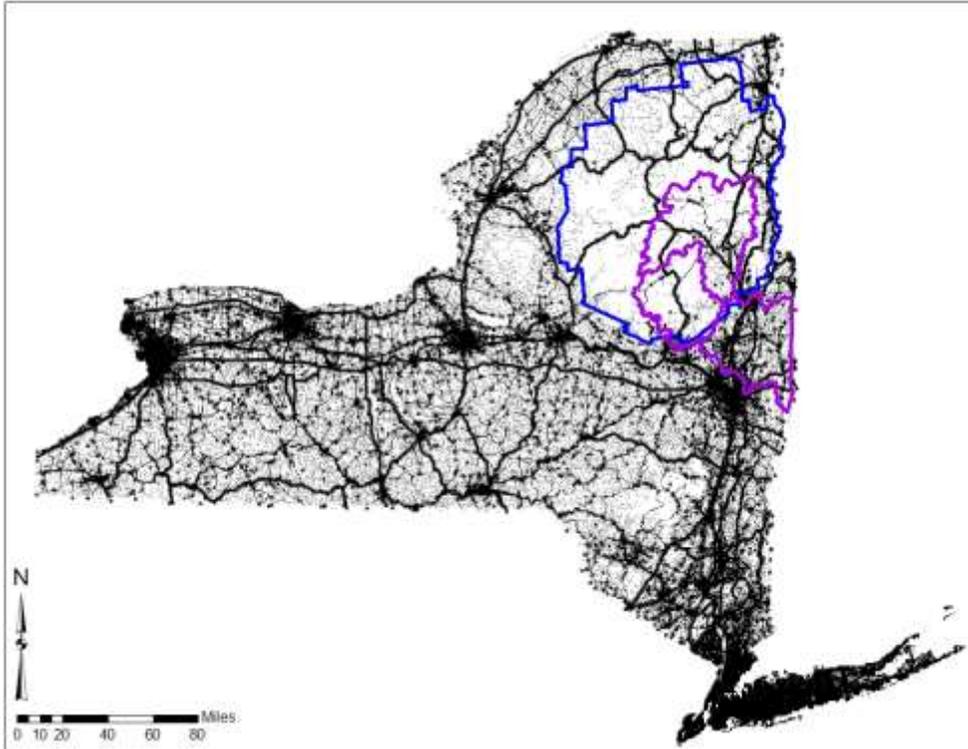


Figure 4. Results from the statewide Landscape Condition Model, depicting areas of high stress in increasingly dark shades of gray. The Adirondack Park boundary is shown in blue and the Upper Hudson River watershed's subbasins are shown in purple.

The pool of wetlands meeting our criteria for accessibility and connection to surface waters was sent to Tony Olsen in the EPA's Western Science Division office (Corvallis, Oregon), who performed a random draw using GRTS spatially balanced sampling (Stevens and Olsen 2004), stratified by the LCA categories. Twenty target ("panel one") locations were chosen for Level 2 field sampling; 14 of those sites were targeted for additional, intensive, Level 3 sampling. Because we expected a high degree of classification error in the sample frame, we received 50 overdraw sites. Each site was assigned a 7 digit unique identification number by Dr. Olsen as part of his random draw procedure; this unique number was used to link specimens, site data, and photographs. These numbers had the following format: NYW12-XX, where NYW = New York wetland, 12=year reference, XX=numerical order of the site in the random draw.

We reviewed the selection remotely using GIS with aerial imagery and other map layers, verifying a connection to surface waters, confirming the classification, and ensuring that sites were located on publically accessible lands. In ten cases sites did not meet those criteria; they were discarded and overdraw sites were substituted. Figure 5 shows our final sampling locations.

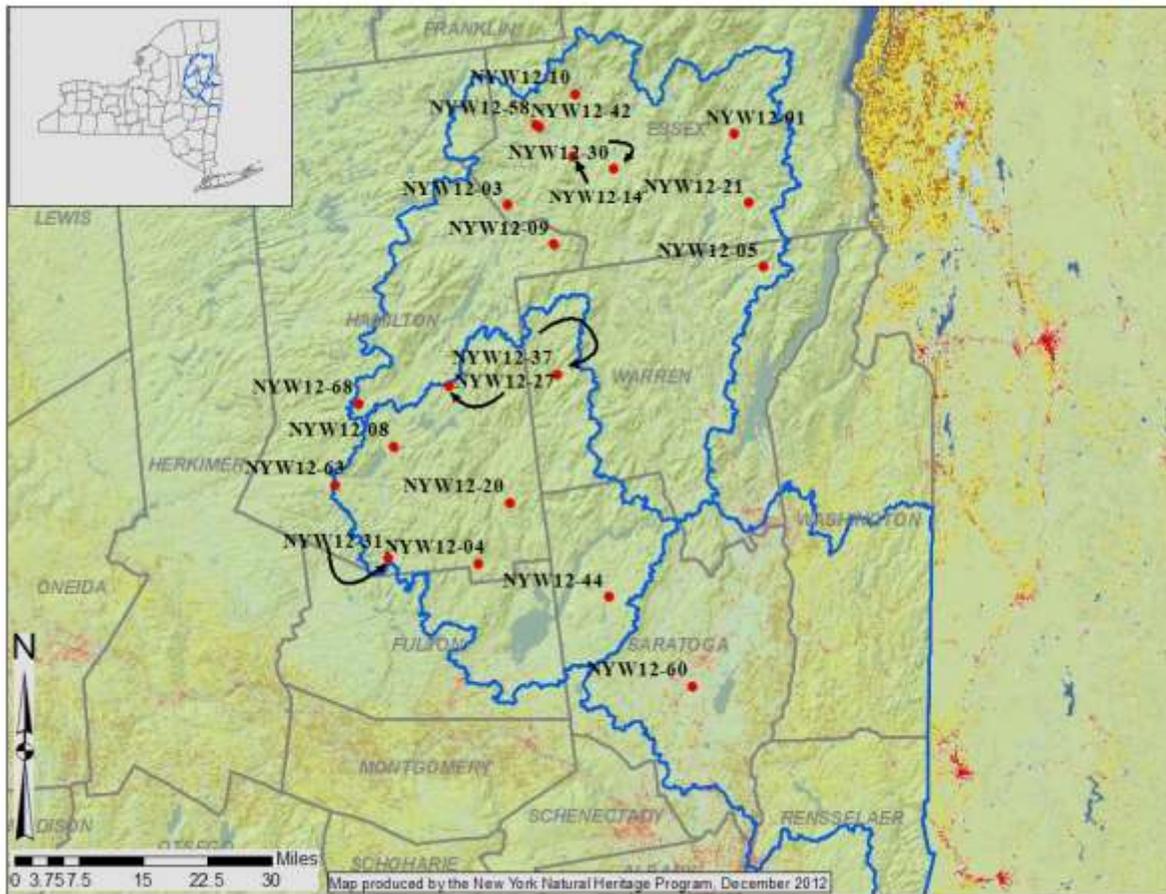


Figure 5. Palustrine emergent wetlands (red dots) selected for sampling in the Upper Hudson River watershed (outlined in blue) displayed over a view of land use-land cover.

4. Field Sampling Methods

We sampled wetlands at two levels of intensity in the field. In both cases, our evaluation was centered on the randomly selected point location described above. Our assessment area (AA) was defined as a 40 m radius circle (0.5 ha, or 1.2 acres) around the center point. An additional 250 m buffer was delineated around the assessment circle. We created paper field maps showing the AA and buffer for each location (Appendix A), and also loaded aerial imagery as well as shapefiles of the center point, AA circle, and buffer circle onto our handheld data collection units (Trimble Nomad).

At least 80% of the AA circle needed to encompass the target type or the point was considered unsuitable for sampling. If we arrived at a site, navigated to the center point, and it was unsuitable, we moved it by up to 60 m into a more appropriate area. This happened at nearly every site because the point was not centered in the target type. In one case, there were no sampling options within 60 m of the original point and the site had to be discarded and replaced with an overdraw location.

A site description was collected at each location, including UTM; elevation, slope, and aspect; narrative comments; and classification to Cowardin class and NYNHP type. At least four photographs were taken, one in each cardinal direction. At all 18 sites we conducted Level 2 Rapid Assessment Method (RAM) sampling; at 14 we also completed an additional, more intensive, Level 3 protocol. See datasheets in Appendix A.

A field training day was held with all technical staff to review data collection protocols and ensure standardized implementation. A guide produced for that training session was distributed and tested during the training. It accompanied each field crew on all subsequent survey days. Level 2 and 3 field sampling was conducted between July 13 and August 23. Of 20 expected sites, we were able to sample 18 wetlands at Level 2 and 14 at Levels 2 and 3 (Table 2).

Table 2. 2012 Upper Hudson watershed palustrine emergent wetland sampling pool.

Site code	Site name	Sample date	Sampling level
NYW12-01	Hatch Pond Marsh	July 30, 2012	L2 & L3
NYW12-03	Cedar River Marsh	Not done	site recently inundated by beaver
NYW12-04	Benson Marsh	July 23, 2012	L2 & L3
NYW12-05	Swede Pond Brook Marsh	August 2, 2012	L2 & L3
NYW12-08	Rudeston Marsh	July 31, 2012	L2 & L3
NYW12-09	Bell Mountain Brook Marsh	August 13, 2012	L2 & L3
NYW12-10	Tahawus Marsh	August 16, 2012	L2 & L3
NYW12-14	Hyslop Pond Marsh	August 15, 2012	L2 & L3
NYW12-20	Freds Mountain Marsh	August 3, 2012	L2 & L3
NYW12-21	Alder Pond Marsh	July 31, 2012	L2 & L3
NYW12-27	Silver Hill Marsh	August 24, 2012	L2 & L3
NYW12-30	Boreas River	Not done	too small for AA
NYW12-31	Chub Lake Mountain Marsh	July 13, 2012	L2 & L3
NYW12-37	Cook Brook Marsh	August 9, 2012	L2 & L3
NYW12-42	Newcomb Marsh South	August 15, 2012	L2
NYW12-44	Thousand Acre Marsh	July 24, 2012	L2 & L3
NYW12-58	Newcomb Marsh North	August 14, 2012	L2
NYW12-60	Saratoga Spa	July 27, 2012	L2
NYW12-63	Route 8 Marsh	July 25, 2012	L2 & L3
NYW12-68	Bloodgood Brook	August 23, 2012	L2

A. Level 2 Rapid Assessment

Level 2 sampling consisted of a rapid, largely qualitative, field-based assessment of ecological integrity and anthropogenic stressors. Data were collected for the 0.5 ha assessment area and in the buffer, confirming what was seen on aerial imagery. Level 2 data collection followed wetland-specific Ecological Integrity Assessment (EIA) protocols developed by NatureServe for the EPA (Faber-Langendoen *et al.* 2012), incorporating some modifications (California Wetlands Monitoring Workgroup (CWMW) 2012, Lemly and Gilligan 2012). We collected data that allowed us to calculate biotic and abiotic metrics (“EIA metrics”) that indicate the condition of key

ecological attributes (e.g., buffer condition, community composition, and hydrologic connectivity; Table 3). We also completed a stressor checklist that informed the condition metrics—we rated the scope and severity of stressors to the landscape, vegetation, soils, and hydrology, both in the assessment area and in the 250 m buffer. In all, Level 2 data collection took about one-half day (4 to 5 hours) for a two-person team to complete. For this part of the project, field data were collected on paper data sheets and transferred into an Excel tool for analysis; we used field computers (Trimble Nomad) with internal and external GPS receivers for GIS navigation, site placement support, and as aids during assessment of some of the landscape metrics.

Table 3. Pilot EIA metrics for the Upper Hudson River basin.

Ecological Categories	Key Ecological Attributes	Metrics
Landscape Context	Landscape Connectivity	Landscape Fragmentation Riparian Corridor Continuity Core & Supporting Land Use Index
	Buffer	Buffer Extent Buffer Width Buffer Condition – biotic & abiotic
Biotic Condition	Plant Community Composition	Relative Cover Native Plant Species Relative Cover Invasive Species
	Plant Community Structure	Vegetation Structure Regeneration of Woody Species Browse on Woody Species
Physiochemical Condition	Soil and Water Quality	Substrate / Soil Disturbance Water Quality - Turbidity/Pollutants Water Quality - Algal Growth
Hydrologic Condition	Hydrology	Water Source Alteration to Hydroperiod Hydrologic Connectivity

B. Level 3 Vegetation Subplot Sampling

Our **Level 3** data collection was an intense and quantitative description of the vegetative characteristics of 14 wetlands, and followed a subplot approach that has been piloted in other states and that is derived from traditional relevé plot work (Peet *et al.* 1998, Walz and Domber 2011, Lemly and Gilligan 2012). We sampled four 10 x 10 m subplots within a larger 20 x 50 m relevé plot. In each subplot, we collected a complete species list by strata with percent cover. We then conducted a search of the remainder of the 20 x 50 m area for additional species, estimating their cover over the whole relevé. Collecting this intense Level 3 vegetation data in addition to the Level 2 metrics doubled the amount of time our two-person teams spent in the field each day. We entered plot data into a handheld database on our field computers (Trimble Nomad).

5. Analytical Methods

Data analysis included calculation of Ecological Integrity Assessment (EIA) scores for each metric at each site as well as a rolled-up site-level score. Floristic Quality Assessment (FQA) metrics, notably Mean C, was calculated for each Level 3 site from vegetation data, and we characterized the vegetation using descriptive statistics and ordination. Finally, we compared the results from all Levels to each other to validate our methods. We used our detailed results from the Level 3 sampling to validate the two levels above, and, similarly, use the EIA scores to evaluate the LCA model.

Our data analysis had the following components:

Level 1 – LCA scores were calculated for each polygon of our target population. A detailed description of this scoring procedure is contained in Comer and Hak (2012). Scores were binned into levels of stress using Jenks natural breaks classification (Jenks 1967).

Level 2 – EIA metrics (ranging from A, best, to D, worst condition) were calculated for each site, as was an overall site score, using a weighted algorithm that integrates the metric scores. We followed Faber-Langendoen et al.’s (2012) scoring methodology and weighting scheme (see Appendix B for an example site EIA calculator). The stressor checklist was used to inform the condition scores.

Level 3 – The detailed Level 3 vegetation data allowed us to explore Floristic Quality Assessment (FQA) metrics, which are calculations centered around each species’ Coefficient of Conservatism (CoC) value (Swink and Wilhelm 1994). This value, which ranges from 0 to 10, is intended to characterize the species’ fidelity to an intact, pre-settlement ecological community. For example, cosmopolitan species that occur in many habitats, like Reed Canarygrass (*Phalaris arundinacea*) receive low scores, a 1 in this case. A score of 10 would be applied to specialists that require intact, possibly relic, habitat, like Northern Bog Aster (*Symphyotrichum boreale*). Non-native species are given a score of zero. Draft C-values were recently developed for New York’s vascular flora by Stephen M. Young and David Werier (Werier and Young 2012)

The FQA metrics that we explored included species richness and Mean C (the mean CoC value for all species at a site), which is, according to Lemly and Rocchio (2009) “perhaps the single strongest measure of biotic wetland condition.” Following Minnesota’s lead, (Milburn *et al.* 2007), we also calculated weighted Mean C, which takes abundance of each species into account (equation 1); the Floristic Quality Index (FQI, which incorporates the Mean C score and species richness, equation 2); and a weighted FQAI (equation 3). We also calculated two diversity indices—Shannon-Weiner and Simpson (equations 4 and 5, respectively)—that integrate richness and abundance (as percent cover, not counts of individuals) and give us a picture of the vegetation apart from the CoC scores. Essentially as richness (the number of species) and evenness (most species have the same abundance) increase, diversity increases. For example, if two areas (A & B) have the same number of species, but one site (B) is strongly dominated by cattail, site A would be more diverse. Shannon-Weiner H' values can range from 0 (only one species present) to over 4.5; the value of Simpson’s D ranges from 0 (no diversity) to 1 (infinite diversity).

$$w\bar{C} = \sum_{i=1}^S p_j C_j / S \quad (1)$$

where p is the proportional (relative) abundance, C is the C-value of each species (i), and S is the number of species.

$$FQI = \bar{C}\sqrt{S} \quad (2)$$

where \bar{C} is the mean C-value, and S is the number of species (species richness).

$$wFQI = w\bar{C}\sqrt{S} \quad (3)$$

$$H' = - \sum_{i=1}^S p_i \ln p_i \quad (4)$$

$$D = 1 - \sum_{i=1}^S p_i^2 \quad (5)$$

where p_i is the proportional abundance of each species (i) and S is the number of species.

The Level 3 data also allowed us to characterize the vegetation of our target wetland population in the Upper Hudson River watershed. We have included summary statistics on species abundance and distribution, and the results of NMDS ordination (non-metric multidimensional scaling), which reveals similarities between wetland sites.

Most importantly, results from each Level have been plotted against each other to assess their degree of correlation. In many cases, metrics at different Levels disagree (e.g., the Level 3 Mean C value indicates a high quality site but the LCA model gave it a Low score), and we have provided broad scale explanations grounded in common sense (e.g., perhaps a recent development lowers the landscape quality but the stressors haven't trickled down to the site level yet). Our suggestions for alterations and improvement to the methodology address some of this variability in response.

III. RESULTS AND DISCUSSION

We present our results here in terms of site scores at each Level and relationships between those Levels. While we do mention some site-specific details, a larger discussion of explanatory factors resulting in site scores is beyond the scope of this project. We are most interested in discussing broad patterns and relationships at this time. Level 1 Landscape Condition Assessment scores, Level 2 Ecological Integrity Analysis scores, and Level 3 Floristic Quality metrics and diversity indices are displayed in Table 4. Raw field data have been stored in the NYNHP Field Form Database and are available upon request.

While all of our sample sites fit into Cowardin's palustrine emergent marsh type, we also classified them to their NYNHP ecological community (Table 4). Twelve sites were typed as sedge meadow (SM; Edinger *et al.* 2002), characterized by organic mucky or peaty soils and dominated by species like tussock sedge (*Carex stricta*), lake-bank sedge (*Carex lacustris*), beaked sedge (*Carex utriculata*) and blue-joint grass (*Calamagrostis canadensis var. canadensis*). Five were shallow emergent marshes (SEM), with species dominance that was occasionally similar to the SM sites, including species like *Carex utriculata* and *Calamagrostis canadensis var. canadensis*, but they were characterized by little to no accumulated peat. The remaining site was a common reed (*Phragmites australis*) marsh (CRM). Our ordination results of the 14 intensively sampled sites supports these classification assignments (Figure 6). Four SEM plots were included and they line up together along the second NMDS axis. Essentially, this ordination routine uses vegetation data to array sites along these two axes; places with similar composition should appear closer together. Next steps in this analysis, if site-level questions were pursued, would be to add a third axis and look for additional patterning, or to add environmental or disturbance variables such as level of beaver activity or amount of standing water.

LCA scores, which were calculated for all 18 sites, range from 0.35 (low condition) at Swede Pond Brook Marsh (NYW12-05) to 1.0 (high condition) at Thousand Acre Marsh (NYW12-44); the mean site score is 0.72 and the median is 0.75 (Medium). By our stratified design, we selected sites with varied landscape condition, but these site scores are still higher than might be expected elsewhere in the state. As mentioned above, the lowest possible score statewide was 0.05. Our high scores are certainly related to the low road density and light development in this part of the state, but they are also an artifact of our sampling criterion that sites be located on publically accessible lands. These accessible lands are more likely to have their wetlands nested within large protected areas, often with few roads and no development. However, we did find that some seemingly quite remote sites received lower scores than expected because of proximity to a seasonally-used snowmobile trail. Such findings will influence our next iteration of the condition model.

The Level 2 EIA scores—also calculated for all 18 sites—do not show as much range as the LCA scores. The lowest score (2.6) came from the Saratoga Spa marsh (NYW12-60), which is dominated by *Phragmites* and had noticeable hydrologic degradation (Appendix 1). All of the remaining sites scored over 4.3 and the vast majority (13) received 4.9, the highest possible value. One obvious reason for these high scores is, again, that our sites were generally high quality, being located on protected lands in the most pristine part of New York. Interestingly, the Saratoga Spa site is the only site that is not within the Adirondack Park's Blue Line boundary, possibly attesting to the powerful legacy of long term conservation planning. It is also possible, as discussed below, that the Level 2 metrics we used are not sensitive enough to distinguish subtle differences in site quality.

TABLE 4



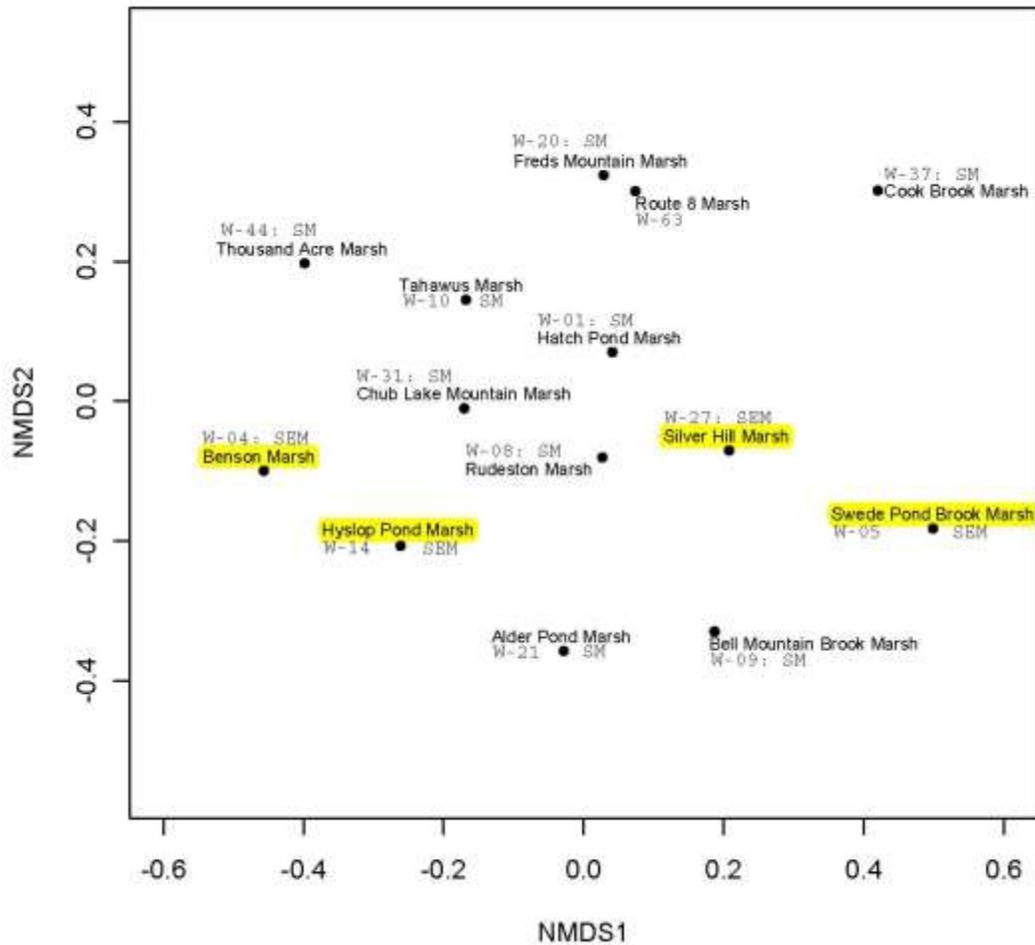


Figure 6. Results of Non-metric Multidimensional Scaling ordination displayed with site names and codes. SM=Sedge meadow, SEM= Shallow emergent marsh.

Level 3 Floristic Quality Assessment scores were calculated for the 14 sites that were intensively sampled with vegetation subplots. Total Mean C ranged from 3.8 to 5.4 and Weighted Mean C scores, which take species abundance into consideration, ranged from 3.2 to 5.8. New York has not yet calibrated Mean C scores for communities using reference sites (determining the highest possible Mean C for a given type in pristine condition), so these data allow us to begin to set a bar for palustrine emergent wetlands classified as sedge meadows. Similarly, we have not yet established a range of expected FQI scores (which combine Mean C-value and species richness) for these communities, but our scores, ranging from 17.3 to 35.5 set a starting point. Our weighted FQI values (calculated using the weighted Mean C) range from 16.3 to 37.9.

Level 3 diversity scores were also calculated for the 14 intensive sites; these measures evaluate species richness and abundance (or ‘evenness’) without the addition of the C-value. Our values for total species richness varied quite a bit from 15 to 54. We consistently documented each species encountered during plot sampling, so this variation is not an artifact of sampling effort. Simpson diversity scores ranged from 0.243 to 0.856 and Shannon-Weiner scores ranged from 0.682 to 2.243.

Once these metrics were calculated for all three scales of sampling, our primary objective was to explore whether scores at one Level, or on one scale, were good predictors of scores at other Levels. To investigate the strength of the (linear) relationship between scores at each Level, we first calculated *r* (correlation coefficient) values between each Level (Table 5). Although the results were not as significant as we had hoped, likely due to our relatively small sample size, we did have some interesting findings. Overall, Level 1 scores were positively correlated with Level 2 scores (*n*=18; Figure 7). Sites located in lower-stress landscapes (higher LCA scores) generally received high Level 2 scores. However, as discussed above, there was not a wide range of variation in the Level 2 values, so we look forward to exploring this relationship more as we improve the sensitivity of our RAM sampling approach.

Table 5. A correlation matrix showing *r* (correlation coefficient) scores between Level 1, 2, and 3 metrics. Stronger relationships are bolded.

	LEVEL 1	LEVEL 2	LEVEL 3-FQI Metrics				LEVEL 3-Diversity Indices		
	LCA score	EIA Site Score	Total Mean C	Weighted Mean C	FQI	Weighted FQI	Total Richness	Simpson	Shannon-Weiner
LEVEL 1: LCA	1	0.520	0.527	0.267	0.313	0.209	0.132	-0.366	-0.384
LEVEL 2: EIA		1	0.452	0.154	0.111	0.017	-0.064	-0.289	-0.414

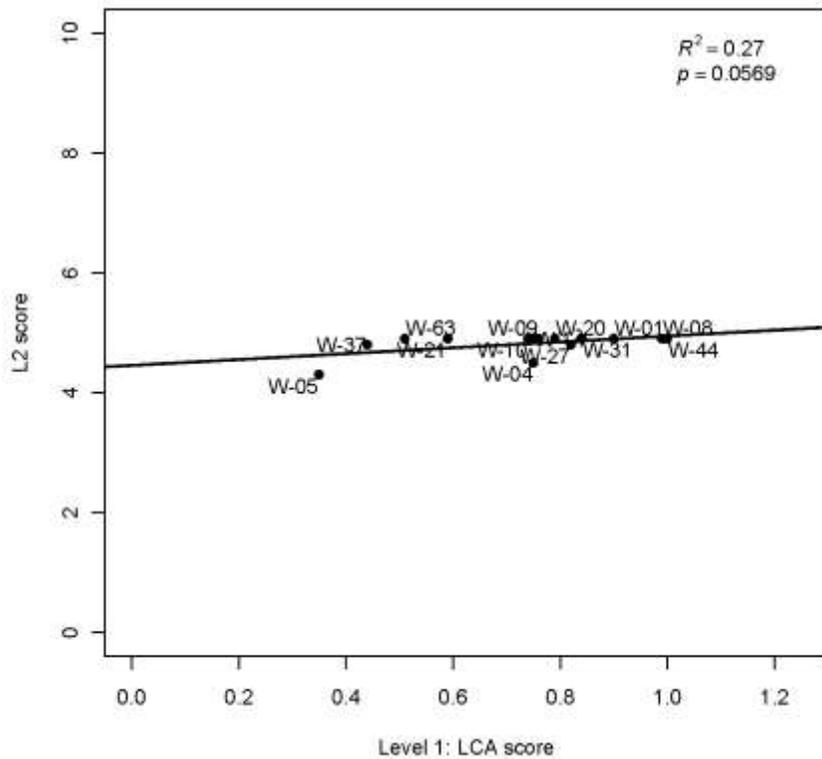


Figure 7. Linear regression solution for a plot of Level 1 LCA scores against L2 EIA scores (*n*=18).

Of all of the Level 3 metrics, we found that Mean C was the most closely correlated with Level 1 and 2 results (n=14; Figures 8 & 9). This finding agrees with that of Lemly and Rocchio (2009) and others who found it to be a strong measure of wetland condition and more strongly correlated with measures of anthropogenic stress than the FQI itself (Cohen *et al.* 2004).

We were interested to discover that measures of diversity, both Simpson's D and the Shannon-Weiner H' were slightly negatively correlated with both Level 1 and 2 results (n=14; Figures 10, 11, and 12). Essentially, diversity decreased as local (Level 2) and landscape (Level 1) condition improved. Some amount of anthropogenic perturbation increased diversity. This finding is consistent with Connell's Intermediate Disturbance Hypothesis (Connell 1978) and likely means that diversity metrics will also need calibration to wetland type to be reliable predictors of wetland quality.

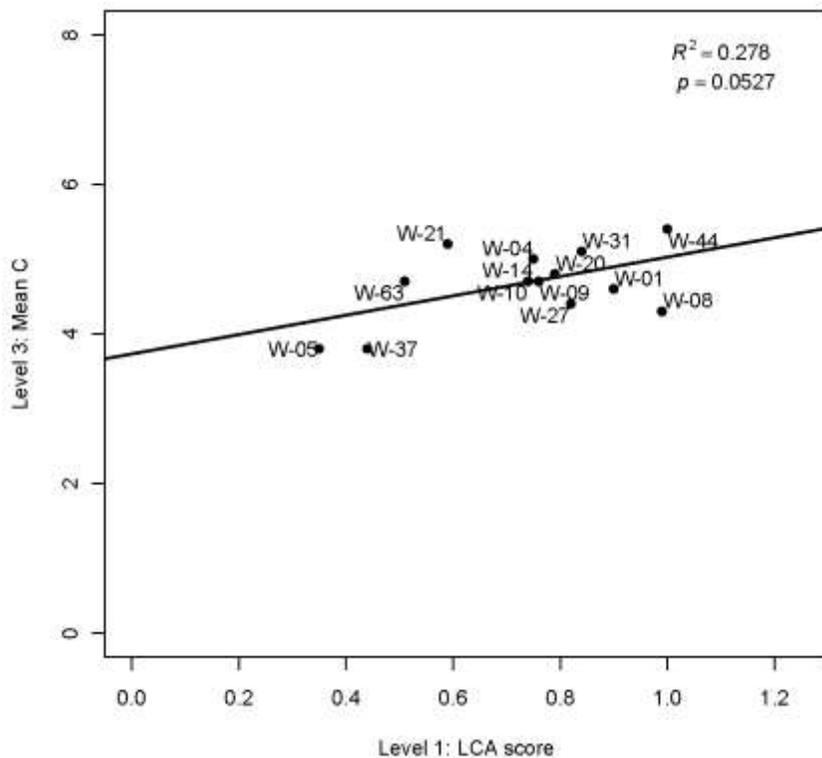


Figure 8. Linear regression solution for a plot of Level 1 LCA scores against Level 3 Mean C scores (n=14).

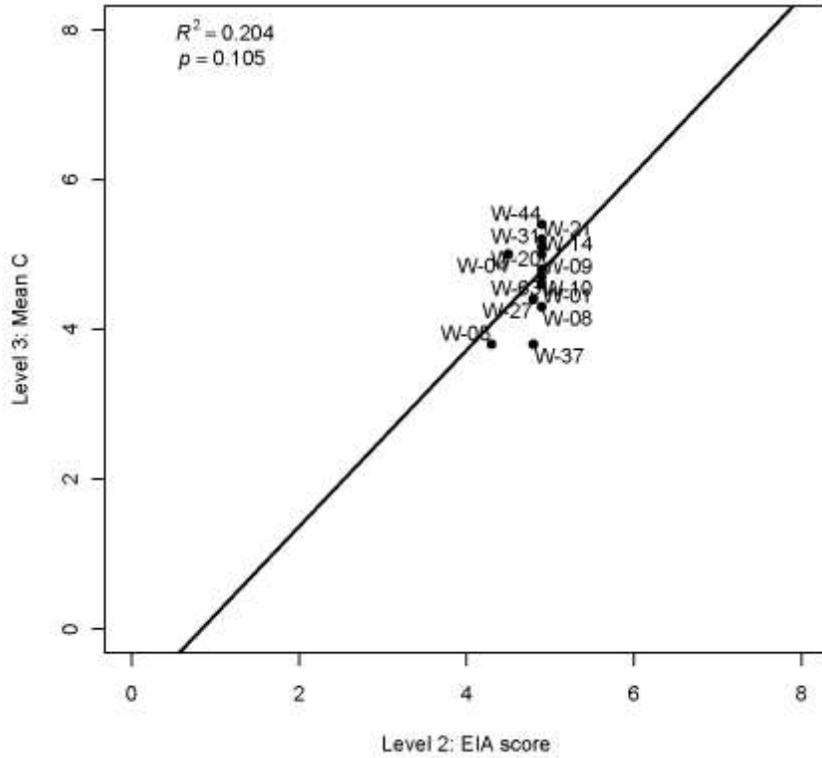


Figure 9. Linear regression solution for a plot of Level 2 EIA scores against Level 3 Mean C scores (n=14).

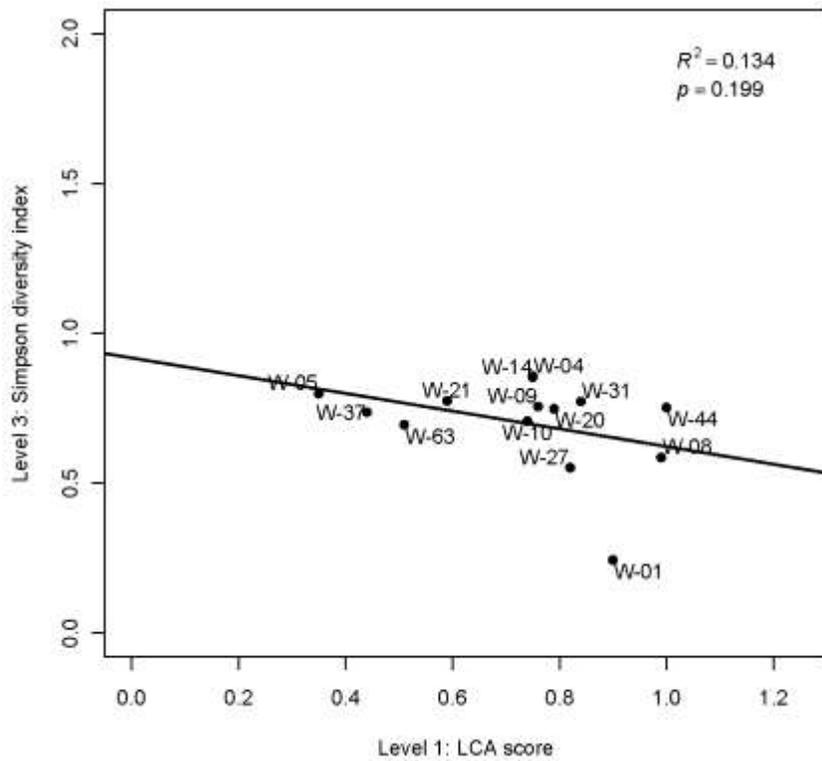


Figure 10. Linear regression solution for a plot of Level 1 LCA scores against Level 3 Simpson diversity index (D) scores (n=14).

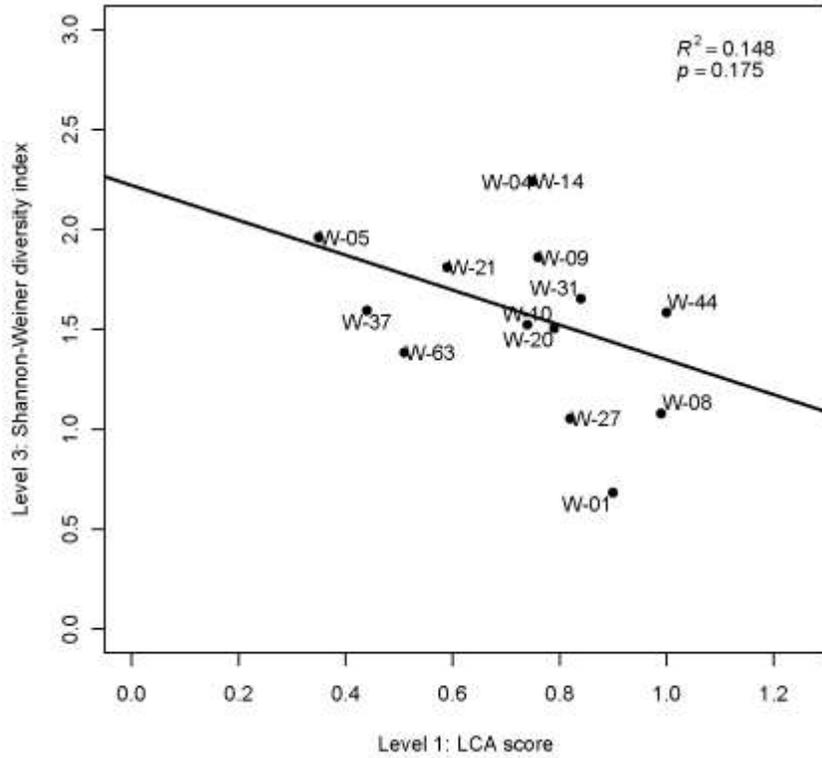


Figure 11. Linear regression solution for a plot of Level LCA scores against Level 3 Shannon-Weiner diversity index (H') scores (n=14).

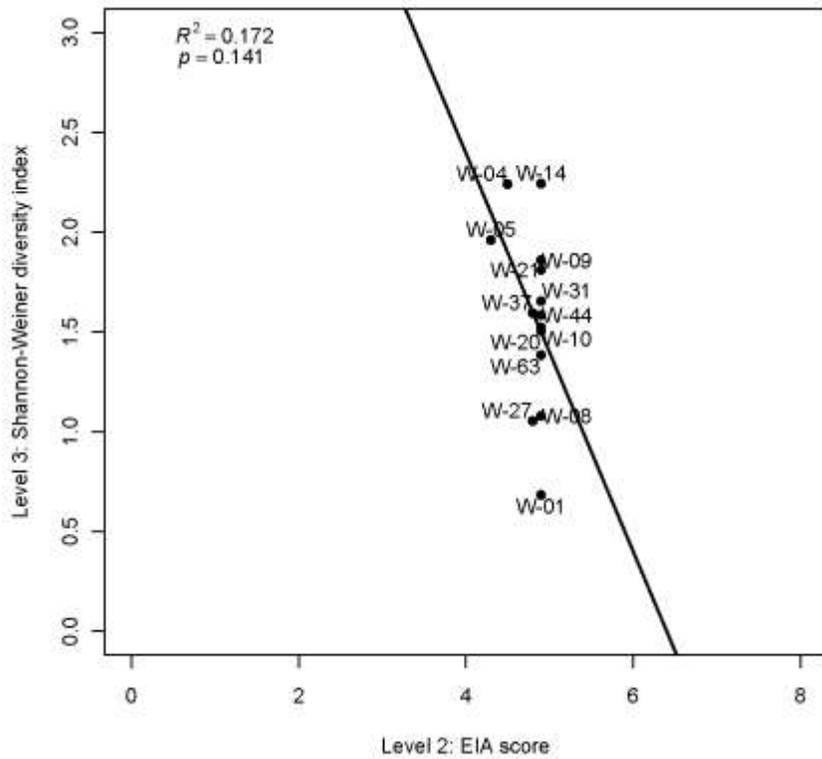


Figure 12. Linear regression solution for a plot of Level 2 EIA scores against Level 3 Shannon-Weiner diversity index (H') scores (n=14).

We can conclude that there are some promising relationships between the results from sampling at different scales, but with this small set of generally higher quality wetlands (based on their landscape position in the protected Adirondack Park), our correlations were weak. As we add more data in subsequent sampling cycles and make refinements to our field and analytical methods, we expect to see tighter links. It was beyond our scope to explore site-specific causation for unexpected results—seeking explanations for a high landscape score and a low Mean C, for example—but such exceptions are intriguing and informative. It may be that such a mismatch can be ‘corrected’ by adding an additional variable to the LCA model, or it may be that the ‘low’ Mean C represents a healthy natural community without exotics with cyclical beaver activity. Going forward, asking questions about causation will be an important way to calibrate and refine metrics and, ideally, will lead to more predictive relationships.

IV. METHODOLOGICAL REFINEMENTS AND NEXT STEPS

As expected, this first cycle of field sampling and methods testing has revealed numerous opportunities for improvement throughout the project’s lifecycle. At the start, we found that the set of polygons used to develop the sample frame contained a degree of classification and delineation error. In parts of the state where NWI polygons are the only delineations available, we will need to draw more than 50 oversample sites from our sample frame, as we very nearly exhausted our options this season using the much more accurate and precise APA wetland set.

Another way to handle the degree of error in the input polygon set is to buffer the interior edge of the polygons, theoretically placing target points in the core of the community. (In nearly all cases, our sample points fell so close to the edge of the wetland that the AA would have been 50% upland.) We should also increase the minimum acreage of the polygons in the sample frame to ensure that an adequate amount of the target wetland type is available for sampling.

Because many wetlands can be a patchy mosaic of emergent herbaceous species, shrubs, and ponded open water, we will standardize the percent of non-target type that can be present within the AA, possibly at 20-25%. We used best professional judgment this year, but will set clear guidance based on review of protocols from the EPA and neighboring states. Also following the EPA’s NWCA guidelines, we will enumerate rules for modifying the AA shape from circular when in narrow wetlands. Even with these standards in place, we expect that we may still need to move center points when they are situated in locations that cannot be sampled or in non-target communities, and we expect that a 60 m allowable movement distance, as employed in the NWCA protocol, should be adequate. Sites will be discarded in favor of oversample locations if no sizable patches of the target type are present within that distance.

Level 1 Landscape Condition Assessment

During our own quality control review of the model, we found that the ‘cultivated lands’ layer derived from NOAA’s CCAP (Coastal Change Analysis Program) Regional Land Cover dataset incorrectly included open, wet meadows (grass or sedge dominated). We had to remove the layer from the model and hope to find another source to represent cropland for future iterations.

As noted above, we found that some seemingly quite remote sites (e.g., NYW12-20, Freds Mountain Marsh) received lower scores than expected because of proximity to seasonally-used snowmobile trails. We will adjust the decay score for input themes that have been observed to



have lower impacts and, specifically, look for additional data layers that represent seasonal dirt roads.

We hope to include some watershed-scale metrics that address impacts directly to the flowing waters our wetlands intersect. These metrics could reveal more, or stronger, relationships between different types of management activities or disturbances and wetland quality. For example, such input themes would address the amount of impervious surface or impoundment in a watershed and quantify accumulated downstream impacts. The model could also benefit from inclusion of water quality data, possibly in the form of highlighting Impaired Waters or adding point source discharge locations.

Our intention with the LCA model was to move away from a desktop assessment of a buffer around an assessment area, but we did discover, as discussed below, that such an assessment may have value. There may, also, be a way to automate the process (Nichols and Faber-Langendoen 2012).

Level 2 Ecological Integrity Assessment/Rapid Assessment Method

This sampling level requires the most refinement, and we have compiled detailed comments on each section of the field data sheet. A summary of our modifications follows.

Most importantly, we will be developing an electronic data collection procedure for the Level 2 data. This year, we used paper fieldforms, which significantly increased data processing time. We have an efficient hand-held database in place for Level 3 field data (see below), and adding a Level 2 module is a high priority. Electronic data sheets would allow us to populate many fields automatically, particularly with spatial and site identification information.

We collected too many GPS points at each sampling location in this cycle. At Level 2, we collected the center point of the AA and four additional readings on the edge of the circle. We took photographs in the same locations, which was excessive. Going forward, we will gather UTMs in the center of our AA and take four photographs there, one in each cardinal direction. We will lay out the AA using two meter tapes that cross in the center, but we will not collect GPS point or photos on the edges.

The site sketch and outline of “biotic and abiotic zones within the AA” may have been too time consuming for this rapid assessment. We would like to develop a quicker tool to assess site patterning and homogeneity that can be processed as a metric and not just retained as a drawing.

Some of the metrics that were included in the Level 2 scheme could be more efficiently and accurately documented remotely as Level 1 metrics. Much of the Landscape Context and Buffer assessment falls into this category. Landscape fragmentation, landscape stressors, buffer extent, and buffer width can all be either automated or otherwise calculated remotely. RAM sampling can appropriately assess evident stress and condition on the ground within the AA itself and, perhaps, a smaller buffer (smaller than 250 m).

We felt that the treatment of vegetation at Level 2 was adequate, but that specific components needed to be refined and standardized to suit wetland types. Details that define “minimally

disturbed structure” should be added, for example. We had also retained two items referring to native woody regeneration and browse that were irrelevant for our target type. We would like to develop a more suitable way to address animal activity, particularly beaver, than just an estimate of browse pressure. A lengthy table intended to document structure in the AA was also a part of the vegetation condition section. It consisted of percent cover breakdowns for ground cover, vegetation strata, and nonvascular components. The table was daunting and difficult to complete in the field but, because it contained useful information, we hope to streamline it and make it more user friendly in its electronic version.

The physiochemical metrics, including soil disturbance, water turbidity, and algal growth, were clear and seemed suitable. We are considering whether a quick soil core to note mineral or organic soil would be a viable addition. Similarly, it would be helpful to measure the pH of any standing water, but that may be more intense than is expected at this Level.

Some of the hydrology metrics felt unclear to us, and this section should also be standardized by community type. A description of “natural hydroperiod” and “equilibrium conditions” should be included for the target type being sampled, for example. As above, we would like to characterize the hydrologic impact of animal activity more clearly as well, perhaps enumerating the relative position in the natural cycling of a beaver-influenced site, from recently flooded to abandoned meadow with decaying stumps.

While the Stressor Checklist contained rich information and was straightforward to complete, we were not certain how to process it into metrics. Rather, we used it to inform and validate the buffer condition ratings. We will explore options for using this information more thoroughly in the next cycle.

Our analysis of Level 2 data here centered around comparing rolled up site-level scores (NYW12-27) rather than individual metric (vegetation) or metric component (% invasives) scores. It will be important to retain the four basic metric categories and to develop a scoring framework that retains the information from each (e.g., low scores for hydrology). Identifying sites by their ‘impairment’ (defined by the four metric categories), would help guide restoration or management actions.

Level 3: Vegetation Subplot Sampling

The intensive Level 3 vegetation subplot sampling scheme was the most refined and standardized component of our condition assessment. Data were efficiently collected on handheld computers and easily uploaded to a central database. We would change a few details about the methods, eliminating the collection of GPS points and photos at four points around the plot array, but for the most part are satisfied with the approach. One piece that could be either standardized or more thoroughly documented is the selection process for the four subplots from with larger array of ten. The plot and subplots were located in a ‘representative’ part of the AA, but whether we aimed to target similar or dissimilar sampling units was not clear and needs further discussion.

As mentioned above, we would like to add a way to describe the nature of the soil at a site (mineral or organic), and will consider incorporating a quick soil core into our Level 3 routine.



Measuring soil pH and the pH of any standing water would also be valuable and would not be very time-intensive. If we could also collect water or sediment samples for quality and contaminant analysis, that would add significantly to our characterization of a site and contribute to development of numerical water quality standards for wetlands in the state.

Next Steps

We began this project by critically evaluating the NWCA's methodology in the context of what might be realistic for a state wetland condition program. We discarded numerous metrics from the start (e.g., algal community composition, soil chemistry) and restructured field sampling, resulting in an overall approach that is significantly more focused and manageable. We have found that the basic model tested here is sound. We will continue to follow the three-Level approach to site evaluation and will retain both Level 2 and Level 3 field sampling, while we work to understand the correlations between each Level.

As we move forward with wetland condition assessment in New York, it will be critical for us to continue to explore the meaning of 'high quality' and 'good condition' both broadly and in reference to specific wetland types. The presence of invasive exotic species is a key condition indicator at both Level 2 and Level 3, and would be a critical component of narrative quality criteria. The *Phragmites*-dominated marsh at Saratoga Spa State Park received a significantly lower Level 2 score, mainly driven by the vegetation metric. The site was not sampled at Level 3, but certainly its Mean C score would be low as well (*Phragmites australis* has a C-value of 0).

Our next sampling cycle will certainly incorporate numerous methodological refinements, but it is worth exploring some additional data sources that could also support development of narrative and numerical quality criteria. We mention adding Impaired Waters to our Level 1 LCA model, and we should explore avenues that allow us to integrate the results of other water quality monitoring efforts, such as stream invertebrate sampling, into our work. We will eventually want to consider expanding our intensive biotic sampling to include wetland invertebrates, perhaps odonates, as well.

We have established relationships, weak in some cases, between our site evaluations at multiple scales, and we hope that the refinements discussed here will strengthen those relationships. This pilot assessment of wetland condition metrics serves as a critical foundation for work to come, and has established a solid methodological framework for wetland evaluation. It also serves as the beginning of what can become an ongoing, sustainable wetland monitoring program for New York.

V. QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) RESULTS

This section includes a brief discussion and summary of the accuracy, precision, completeness, comparability, and representativeness observed during the study (NYNHP and NYSDEC 2012). Informal audits to ensure compliance with the Quality Assurance Plan were conducted during fieldwork by the project manager (A. Feldmann). These audits showed that paper field forms were being completed consistently and that plots were being delimited and sampled appropriately. Teams were collecting photographs and GPS points as prescribed. For two days of Level 2 sampling at the

Newcomb Marsh North and South sites (NYW12-42 and NYW12-48), Don Faber-Langendoen from NatureServe, the primary author of our Level 2 methodology (Faber-Langendoen *et al.* 2012), accompanied us in the field. His feedback served as a sort of informal audit and his comments have been included in the Methodological Refinements section, above.

Precision. Precision can be defined as the relative uncertainty about a given measurement and is determined by replicate analyses. Replicate sampling (multiple plots per site) is a part of the Level 3 relevé plot design; we will be sampling four 10x10 m subplots within a 20x50 m array. We have illustrated within-wetland variance for our repeated measures as the box plot in Figure 13. This graphic displays the mean and variance of the most abundant species in each subplot at each wetland sampled at Level 3. Tight plots (NYW12-10) represent similar composition of dominant species from one subplot to the next, or low subsample variability.

Accuracy. Accuracy of wetland condition assessment at each Level can be assessed in comparison with results from other Levels, although we certainly do not expect correlation between each metric at one Level and those of the Levels above. High correlation supposes high accuracy. Our project's goal, to evaluate assessments of wetland condition at three levels of sampling effort, requires calculation of the degree of correlation between results at different levels. Table 5, a correlation matrix, and the plots that follow it highlight the stronger relationships that we found. We hope that methodological refinements will strengthen these relationships and improve our accuracy in the next sampling cycle.

Completeness. We expected 100% completeness in wetland sampling, which translated to Level 2 field data collection in twenty wetlands and Level 3 field data collection in fourteen of those twenty sites. We intended to complete remote Level 1 assessments for each wetland of our chosen type in the basin. We set our determination of compliance at 75%, or sampling 15 wetlands at Level 2 and 11 of those at Level 3. Although we did not meet our goal of 100% completeness, we were compliant by sampling 90% of the expected sites, or 18 wetlands, at Level 2 and 100%, or 14, at Level 3.

Comparability. We have culled a suite of standard wetland condition assessment methods to evaluate in this study, so our results are comparable to data collected in similar investigations (e.g., Mack 2001, Walz and Domber 2011, Lemly and Gilligan 2012). Our field methods, landscape modeling, and data analyses are derived from national and regional approaches, ensuring compatibility.

Representativeness. Our sample wetlands should ideally represent wetlands of our target population throughout the Upper Hudson River watershed. To satisfy this criterion, sampling was spatially balanced using the Generalized Random Tessellation Stratified (GRTS) strategy (Stevens and Olsen 2003, 2004, Kincaid and Olsen 2011) and stratified by landscape condition assessment (LCA) scores. The total sample draw was 20 wetlands with an overdraw of 50 that were used when wetlands from the initial set were not accessible, not large enough, or not of the target type.

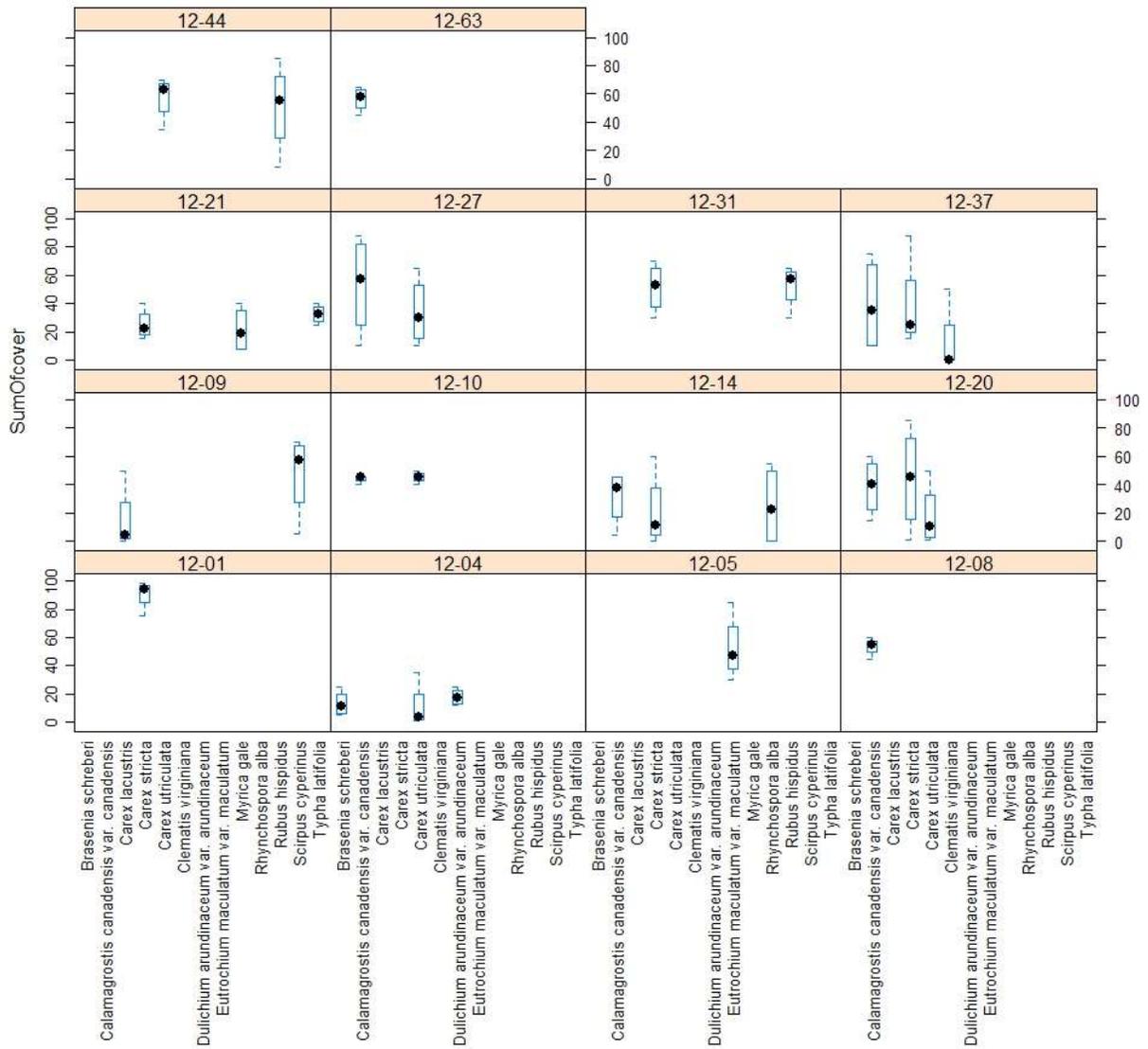


Figure 13. Box plots for each site sampled at Level 3 showing mean and variance of dominant species seen in subplots.



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Appendix A



Appendix B

