New York State

Wetland Condition Assessment

EPA Wetland Program Development Grant

New York Natural Heritage Program

A Partnership between the NYS Department of Environmental Conservation and the SUNY College of Environmental Science and Forestry

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The New York Natural Heritage Program

The NY Natural Heritage Program is a partnership between the NYS Department of Environmental Conservation (NYS DEC) and the State University of New York College of Environmental Science and Forestry. Our mission is to facilitate conservation of rare animals, rare plants, and significant ecosystems. We accomplish this mission by combining thorough field inventories, scientific analyses, expert interpretation, and the most comprehensive database on New York's distinctive biodiversity to deliver the highest quality information for natural resource planning, protection, and management.

NY Natural Heritage was established in 1985 and is a contract unit housed within NYS DEC's Division of Fish, Wildlife & Marine Resources. The program is staffed by more than 25 scientists and specialists with expertise in ecology, zoology, botany, information management, and geographic information systems.

NY Natural Heritage maintains New York's most comprehensive database on the status and location of rare species and natural communities. We presently monitor 174 natural community types, 802 rare plant species, and 441 rare animal species across New York, keeping track of more than 12,500 locations where these species and communities have been recorded. The database also includes detailed information on the relative rareness of each species and community, the quality of their occurrences, and descriptions of sites. The information is used by public agencies, the environmental conservation community, developers, and others to aid in land-use decisions. Our data are essential for prioritizing those species and communities in need of protection and for guiding land-use and land-management decisions where these species and communities exist.

In addition to tracking recorded locations, NY Natural Heritage has developed models of the areas around these locations important for conserving biodiversity, and models of the distribution of suitable habitat for rare species across New York State.

NY Natural Heritage has developed two notable online resources: Conservation Guides include the biology, identification, habitat, and management of many of New York's rare species and natural community types; and NY Nature Explorer lists species and communities in a specified area of interest.

NY Natural Heritage also houses *i*MapInvasives, an online tool for invasive species reporting and data management.

In 1990, NY Natural Heritage published *Ecological Communities of New York State*, an all inclusive classification of natural and human-influenced communities. From 40,000-acre beech-maple mesic forests to 40-acre maritime beech forests, sea-level salt marshes to alpine meadows, our classification quickly became the primary source for natural community classification in New York and a fundamental reference for natural community classifications in the northeastern United States and southeastern Canada. This classification, which has been continually updated as we gather new field data, has also been incorporated into the National Vegetation Classification that is being developed and refined by NatureServe, The Nature Conservancy, and Natural Heritage Programs throughout the United States (including New York).

NY Natural Heritage is an active participant in NatureServe – the international network of biodiversity data centers. NatureServe's network of independent data centers collect and analyze data about the plants, animals, and ecological communities of the Western Hemisphere. Known as natural heritage programs or conservation data centers, these programs operate throughout all of the United States and Canada, and in many countries and territories of Latin America. These programs work with NatureServe to develop biodiversity data, maintain compatible standards for data management, and provide information about rare species and natural communities that is consistent across many geographic scales.

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Final Report

Laura J. Shappell, Aissa L. Feldmann, Elizabeth A. Spencer, and Timothy G. Howard.

A report prepared by the

New York Natural Heritage Program

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for the

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EPA Region 2
New York, NY

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Cover design by Greg Edinger. Photos, top: black spruce-tamarack bog; center (left to right): shallow emergent marsh, shrub swamp, northern white cedar swamp; bottom (left to right): culvert stressor, rose pogonia (*Pogonia ophioglossoides*), common reed (*Phragmites australis*). Photos taken by NYNHP staff at wetlands surveyed for this project.

Acknowledgments

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PROJECT SUMMARY

Wetland ecosystem services such as stormwater management, water quality, and water security, are a function of wetland condition. This project addresses the absence of monitoring protocols for freshwater wetlands in New York State (NYS), a need identified in the New York State Water Quality Monitoring Program Strategy 2005-2014 (June 2006). Our objectives were to: 1) assess the condition of NYS wetlands using a three-level sampling approach, and 2) develop a rapid assessment protocol that effectively quantifies wetland condition. To assess the condition of NYS wetlands remotely (Level 1), we developed a statewide Landscape Condition Assessment (LCA) model that cumulatively depicts anthropogenic stressors across the New York landscape (30 x 30-m resolution). Rapid assessment methods developed for Level 2 quantified anthropogenic stressors using basic air photo interpretation and field surveys. At the finest scale of measurement (Level 3), plot arrays captured vegetation structure and floristic biodiversity. To create an effective but relatively simple Level 2 protocol that could easily be used by others throughout New York, we used data from Levels 1 and 3 to test, refine, and support the Level 2 rapid assessment method (RAM). The end result is a set of robust wetland assessment protocols using a three-level sampling design. This flexible method allows practitioners to select the level of sampling that is most applicable to their project goals and resources.

RESEARCH RELEVANCE

Wetlands provide fundamental ecosystem services, but their ecological integrity is under increasing pressure from human activities (Kentula et al. 2004, Dahl and Allord 1996, Johnson et al. 2013). Healthy wetland systems are fundamental to protecting natural resources and water quality, functions that can be compromised by human alterations (McLaughlin and Cohen 2013, Bettez and Groffman 2012, Richardson et al. 2011, Tiner 2005). Establishing a baseline of wetland condition, in addition to accurate acreage estimates, is critical for effective resource management whether at the catchment or watershed scale. Further, developing reference standards relative to specific wetlands types provides a critical framework by which to measure mitigation and restoration actions.

Wetland degradation reflects multiple stressor types (e.g., hydrologic, nutrient) compounded over time and space. Landscape-scale monitoring efforts therefore need to take a holistic approach to help identify data gaps, and prioritize management efforts. Recently, stakeholders have begun to develop multi-tiered monitoring approaches that include indicator metrics applicable to multiple spatial scales (e.g., Solek et al. 2011). This approach provides an organizational tool that is flexible enough to be incorporated into routine watershed monitoring, as well as site-specific conservation and management activities (Brinson and Rheinhardt 1996).

Freshwater wetlands comprise approximately 2.5 million acres of New York State (NYS DEC 2010), an estimated 60% reduction since European settlement in the 1600s (Barringer et al. 1996). Although NYS Division of Fish, Wildlife, and Marine Resources has ongoing mapping efforts and attempts to measure net gains or losses of wetlands, no current methods are in place estimate wetland condition. This project aims to fill this data gap by developing and enacting a protocol for evaluating the health and quality of the NYS wetlands.

Project Objectives

1) Develop a three-tier framework for monitoring and assessment of New York State wetlands. For each tier, identify indicator metrics that correlate with wetland health.

2) Level 1 (L1): Generate a statewide landscape condition assessment model that reflects the cumulative impacts of anthropogenic stressors.

3) Level 2 (L2): Create a rapid, field-based protocol that assess wetland structure and function. Further, the protocol should be repeatable, and accessible to users without extensive additional training.

4) Level 3 (L3): Collect quantitative data characterizing vegetation structure and biodiversity.

METHODS

Level 1: Landscape Condition Assessment (LCA)

Whether natural or human-mediated, disturbance magnitude reflects the intensity, return interval, and spatial extent of a given disturbance. Stressor attenuation therefore varies with disturbance type. We incorporated this fundamental concept into the landscape condition assessment (LCA) model (Comer and Hak 2012, Grunau *et al.* 2012), which synthesizes stressors at the 30 m x 30 m-pixel scale. This section describes the LCA in general terms; we provide more details in Appendix A.

The model begins with a series of GIS layers representing environmental stressors. Selected input themes (GIS feature classes) had consistent statewide coverage and included elements that, research suggests, have a negative influence on wetland structure and function. The final model (LCA2) included elements from transportation, urban/industrial development, utilities corridors, and land use-land cover, for a total of 13 feature classes (Table 1).

Following Comer and Hak (2012) and Grunau et al. (2012), the extent of impact for even the greatest stressor did not extend more than 2,000 m beyond the site of impact. Our approach was to calculate a distance-to-stressor raster surface for each of the 13 features using the Euclidian distance tool in ArcGIS (ESRI Inc 2010). Through these analyses we produced 13 rasterized layers (30 m x 30 m pixel size) in which pixel scores increased with distance from a stressor (i.e., impact site pixel = 0). We were then able to calculate a stressor value for each pixel using Equation 1, where *x* is the Euclidian distance value, *a* shifts the curve away from the center, *b* determines decay distance slope, *c* is a constant, and *w* is the stressor's weight (R Core Team 2013). The final model applied six different decay functions to estimate the spatial extent of anthropogenic stressors (Figure 1).

Equation 1

$$stressor\ attenuation = \frac{1}{1 + \exp\left(\left(\frac{x}{100} - a\right) \times b\right)} \times w$$

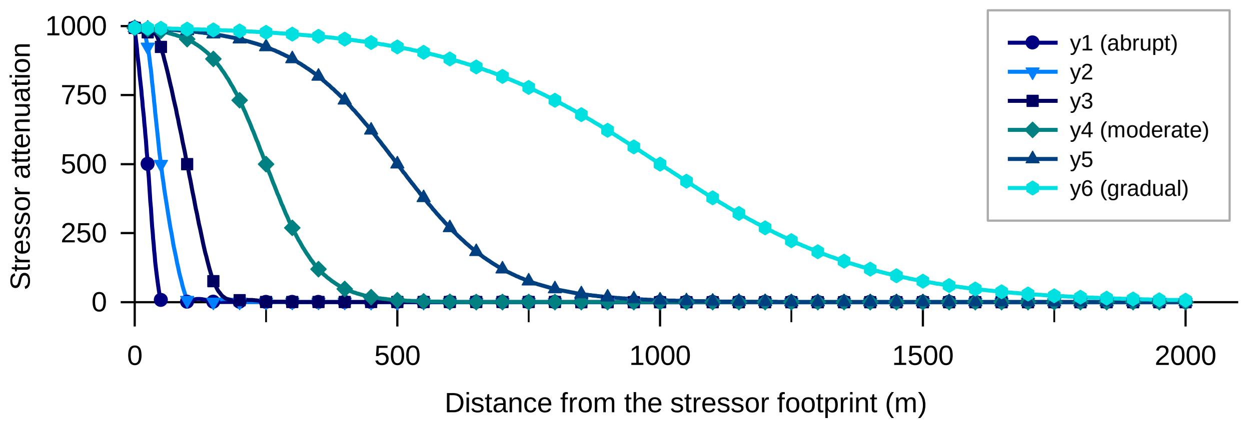

Figure 1: Sigmoid decay curves used to model the attenuation of ecological effects away from the footprint of a stressor. For stressors modeled with the y1 curve, impacts declined rapidly with distance (e.g., ATV trail); those assigned to the y6 curve had impacts declining more gradually from the footprint (e.g., urban development).

The cumulative nature of the final LCA model incorporates the compounding effects of multiple stressors at the relatively fine spatial scale of 30 x 30-m. We used this rasterized data layer to calculate an average LCA score based on pixels within a defined area. As shown in Figure 2, low LCA scores reflect low levels of human disturbance within the local landscape. For reference, the average LCA score for the Adirondack Park polygon was 105 (standard deviation = 256). In contrast, urban areas/clusters in the NY region as defined by the 2010 US census provided an upper estimate for "urban"; average LCA in these highly developed areas was 1421 (SD = 488).

Table 1: LCA2 included themes were each assigned a distance decay function, Equation 1 values (a, b, w), and the distance at which an impact becomes negligible (max dist.). As shown in Figure 1, *y1* represents the most abrupt decay curve and *y6* the most gradual. Some values were changed during model development (LCA1 → LCA2) as indicated below: ^{D}decreased; ^{I}increased. Cropland and active rail lines were new to LCA2.

LCA2 feature class input theme	Decay func.	*a*	*b*	*w*	Max dist. (m)
Transportation					
Unpaved vehicle trails	*y1*	0.25	20	100	50^{D}
Active rail lines	*y2*	0.5	10	500	100
Local, neighborhood, rural roads	*y3*	1.0	5	300	200
Secondary, connecting roads	*y4*	2.5	2	500	500
Primary highways, limited access	*y5*	5.0	1	500	1000
Primary highways, w/o limited access	*y5*	5.0	1	500	1000^{D}
Urban and industrial development					
Electric transmission corridor	*y2*	0.5	10	300	100
Natural Gas corridor	*y2*	0.5	10	300	100
Medium intensity development	*y4*	2.5	2	400	300^{I}
Low intensity development	*y4*	2.5	2	300	300^{I}
High intensity development	*y6*	10.0	0.5	500	2000
Managed and modified land use-land cover					
Cropland	*y3*	1.0	5	300	200
Open spaces	*y3*	1.0	5	300	200

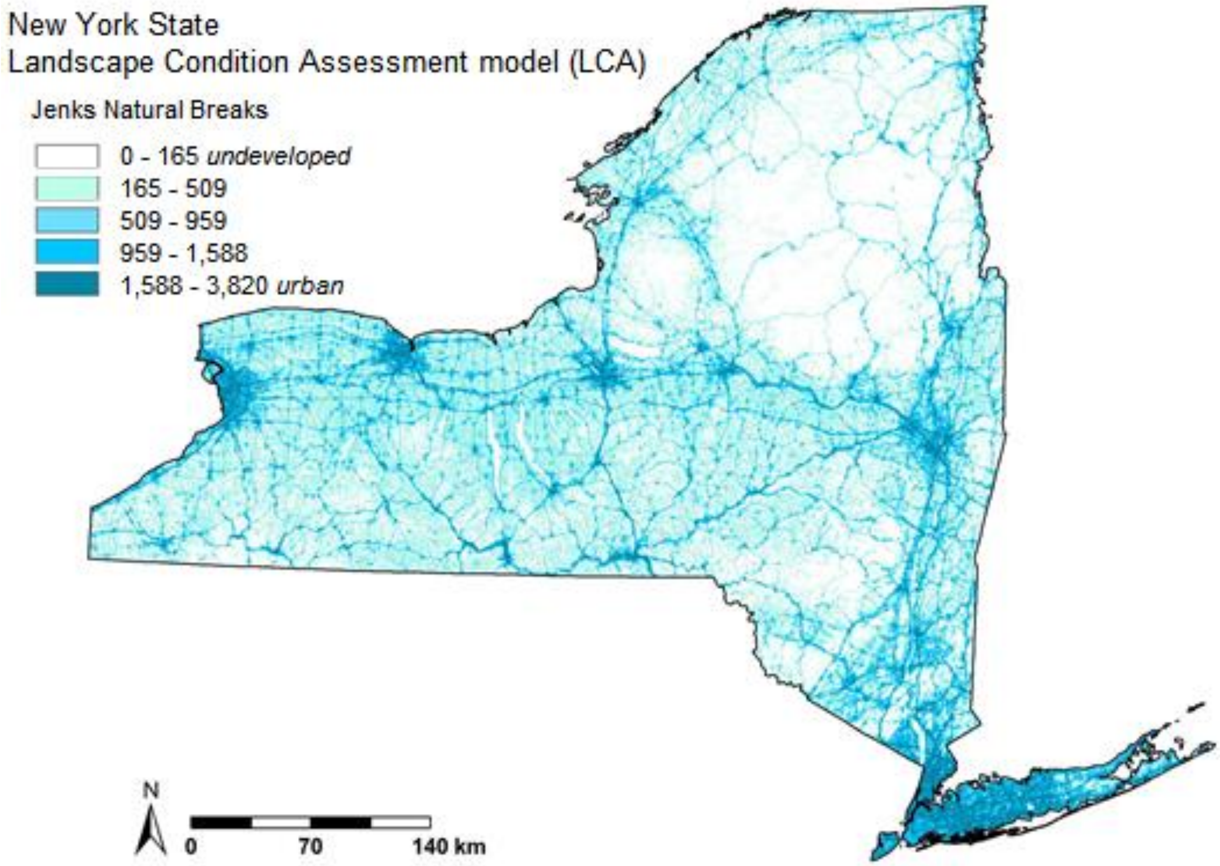

Figure 2: The landscape condition assessment model incorporated 13 human land use input classes. White and mint green colors indicate least developed/most natural while medium to dark blue show highly developed areas. Model resolution: 30 m x 30 m. Color categories follow Jenks (1967). This LCA GIS data layer is available as a free download at http://nynhp.org/data.

Field sampling

Study area

For this study, we focused on non-tidal freshwater systems primarily within the Lower Hudson River and Susquehanna River watersheds of New York (Figure 3). Watershed selection followed NYS DEC Division of Water's established rotating assessment cycle. We included four additional points located in the Adirondack Park (St. Lawrence River watershed). These additional points were sampled in 2014 under a different project, but employed the same sampling methods as described here. The Susquehanna basin is located within the Northern Allegheny Plateau of south-central NYS. Low rolling hills with wide valleys typify the area, which is predominately forested (59%) and agricultural (28%, Homer et al. 2015). Wetland coverage in the Lower Hudson is more than three times that of the Susquehanna watershed (10 vs. 3%). The Lower Hudson has comparable forest cover (56%), but cultivation is lower (17%) and urban and exurban development is higher (12 vs. 5%). Dominant ecoregions in the latter watershed include the Northern Allegheny Plateau, Hudson Valley, Northeastern Highlands/Coastal Zone, and Ridge and Valley (Bryce et al. 2010). Ecological integrity of the sample points ranged from pristine peatlands to exurban floodplain swamps of the Lower Hudson Valley.

Sample frame

For this study we focused on naturally-occuring vegetated wetlands >2 ha (≥5 acres) that were within 20 m of flowing surface water (1:24,000: USGS 2002). We targeted the following National Wetland Inventory (NWI) non-tidal freshwater community types: emergent (EM), broad-leaved deciduous (FO1) and needle-leaved green (FO4) forested wetlands, and scrub-shrub (SS) (USFWS 2015). The 2013 sample frame consisted of EM and SS types, while the 2014 frame included all four types outlined above.

Adjacent polygons of the same wetland type were merged prior to polygon size (ha) and Landscape Condition Assessment (LCA) calculations in ArcGIS (ESRI Inc 2010). Wetlands were then binned by wetland size (2-4 ha. 4-8.1 ha, 8.1-20.2 ha, and >20.2 ha) and polygon mean LCA score (LCA <300; 300-600; 600-1000; and >1000). These bins follow the Jenks natural breaks classification method (Jenks 1967).

Site selection

The wetland sample pool was stratified by NWI community type, polygon size (ha), and the LCA score. We then submitted the pool of potential wetlands to EPA statistician Tony Olsen to prioritize wetland site selection. The final sample pool used the Generalized Random Tessellation Stratified sample design (Stevens and Olsen 2004) stratified by LCA bins, wetland size bins, and community type. The GRTS method produced a spatially balanced sample draw and provided five random sample points within each wetland.

Sercuing land owner access was critical step in the site selection process. During this project, 350 access request letters were mailed to land owners. Of those that responsed, 29% agreed to grant access and 11% denied access. Selected sites ranged in hydroperiod classes (*sensu* Cowardin et al. 1979) ranged from temporarily flooded to semipermanently flooded, however, 74% of all sample points were classified as seasonally flooded/saturated by NWI maps (USFWS 2015).

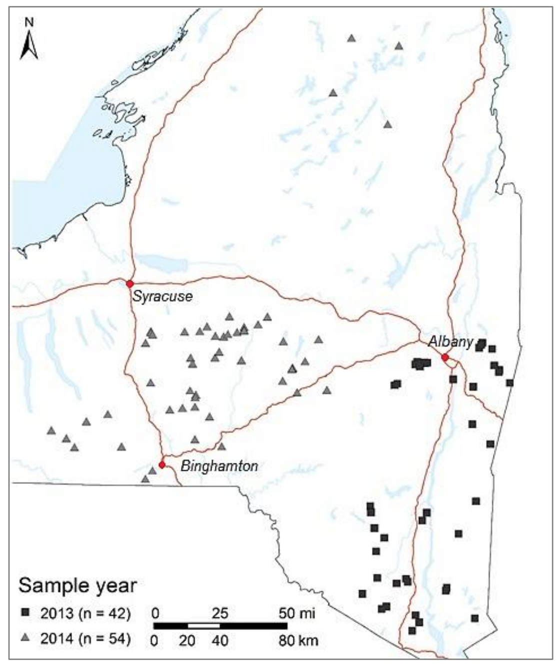

Figure 3: Level 3 vegetation plots were surveyed at all 96 sites; Level 2 rapid wetland assessment (NYRAM) was conducted only at the 2014 sites.

Level 2: Rapid Assessment Methods

Ecological Integrity Assessment (EIA)

Level 2 data collection during the 2013 season followed wetland-specific Ecological Integrity Assessment (EIA) protocols developed by NatureServe for the EPA (Faber-Langendoen et al. 2012), incorporating some modifications (CWMW 2012, Lemly and Gilligan 2012). Preliminary Level 2 surveys employed EIA at 18 sites located within or near the Adirondack Park Blue Line boundary. Encompassing a 40-m assessment area around each sample point, plus a 250-m buffer, the implemented EIA methods took our two-person team 4-5 hours to complete. Results from the preliminary 2012 season reported by Feldmann et al. (2012) highlight some of the obstacles this method posed relative to our objectives. A primary concern with EIA was reliance on “best professional judgement,” which has been reported to reduce repeatability and among-user comparisons (Fennessy et al. 2007). Additionally, EIA rapid scores correlated poorly with indictors from other levels of assessment; for example, no trend was observed between LCA1 and EIA scores (linear regression: $n = 18$, $r^2 = 0.270$, $p = 0.057$). These findings led us to develop a new Rapid Assessment Method (RAM) for New York State freshwater wetlands. We applied this approach in 2014 and our final analyses necessarily only use these 2014 data.

New York Rapid Assessment Method (NYRAM)

NYRAM is divided into two sections that broadly assess hydrology, fragmentation, plant community composition, and water quality. The first section, Part A, uses aerial imagery to assess a 500-m landscape buffer around the Sample Area (SA) of interest (Figure 4). Part B is a field stressor checklist encompassing a broad range of potential anthropogenic stressors that may influence natural wetland structure (e.g., plant species composition) and function (e.g., ground water recharge, nutrient cycling). This checklist was modeled after established RAM methods for Mid-Atlantic States (PA DEP 2014, Jacobs 2010). Methods discussed here are based on a “standard” 40-m radius SA that includes ≥90% vegetated wetland (SA = 0.5 ha, 1.24 ac; Figure 4). In a few cases, we employed a “non-standard” layout if the standard approach was unworkable (e.g., small wetlands, riparian systems). Non-standard SAs ranged in shape and size (0.5-0.1 ha). Calibration of this method and NYRAM data presented here include 54 survey sites sampled during the 2014 growing season; 50 from the upper Susquehanna River watershed, and four from the Adirondack Park region. Non-tidal palustrine wetlands were our target system so we did not include stressors unique to lacustrine, tidal, brackish, or estuarine environments (e.g., tidal flow restrictions).

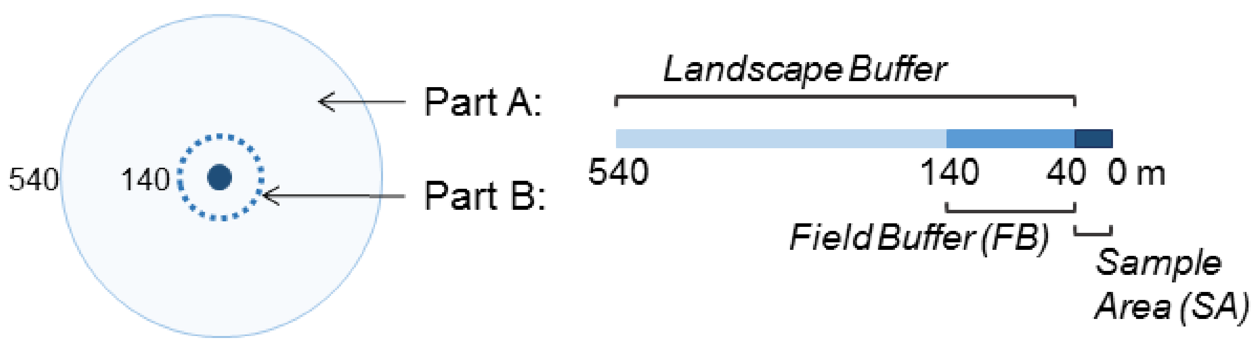

Figure 4: Schematic of the standard Level 2 rapid assessment sample design: Part A - onscreen evaluation of the landscape buffer; Part B – field stressor checklist. As shown here, the standard SA layout is a 40-m radius plot (0.5 ha), however, non-standard SAs may vary in shape and size 0.1-0.5 ha (0.25-1.24 ac).

Part A: NYRAM onscreen assessment

The first part of the NYRAM consists of a rapid onscreen assessment of stressors near the wetland. Anthropogenic stressors outlined in Table 2 are assessed using basic aerial photography interpretation (e.g., ArcGIS, Google Earth) to a 500-m radius around the SA (i.e., landscape buffer, Figure 4). Each stressor is assigned a multiplier that is weighted based potential ecological impact (modified after PA DEP 2014). The final landscape buffer score for Part A represents the cumulative stressors observed in the landscape surrounding the SA (Figure 5).

Table 2: Onscreen assessment categories and weights used for Level 2, Part A, which assess land use/land cover (LULC) and fragmenting features within the 500-m landscape buffer zone around the Sample Area. The total LULC score is obtained by dividing the sum of the type scores by 10. Sum all feature scores to obtain the total fragmenting feature score. Sum these two totals to produce the Part A score.

Land Use/Land Cover	Examples	% Cover	Multiplier		Type score
Natural	*forest, wetland, shrubland*	________	× 0	=	________
Lightly managed	*old field, plantation*	________	× 2	=	________
Actively managed	*timber, lawn, hay, ROW, grazing*	________	× 3	=	________
Intense management	*golf, row crops, sand/gravel mining*	________	× 4	=	________
Impervious surface	*pavement, buildings, rock*	________	× 4	=	________

Fragmenting features	Examples	Feature tally	Multiplier		Feature score
Unpaved road/trail	*gravel/dirt road, hiking trail*	________	× 1	=	________
Utility line	*right of way (ROW)*	________	× 2	=	________
Railroad	*active or abandoned*	________	× 4		________
2-lane paved road		________	× 4	=	________
4-lane paved road	*4 lanes or larger*	________	× 6	=	________
Other*		________	×	=	________

*Select an equivalent multiplier: 1, 2, 4, or 6

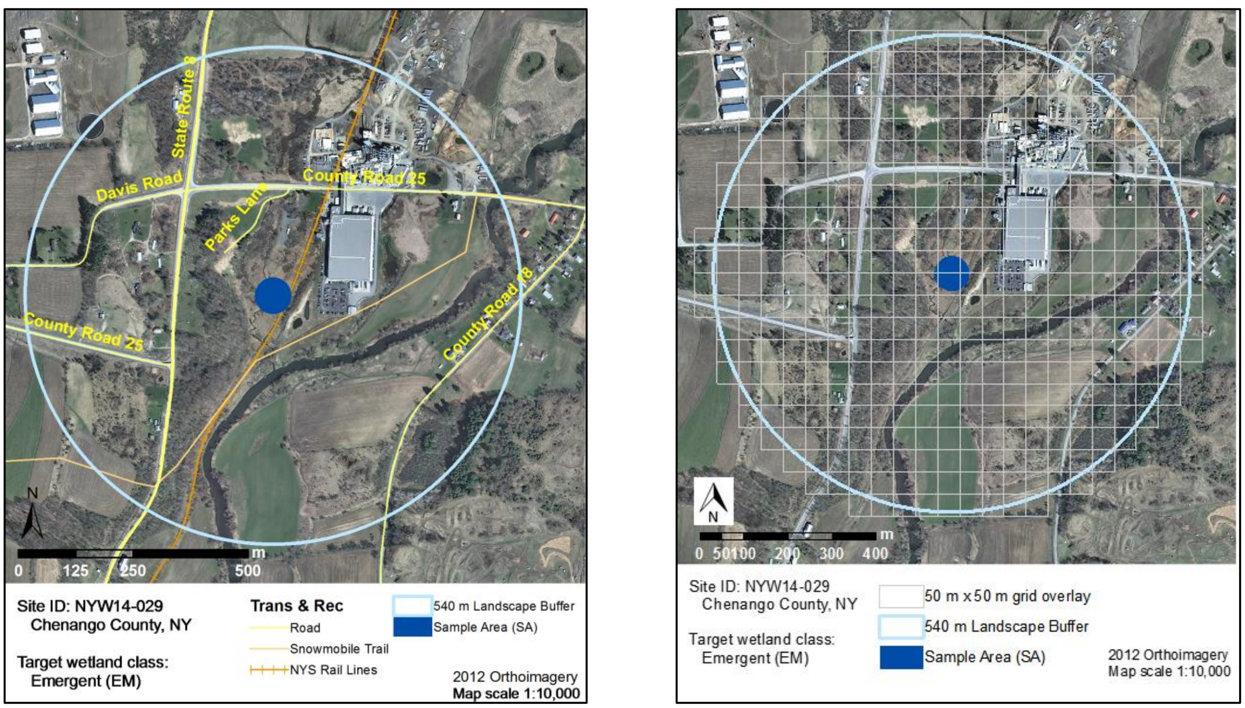

Figure 5: NYRAM, Part A, includes an onscreen tally of fragmenting features (figure left) and percent cover of land use land cover (LULC) classes. The latter metric can be aided by applying a grid overlay (figure right).

Table 3: An abbreviated summary of stressor categories and subcategories included in the field stressor checklist (Part B). Additional details are in the NYRAM field manual (Appendix B).

Vegetation	**Examples**
V1. Vegetation modifications	*livestock grazing, golf course/lawn, right-of-way, row crops*
V2. Invasive plants	*absent, present: uncommon (≤20%) or common (>20%)*
Hydroperiod	
H1. General hydro.	*ditching/draining, stormwater inputs, modified inflow/outflow*
H2. Stream/riverine-specific	*artificial levee, channelization*
Other hydro/topographic	
T1. Development	*residential/commercial, filing, grading, landfill*
T2. Material removal	*artificial pond, dredging, mining/quarry*
T3. Road, railroad, trail	*hiking/ATV trails, unpaved/paved road,*
T4. Microtopography	*ATV/skidder vehicle tracks, livestock tracks*
Sediment transport	
S1. Potential stressors	*active construction, forestry, livestock, eroding banks*
Eutrophication	
H1. Nutrient inputs	*direct discharge, adjacent row crops or pasture grazing*

Part B: NYRAM field survey

The second part of the NYRAM consists of a stressor checklist completed in the field. This checklist addresses five main categories representing ecosystem structure and function: vegetation alteration, hydroperiod, topography, sediment transport, eutrophication, and invasive species (Table 3). Field observers simply check off the presence or absence of a given stressor in the SA and/or the adjacent 100-m Field Buffer (FB = 5.65 ha “doughnut” Figure 4). Similar to Part A, stressor tallies are summed and multiplied by a weighting factor relative to their presence in the SA and/or FB. If invasive plants species are present, their percent cover (>20% or ≤20%) and richness (# of species) are also assessed. Following completion of the checklist, a final step is to assign a qualitative condition rating ranging from least disturbed (1) to highly disturbed by human activities (Figure 6). Data analysis presented here combines the 5-6 because only two sites received the poorest quality rating. The cumulative score for Part B is a summation of the stressor and invasive cover scores, invasive richness, and the qualitative condition rating.

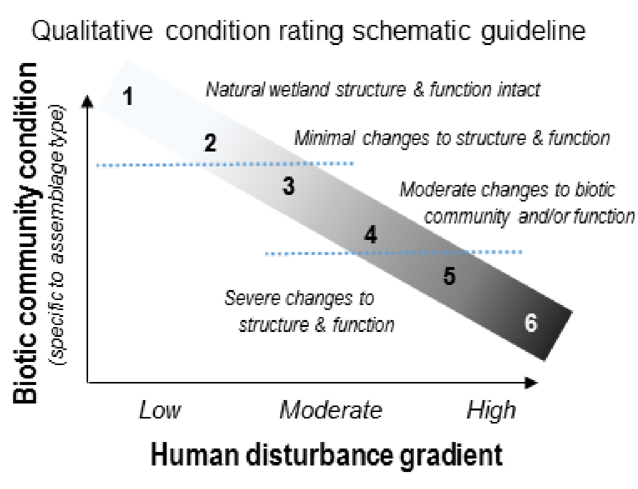

Figure 6 : Following completion of the field stressor checklist, users employ their professional judgement to select a disturbance score that best reflects the SA and FB.

Level 3: Vegetation plot arrays

Field ecologists quantified vegetation structure and floristic biodiversity at each of the 96 sample points, using a modified relevé technique described by Peet et al. (1998). At each targeted sample point, we set up a rectangular macroplot measuring 20 m x 50 m, divided into 10 equal subplots (Figure 7). Surveyors then selected four representative subplots based on their alignment with the target wetland assemblage. Tree Diameter at Breast Height (DBH) was measured 1.3 m above ground level for all live and dead trees with a DBH $\geq$10 cm. These data were converted to standing live basal area (BA m^2/ha) and tree density (stems/ha). Percent cover for each of the following strata were estimated for each species: nonvascular, aquatic, herbaceous, vine, shrub, tree seedlings (<2 m in height), saplings (2-5 m) and mature/emergent trees (height relative to plant community type). When possible, we identified all plants to species following current taxonomy stated in the New York Flora Atlas (newyork.plantatlas.usf.edu). We collected unidentified/unknown plants, tagged them with site information, and pressed them for later identification. For wetlands with high bryophyte diversity or abundance, we collected specimens and recorded their percent cover. Percent cover of environmental variables such as down woody debris, water, and bare soil were also estimated within each subplot. For each macroplot, we noted landscape context, herbivory, forest stand health, recent disturbance, or evidence of historic disturbance.

Macroplot data were collected with a hand-held computer (Samsung Galaxy tablet), allowing direct import into the NY Natural Heritage Program's Field Forms Database. Field surveyors used GPS navigation and mapping software to help locate the target wetland community. Representative photographs of vegetation composition were taken at each subplot, as well as photos of unidentified or interesting plants, or anthropogenic stressors. All photos were tagged with site information and uploaded them to the Program's digital image database. Location coordinates were recorded with a Garmin 60Cx GPS unit set to Universal Transverse Mercator Zone 18, North American Datum 1983, meters.

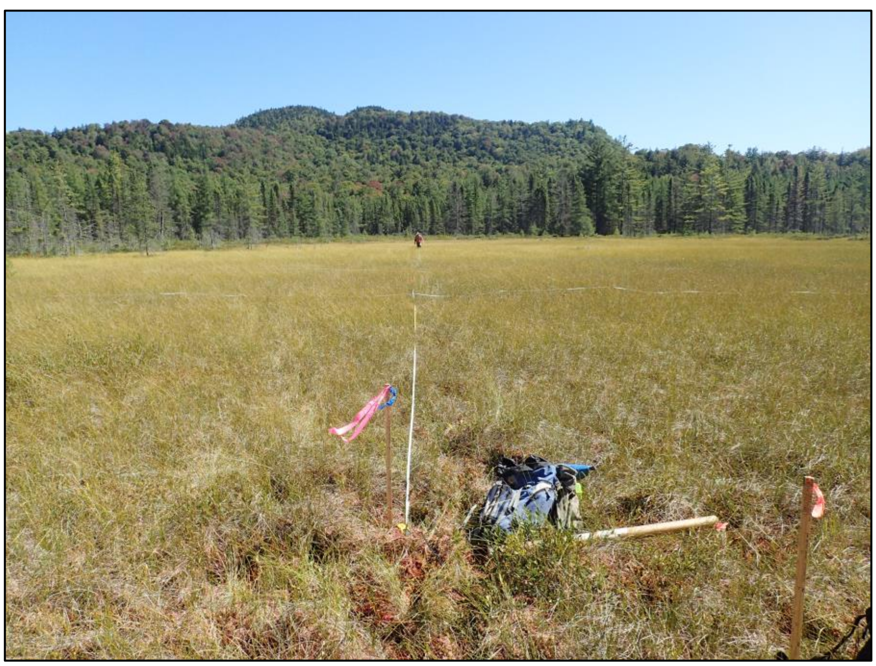

Figure 7: Example layout of a 50-m long (from flag to person) and 20-m wide macroplot. Site: Goodnow Pond, Adirondack Park.

Statistical Analysis

Biodiversity metrics

Vascular plant nomenclature was updated prior to analyses per Werier (2015). Richness values ("S") presented here include vascular and nonvascular plants identified to genus or species. Each species was assigned a coefficient of conservatism value ("C" value) that reflects a species' fidelity to a remnant plant assemblages in NYS (i.e., 10 = highly conservative/narrow ecological tolerance, 0 = cosmopolitan) (Swink and Wilhelm 1994). *C* values for a given site were averaged ("mean *C*": $\overline{C}$), and weighted by the proportion ("p") of cover they contributed to a given site ($\overline{C}_{wt}$, Equation 2). Floristic Quality Assessment Index (FQAI) scores were also calculated using $\overline{C}$ (Equation 3); weighted FQAI followed a similar equation, replacing $\overline{C}$ with $\overline{C}_{wt}$. NYS botanists produced these C-values (reported by Ring 2016) with funds from the EPA Wetland Program Development Fund (EPA CD96294900-0).

Equation 2

$$\overline{C}_{wt} = \sum_{i=1}^{S} \frac{p_i C_i}{S}$$

Equation 3

$$FQAI = \overline{C}\sqrt{S}$$

Data analyses

Trends among and within indictors from each of the three levels were analyzed using correlation analysis and pairwise comparisons. Unless notes, data are present as means ± standard error of the mean (SEM). Analyses were completed in SPSS (IBM Corp 2015), and supported by SigmaPlot graphing software (Systat Software Inc. 2008). Scatter plot graphs were used to ensure the majority of the data points fell within the 95% prediction interval, and that a few outliers were not driving the significant correlation trend. Boxplot graphs presented here indicate the median line, 5^{th} and 95^{th} percentiles (error bars), and outliers (dots or asterisks).

Nonparametric correlation analysis employed Spearman rank, the correlation coefficient (hereafter r_s) values from which range from +1 to -1, with zero indicating no correlation. A significance level of $p < 0.01$ was used for Spearman's correlation analysis. Similarly, Tukey or Dunnett adjustments were applied to pairwise analysis of variance (ANOVA) tests (Zar 1999). A significance level of $p < 0.05$ was used for linear regression and one-way ANOVA analyses. Data that violated ANOVA assumptions were transformed or analyzed with Kruskal-Wallace (K-W) one-way analysis of variance on ranks using a significance level of $p < 0.05$.

RESULTS AND DISCUSSION

The primary goal of this section is to report on the patterns of association among the final versions of the Level 1, Level 2, and Level 3 assessments. This important comparison emphasizes the practicality and effectiveness of using remote-sensed (Level 1) or very rapid on-site (Level 2) estimates of wetland condition. We begin with a discussion of overall patterns among all plots and then discuss how the scores can be used can be interpreted with the use of integrity classes. Understanding which integrity class applies to a new sample site provides context and perspective on the condition of that wetland.

As expected, dissimilar wetland types respond differently to the three-tiered assessment protocols. We discuss these details for emergent, forested, and scrub-shrub wetlands after examination of the integrity classes. This section continues with a description of biodiversity and physical structure at the wetland sites. We finish with a short discussion on applying these protocols in restoration, management, or conservation applications throughout New York State.

Indicator performance among and within levels of assessment

There were strong relationships among indicators scores at all levels of assessment. Anthropogenic land use within the local landscape was captured in the GIS model, and was positively correlated with the qualitative rapid assessment score (NYRAM; Figure 8A). This positive relationship shows that stressors captured in the rapid assessment correlate with the LCA GIS model, thereby providing support for the Level 1 model. Similarly, a significant linear relationship was present between NYRAM and the proportion of nonnative species surveyed in the Level 3 vegetation plots (Figure 8B). When compared to LCA scores, the Level 3 biotic integrity scores further demonstrate how

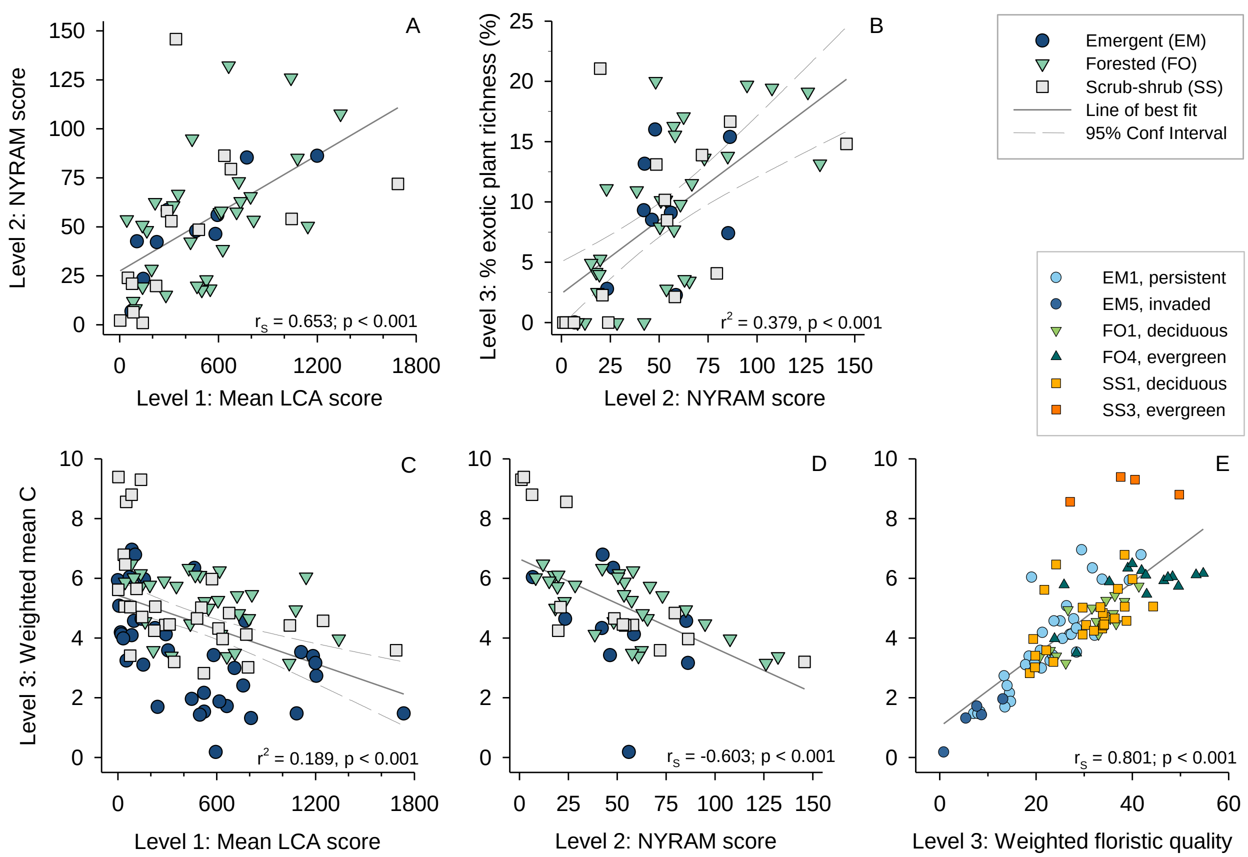

Figure 8: Condition metrics across all levels of assessment were significantly correlated. Trends were consistent across wetland community classes. A) Landscape Condition Assessment (LCA) score positively correlated with the NY Rapid Assessment Method (NYRAM) score of wetland stressors (Spearman's, n = 54). B) Relative richness of invasive and exotic plants within the Level 3 vegetation plots strongly correlated with the NYRAM score [n = 54; $S_{\%Inv}$ = 2.402 + (0.122 * NYRAM)]. C) Developed landscapes contained fewer specialist plant species [n = 96; $\bar{C}_{wt}$ = 5.425 - (0.002 * LCA)]. D) Increasing NYRAM stressor scores were also negatively correlated with specialist plants (Spearman's, n = 54). E) Weighted floristic quality assessment index was correlated with weighted mean C, but the latter performed better when comparing among assessment levels (Spearman's, n = 96). Graphs C-E share the same y-axis. Where linear regression was appropriate, 95% confidence intervals are shown (B, C), in addition to a line of best fit.

specialist plant species, those with moderate-narrow ecological tolerances (i.e., $\overline{C}$ >6), are sensitive to surrounding land use (Figure 8C). Negative correlations between anthropogenic stressors and floristic integrity were also captured via NYRAM (Figure 8D). Compared to $\overline{C}_{wt}$, weighted FQAI had weaker correlations with Level 1 LCA scores ($r_s = -0.243$, $p = 0.017$) and Level 2 NYRAM scores ($r_s = -0.468$, $p < 0.001$). Differences between these floristic integrity metrics were most pronounced in peatland, wet sedge meadow, and evergreen forested systems (Figure 8E). Many other studies have found C-value metrics perform more strongly in wetland systems than FQAI (e.g., Bried et al. 2013, Miller and Wardrop 2006, Chamberlain and Brooks 2016, Matthews et al. 2005).

Table 4: Distribution of randomly sampled wetlands among Landscape Condition Assessment groups (LCA, Level 1): nearly pristine/undeveloped (<120), rural/low development (120-600), and moderate /heavy development (>600); and weighted mean C groups (Level 3) that reflect plant species' ecological tolerance (e.g., wide = generalists). n = 71.

Watershed	LCA group		
Weighted mean C	<120	120-600	>600
Lower Hudson			
0-3 wide		2	9
4-6 intermediate	3	4	2
7-8 moderate	1		
Susquehanna			
0-3 wide		3	3
4-6 intermediate	4	22	16
7-8 moderate	2		
	14%	44%	42%

Integrity classes

Providing context is crucial when developing assessment protocols. We have created primary ecological integrity classes relative to each level of assessment based on data distributions and the qualitative disturbance rankings from NYRAM. Pairwise comparisons within and among levels were used to produce wetland condition integrity classes (Figure 9). Weighted mean *C* groups were modeled after descriptive classes used to assign coefficient of conservatism values (Ring 2016).

Among randomly sampled wetlands, 14% occurred within nearly pristine environments, while 3x as many occurred in moderate/heavily-developed landscapes (LCA >600; Table 4). In the Susquehanna watershed, 20% of sites were of high quality (NYRAM score <22). Further, these wetlands only occurred in natural/rural landscapes (LCA <600), and were dominated by plants with moderate- to

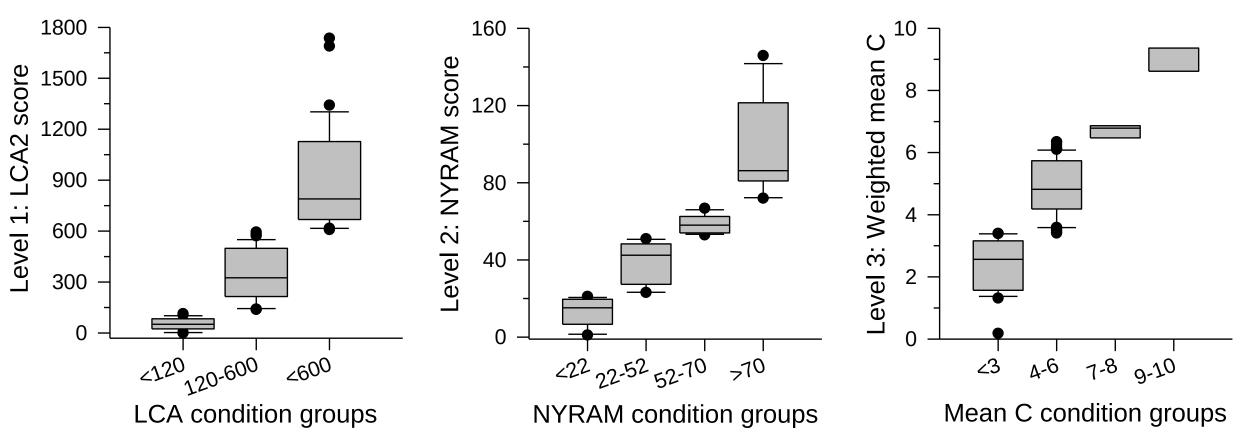

Figure 9: Integrity classes relative to indicator metrics used to assess wetland quality at each level of sampling: Level 1 (L1, n = 96): Landscape Condition Assessment (LCA); Level 2 (L2, n = 54): New York Rapid Assessment (NYRAM); and Level 3 (L3, n = 96): mean coefficient of conservatism ("C") scores weighted by species abundance.

Table 5: General description of sampling effort and community composition across wetland types as classified by Cowardin et al. (1979). Mean Landscape Condition Assessment score (LCA) is an average LCA for the 540-m area surrounding a given sample point. Rapid Assessment Method (RAM) grand score is the final Level 2 metric (see Appendix B). For both LCA and NYRAM, higher values indicate poor condition. Weighted Mean C is the average coefficient of conservatism for all identified plants within a plot, weighted by their abundance. Percent wetland plants ($S_{\%Wet}$) includes those classified as facultative, facultative wetland, and obligate (ACOE NWPL 2015). Unless noted, data are presented as the sample mean ± standard error of the mean.

	n	**Level 1**	**Level 2**	**Level 3**	
Wetland type	*2013-2014*	*LCA score*	*NYRAM score*	Weighted mean C ($\bar{C}_{wt}$)	$S_{\%Wet}$ (%)
Emergent, persistent (EM1)	32	455 ± 82	49 ± 9[a]	3.9 ± 0.3[a]	93 ± 1
Emergent, invaded (EM5)	5	602 ± 63	56 ± −	1.3 ± 0.3[b]	87 ± 5
Deciduous swamp (FO1)	17	590 ± 62	64 ± 8[a]	4.5 ± 0.2[a]	67 ± 4
Evergreen swamp (FO4)	13	447 ± 117	40 ± 8[ab]	5.9 ± 0.2[c]	65 ± 2
Decid. scrub-shrub (SS1)	25	459 ± 84	64 ± 11[a]	4.6 ± 0.2[a]	88 ± 2
Everg. scrub-shrub (SS3)	4	69 ± 29	8 ± 5[b]	9.0 ± 0.2[d]	100 ± 0

[abcd] Different letters indicate significant pairwise differences among wetland classes ($p < 0.05$, Tukey or Dunnett adjusted). 2014 RAM sampling effort: EM = 10; FO1 = 17; FO4 = 13; SS1 = 10; SS3 = 4. C-values: Ring (2016).

narrow-ecological tolerances (Figure 9). With relatively low anthropogenic stress and high floristic integrity, this subset of sites may serve as a restoration and mitigation reference standard for comparable wetlands in NYS. Peatlands were the only wetland assemblage dominated by plant species that have narrow ecological tolerances. Further, sites with $\bar{C}_{wt}$ >8 were only observed in the Adirondack Park. In contrast, assemblages dominated by generalist plant species ($\bar{C}_{wt}$ <3.5) comprised 25% of all wetland sites.

Wetland communities vary in their resistance and resilience to direct and indirect anthropogenic disturbance. Average LCA scores were highest for invasive-dominated marshes (EM5) and deciduous swamps (FO1) and lowest in broad-leaved-evergreen scrub-shrub (SS3) wetlands (Table 5). Although this trend is not surprising, it does signal that he LCA model adequately captures local stressors that influence the expressed plant assemblage. Similarly, NYRAM scores were highest for deciduous shrub and forested wetlands, followed by emergent marshes (Table 5). Aside from invaded emergent communities ($\bar{C}_{wt}$ = 1.3), sampled wetlands were characterized by plants with intermediate ecological tolerances (i.e., C-value range 4-6). Significant differences among the assemblages' $\bar{C}_{wt}$ scores suggest the need for benchmarks that are relative to each community type. The high proportion of wetland plants ($S_{\%Wet}$) at these sites aligns with the majority of them being classified as seasonally flooded/saturated (Cowardin et al. 1979). Beyond the 50% wetland plant rule (*sensu* Cowardin et al. 1979), hydrophyte benchmarks for quality assessment and restoration success may also need to be adjusted relative to community type.

Wetland community condition

Emergent marshes

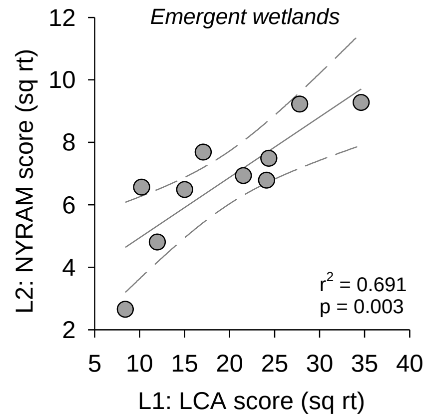

Figure 10: Level 2 NYRAM stressor score increased rapidly with mean site Landscape Condition Assessment (LCA) score [NYRAM = 3.007 + (0.194 * LCA); $F_{1,8}$ = 17.859]. As shown, data were square root transformed regression analysis (i.e., sqrt(600) = 24.5, sqrt(52) = 7.2).

Across all levels or assessment and wetland communities, emergent marshes most strongly reflected landscape development. Reference-quality marshes in the least disturbance landscapes (LCA <120) accounted for a third of the sampled marshes. Stressors captured in the Level 2 rapid assessment clearly correlated with site LCA scores (Figure 10), a trend that highlights the utility of either method in identifying emergent wetland communities for restoration or preservation.

Accuracy of Level 1 and Level 2 metrics were further supported by Level 3 biotic integrity indices. As expected, generalist plant species dominated marshes in developed landscapes (LCA >600, $\overline{C}_{wt}$ = 2.6). By comparison, $\overline{C}_{wt}$ scores for marshes in rural/undeveloped environments were 65% higher ($\overline{C}_{wt}$ = 4.0; ANOVA: $F_{1,35}$ = 6.466, p = 0.016). Reference-quality systems were dominated by obligate plant species (57 ± 2%), and site $\overline{C}$ ranged from 3.7 to 6.4 (5 ± 0.4; Figure 11). Based on these data, an indicator of high quality marshes of restoration success would be an established emergent community with a $\overline{C} \geq 5$ ($\overline{C}$ or $\overline{C}_{wt}$). This target is particularly reasonable for lacustrine fringe or riverine marshes. However, plants with narrower ecological tolerances often characterize other hydrogeomorpic (HGM) settings such as slope, mineral/organic flats, and depressional marshes (e.g., wet sedge meadow, inland poor fen, HGM *sensu* Brooks et al. 2011). For these systems, a minimum $\overline{C}$ target of 6 or 7 may be more appropriate.

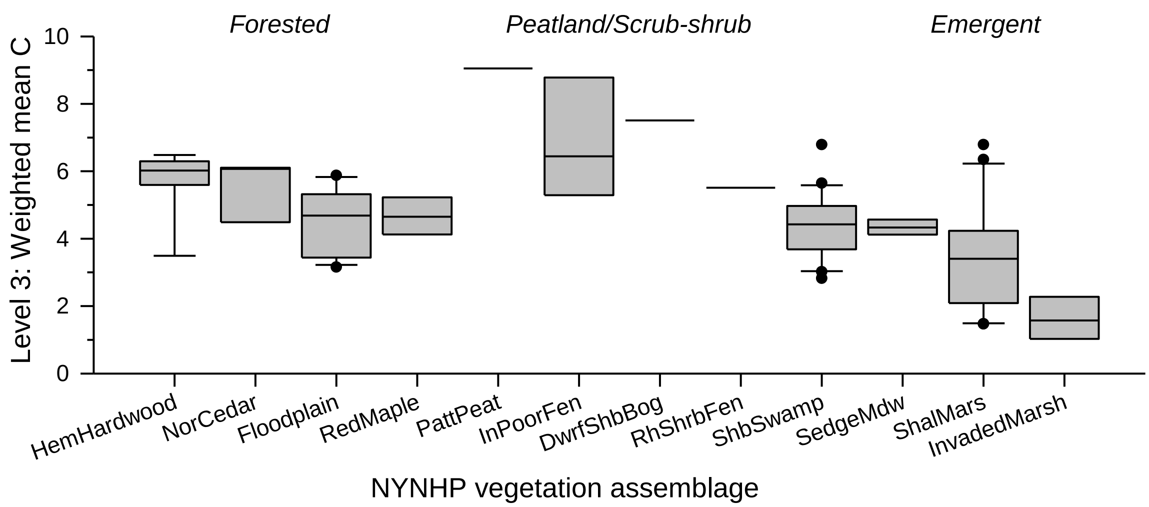

Figure 11: Mean coefficient of conservatism scores across NYNHP vegetation assemblages. Each boxplot contains ≥2 sites; error bars = 5th and 95th percentiles; dots = outliers; asterisks = far outliers. From left to right (n): Hemlock hardwood swamp (9); Northern white cedar swamp (4); Floodplain forest (12); Red maple hardwood swamp (3); Patterned peatland (2); Inland poor fen (4); Dwarf shrub bog (2); Rich shrub fen (2);Shrub swamp (20); Sedge meadow (7); Shallow emergent marsh (22); Invaded reedgrass/purple loosestrife marsh (6). Excluded assemblages not shown (n <2): Spruce/fir swamp; Ash/silver maple swamp; and Highbush blueberry bog.

Suggestions for these systems are based on vegetation data collected during normal to slightly wet growing seasons. Climatic conditions should therefore be considered when developing monitoring or restoration goals. For example, weedy or invasive plants with low C-values (<2; Figure 11) may increase in abundance during extended natural drawdown or prolonged drought conditions (van der Valk, A. G. 1981, Zedler and Kercher 2004). Slight seasonal differences in $\overline{C}$ scores has been observed by Bried *et al.* (2013) in NYS, however within-site differences were minimal (average range <0.5).

Forested wetlands

Reference-quality swamps comprised only 20% of sites within our dataset (LCA <600 and NYRAM <22) – hardwood trees dominated only *one* of these sites. Similarly, plants typical of evergreen swamps had narrower ecological tolerances when compared to those of broad-leaved deciduous assemblages (Table 5). Understanding how these two systems respond to anthropogenic stressors is crucial for developing attainable restoration goals and biotic integrity benchmarks that are appropriate for each system.

Evergreen swamp condition reflected all levels of assessment. Level 2 NYRAM scores in developed landscapes averaged 66 (± 11), more than twice the average score observed in undeveloped/rural environments (27 ± 5; Kruskal-Wallice: n = 15, H = 7.260, p = 0.007). Further, these highly-stressed systems (NYRAM >52) contained nearly 4x as many nonnative plants compared to sites with fewer anthropogenic stressors (11.2 vs. 3.6%, respectively; ANOVA: $F_{1,13} = 8.965$, p = 0.010). Independent of stand basal area, snag density in the latter group was much higher, averaging 33 stems ha^{-1}, compared to stressed sites (5 stems ha^{-1}). This significant difference in snag density has strong implications for wildlife habitat in evergreen swamps (ANOVA: $F_{1,13} = 5.891$, p = 0.030).

None of the hardwood swamps occurred in undeveloped landscapes, instead they were divided among rural (LCA 120-600) and developed environments (LCA>600). Among all forested wetlands, deciduous swamps comprised 66% of those ranked as moderate- to highly-stressed (i.e., NYRAM >52). As seen in previous studies (e.g., McDonnell et al. 1997, Ehrenfeld 2005, Burton et al. 2005), live tree stem density decreased as landscape development increased ($r^2 = 0.275$, $Tree_{Den} = 888.073 - (0.455 * LCA)$; ANOVA: $F_{1,13} = 4.928$, p = 0.045). Using the proportion of wetland plants as a proxy, we found that wetter deciduous swamps contained relatively fewer invasive plant species ($r^2 = 0.278$, $S_{\%Inv} = 21.659 - (0.179 * S_{\%Wet})$; ANOVA: $F_{1,13} = 5.004$, p = 0.043). These results align with previous research showing that human-mediated changes to hydrology that result in reduced flood duration or depth can make wetland systems more susceptible to invasive plant establishment and dominance (Shappell et al. In preparation, Price et al. 2011, Alpert et al. 2000).

Scrub-shrub

Unlike forested and emergent systems, most shrub wetlands occurred in undeveloped (40%) or rural (36%) landscapes. When compared to developed sites (LCA >600; $\overline{C}_{wt} = 4.1 \pm 0.2$) weighted mean C scores averaged two points higher when LCA was less than 120 ($\overline{C}_{wt} = 6.5 \pm 0.6$; ANOVA: $F_{2,26} = 5.423$, p = 0.011). The same trend was observed with NYRAM scores, averaging 13 (± 5), 54 (± 20) and 72 (± 7) in undeveloped, rural, and developed landscapes, respectively (K-W: H = 6.024, p = 0.041). Invasive plant richness nearly tripled from 3.4% ± 1.4% in undeveloped landscapes to 8.8% ± 1.0% in the highest LCA group (ANOVA: $F_{2,26} = 3.918$, p = 0.33). Although differences between broad-leave deciduous and evergreen shrub wetlands were observed (Table 5), the latter type only included four high-quality sites (i.e., LCA ≤140 and NYRAM ≤24). In contrast, 50% of the deciduous scrub-shrub sites were rural (LCA 120-600) and 40% occurred in developed landscapes (LCA >600).

The Level 2 rapid assessment was completed at 14 shrub wetlands, five of which exhibited very low levels of anthropogenic stress (NYRAM <22; $\bar{C}_{wt}$ = 7.4). Although moderate to highly stressed wetlands had lower $\bar{C}_{wt}$ scores (4.4 and 3.8, respectively), significant differences among the NYRAM groups were not detected (K-W: df = 3, X^2 = 6.803, p = 0.078). At extreme ends, the LCA model adequately reflected observed scrub-shrub wetland condition, and the NYRAM methods captured stressors that influence scrub-shrub quality.

Plant biodiversity and wetland structure

We identified 569 vascular plant species, including nine species listed as threatened or rare in New York State (i.e., S1 and S2, Young 2010). These listed plant species were present among all of the integrity classes outlined above. Further, only 21% of occurrences were in sites where LCA scores were low (<120). In contrast, the intermediate LCA class contained 42% of occurrences, followed by 37% in the highest LCA class (>600). A similar pattern was seen in the NYRAM and $\bar{C}_{wt}$ groups. These results show that even highly impacted wetlands can serve as a haven for rare and threated plant species, which could be responding positively to periodic anthropogenic disturbances

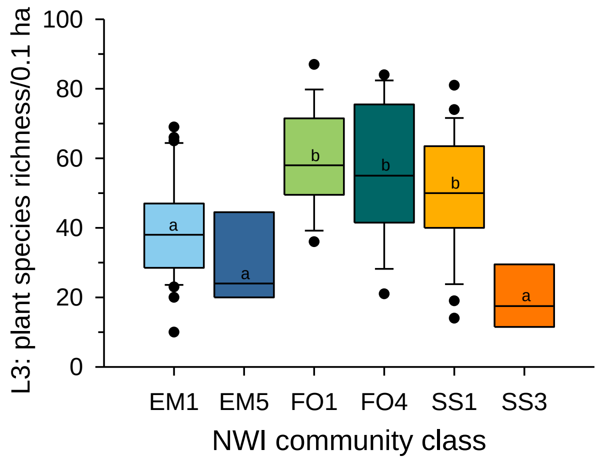

Figure 12: Plant species richness among National Wetland Inventory (NWI) community classes. Differing letters denote significant pair-wise differences (ANOVA, p < 0.05). EM1: emergent, persistent (n = 32); EM5 = emergent, invasive-dominated (n = 5); FO1 = forested, deciduous (n = 17); FO4 = forested, broad-leaved evergreen (n = 13); SS1 = scrub-shrub, deciduous (n = 25); SS3 = scrub-shrub, broad-leaved evergreen (n = 4).

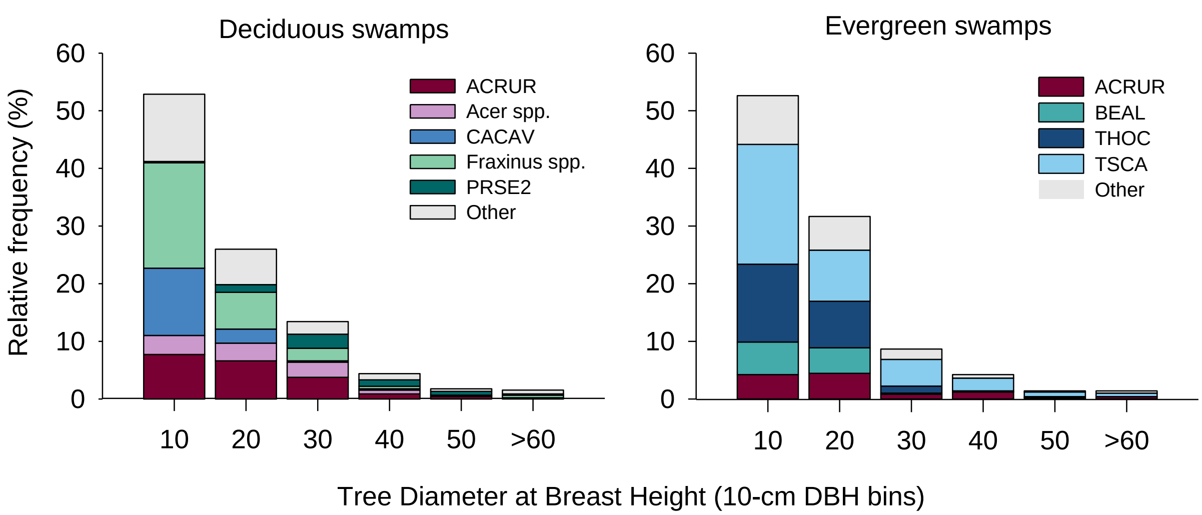

Figure 13: Tree canopy composition in deciduous (n = 17) and evergreen forested wetlands (n = 13) of central and eastern New York State. ACRUR: *Acer rubrum* var. *rubrum*; *Acer* spp.: *Acer* x *freemanii, A. negundo* var. *negundo, A. saccharinum, A. saccharum* var. *saccharum*; CACAV: *Carpinus caroliniana* ssp. *virginiana*; ash species: *Fraxinus Americana, F. nigra, F. pennsylvanica*; PRESE2: *Prunus serotina*; BEAL: *Betula alleghaniensis*; THOC: *Thuja occidentalis*; TSCA: *Tsuga canadensis*.

Forested systems supported the most diverse plant assemblages (59 ± 3 species 0.1 ha^{-1}), followed by shrub-scrub shrub and emergent wetlands (46 ± 4 and 38 ± 2, respectively; Figure 12). Dwarf shrub bog assemblages contained the fewest vascular species (10 spp. 0.1 ha^{-1}), but peatlands in general produced the highest mean coefficient of conservatism scores (Figure 11). Emergent wetlands produced the greatest range in $\overline{C}_{wt}$ scores (0.2 - 6.8), which was highest in a shallow emergent marsh and was lowest in an invaded reedy canary grass marsh (*Phalaris arundinacea* L.). Bryophytes composed 88% of observed nonvascular species (59). Given bryophyte dominance in some wetland systems, we hope to incorporate them into future condition assessment methods.

Canopy structure

Forested wetlands were primarily late-successional (75% BA >30 m^2 ha^{-1}), with an average of four tree species per 0.1 ha (4.8 ± 0.3; Figure 13). Live standing basal area in evergreen-dominated systems was nearly 25% greater than deciduous systems (42.5 ± 3.7 vs. 32.9 ± 2 m^2/ha; ANOVA: df = 28; F = 5.068, p = 0.032). Standing dead tree (snag) density was also significantly greater in evergreen systems (10 ± 4 vs. 27 ± 7 stems/ha; F = 5.355, p = 0.028). Producing a baseline understanding of canopy composition can inform restoration practices and help mitigate forested wetland loss due to human actions and invasive insects and pathogens (Rheinhardt et al. 2009).

Although 33 tree species were observed across the 30 forested sites, only a handful of species comprised >5% of stems (Figure 13). Red maple (*Acer ruburm* var. *rubrum*) was the most common tree, occurring in both deciduous- and evergreen-dominated systems. Large trees were infrequent (DBH > 50 cm), and when present, their density averaged 15 ± 1 stems/ha.

Invasive plants

Invasive and nonnative species were present in all community types with the exclusion of evergreen scrub-shrub wetlands (Figure 14). Of the 96 sites, 83% contained invasive/nonnative species at an average of 4 (SEM ± 0.3) species per site. Emergent wetlands appeared the most vulnerable to dominant invasive species, followed by deciduous hardwood systems (Figure 14). Vegetation composition in evergreen systems appeared the least influenced by nonnative plants, a result which may reflect broader landscape-scale patterns.

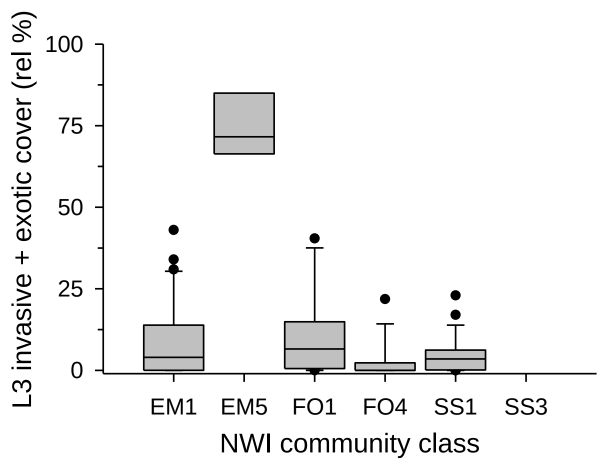

Figure 14: Relative percent cover of invasive and nonnative plant species by wetland subclasses. EM1: emergent, persistent (n = 32); EM5 = emergent, invasive-dominated (n = 5); FO1 = forested, deciduous (n = 17); FO4 = forested, broad-leaved evergreen (n = 13); SS1 = scrub-shrub, deciduous (n = 25); SS3 = scrub-shrub, broad-leaved evergreen (n = 4).

Purple loosestrife (*Lythrium salicaria* L.) was the most common invasive, occurring at 39% of all sample points (Figure 15). Percent cover of purple loosestrife was 9x greater at emergent wetlands within developed landscapes (18.4 ± 6.3% per m^2; n = 12) compared to sites in more rural settings (i.e., LCA2 score <600; n = 25) where cover averaged 2.5 ± 0.9% (Figure 16).

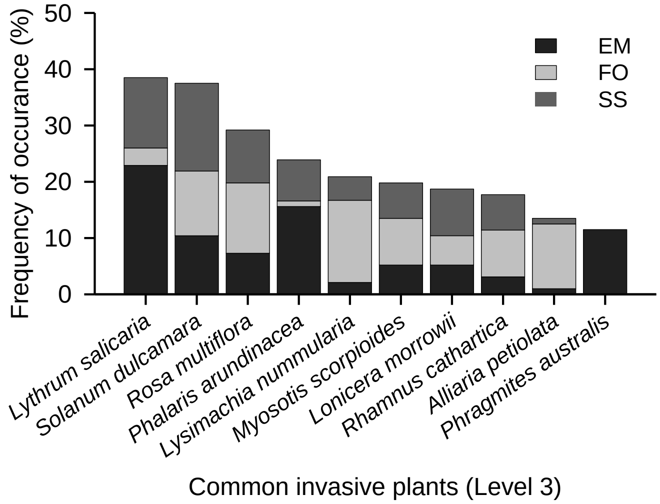

Figure 15: Invasive plant species shown above occurred in >10% of sampled sites and across emergent (EM), forested (FO), and scrub-shrub (SS) wetland communities.

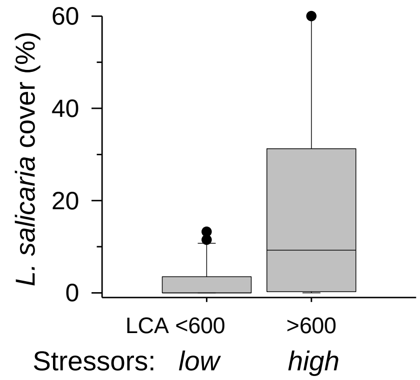

Figure 16: In emergent wetlands, purple loosestrife cover was significantly higher when Level 1 mean LCA scores were above 600 (Kruskal-Wallace: H = 5.929, p = 0.015).

Qualitative disturbance rankings &future method refinement

Following completion of the NYRAM field stressor checklist field teams used their best professional judgment to assign a qualitative disturbance ranking. These rankings are helpful to validate assessment scores across levels, and identify potential weaknesses in the current methodology. Rankings in this dataset were most definitive in wetlands experiencing low- to moderate-stress due to direct or indirect human activities (i.e., score: 1-3, Table 6). Interestingly, wetlands perceived to be the most altered actually produced NYRAM scores ranging from moderate- to highly-stressed. When applied to the Level 1 LCA scores, we saw a similar trend of decreasing disturbance rank precision with increasing levels of perceived disturbance.

These results highlight the importance and need for developing condition assessments that characterize wetland health across a spectrum of development intensities. Further, understanding the underlying discrepancies will help us to refine the methods – for example, high rankings in forested systems were associated with severe over-browsing (e.g., sparse shrub and herbaceous layer). This

Table 6: Qualitative human disturbance ratings were assigned to each site as part of the NYRAM sampling design (low = 1 to highly disturbed = 5/6). Sites were grouped based on their disturbance ratings and indicator metrics from each level of sampling (L1-L3) were compared across these groups. Data are shown as mean ± standard error.

Dist. score (*n*)	L1: LCA	L2: NYRAM	[min-max]	L3: $\bar{C}_{wt}$
1 (*9*)	184 ± 59^{a}	12 ± 3^{a}	[1-23]	7.0 ± 0.6^{a}
2 (*15*)	356 ± 73^{ab}	34 ± 4^{b}	[7-59]	5.6 ± 0.3^{ab}
3 (*13*)	609 ± 113^{bc}	57 ± 4^{c}	[21-80]	4.8 ± 0.2^{bc}
4 (*7*)	789 ± 125^{c}	80 ± 5^{d}	[54-95]	4.5 ± 0.3^{bc}
5 (*10*)	589 ± 123^{abc}	86 ± 12^{cd}	[54-146]	3.6 ± 0.5^{c}

^{abcd} Differing letters indicate pairwise differences among rankings. LCA: ANOVA, F = 4.610, p = 0.003 (Tukey adj); NYRAM: K-W, *X* 2 = 39.413, p < 0.001 (Dunnett T3 adj); $\bar{C}_{wt}$: ANOVA, F = 9.039, p < 0.001 (Tukey adj).

disconnect highlights the need for further data collection and method validation in moderate- to highly-stressed wetlands.

CONCLUSIONS

Our goals during this research were to produce a three-tiered framework for wetland monitoring and assessment in New York State, create a rapid assessment protocol, develop wetland condition indictors, and produce guidelines for indicator interpretation. Tools developed here can be used to prioritize wetland preservation and restoration efforts, and aid wetland mitigation planning by government and private stakeholders. Application of Levels 1 and 2 is ideal for assessing, monitoring, and mitigating anthropogenic stressors, a necessary component for developing holistic watershed management plans. Rapid assessment (NYRAM) is a verified and accessible tool that can help establish ambient wetland conditions for water management areas. The NYRAM score and guidelines in this report can also aid regulatory decisions. These methods will continue to be refined to ensure we are adequately capturing stressors in moderate- to highly-developed landscape. We anticipate monitoring at Level 3 will likely be applied only to sites of significant ecological importance or to assess restoration success. Most importantly, results presented here provided a quantitative link between comprehensive sampling (Level 3) and rapid (Level 2) or remote (Level 1) condition assessment protocols for NYS wetlands.

OUTREACH AND EVENTS

We took an inclusive approach during all phases of method development. Getting stakholders involved early in this project was cruical for producing methods that met their needs and our project goals. Below is a list of presentations we gave, conferences we attended, and interactive workshops we held to teach the NYRAM methodology.

Conference Presentations

NYS DEC Habitat Bureau Conference. March 2013. Hamilton, NY. Presenter: Aissa Feldmann. Title: Pilot wetland condition assessment of palustrine emergent marshes in the Upper Hudson River watershed.

New York State Wetlands Forum Conference. April 23-24, 2014. Lake George, NY. Attendee: Aissa Feldmann.

FQA Workshop and NEBAWWG Meeting. May 1-2, 2013. Albany Pine Bush Preserve Commission Discovery Center. Albny, NY. Presenter: Aissa Feldmann. Title: Developing a database tool to calculate FQA metrics: Upper Hudson River watershed, NY.

NEBAWWG Workgroup Meeting. December 11, 2013. New England Interstate Water Pollution Control Commission, Lowell, MA. Presenter: Aissa Feldmann. Title: Developing a database tool to calculate FQA metrics: Upper Hudson River watershed, NY.

NYS DEC Habitat Bureau Conference. March 2015. Hamilton, NY. Presenter: Dr. Tim Howard. Title: Wetland condition assessment: Developing protocols for New York.

NYS DEC Habitat Bureau Conference. March, 2016. Hamilton, NY. Presenter: Dr.Laura Shappell. Title: Wetland Assessment and a Novel Approach to Quantify Adjacent Area Impacts.

NYRAM webinars and workshops

Webinar: Using wetland condition assessment protocols to support your work. Presenter: Dr.Tim Howard. This 1-hour webinar included an introduction to the project and walk through of NYRAM Part A, the on-screen assessment. This webinar was presented twice. The majority of attendees were from NYS DEC (64%) and NYS DOT (28%), but we also had representatives from EPA and USACOE.

Sept. 2, 2015: 58 unique email addressed registered, approximately 70-82 participants.

Sept. 10, 2015: 43 unique email addressed registered, approximately 50 participants.

Field training workshop: NYRAM field stressor assessment. Co-led by Greg Edinger and Elizabeth Spencer. Attendees used NYRAM to assess a poor quality wetland and a good quality wetland. Grand total: 81 participants.

Workshops were co-led by Greg Edinger and Ecologist Elizabeth Spencer, with assistance from Program Director DJ Evans and Director of Science Tim Howard.

9/15: Fahnestock State Park, Putnam County – 29 attendees, including 3 NYNHP staff.

9/16: Carters Pond WMA, Washington County & Bog Meadow Brook, Saratoga County – 38 attendees, including 3 NYNHP staff.

9/18: Rush Oak Openings DEC Unique Area & Quaker Pond Fen in Mendon Ponds County Park, Monroe County – 14 attendees, including 2 NYNHP staff.

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APPENDIX A: A DETAILED SUMMARY OF LCA MODEL DEVELOPMENT

New York Natural Heritage Program

A Partnership between the New York State Department of Environmental Conservation and the State University of New York College of Environmental Science and Forestry

Landscape Condition Assessment (LCA2) for New York.
October 2013, New York Natural Heritage Program, Albany, NY.

By Aissa Feldmann and Tim Howard

In the context of developing protocols to assess wetland condition in New York, the New York Natural Heritage Program developed a Landscape Condition Assessment model (Comer and Hak 2012, Grunau *et al.* 2012) to cumulatively depict a suite of anthropogenic stressors across the landscape of the state. The model synthesizes these stressors at the 30 m x 30 m pixel scale – each pixel has a score representing cumulative stress – and, while it was developed to support a wetland project, it can be more broadly applied to answer questions about landscape or site-specific stress. The effectiveness of the model for estimating wetland quality is being evaluated with field work at two levels of sampling intensity.

We began with a set of GIS feature classes (input themes) with consistent statewide coverage representing elements that were expected to negatively affect wetland community composition, physical structure, and function. The first version of the model (LCA1), reported in Feldmann *et al.* (2012), included 12 inputs (Table 1, below): five transportation themes depicting roads of increasing size and impact, three development themes that increase in intensity, two types of utility corridor, and two managed open space themes (pasture and open space). Our second version (LCA2) included 13 inputs (Table 2, below); we added active rail lines to our set of transportation themes and replaced the pasture theme with a comprehensive agricultural (cropland) layer.

Following both Comer and Hak (2012) and Grunau *et al.* (2012), we incorporated the assumption that ecological effects of all input themes would decrease to zero within 2000 m of their mapped footprint. To begin our raster analysis, we prepared the input layers by creating this 2000 m ‘calculation space’ around them using the Euclidean distance tool in ArcGIS. Each input theme was thus converted into a raster with a 30 m x 30 m grid size extending to a distance of 2000 m from the theme’s footprint. Cell values were equal to the distance value (i.e., x = 0 at the impact site).

Methodology for the LCA1 model adhered strictly to Comer and Hak’s (2012) approach, using a linear decay function (Equation 1) to depict the decreasing ecological effects of the input themes. We first assigned impact scores, ranging from 0.0 to 1.0, to each input theme based on their presumed relative onsite influence, with the highest stress inputs receiving scores closer to zero. Inputs were also assigned a decay distance, the distance at which they no longer produce ecological effects. Our variable weights and decay distances were, for the most part, identical to Comer and Hak’s (2012, Table 1).

Table 1. Input themes, impact scores, and decay distances for LCA1, 2012.

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

Stressor values for pixels in each layer were calculated as follows:

$$val = \left(\frac{x}{ddist} * (1 - imp)\right) + imp \qquad [1]$$

where *x* is the the Euclidian distance value, *ddist* is the decay distance, and *imp* is the impact score.

After the linear function was calculated for each input and stored as a stack of values, the final score for each cell was set as the minimum of all values, or the highest stress for that location. Statewide, pixel scores ranged from 0.05 in the most 'stressed' locations to 1.0 in areas with no ecological stress. Using Jenks natural breaks classification (Jenks 1967), these statewide scores were binned into categories to represent levels of stress, from low (including none) to high (Figure 1).

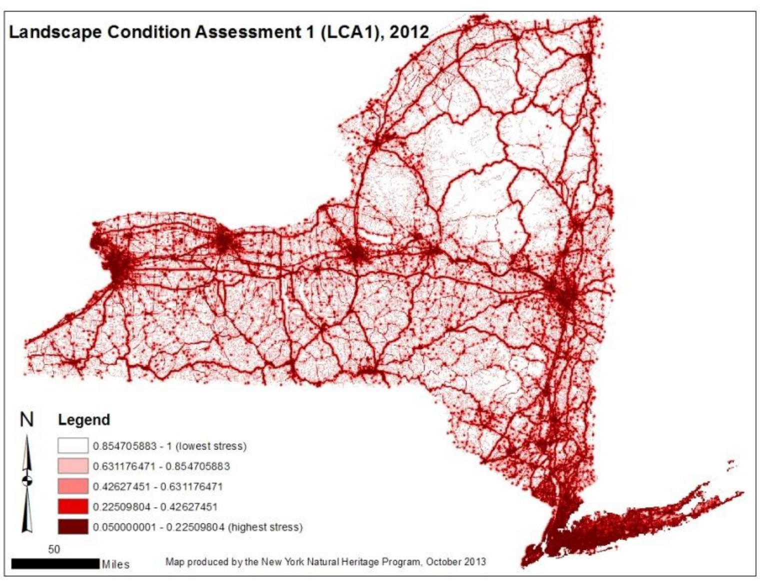

Figure 1. Statewide Landscape Condition Assessment model, version 1 (LCA1).

For our LCA2 model, we modified the decay functions from linear to sigmoidal (s-shaped), following Grunau *et al.* (2012) to better represent "effects that remain strong near the source for some distance before decreasing." We assigned each of our 13 themes (Table 2) to one of six sigmoid decay curves, each tailored to model a different degree of threat attenuation, from gradual to abrupt (Figure 2).

Table 2. Input themes, function types, variable values, and decay distances for LCA2, 2013.

Input theme	**Distance decay function type**	**a**	**b**	**c**	**w**	**Decay distance**
Transportation						
Vehicle trails, 4-wheel drive	y1 (most abrupt)	0.25	20	100	100	50*
Local, neighborhood, rural roads	y3	1	5	100	300	200
Secondary, connecting, special roads	y4	2.5	2	100	500	500
Primary highways, limited access	y5	5	1	100	500	1000
Primary highways, w/o limited access	y5	5	1	100	500	1000*
Active rail lines ***	y2	0.5	10	100	500	100
Urban and Industrial Development						
High intensity development	y6 (most gradual)	10	0.5	100	500	2000
Medium intensity development	y4	2.5	2	100	400	300**
Low intensity development	y4	2.5	2	100	300	300**
Utility Corridors						
Electric transmission corridor	y2	0.5	10	100	300	100
Natural Gas corridor	y2	0.5	10	100	300	100
Land Use-Land Cover						
Cropland***	y3	1	5	100	300	200
Open spaces	y3	1	5	100	300	200

* Decay distance decreased for this input theme from LCA1 to LCA2
** Decay distance increased for this input theme from LCA1 to LCA2
*** New input theme for LCA2

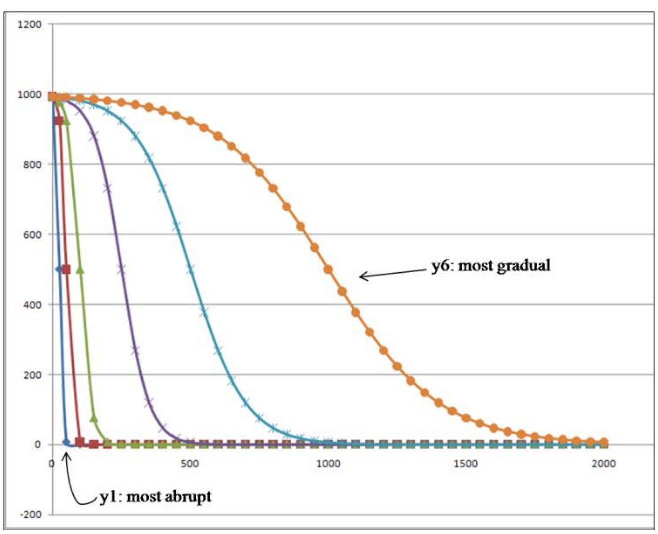

Figure 2. Sigmoid decay curves used to model the attenuation of ecological effects away from the footprint of a stressor. For stressors modeled with the y1 curve, impacts dropped off rapidly with distance (e.g., unpaved trails); stressors associated with the y6 curve had impacts that were assumed to persist further from the footprint (e.g., high intensity urban development).

The shape of the curves was primarily defined by two variables, one (*a*) that shifts the inflection point away from center (higher *a* value implies an impact that remains high moving away from the footprint), and a second (*b*) that determines the slope of the decreasing part of the curve. A constant (*c*) was included that set the function's distance of interest to 2000 m (Equation 2), as shown below:

$$c = \frac{dist}{20} \qquad [2]$$

where *dist* is the total distance of interest, in this case equal to 2000 m.

We assigned a weight (*w*) to each stressor, from 100 to 500, which was set as its maximum value in the impact footprint. We also set a decay distance, a distance at which the stressor no longer had any effect, for the inputs, guided by Grunau *et al.* (2012), Comer and Hak (2012), and additional literature review (van der Zande *et al.* 1980, Forman and Deblinger 2000, Forman 2000, McDonald *et al.* 2009, Parris and Schneider 2009, Benítez-López *et al.* 2010, McLachlan *et al.* 2013). Some 2012 decay distances were modified in this process. In most cases, this decay distance marked a natural asymptotic approach to zero, but we did opt to set decay distances that were further up the curves in two cases (medium and low intensity development). We thought the gradual attenuation was a likely depiction of the stressors' impacts, and adopted the early cutoff from McDonald *et al.*'s (2009) data on invasive species. For this version of the model, we treated the new cropland input fairly conservatively because of limited relevant scientific data on landscape-level ecological effects of various agricultural practices (Davis *et al.* 1993, Carpenter *et al.* 1998, de Jong *et al.* 2008). More extensive literature review could uncover justification for splitting agriculture into levels of intensity and modeling each separately, as has been done here for development.

We prepared our new set of 13 input themes as we had for LCA1, creating a 2000 m Euclidean distance 'calculation space' around each. Decay distances for each theme were then implemented by assigning null values to cells that exceeded them, essentially shrinking the 'calculation space.' Stressor values for remaining pixels in each layer were calculated as follows:

$$val = \frac{1}{1 + \exp\left(\left(\frac{x}{c} - a\right) * b\right)} * w \qquad [3]$$

where *x* is the Euclidean distance value, *a* shifts the curve away from center, *b* determines slope of the decreasing part of the curve, *c* is a constant reflecting the total distance of interest, and *w* is the stressor's weight.

We next stacked the calculated rasters, replaced null values with zeros, and, following Grunau *et al.* (2012), we summed their scores to produce a "single…layer representing the cumulative impact to an area from the included land uses." As for the LCA1, 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 (Figure 3).

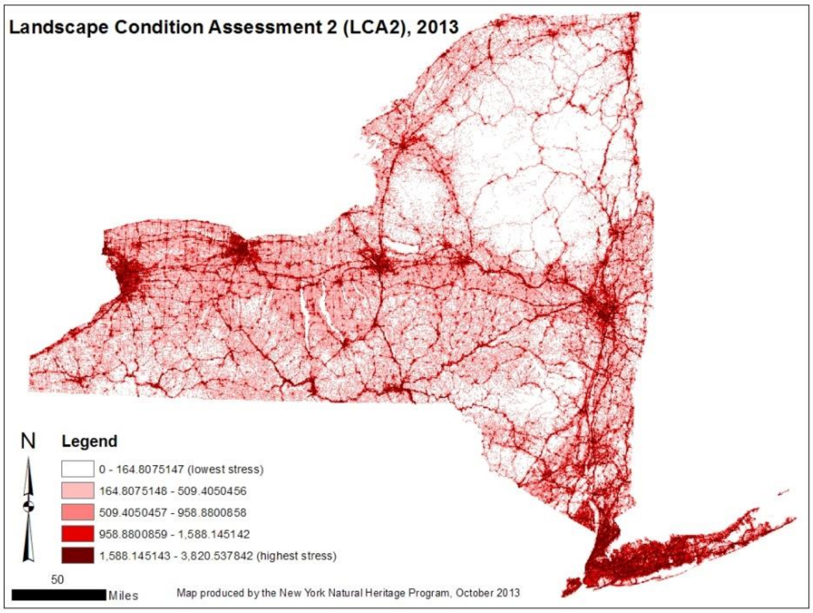

Figure 3. Statewide Landscape Condition Assessment model, version 2 (LCA2).

Notable improvements from LCA1 to LCA2:

1. Addition of agricultural lands, significantly improving stressor assessments in central and western New York.
2. Adoption of sigmoid decay curves, likely producing a more realistic depiction of stressor attenuation (Figure 4).
3. Summing the stressor impact scores to show cumulative stress.

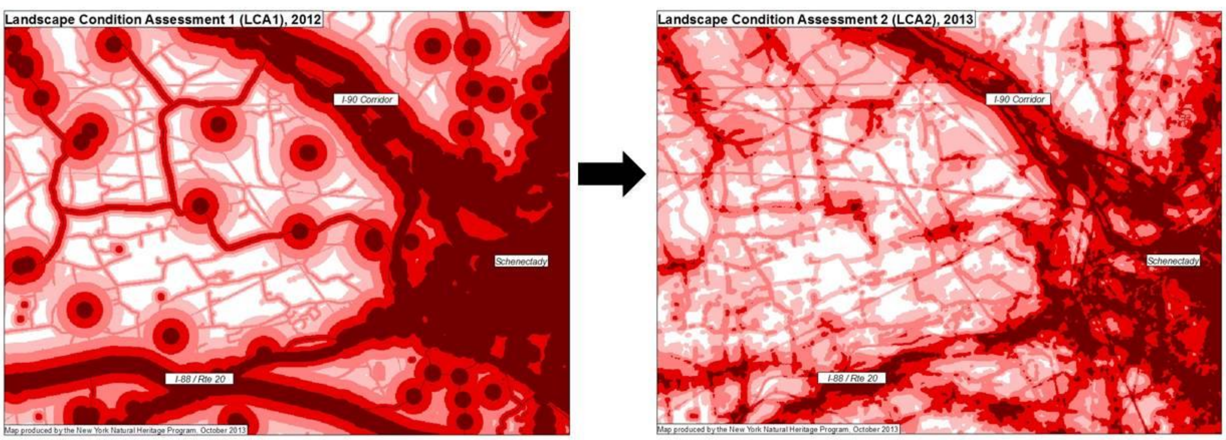

Figure 4. Depiction of landscape stress west of Schenectady, New York from the LCA1 model (left) and the LCA2 model. Sigmoid modeling of stressor reduction and cumulative (instead of maximum) stressor scoring produces a more natural, less stylized stress assessment.

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APPENDIX B: NYRAM FIELD MANUAL AND DATA SHEETS

New York State Wetland Condition Assessment

Level 2 Rapid Assessment Method
NYRAM Version 4.2

User's Manual and Data Sheets

NYRAM Field Manual

Project scope

Method development

The New York Rapid Assessment Method (NYRAM) provides users with a relatively quick procedure for assessing the quality and condition of New York State (NYS) wetlands. Methods presented here are part of a three-tiered sampling approach (Level 1, 2, 3); similar methods have been employed by federal and state agencies in an effort to develop environmental monitoring protocols (Faber-Langendoen et al. 2012, PA DEP 2014, Jacobs 2010). For Level 1, the New York Natural Heritage Program (NYNHP) developed a statewide Landscape Condition Assessment (LCA) model that cumulatively depicts key anthropogenic stressors across the NYS landscape at a 30 x 30-m resolution. Rapid assessment methods (RAM) developed for Level 2 classify and catalog anthropogenic stressors using basic quantitative air photo interpretation and qualitative field surveys. NYRAM field methods employ a stressor checklist that was modeled after established RAM procedures developed for Mid-Atlantic States (PA DEP 2014, Jacobs 2010). At the finest scale of measurement, Level 3 relevé sampling protocols modified from those developed by Peet et al. (1998) captured vegetation structure and floristic biodiversity. Level 1 and Level 3 data were used to refine and support the Level 2 RAM presented here.

NYRAM incorporates onscreen (Part A) and field (Part B) components that broadly assess hydrology, fragmentation, vegetation composition, and water quality. The field stressor checklist encompasses a broad range of potential stressors that may influence natural wetland structure (e.g., plant species composition) and function (e.g., ground water recharge, nutrient cycling), while providing flexibility for practitioners to document unique stressors present at their assessment site.

This rapid assessment method will continue to be refined as we expand our wetland assessment dataset. Updated NYRAM versions will be posted on the New York Natural Heritage website (www.nynhp.org). Please consider sharing your NYRAM data with NYNHP to help build our understanding of wetland condition in NYS.

Development of NYRAM

When developing this method, we aimed for it to be relatively quick, repeatable, and applicable to wetlands throughout NYS (Feldmann 2013, Feldmann and Spencer 2015). Most of the 54 survey sites used to calibrate NYRAM fell within the Lower Hudson River and Susquehanna River watersheds; a few additional points were located in the Adirondack Park. Non-tidal palustrine wetlands were our target system so stressors unique to lacustrine, tidal, brackish, or estuarine environments are not addressed (e.g., tidal flow restrictions). Using NYRAM on non-target wetland systems is not recommended as appropriate stressors have not been identified and evaluated during the development of this protocol.

Sampling effort

Part A: The onscreen portion of this method assesses the 500 m Landscape Buffer around the target Sample Area (see figure below). This step may be conducted using ArcGIS, Google Earth, or other air photo sources. Depending on landscape complexity and observer experience, Part A may be completed within 15-60 minutes. See the next section for tips and an example of this method.

Part B: The field portion of this method covers up to 6.15 ha (15.2 ac), including the Sample Area and surrounding 100-m radius Field Buffer that surrounds the Sample Area (i.e., 140-m out from the center point). Once at the Sample Area, a two-person team may complete the field stressor checklist in approximately 1 hour. However, sites that are difficult to traverse, such as shrub swamps or semipermanently flooded areas may take ≥1.5 hours to complete.

Overview of the NYRAM sampling design

This Level 2 rapid assessment method was designed to be suitable for a range of project needs from site assessment to establishing a reference baseline. Depending on project objectives, wetland site selection may be random, stratified random, or subjective. The Sample Area (SA) is the targeted area within a wetland that will be the focus of your NYRAM sampling. Standard sample designs focus around a 0.5 ha SA, but nonstandard layouts may vary in shape and range in size from 0.1 to 0.5 ha. The Landscape Buffer, a 500-m area surrounding the SA, is assessed in Part A of NYRAM through basic air photo interpretation. The field survey assesses stressors within the SA, and surrounding 100-m Field Buffer (Part B; Figure 17).

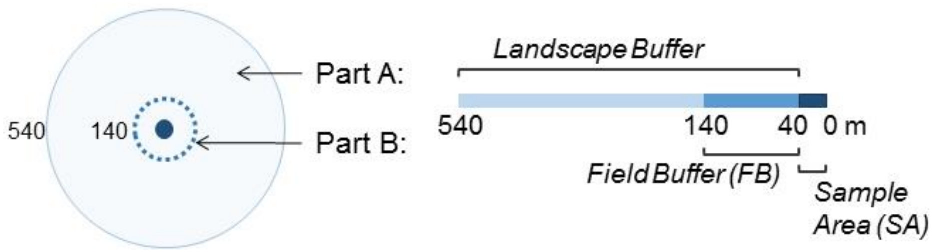

Figure 17: Schematic of the standard Level 2 rapid assessment survey design, which includes an onscreen evaluation of the Landscape Buffer (Part A), and a field survey assessing wetland quality (Part B). The standard SA is a 40-m radius plot 0.5 ha (1.24 ac), but non-standard SAs range in size (0.1-0.5 ha) and shape.

Site vetting and establishment

Sample Area

Prior to field work, try to establish an appropriate Sample Area (SA) via aerial or satellite imagery software such as ArcGIS, Google Earth (earth.google.com), Google Earth Pro (includes advanced functions, GIS file import: (http://www.google.com/earth/download/gep/agree.html), or via online maps (e.g., Bing Maps: bing.com/maps/). Interactive mappers produced by the U.S. Environmental Protection Agency (EPA), U.S. Geologic Survey (USGS), U.S. Department of Agriculture (USDA) are also useful, as outlined below on page 41.

Additional mapped data such as topography, USGS SSURGO2 soils, or National Wetlands Inventory maps should be consulted in tandem with the imagery. Confirm that you are viewing the most up-to-date imagery available to you - site conditions and land use can change drastically over short periods. Work through the following steps to pre-screen SAs relative to your research objectives.

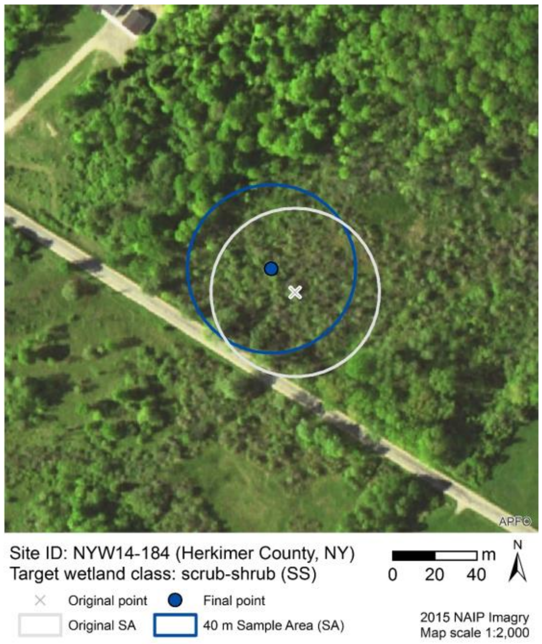

Figure 18: Sample Area around original random point included a road and some forested area (>10% non-target), so the point was moved ~15 m northwest.

1) Depending on project goals, point placement may be determined randomly, on a target wetland assemblage class (*sensu* Cowardin et al. 1979), or subjectively. The SA will encompass this point, ideally with the point in the center of the SA. If the SA is *subjective*, points may be moved to any location yielding a SA that meets the minimum sampleable criteria outlined below (i.e., disregard the 60-m move maximum discussed below).

2) Remote assessment of potential SA

   Sample Area composition

   ≤10% of the *total* SA may include water ≥1 m deep; standing water or soft substrates that are unsafe to sample effectively; or upland systems; and if applicable, ≤10% of a non-target wetland assemblage class. **If these criteria are not met**, try moving the point ≤60 m (e.g., Figure 18).

   SA size & shape

   Standard SA: accommodates a 40-m radius plot 0.5 ha (5,025 m^2 ≈ 1.24 ac), while maintaining the above composition criteria.

   Non-standard SA: if a standard SA is unworkable (e.g., small wetlands, riparian systems), alternative SA shapes and sizes (0.5-0.1 ha ≈ 0.25-1.24 ac) may be employed.

   Example: Due to a railroad and non-target scrub-shrub vegetation, the example site in Figure 19 does **not** meet the standard SA criteria for size or as shape. Instead, a 20 m x 50-m rectangular non-standard SA was employed.

   Accessibility

   Ownership – determine ownership using tax parcel or other government records. Private and public landowners/proprietors must grant you access to visit their property for each field-sampling event.

   Physical obstructions – sketch an access route to the target wetland. Determine if non-wadeable water bodies >1 m deep or another physical obstruction would prevent you from reaching and sampling the SA within a reasonable timeframe.

3) If the SA does not meet the criteria outlined above and you are using random point placement, try moving the point within 60 m of its *original* location. If moving the point does not address the issue, try selecting another random point within the wetland polygon. [Still can't establish an SA? It may be time to move on to a different wetland.]

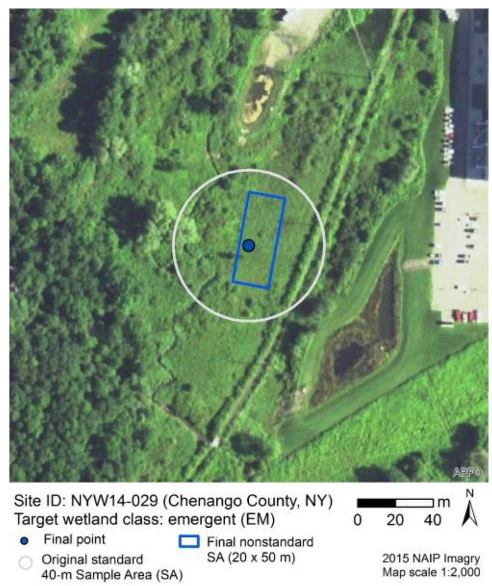

Figure 19: The original SA was <90% emergent, the target class for this survey, so a smaller nonstandard SA was established (0.1 ha).

Digital resources for the field (Part B)

After the above criteria have been confirmed, save/print locator maps for each site. Include the 40-m SA (or non-standard SA polygon), as well as the 100-m radius Field Buffer (FB) that surrounds the SA (i.e., 140-m out from the center point). For example, the non-standard SA shown in Figure 19 would have a 100-m rectangular FB around the 20 m x 50 m SA (i.e., FB perimeter = 120 m x 150 m rectangle).

Additional helpful data to include with the map: site ID, target wetland boundary, topography, soils, tax parcel data, and site owner/manager contact information. If using a handheld digital device in the field, load the digital layers onto the device (e.g., point files, and SA polygon layers). Print the NYRAM 4.2 field datasheets or load an electronic version onto your field tablet. If completing Part A prior to the field survey (Part B), bringing a copy of the form with you to the field for orientation.

Part A: Onscreen assessment example

This step should be conducted prior to the field assessment in Part B except when the SA is likely to be moved in the field. If the point will likely be moved, Part A should be completed *following* the field survey. Viewing the aerial photography in advance helps in identify potential stressors or ambiguous features that may be on the edge of the FB (e.g., an abandoned ditch), in difficult to access areas, or are otherwise likely to be overlooked in the field.

Materials & resources

Aerial imagery - required

Use the most recent imagery that is available via ArcGIS, Google Earth, Bing Maps, or one of the interactive mappers listed below.

US EPA, "MyWATERS": http://watersgeo.epa.gov/mwm/
Relevant content: base maps (satellite imagery from Bing Maps, topography, street maps); water quality status/permitting; rivers and streams (National Hydrography Dataset, NHD), and wetland data (National Wetlands Inventory, NWI).

USGS National Map Viewer: http://viewer.nationalmap.gov/viewer/
Relevant content: base maps (satellite, orthoimagery, topography), elevation contours, NHD including flow direction, National Land Cover Database (NLCD), protected areas (status, type, owner/manager), and wetland data (NWI). All of the data layers accessible here may be exported and viewed in ArcGIS or Google Earth.

Additional spatial data – optional

Wetland, hydrography, and soils:

NWI data published by US Fish & Wildlife Service (USFWS) - Interactive mapper, GIS & Google Earth data downloads: http://www.fws.gov/wetlands/

EPA WATERS data, Google Earth download - Includes NHDPlus surface water features, water quality feature: http://www.epa.gov/waterdata/viewing-waters-data-using-google-earth

USGS National Hydrography Data: http://nhd.usgs.gov/data.html

USDA soils:

Interactive mapper: http://websoilsurvey.sc. egov.usda.gov/App/HomePage.htm

GIS data: https://gdg.sc.egov.usda.gov/ or via interactive downloader: http://www.arcgis.com/home/item.html?id=4dbfecc52f1442eeb368c435251591ec

Transportation & recreation: New York State (NYS) roads, railroad (active and abandoned), trails (hiking, horse, and snowmobile) trail layers.

NYS GIS clearing house (general data source): http://gis.ny.gov/gisdata

NYS Department of Environmental Conservation (NYSDEC) State Lands Interactive Mapper: http://www.dec.ny.gov/outdoor /45478.html

NYS Google Earth file formats (.kml): http://www.dec. ny.gov/pubs/42978.html

Snowmobile trails: Private entities have made statewide snowmobile trails publicly available (e.g., JIMAPCO, Inc. http://jimapco.com/maproom/snowmobile/nys/)

Methods for determining % LULC type

Delineate areas of interest

In ArcGIS, use the geoprocessing buffer tool to create three buffers: 40 m and 540 m around the center point (e.g., Figure 20). For consistency, use these buffers for Part A even if your final SA is not a 40-m radius circle.

In Google Earth *Pro* you should be able to draw in circles with a defined radius (this is a relatively new program, released in 2015, so its functionality is evolving).

Overlay a standard grid - makes photo interpretation more efficient and repeatable

In ArcGIS, apply a measured grid overlay.

In *Layout View* of ArcGIS 10.3 go to View > Data Frame Properties > New Grid > Measured Grid > Intervals > 50 x 50 m). If viewing a 50 x 50 m grid, the Landscape Buffer contains approximately 364 full cells. Each cell is 2500 m^2 (0.62 ac). Tip: 4 cells = 1%. 18 cells = 5%.

To make a shapefile in *Data View* of ArcGIS 10.3 (shown in Figure 20), open the ArcToolbox > Cartography Tools > Data Driven Pages > Grid Index features. Use the 540-m buffer layer as your input, use 50 meters as your polygon width and height (e.g., Figure 20). [Note: depending on your computing power, this process may take 1+ hours to run if using >25 points.]

In Google Earth, you can display georeferenced grids that are distributed by private entities.

For example, the Earthpoint "UTM" grid (http://www. earthpoint .us/Grids.aspx), scales the grid relative to your viewing altitude. If using this tool, make sure to measure the cell size of your grid and adjust your calculations accordingly – methods discussed here are based on a 50 m x 50 m grid.

Additional tips

Orthoimagery help identify "actively-" and "intensively-managed" agricultural land use types (i.e., hay or lawn vs. row crops). The former appears bright green early in the growing season (or red if infrared). In contrast, land used for intensive row crops appear as smooth or finely striated dull tan/brown/grey.

Worked example: Figure 20

Part A: Land Use Land Cover (LULC)

Looking forward to LULC percent cover estimates in the field manual appendix, you will see four classes of anthropogenic LULC, plus a natural cover class.

Using Figure 20 (site ID NYW14-029), we will start with the "**Impervious Surface**" cover type, which is often easiest to identify due to its clearly defined boundaries. Approximately how many cells are filled with urban or built-up land (e.g., buildings, paved roads/parking lots, industrial, residential)? For partially filled cells, such as roads and house, visually aggregate features to produce the equivalent of a "filled" cell.

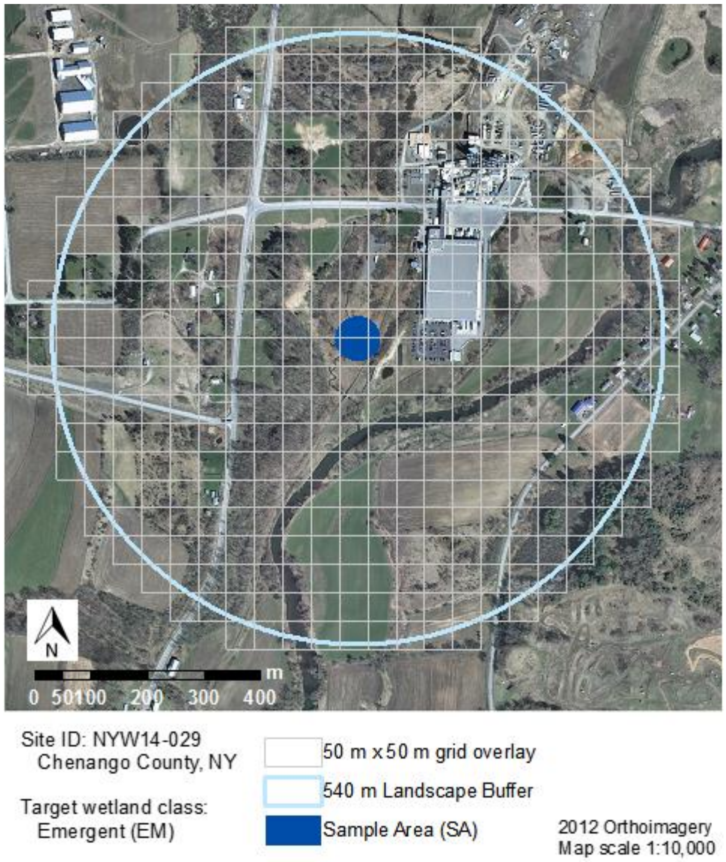

Figure 20: Part A assess the Landscape Buffer that extends 500 m from the *outer edge* of the Sample Area. An overlay grid aids percent cover estimates of LULC types.

Repeat this process for the remaining types:

"**Intensely managed**" such as golf courses, sand or gravel mining, warm season row crops (e.g., corn, soy), and pervious land/ponds associated with confined feeding animal operations (e.g., upper left corner of Figure 20). In this example, warm season cropland appears finely striated with a tan/brown or grey color; this pattern is best seen in spring air photos.

"**Actively managed**" types include lawn, hay, or winter wheat (all appear green in 20), vineyards, golf courses, and timber harvesting.

"**Lightly managed**" such as inactive cropland/old fields, pasture (compared to "active" cropland, pastures often occur near barns/buildings and has a more mottled texture), pine plantations (usually planted in uniform blocks), orchards.

The remaining cells should be "**Natural"** forests, wetlands, shrubland, surface water (excluding agricultural ponds), and/or barren land. Assuming the previous categories were correct, subtract the sum of those tallies from 364 to obtain the number of "**Natural**" cells.

Minor variations among observers is expected, as shown in Table 7, but these differences are marginal once the weighted percent cover scores are calculated and the total LULC score is obtained (see page 46 for weights and calculation). Total LULC scores produced form Table 7 averaged 17.6 (± 1.2).

Part A: fragmentation

Five fragmenting features categories are assessed and tallied. These range in magnitude from 4-lane highways to unpaved roads and trails (e.g., hiking, snowmobile, horse). Additional intermediate categories include 2-lane roads, railroads (i.e., active, abandoned, rail-to-trail), and utility line Right of Way (ROW). Continuing with the same example site (Figure 5 21), the Landscape Buffer includes one (1) unpaved trail (snowmobile), one (1) railroad, and 5 continuous named roads.

Table 7: Variation among three independent observations for Land Use Land Cover (LULC) at site NYW14-029. Values are present as mean tallies ± standard error (n = 3). Tallies were based on the 50 m x 50-m grid overlay; % LULC = # / 364 *100.

LULC type	cell tally (#)	LULC (%)
Impervious	44 ± 3	12 ± 1
Intense	39 ± 3	11 ± 1
Active	79 ± 10	22 ± 3
Light	37 ± 6	10 ± 2
Natural	164 ± 0	45 ± 0

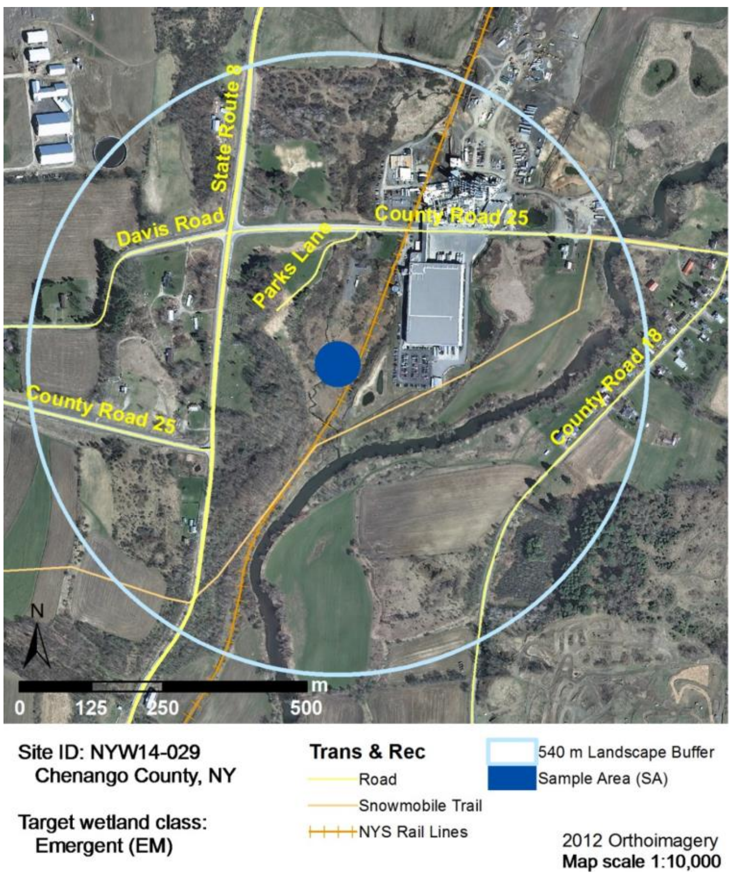

Figure 21: Fragmenting feature tally example. This site includes three categories of features: 2-lane roads, railroad, and an unpaved trail.

Appendix B Works cited

Cowardin, L. M., V. Carter, F. C. Golet and E. T. La Roe. 1979. Classification of wetlands and deepwater habitats in the United States. Rep. FWS/OBS-79/31. U.S. Fish and Wildlife Service, Washington, DC.

Faber-Langendoen, D., J. Rocchio, S. Thomas, M. Kost, C. Hedge, B. Nichols, K. Walz, G. Kittel, S. Menard, J. Drake, and E. Muldavin. 2012. Assessment of wetland ecosystem condition across landscape regions: A multi-metric approach. Part B. Ecological Integrity Assessment protocols for rapid field methods (L2). Report nr EPA/600/R-12/021bU.S. Environmental Protection Agency Office of Research and Development, Washington, DC.

Feldmann, A. L. 2013. Quality Assurance Project Plan (QAPP): Development of wetland assessment protocols in New York. Version 2. 26. New York Natural Heritage Program, SUNY-ESF Research Foundation, Albany, NY.

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PA DEP. 2014. Pennsylvania Wetland Condition Level 2 Rapid Assessment. Report nr 310-2137-002. 37 pages. Pennsylvania Department of Environmental Protection, Harrisburg, PA.

Peet, R. K., T. R. Wentworth, and P. S. White. 1998. A flexible, multipurpose method for recording vegetation composition and structure. Castanea 63:262-274.

WETLAND CONDITION LEVEL 2 RAPID ASSESSMENT SCORING FORMS

Part A: Onscreen rapid assessment

Area of focus for Part A is the Landscape Buffer, located 40-540 m around center point.
Note: If the sample point will likely be moved in the field, complete this portion *after* the field survey.

Site description

Observer ______________________ Date of onscreen assessment __________

Site name ______________________ Site code ______________________

Pub. date of the imagery: ______________ Sample location was determined (*circle one*): *Randomly* *Subjectively*

Please note: Although score calculations are shown below, these may be completed after field survey or in Microsoft Excel. The % LULC column should sum to 100%, and the max Total LULC score is 40.

Land Use Land Cover (LULC)

Qualitatively assess the percent area occupied by each of the following land cover types.

GIS tip: in layout view, apply a 50 x 50 m grid to the data frame. Google Earth or GIS: use the measure polygon tool to measure type area.

	% LULC		*Type score*
Impervious surface *pavement, buildings, rock quarries*	______	*x 4 =*	______
Intensely managed *golf, row crops, sand/gravel mining*	______	*x 4 =*	______
Actively managed *timber, lawn, hay, ROW, grazing, unpaved road*	______	*x 3 =*	______
Lightly managed *old field, ditch, plantation, Stormwater pond*	______	*x 2 =*	______
Natural *forest, wetland, shrubland, water*	______	*x 0 =*	______

Sum type scores = ______ *÷ 10*

Total LULC score = ______

Fragmenting features

Tally the number of fragmenting features in each category found in Landscape Buffer.

GIS tip: add New York State road, railroad, hiking & snowmobile trail layers

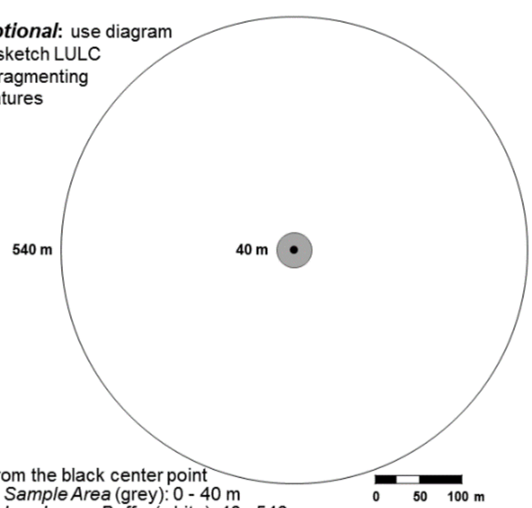
	Feature tally		*Feature score*
4-lane paved road *4-lanes or larger*	______	*x 6 =*	______
2-lane paved road	______	*x 4 =*	______
Railroad *Active or abandoned*	______	*x 4 =*	______
Utility line *Right-of-way (ROW)*	______	*x 2 =*	______
Unpaved road/trail *Grave/dirt road, hiking or snowmobile trail*	______	*x 1 =*	______
Other*:	______	*x =*	______

**Select an equivalent multiplier: 1, 2, or 4*

Total fragment score = ______
[sum feature scores]

Part A cumulative score: ______
[LULC score + frag score]

Optional: use diagram to sketch LULC & fragmenting features



From the black center point
Sample Area (grey): 0 - 40 m
Landscape Buffer (white): 40 - 540 m

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NYRAM 4.2 - Level 2

Part B: Wetland stressor field worksheet

Area of focus: 40-m radius Sample Area (SA) & the surrounding 100-m Field Buffer (FB)

Observers ______________________________ Date ______________

County ____________________ Town ____________________

Site name ____________________ Site code ____________________

UTM or Lat/Long: ______________ / ______________ Field point in the GPS? Yes No

Wetland community description

Target NWI wetland class (≥ 90% of SA): EM SS FO1 FO4

Optional: NYNHP/ Nature-Serve/ other comm. class ______________

Optional: Landscape setting or Wetland origin (e.g., natural, created) ______________________________

Basic guidelines for establishing a Sample Area (SA) in the field

Refer to the methods manual for detailed guidelines and pre-field office activities. Note: <10% of SA should contain water >1 m deep. If applicable, randomly generated points are invalidated if moved >60 m.

Standard, 0.5 ha (5,025 m^2; 1.24 acres)

☐ CIRCLE - 40-m radius

SA dimensions determined by (circle one):

tape measure visual estimate

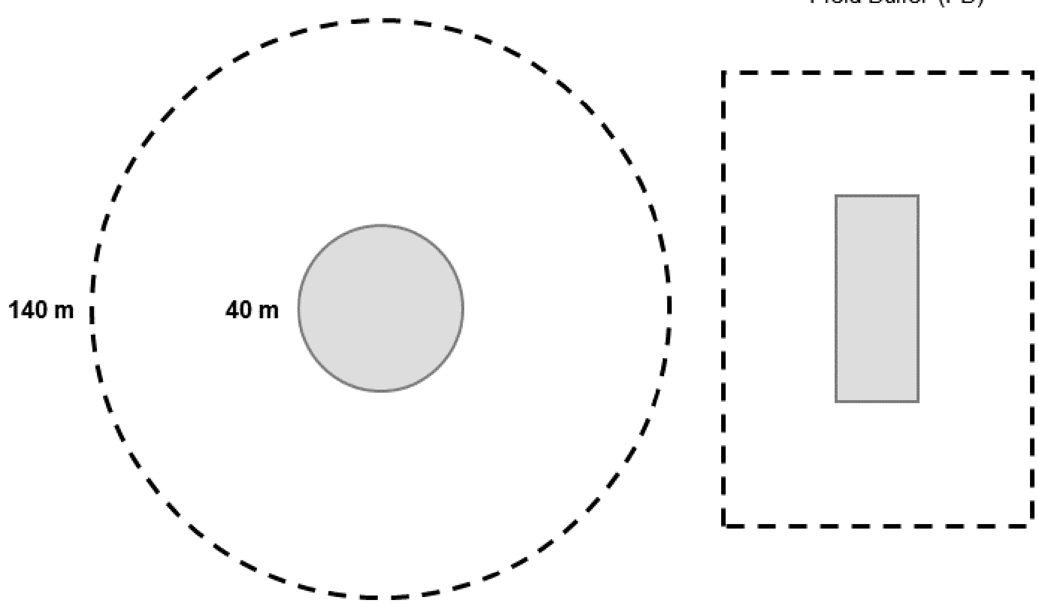
Non-standard, 0.1-0.5 ha

☐ RECTANGLE
e.g., 20 m x 50 m plot array

☐ OTHER
Use space at the *end of the stressor checklist* to sketch SA shape

Optional: sketch observed features below
(e.g., stream, road, trail)

Sample Area (SA)
Field Buffer (FB)



0 50 100 m
10 m = 32.8 ft

Standard Circle
SA 40-m radius *[0-40 m]*
FB 100-m radius *[40-140 m]*

Non-standard rectangle
SA ______________
FB ______________

 Site code: ____________ Date: ___________

Wetland stressor checklist

Mark “X” in each applicable column if stressor is present in the Sample Area (SA), Field Buffer (FB), or absent (Abs) from both areas.

Tips: Keep an eye out for invasive species to include in the Invasive Richness Survey (pp. 7-8). Stressor sums at the bottom of each page are optional, but may be helpful when making the final checklist sum for each column.

VEGETATION ALTERATIONS

V1. Vegetation modification occurred within the past year, unless noted	SA	FB	Abs
Excessive wildlife herbivory *(e.g., deer, geese, insects)*	____	____	____
Moderate/intense livestock grazing *(>25% bare soil)*	____	____	____
Mowing *(low intensity lawn or hay)*	____	____	____
Golf course or highly maintained turf *(NOT typical residential lawns)*	____	____	____
Right-Of-Way: cleared *(brush cutting, chemical, etc. assoc. with powerlines & roads)*	____	____	____
ROW, but no maintenance evident within past year	____	____	------
Logging within 2 years	____	____	____
Annual agricultural row crops	____	____	____
Plantation *(conversion from natural tree species, e.g., orchards, forestry)*	____	____	____
V2. Invasive plant species abundance (see invasive richness list)			
Absent (circle one if applicable): SA FB Both	------	------	____
Uncommon (Present, ≤ 20% cover) – List species in the invasive survey (see end)	____	____	------
Abundant (Present, > 20% cover) – List species in the invasive survey (see end)	____	____	------
V3. Other vegetation alterations *(e.g. woody debris removal)*			
____________________	____	____	____
____________________	____	____	____

HYDROPERIOD MODIFICATION

H1. General hydroperiod alterations			
Ditching, tile draining, or other dewatering methods	____	____	____
Stormwater inputs *(e.g., source pipe, impervious surface/roads/parking lot)*	____	____	____
Water inflow reduced by upstream structure *(dam / weir / culvert; including perpendicular road, railroad beds)*	____	____	____
Water outflow reduced due to impounding structure *(see above examples)*	____	____	____
H2. Stream/riverine-specific modifiers			
Artificial levee *parallel* to stream *(including parallel road, railroad beds)*	____	____	____
Channelized stream: straightened, hardened, or incised	____	____	____
H3. Other indicators of hydro modification *(e.g. high temperature discharge, dead/dying standing trees)*			
____________________	____	____	____
____________________	____	____	____
Sum of stressor tallies for each column on this page:	____	____	____

 Site code: ____________ Date: ____________

OTHER HYDRO/TOPOGRAPHIC MODIFICATIONS

T1. Development, filing, grading	SA	FB	Abs
Residential development: Low-moderate (≤2 houses/acre)			
High (>2 houses /acre)			
Commercial development *(e.g., buildings, factories, parking lots)*			
Other filling/grading activity (not road-related*; e.g., exposed soils, dredge spoils*)			
Landfill or illegal dump (*excessive garbage, trash*)			
T2. Material removal			
Artificial pond, dredging (not ditch-related)			
Mining/quarry (circle those present): sand gravel peat topsoil			
T3. Roads, railroads, trails			
Hiking or biking trail (well-established)			
Unpaved dirt/gravel road (established ATV, logging roads)			
Railroad (circle those present): active abandoned rail-to-trail			
Paved road: 2 lane			
4 lane or larger			
T4. Microtopography Soil surface variation <1 m in height (not pavement)			
Vehicle or equipment tracks: ATV, off-road motorcycles			
Skidder or plow lines			
Ruts in unpaved road (within poorly maintained *unpaved* roads)			
Livestock tracks			

SEDIMENT TRANSPORT

S1. Potential sediment stressors (within past year, unless noted)	SA	FB	Abs
Active: construction (soil disturbance for development)			
plowing (agricultural planting)			
Forestry (circle if known): clear cut, even-aged management (within 2 years)			
selective tree harvesting, salvage (within 1 year)			
Livestock grazing (intensive, ground is > 50% bare)			
Sediment deposits / plumes			
Eroding banks / slopes			
S2. Other evidence of sedimentation / movement (water consistently turbid, active mine, etc. – list if present)			
Sum of stressor tallies for each column on this page:			

 Site code: ____________ Date: ___________

EUTROPHICATION

E1. Nutrient inputs		SA	FB	Abs
Direct discharge:	agri. feedlots, manure spreading/pits, fish hatcheries	______	______	______
	septic/sewage treatment plant	______	______	______
Adjacent to intensive annual row crops		______	______	______
Adjacent to intensive pasture grazing (>50% bare soil)		______	______	______
Dense/moderate algal mat formation		______	______	______

E2. Other evidence of contamination or toxicity

(acidic drainage, fish kills, industrial point discharge, etc. – list if present)

____ ______ ______

____ ______ ______

Sum of stressor tallies for each column on this page: ______ ______ ______

ADDITIONAL NOTES OR SKETCH OF NON-STANDARD LAYOUT

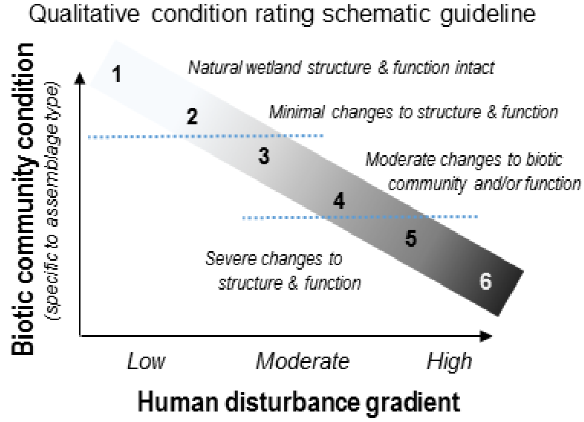
Qualitative condition rating

After completing the survey, describe overall site quality (SA + FB) as it relates to the level of human-mediated disturbance.

Circle the number that best describes the site:

Least disturbed 1 2 3 4 5 6 *Highly disturbed*

Qualitative condition rating schematic guideline



 Site code: ______________ Date: ____________

Invasive & nonnative species richness survey

Check or list all invasive and nonnative species present in the Survey Area (SA) and/or Field Buffer (FB). Note that the richness value only represents the number of *unique* species observed in both the SA and FB (i.e., *do not double* count a species).

Plants

Scientific name	Common name	USDA code	SA	FB
Agrostis gigantea	Redtop	AGGI2		
Ailanthus altissima	Tree-of-heaven	AIAL		
Alnus glutinosa	European alder	ALGL2		
Alliaria petiolata	Garlic mustard	ALPE4		
Aralia elata	Japanese angelica tree	AREL8		
Artemisia vulgaris	Mugwort	ARVU		
Berberis thunbergii	Japanese barberry	BETH		
Butomus umbellatus	Flowering rush	BUUM		
Celastrus orbiculatus	Oriental bittersweet	CEOR7		
Centaurea stoebe	Spotted knapweed	CEST8		
Cichorium intybus	Chicory	CIIN		
Cirsium arvense (syn. *C. setosum, C. incanum, Serratula arvensis*)	Canada thistle	CIAR4		
Cynanchum louiseae	Swallowwort, black	CYLO11		
Cynanchum rossicum	Swallowwort, pale	CYRO8		
Daucus carota	Queen Anne's lace	DACA6		
Dioscorea oppositifolia	Chinese yam	DIOP		
Dioscorea polystachya	Chinese yam	N/A		
Elaeagnus umbellata	Autumn olive	ELUM		
Frangula alnus	Glossy/smooth buckthorn	FRAL4		
Galeopsis tetrahit	Hemp-nettle	GATE2		
Glechoma hederacea	Ground ivy	GLHE2		
Glyceria maxima	Reed manna grass	GLMA3		
Heracleum mantegazzianum	Giant hogweed	HEMA17		
Hypericum perforatum	Common St. Johnswort	HYPE		
Iris pseudacorus	Yellow iris	IRPS		
Lonicera japonica	Japanese honeysuckle	LOJA		
Lonicera spp.	Shrub honeysuckles (nonnative)	LONIC		
Lysimachia nummularia	Creeping Jenny, moneywort	LYNU		
Lythrum salicaria	Purple loosestrife	LYSA2		
Microstegium vimineum	Japanese stiltgrass	MIVI		
Murdannia keisak	Marsh dewflower	MUKE		
Myosotis scorpioides	True forget-me-not	MYSC		
Myriophyllum spicatum	Eurasian water-milfoil	MYSP2		
	Sum of <u>unique</u> species observed on this page	________		

NYRAM 4.2 - Level 2, Part B

Site code: ______________ Date: ____________

Scientific name	Common name	USDA Code	SA	FB
Persicaria hydropiper (syn. *Polygonum hydropiper)*	Water-pepper smartweed	PEHY6 (POHY)		
Phalaris arundinacea	Reed canarygrass	PHAR3		
Phragmites australis	Common reed	PHAU7		
Poa compressa	Canada bluegrass	POCO		
Poa trivialis	Rough bluegrass	POTR2		
Prunus avium	Sweet cherry	PRAV		
Ranunculus ficaria	Lesser celandine	RAFI		
Reynoutria japonica (syn. *Polygonum cuspidatum*, *Fallopia japonica*)	Japanese knotweed	REJA2 (POCU6, FAJA2)		
Rhamnus cathartica	Common buckthorn	RHCA3		
Rosa multiflora	Multiflora rose	ROMU		
Rubus phoenicolasius	Wineberry	RUPH		
Solanum dulcamara	Climbing nightshade	SODU		
Trapa natans	Water chestnut	TRNA		
Trifolium repens	White clover	TRRE3		
Tussilago farfara	Coltsfoot	TUFA		
Typha x *glauca*	Hybrid cattail	TYGL		
Verbascum thapsus	Common mullein	VETH		
Veronica officinalis	Common speedwell	VEOF2		

Animals & pathogens

Adelges tsugae	**Hemlock Wooly Adelgid**		
Agritus planipennis	Emerald Ash Borer		
Anaplophora glabripennis	Asian Longhorned Beetle		
Cipangopaludina spp aquatic snails	Invasive Aquatic Snails		
Dendroctonus frontalis	Southern Pine Beetle		
Orconectes rusticus	Rusty Crayfish		
Lymantria dispar	Gypsy Moth (caterpillar)		

Additional species observed, but not listed above

Sum of unique species observed on this page ________________

NYRAM 4.2 - Level 2, Part B

Site code: ______________ Date: ____________

Part B *field data summary*

Summarize your data and enter values into the empty spaces below.

STRESSORS

Sum tallies in the Wetland Stressor Checklist (do *not* include invasive richness survey data here). Use the stress multiplier to calculate the Metric Score. Stressor score = sum of the metric scores.

		SA		FB		Absent
Stressor tally sum						
Stressor Multiplier (SM)	×	*8*	×	*4*	×	*0*
Metric Score	=	________	=	________	=	________
Stressor score		________				

INVASIVE PLANT COVER (%)

Where invasives are present, circle the number that corresponds to tallies indicated in section V2. Sum the values to obtain the invasive cover score. (No invasives in SA and FBInvasive score = zero.)

Please note: All values below account for points earned when tallied in section V2 above. This scoring adjustment removes double-counting concerns for this metric, and in doing so, causes some values to be negative.

	SA	FB
Uncommon (≤ 20% absolute cover)	*-4*	*-2*
Abundant (>20% absolute cover)	*8*	*4*

Invasive cover score ____________

INVASIVE & NONNATIVE PLANT SPECIES RICHNESS (#)

Count all unique plant, animal, & pathogen species observed in the SA & FB. If absent, write zero.

Invasive & nonnative richness ________

QUALITATIVE CONDITION RATING

Value generally describes the SA *and* the buffer, from least disturbed (1) to heavily disturbed (6).

Condition rating ________

Part B cumulative score ________

Stressors score + Invasives cover score + Invasive richness + Condition score.

NYRAM Level 2 Grand Score: ____________

[Part A + Part B cumulative scores]

Submit your NYRAM score to NYNHP's databank & see how your score stacks up: www.nynhp.org

Helpful Invasive Species References

Identification and General information

New York Invasive Species Information

www.nyis.info/

Website includes plants, animals and pathogens

Invasive Plants and their Native Look-Alikes: an Identification Guide for the Mid-Atlantic

www.nybg.org/files/scientists/rnaczi/Mistaken_Identity_Final.pdf

Invasive Species ID Training Modules by Midwest Invasive Species Info. Network

www.misin.msu.edu/training/

Website includes plants, animals, and pathogens.

A Field Guide to Invasive Plants or Aquatic and Wetland Habitat for Michigan

http://mnfi.anr.msu.edu/invasive-species/AquaticsFieldGuide.pdf

Prohibited and Regulated Invasive Plants of New York State

www.dec.ny.gov/docs/lands_forests_pdf/isprohibitedplants2.pdf

USDA National Invasive Species Information Center – Identification Resources

www.invasivespeciesinfo.gov/resources/identify.shtml

Website includes plants, animals, and pathogens.

Invasive species mapping

iMapInvasives

www.imapinvasives.org/

Website includes plants, animals, and pathogens – serves as the central repository for existing locations of invasive species in New York state.

Features/tools:

- Generate species lists by geographic, municipal, property, or jurisdictional boundaries.
- Contribute data from *your* field observations.
- Learn about invasive management methods.

Invasive Plant Atlas of New England (IPANE)

www.eddmaps.org/ipane/Species/