Lake Champlain Basin Program

TECHNICAL REPORT NO. 106

Using multi-metric modeling, field surveys, and online spatial tools to support conservation and management for flood resilience, water quality, and native species habitat

August 2023

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For:
The Lake Champlain Basin Program and
New England Interstate Water Pollution Control Commission

This report was funded and prepared under the authority of the Lake Champlain Special Designation Act of 1990, P.L. 101-596 and subsequent reauthorization in 2002 as the Daniel Patrick Moynihan Lake Champlain Basin Program Act, H. R. 1070, through the US EPA. Publication of this report does not signify that the contents necessarily reflect the views of the states of New York and Vermont, the Lake Champlain Basin Program, or the US EPA.

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NEIWPCC Job Code: 0356-003-001

FINAL REPORT

NEIWPCC Job Code:	0356-003-001
Project Code:	LS-2020-084
Contractor:	New York Natural Heritage Program
Prepared By:	Amy K. Conley, Timothy G. Howard, Laura J. Shappell, and Erin L. White
Project Period:	01/22/2021 to 01/31/2023
Date Submitted:	January 31, 2023
Date Approved:	June 2, 2023

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This is an EPA funded project.

This project was funded by an agreement awarded by the United States Environmental Protection Agency (EPA) to NEIWPCC in partnership with the Lake Champlain Basin Program.

Although the information in this document may have been funded wholly or in part by the United States Environmental Protection Agency (under agreement LC-00A00695), it has not undergone the Agency's publications review process and therefore, may not necessarily reflect the views of the Agency and no official endorsement should be inferred.

The New York Natural Heritage Program

The New York Natural Heritage Program (www.nynhp.org) is a program of the State University of New York College of Environmental Science and Forestry that is administered through a partnership between SUNY ESF and the NYS Department of Environmental Conservation. We are a sponsored program within the Research Foundation for State University of New York.

The mission of the New York Natural Heritage Program is to facilitate conservation of rare animals, rare plants, and significant New York ecosystems. We accomplish this mission by combining thorough field inventories, scientific analyses, expert interpretation, and a comprehensive database on New York's distinctive biodiversity to deliver high-quality information for natural resource planning, protection, and management.

Established in 1985, our program is staffed by over 30 scientists and specialists with expertise in ecology, zoology, botany, information technology, and geographic information systems. Collectively, the scientists in our program have over 300 years of experience finding, documenting, monitoring, and providing recommendations for the protection of some of the most critical components of biodiversity in New York State. With funding from a number of state and federal agencies and private organizations, we work collaboratively with partners inside and outside New York to support stewardship of New York's rare animals, rare plants, and significant natural communities, and to reduce the threat of invasive species to native ecosystems.

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 is continually updated as we gather new field data, has also been incorporated into the National Vegetation Classification.

NY Natural Heritage is an active participant in NatureServe (www.natureserve.org), the international network of biodiversity data centers. NatureServe's network of independent data centers collects and analyzes data about the plants, animals, and ecological communities of the Western Hemisphere. The programs in the NatureServe Network, known as natural heritage programs or conservation data centers, operate throughout all of the United States and Canada, and in many countries and territories of Latin America. Network 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.

New York Natural Heritage Program
A Partnership between the
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Executive Summary

This project aimed to develop assessment tools that support wetland and riparian management and stewardship to improve flood resiliency, water quality, and habitat for native species in the New York State (NYS) portion of the Lake Champlain Basin. The primary objective was to produce a comprehensive wetland and stream assessment dataset available through an interactive online mapping tool to increase the effectiveness of conservation decision-making in the basin. Our strategy included synthesizing scientific information about streams and wetlands and validating this information with field surveys in both systems. This project spanned from January 2021 to January 2023 and was funded by an agreement awarded by the United States Environmental Protection Agency to NEIWPCC in partnership with the Lake Champlain Basin Program.

We developed a spatial model to estimate stream water quality and evaluated these model results through field sampling at 20 locations in 2021 and 2022. We used aquatic macroinvertebrate and water quality metric data from the Stream Biomonitoring Unit of NYS Department of Environmental Conservation and the high-resolution National Hydrology Dataset as our stream layer, with an additional 205 environmental variables. Water quality model outputs were used to generate a list of sampling sites distributed along a gradient of predicted water quality. Our model validation was successful, showing statistically significant correlations for at least two water quality indices, with a trend that streams with lower predicted condition tended to have lower sampled condition. We provide the predicted water quality scores by stream reach in an Online Interactive Map and Data Explorer (Interactive Map) as the "Stream Water Quality Models" layer under Additional Models.

We assessed the relative opportunity of wetlands to desynchronize flood pulses by slowing and retaining overland surface flow from precipitation and snow melt. We first calculated wetland metrics including wetland size, wetland cover types, floodplain metrics, interception opportunity, and upslope condition. We then "rolled-up" these metrics into a combined desynchronization score available in our Interactive Map as the layer "Wetland Complex Overland Flow Interception".

We also assessed wetland connectivity to streams, wetland proximity to surface water, and the proportion of the riparian zone that is wetland, as well as detected barriers between wetlands and streams. We calculated these metrics independently and as a combined, rolled-up score that strives to estimate stream-floodplain functional connectivity, providing insight into a stream reach's ecological health. The final scores are available in the Interactive Map as layer "Wetland Complex Floodplain and Surface Water Connectivity".

Through other project work, our three-tiered wetland assessment framework for NYS has demonstrated strong, significant correlations between our remote "Level 1" Landscape Condition Assessment model (LCA), rapid wetland condition assessment ("Level 2": NY Rapid Assessment Method), and intensive vegetation plot surveys including floristic quality metrics ("Level 3"; Shappell and Howard 2018: www.nynhp.org/epa-adjacent-areas). That is, wetlands with good floristic quality scores (Level 3) or condition scores (Level 2) tend to have comparable LCA scores (Level 1). We assessed the condition of wetlands remotely using the LCA in order to estimate the cumulative effects of anthropogenic stressors at a given location. We validated the model through field sampling at 20 locations, stratified along an ecological condition gradient to ensure our surveys captured the range of anthropogenic stressors present in the basin. Our model validation was again successful, showing a statistically significant relationship between condition scores (NYRAM) and LCA model predictions with a trend that wetlands with lower predicted condition tended to have

lower sampled condition. Our wetland assessment field metrics aligned well with key spatial analytic metrics, including Connectivity to Surface Water, Percent Core Floodplain, and Floodwater Desynchronization Capacity.

In all, the intermediate products, final synthesis products, and the tools developed from this project provide land managers with data and tools that can be used to help prioritize conservation and protection work within the Lake Champlain watershed. The landscape in the basin, however, is continually changing, as are the analytic resources available for these types of assessments. We look forward to finding opportunities to make this an iterative product that improves and better fits the needs of resource managers with each iteration.

Contents

Executive Summary 4

Table Of Tables 7

Table Of Figures 7

Project Synopsis 9

Tasks Completed 12

Methodology 14

Objective B. Build and validate a spatial model estimating stream water quality in the NY portion of the Lake Champlain Basin 14

Objective C. Estimate potential wetland capacity to intercept and desynchronize floodwater . 19

Objective D. Model ecological condition for all wetland units across the NY portion of the Lake Champlain Basin and validate these estimates with field sampling 36

Objective E. Provide an interactive tool to decision makers and the public for viewing and using these data 40

Quality Assurance Tasks Completed 42

Deliverables Completed 54

Objective A. Develop a detailed Quality Assurance Project Plan 54

Objective B. Build and validate a spatial model estimating stream water quality in the NY portion of the Lake Champlain Basin 54

Objective C. Estimate potential wetland functional capacity to desynchronize floodwater 57

Objective D. Model ecological condition for all wetland units across the NY portion of the Lake Champlain Basin and validated these estimates with field sampling 59

Objective E. Provide an interactive tool to decision makers and the public for viewing and using these data 63

Conclusions 67

Acknowledgements 69

References 69

Appendices 72

Appendix A. Landscape Condition Assessment (LCA ver. 2) for New York. Albany, NY. New York Natural Heritage Program. October 2013 72

Appendix B. Level 2 Rapid Assessment Method 78

Appendix C. Wetland Assessment Level 3 Protocols 101

Appendix D. Functional Rapid Assessment Methodology (FRAM) 110

Appendix E. Remote Assessment Score for HUC 10 Watersheds 133

Table Of Tables

Table 1. Project objectives, tasks, deliverables, and timeline. 10
Table 2. Of the samples provided by NYS DEC Stream Biomonitoring Unit (SBU) fewer than 4% had more than one sampling event for a single stream reach (redundant sampling). 16
Table 3. Stream condition metrics modeled in the basin and the internal validation results reported by the random forest package. 17
Table 4. Comparisons of stream condition metrics calculated from the Stream Biomonitoring Unit (SBU) samples, our field samples (NHP), and the predicted values for all appropriate reaches throughout the basin (pred). 46
Table 5. Summary of the distributions of remotely sensed metrics for wetland complexes in the Lake Champlain basin. 52
Table 6. Coordinates sampled for stream quality validation and the date each point was sampled. 55

Table Of Figures

Figure 1. Left: Black outline delineates the NY portion of the Champlain Basin, the focus of our project, with NYS DEC biomonitoring data collection points since 2010 (purple triangles). ...13
Figure 2. Comparison of wetland complexes as defined using high resolution landcover data (purple) or wetlands from the National Wetland Inventory (green). 22
Figure 3. Example of the base riparian zones of the Active River Area for a portion of the project study area. Boundaries of the Active River Area are in purple, nearby National Wetlands Inventory wetlands are outlined in white, and the National Hydrography Dataset flowline is in blue. 24
Figure 4. Active River Area: The active river area is composed of the main riparian zone in purple, riparian wet flats, in blue, and material contribution zones: wet (brown) and dry (yellow). 25
Figure 5. Active River Area with wetland complexes in green. 25
Figure 6. Example of an upstream accumulation area (gray) for a single wetland (green). The right hand picture zooms in on the wetland (green) that intersects the flowines (blue). The boundary of the study area is in red. 26
Figure 7. An NWI wetland in green. Blue lines show the NHD Plus HR flowlines, purple lines show the flowlines derived from the digital elevation model. 27
Figure 8. NWI wetland is in green, yellow area shows the complete extent of the upstream accumulation area of the wetland, calculated using the improved method. 28
Figure 9. Boundaries for assessing upslope condition. 28
Figure 10. Calculation of the Score for Wetland Catchment Area relative to Wetland Complex Area. 30
Figure 11. Wetland to stream connectivity example. Left panel: digital elevation model (DEM) and sections of two streams built with the DEM. 33
Figure 12. Elevation information for the three wetland complexes (wc) identified in Figure 11. ...34
Figure 13. Histogram of the five LCA bins used to stratify the randomized sample draw used for wetland assessment surveys. 37

Figure 14. Preliminary stream model results (left) and targeted survey sub-basins (right) for ecological wetland sampling. 38
Figure 15. Schematic of the evaluation areas used in our three-tiered wetland assessment protocols. Please see appendices for detailed descriptions of our assessment protocols. 39
Figure 17. Comparison of data distribution for remotely sensed metrics among sampled wetland complexes (n=20) and all wetland complexes in the Lake Champlain Basin (n=13772). "Upland area" or "wetland catchment" refers to the immediate upslope drainage area that we generated for all wetland complexes. 49
Figure 18. Comparison of data distribution for remotely sensed metrics among sampled wetland complexes (n=20) and all wetland complexes in the Lake Champlain Basin (n=13772). Upland area refers to the contributing upland area that flows into the wetland. 50
Figure 19. Comparison of data distribution for remotely sensed metrics among sampled wetland complexes (n=20) and all wetland complexes in the Lake Champlain Basin (n=13772). 51
Figure 20. Interactive Map screen capture with the layers dialogue open to show where and how to turn on the stream water quality models. 54
Figure 21. Stream sites sampled (kicknet sampling) for stream quality validation (green dots). Twenty sites were sampled over 2021-2022. 55
Figure 22. Predicted stream condition scores plotted against sampled scores for the same reach. HBI is the Hilsenhoff Biotic Index, BAP is the Biodiversity Assessment Profile, and EPT the index for diversity of the taxonomic groups Ephemeroptera, Plecoptera, and Trichoptera. 56
Figure 23. Predicted stream condition, based on HBI, for stream reaches in the NY side of the Champlain Basin. 57
Figure 24. Interactive Map screen capture with the layers dialogue open to show where and how to turn on the layers depicting wetland complexes. 58
Figure 25. The above map shows the distribution of our 2022 wetland ecology assessment sites (n = 20) and sites in our database from previous projects/collaborations (n = 10, 2013-2021). 60
Figure 26. Cross validation of our rapid field condition assessment score (NYRAM) and average landscape condition score (LCA 540 is average score within a 540-m radius buffer around the sample point). Unlike other metrics used in this project, high scores for NYRAM and LCA indicate worse ecological condition. 61
Figure 27. The HBI water quality index was positively correlated with wetland catchment condition (left) and wetland surface water desynchronization metrics (right). This analysis was applied to sites where we had wetland field assessment data and nearby water quality indices (n = 21). 62
Figure 28. Intuitive results from our spatial models indicates that: Upper left) wetlands in poor condition co-occur where the upslope catchment is in poor condition, too. Upper right: Functional capacity in the form of WFD may be compromised by ecological condition of the wetland. Lower graph: Wetlands with a greater percentage of core floodplain area have greater modeled connectivity scores. 63
Figure 29. General layout of the Interactive Map. The four panels are shown with the boxes and making each viewable is controlled by buttons at the circled locations. 64

Project Synopsis


Crown Point Historical Area *by Lydia Sweeney*

This project aimed to develop watershed assessment tools that support wetland and riparian management and stewardship with the goal of improving ecological services such as flood mitigation (Watson et al. 2016), water quality (Bode et al. 2004) and habitat for native species (Faber-Langendoen et al. 2019). These tools can be used to help identify where management and conservation actions should take place, increasing the power and effectiveness of conservation decision making in the Lake Champlain Basin. Our spatial data set and supporting field work complements the management themes and priorities set forth in *Opportunities for Action* ("OFA"; 2022 LCBP). Municipalities and non-governmental organizations (NGOs) will be able to use these tools to prioritize Water Quality Improvement Program (WQIP) activities such as land acquisition for source water protection, abatement of residential/urban nonpoint source pollution, and aquatic connectivity restoration.

Improving water quality, safeguarding drinking water, and maximizing flood resiliency are crucial for supporting vibrant communities and ecological health of the Lake Champlain Basin. Supporting the strategies and tasks identified by the strategic goals outlined in the OFA (Lake Champlain Basin Program 2022) requires science-based management actions. Further, collaboration among entities working in the basin will increase efficacy of management-oriented research and bolster monitoring program efforts through increased visibility and data interpretation tools. To effectively accomplish goals in the OFA, natural resource managers and conservation practitioners need accessible tools that synthesize data and help them prioritize conservation and management actions.

Our strategy in creating these tools was to synthesize information about streams and wetlands, validate this information with field surveys, and then make this information available via an online mapping portal. Outcomes include a better understanding of wetland, riparian, and stream resources in the Champlain basin, and science-based prioritization that maximizes conservation efforts aimed at improving flood resiliency, water quality, and habitat for native species.

The Vermont portion of the Champlain Basin has an online mapping system combining multiple projects, ranging from conservation prioritization to modeling nutrient loading (Farrell et al. 2018). This tool synthesizes a suite of spatial, often Vermont-specific, datasets highlighting areas with high conservation value and areas where management may affect water quality. Such a tool was not previously available for the New York portion of the Champlain Basin and through this project we aimed to create tools with similar utility for partners on the New York side. We developed fine scale, basin-specific analytics that focused on floodwater desynchronization, wetland ecological condition, and stream health. Our modeling efforts leveraged our previous state-wide water quality (White et al. 2011) and riparian modeling (Conley et al. 2018) expertise, and water quality bioindicator data (e.g. from DEC (NYS DEC 2021), and USEPA (2016). With a focus on New York wetlands and streams flowing into Lake Champlain, this project complements work already completed for Lake Champlain and Richelieu River (ILCRRWG 2013, 2015).

The following timeline describes when we worked on project objectives and tasks. Tasks completed are enumerated in the next section.

Timeline

Throughout the entire project we had team meetings and collaborated with partner staff. Project administration and management (Objective F) was ongoing for the duration of the project. Example administrative tasks included QAPP development, communicating/meeting with partners, regular project reporting (Objective F), budgeting, and coordinating tasks (modeling, field surveys). The table below outlines project task dates relative to fiscal quarter. Milestone deliverables or outputs are noted as well.

Table 1. Project objectives, tasks, deliverables, and timeline.

Objective	Task components	Deliverable or Output	Timeline
A. Describe quality assurance procedures that will maintain project performance.	1. Develop a Quality Assurance Protocol Plan (QAPP)	Approved QAPP	Q1 2021
B. Build and validate a spatial model estimating stream water quality in the NY portion of the LCB	2. Build a spatial model estimating water quality	GIS layer of water quality	Q2 2021
	3. Preparations for field work.	Sampling plan and permissions	Q2 2021
	4. Field Sampling, at least 10 sites	Site samples	Q3 2021
	5. Specimen sorting and ID	Curated site data	Q4 2021
	6. Field Sampling, bringing total to at least 20 sites	Site samples	Q3 2022
	7. Specimen sorting and ID	Curated site data	Q4 2022
	8. Specimen curation; Validation analysis	Validation results	Q4 2022
C. Model potential wetland functional capacity to desynchronize floodwater	9. Collect and organize wetland and other data layers	Prepped data	Q3 2021
	10. Calculate metrics for wetland size, wetland cover types, and GIW	GIS data for these metrics	Q4 2021
	11. Calculate floodplain metrics and for interception opportunity of wetlands	GIS data for these metrics	Q1 2022
	12. Calculate metric for upslope condition; roll up.	GIS data for these metrics	Q2 2022
	13. Assess wetland connectivity to streams	GIS data for these metrics	Q3 2021

Objective	Task components	Deliverable or Output	Timeline
	14. Wetland proximity to surface water	GIS data for these metrics	Q4 2021
	15. Detect barriers between wetland and stream	GIS data for these metrics	Q1 2022
	16. Assess proportion of riparian zone that is wetland; roll up	GIS data for these metrics	Q2 2022
D. Develop ecological condition estimates for wetland units across the NY portion of the Lake Champlain Basin	17. Remote condition assessment of wetlands	GIS data, L1 assessment	Q2 2022
	18. Prep for field work	Site data	Q2 2022
	19. Wetland field surveys of at least 10 sites	Site data	Q3 2022
	20. Wetland field surveys to bring the total to at least 20 sites	Site data	Q4 2022
E. Make data available to users online	21. Organize data to include in the online tool	Collected, structured data	Q3 2022
	22. Develop a mockup of the site and explore online tool components	An organized mockup and production plan	Q4 2022
	23. Finalize and publish the online tool	Website for public use	Q1 2023
F. Maintain timely project administration and reporting	24. Project oversight, complete quarterly report	Approved report	Q1 2021
	25. Project oversight, complete quarterly report	Approved report	Q2 2021
	26. Project oversight, complete quarterly report	Approved report	Q3 2021
	27. Project oversight, complete quarterly report	Approved report	Q4 2021
	28. Project oversight, complete quarterly report	Approved report	Q1 2022
	29. Administer project, complete quarterly report	Approved report	Q2 2022
	30. Project oversight, complete quarterly report	Approved report	Q3 2022
	31. Project oversight, complete quarterly report	Approved report	Q4 2022
	32. Project oversight, complete final report: compile project summary, maps, results, etc.	Final report	1/31/2023
QAPP expiration date		QAPP valid through this date	7/31/2023

Tasks Completed

The following task list describes the steps we took to accomplish each project objective. We articulate an iterative approach for developing and refining our estimated water quality and wetland/riparian spatial models. Field data collected during this project were used to test the accuracy of our model outputs and provide baseline information on native species biodiversity and ecological condition.

Objective A. Develop a detailed Quality Assurance Project Plan
Task 1. Wrote the QAPP, submitted for approval, revised as needed.
Output: a final, approved QAPP on April 14, 2021.

Objective B. Build and validate a spatial model estimating stream water quality in the NY portion of the Lake Champlain Basin
Task 2. Model development: Used partner biomonitoring data to build a model estimating water quality.
Output Task 2: Predicted water quality scores for stream reaches in the study area.

Tasks 3-7. Prepared for field work. Field sampled to evaluate water quality model results. Sorted and identified specimens.
3. Prepared for field sampling, in the office: develop sample draw of sites, site review, access permissions, permits, data collection design and development, gear preparation.
4. Field sampled in 2021 to evaluate water quality model results, at least 10 sites.
5. Sorted and identified specimens.
6. Field sampled in 2022, bringing total to at least 20 sites.
7. Sorted and identified specimens.
Output Tasks 3-7: Curated aquatic insect presence data for the sampled sites.

Task 8. Water quality model validation.
Output Task 8: Calculated model validation metrics reflecting the relative accuracy of the predicted water quality scores produced in Task 2.

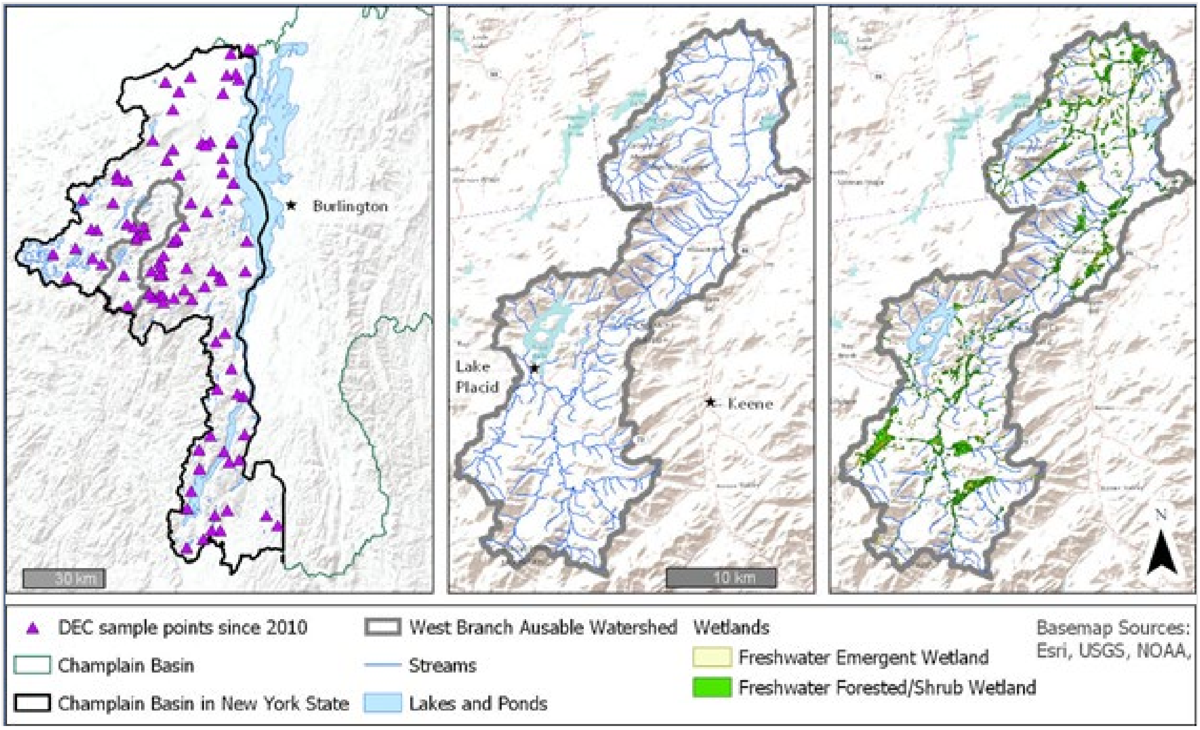


Figure 1. Left: Black outline delineates the NY portion of the Champlain Basin, the focus of our project, with NYS DEC biomonitoring data collection points since 2010 (purple triangles). The middle and right panels zoom in to an example HUC 10 watershed, West Branch Ausable (outlined in grey) and illustrate mapped streams (NHD, middle panel) and wetlands (NWI, right panel) in the watershed. Note the high resolution of streams and diversity of wetland sizes and positions with respect to stream location.

Objective C. Estimate potential wetland functional capacity to desynchronize floodwater

Tasks 9-12. Ranked wetland complexes by their opportunity and relative capacity to slow water movement into streams.

9. Aggregated, prepared, and organized wetland data and other data layers for analyses.
10. Calculated metrics for wetland size, wetland cover types, and geographically isolated wetlands.
11. Calculated floodplain metrics for interception opportunity of wetlands.
12. Calculated metric for upslope condition, rolled up metrics into a combined desynchronization score.

Output for Tasks 9-12: Calculated metrics for each wetland within the study area, estimated as best as possible, the ability of the wetland to desynchronize flood pulses.

Tasks 13-16. Stream-Floodplain connectivity ranking: overbank flooding (flood pulse)

13. Assessed wetland connectivity to streams.
14. Assessed wetland proximity to surface water.
15. Detected barriers between wetland and stream.
16. Assessed proportion of riparian zone that is wetland, rolled up individual metrics into a combined score.

Output for components 13-16: Calculated metrics for each wetland within the study area, estimated as best as possible, the connectivity between stream and wetland and a combined scoring for wetlands in the study area.

Objective D. Model ecological condition for all wetland units across the NY portion of the Lake Champlain Basin and validate these estimates with field sampling
Task 17. Conducted remote ecological condition assessment (Level 1) of wetlands
Output for Task 17: Level 1 condition estimates for wetlands in the study area.

Task 18-20. Prepared for wetland field surveys: ecological/functional assessment, model validation, targeted surveys of high-quality wetlands.
18. Prepared for field sampling, in the office: site choice, access permissions, permits, data collection design and development, gear preparation.
19. Wetland field surveys of at least 10 sites.
20. Wetland field surveys to bring the total to at least 20 sites.
Output for Tasks 18-20: Field data and the generated condition scores for the sampled wetland sites.

Objective E. Provide an interactive tool to decision makers and the public for viewing and using these data
21. Organized data to include in the online tool.
22. Developed a mockup of the site and explored online tool components.
23. Finalized and published the online tool.
Output: An interactive online mapper that displays spatial model outputs and provides interpretation guidance.

Objective F. Efficiently and effectively administer all participants and components of this project, submit and obtain approval for all progress reports, and submit and obtain approval for a final report

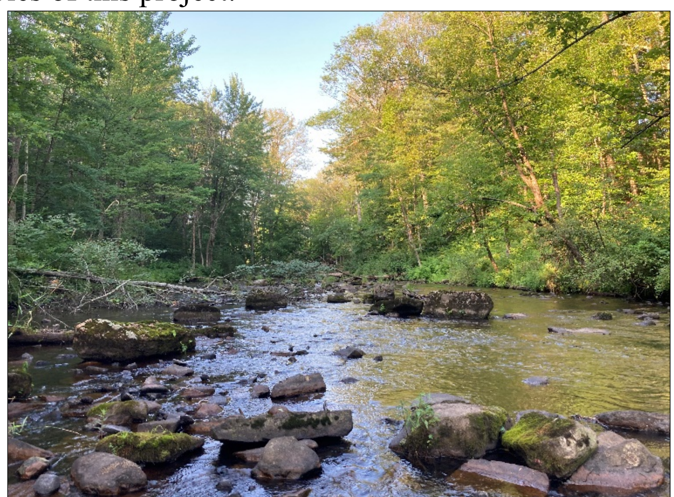
24. Conducted project oversight, submitted progress report for Q1 (Jan – Mar) 2021
25. Conducted project oversight, submitted progress report for Q2 (Apr - June) 2021
26. Conducted project oversight, submitted progress report for Q3 (July - Sept) 2021
27. Conducted project oversight, submitted progress report for Q4 (Oct – Dec) 2021
28. Conducted project oversight, submitted progress report for Q1 (Jan – Mar) 2022
29. Conducted project oversight, submitted progress report for Q2 (Apr - June) 2022
30. Conducted project oversight, submitted progress report for Q3 (July - Sept) 2022
31. Conducted project oversight, submitted progress report for Q4 (Oct – Dec) 2022, deferred by permission to include with final report
32. Conducted project oversight, completed final report January 31, 2023
Output: Approved quarterly reports and a final report.

Methodology

OBJECTIVE B. BUILD AND VALIDATE A SPATIAL MODEL ESTIMATING STREAM WATER QUALITY IN THE NY PORTION OF THE LAKE CHAMPLAIN BASIN

The NYS DEC Stream Biomonitoring Unit's (SBU) database (NYS DEC 2021) was the source of data for analyses of the diversity of aquatic macroinvertebrates and water quality indices in Task 2, developing a model to estimate water quality. The SBU's standard operating procedures (NYS DEC 2019) document the quality control methods, corrective procedures, and accuracy of data collected as part of biological monitoring. Their dataset included information for 181 sample events (a subset shown in Figure 1), with sampling years ranging from 2008 to 2019. Fewer than 4% of their sample sites had repeat (redundant) data. How we addressed redundant data is outlined in Table 2. The preliminary water quality models were developed using these data.

We next acquired the National Hydrography Dataset High Resolution Plus (NHD Plus HR) 1:24,000 scale stream set for the 4-digit Hydrologic Unit – 0430. We supplemented the data provided in the Value-Added Attributes that ship with the NHD Plus HR (https://www.usgs.gov/core-science-systems/ngp/national-hydrography/nhdplus-high-resolution) with additional metrics derived for the streams and catchments describing geology, land cover, and landforms. We modeled these calculations on metrics used in earlier stream water quality modeling projects, the Northeast Aquatic Habitat Classification (Olivero and Anderson 2008). We used the newly released "xstrm" python package (Wieferich et al. 2021) to help calculate upstream areas for each stream reach, allowing us to include metrics for landcover, geology, and landform cover in the upstream accumulation area as well. A stream reach is the smallest unit in the NHD Plus HR dataset and these units are extremely variable in length. The final attributed stream set for the entire basin is provided in a geodatabase as one of the deliverables of this project.


Salmon River *by Erin L. White*

Using the NHD Plus HR stream dataset, we attributed the nearest stream segment with five calculated water quality indices based on stream macroinvertebrate biodiversity. Richness of mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) found in an average 100-organism subsample is the EPT index. Species Richness is the total number of species or taxa found in a sample. Percent Model Affinity (PMA) is a measure of a sample's similarity to a high quality non-impacted "reference" community, based on percent abundance in seven major macroinvertebrate groups. The Biological Assessment Profile (BAP) of index values is a method of plotting biological index values on a common scale of water quality impact. The Hilsenhoff Biotic Index (HBI) summarizes the tolerance of the insects sampled to pollutants (Hilsenhoff 1988, 2017). Values from these indices – Species Richness (SPP), EPT richness (EPT), Hilsenhoff Biotic Index (HBI), Percent Model Affinity (PMA) are converted to a common 0-10 scale (NYS DEC 2019). The SBU samples macroinvertebrates statewide in riffles of rivers and streams. In wadable streams, they use kicknets. Kicknet sampling does not yield reliable abundance estimates, only richness estimates. Metrics measured from macroinvertebrates collected using the SBU Standard Kicknet method were included in our analyses. We expected to model at least two biological water quality indices, including Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) richness (EPT richness), and Biological Assessment Profile (NYS DEC 2019). Likewise, model validation was completed using the standard kicknet method.

We expected variability in the input data sets used for our spatial modeling. We minimized sources of variability that affect spatial analyses by converting all spatial data layers to the same projection (NAD 83 UTM Zone 18) and ensured our modeling footprint extended to include all small tributaries within the watershed. We visually checked inputs and outputs to ensure they represented what we intended. Most important was whether the variability we detected in our estimated functional metrics was truly representing the variability measured on the ground.

When attributing water quality metric data to stream reach, we used the near function in ArcGIS to grab the closest stream reach, omitting kicknet points that are >100 m from a reach. When two or more collection points were closest to the same stream segment, we followed the QAPP, choosing to average values (four cases) or use the more recent value (two cases), as shown in Table 2.

Once we had all water quality indices attributed to stream reach in the study area, we then combined the information and represented these data consistently in GIS. For each of the metrics, we used the "Random Forests" algorithm (Breiman 2001, Cutler et al. 2007) from the randomForest package in R (Liaw and Wiener 2002) to model the relationship between environmental variables and observed measures. We followed this procedure:

Table 2. Of the samples provided by NYS DEC Stream Biomonitoring Unit (SBU) fewer than 4% had more than one sampling event for a single stream reach (redundant sampling). We evaluated the redundant data for each site, outlining our course of action in the table below. Redundant samples collected in similar time frames were averaged because they were within an order of magnitude.

SBU Sample ID	SPP	EPT	HBI	BAP	PMA	Sample year	Stream segment ID	Modeling decision
10-ADKS11_2005-3.2	5.29	5.91	7.31	6.01	2.98	2011	60000200026965	Drop older
10-ADKS12_257-0.7	8.33	10	9.36	8.88	8.94	2012	60000200026965	Use most recent
10-GULB-0.1	7.35	9.5	8.58	7.9	8.27	2018	60000200013772	Use mean
10-GULB-0.6	6.76	9.5	9.39	7.84	8.08	2018	60000200013772	Use mean
10-NMOW_T1-1.7	5.29	6.82	8.73	7.44	8.85	2019	60000200042262	Use mean
10-NMOW_T1-1.8	7.35	7.27	9.84	8.23	8.75	2019	60000200042262	Use mean
10-SABL_W_T27-0.1	8.06	9	7.24	6.79	5.97	2019	60000200010101	Use mean
10-SABL_W_T27-0.2	8.33	8	7.48	7.86	7.6	2019	60000200010101	Use mean
10-SENT-0.1	6.47	9	7.28	7.44	5.81	2019	60000200005846	Use mean
10-SENT-0.3	9.17	9	7.6	8.49	8.75	2019	60000200005846	Use mean
10-WSBR-0.2	8.89	8.5	7.74	7.3	9.62	2018	60000200062817	Use most recent
10-WSBR-1.0	6.18	9	8.24	7.89	8.56	2013	60000200062817	Drop older
10-WSBR-0.5	NA	NA	NA	NA	NA	NA	60000200062817	Drop incomplete

1. Attributed all stream reaches in the Lake Champlain Basin watershed with environmental variables. We used the NHD Plus HR (https://www.usgs.gov/core-science-systems/ngp/national-hydrography/nhdplus-high-resolution) as our base dataset.
2. Extracted those stream segments with observed EPT data. We had 125 observations in our final data set.

3. Used kicknet sample data for EPT, SPP, PMA, HBI, and Biological Assessment Profile (BAP).
4. Ran the regression trees option within the randomForests package in R, using only the observed data. Model fits are described below.
5. Used the relationship modeled in step 4 to predict the value for each metric throughout the rest of the Basin. Because we used only kicknet data, we removed segments with size classes 4 and 3b (large rivers and medium mainstems) from the model output. The modeled metrics were only applicable for the wadable riffles of the remainder of streams and are provided as a feature class in a geodatabase deliverable.

Model fits for each of the variables are reported in the table below. The Hilsenhoff Biotic Index performed the best of the five metrics, with 32% of the variance explained while Species Richness had the worst performance.

Table 3. Stream condition metrics modeled in the basin and the internal validation results reported by the random forest package.

Water quality metric	% Variance explained
Hilsenhoff Biotic Index (HBI)	31.88
Biologic Assessment Profile (BAP)	23.95
EPT richness (EPT)	21.65
Percent Model Affinity (PMA)	20.17
Total Species Richness (SPP)	2.97

The field sampling component of Objective B (Tasks 4 and 6) targeted locations not surveyed by NYS DEC in 2018. We used the water quality model outputs to generate a sampling design (list of sampling sites) distributed along a gradient of predicted water quality.

To prepare for field sampling (Task 3), we chose sites for invertebrate sampling based on a random selection of streams in the Lake Champlain Basin of varying quality based on model predictions. As the HBI had the best model fit of all the water quality indices, we used this model to stratify our field validation sampling design using the Generalized Random Tessellation Stratified (GRTS) methodology. We used the R Statistical package *spsurvey* to conduct a spatially balanced random sample of stream segments, stratified by predicted stream quality (Stevens and Olsen 2003, 2004, Kincaid and Olsen 2011). To complete our sampling plan, we generated random sample draw of points stratified along a gradient of predicted water quality, with an "overdraw" of back-up sites. Sites were also selected to either intersect a road, public land, or fishing access to streamline field preparations due to our tight timeline prior to the beginning of sampling.

Initial site evaluation of the random sample point was conducted remotely using ArcGIS mapping software, reviewing sites for sampling and access issues. If a point was rejected, we replenished from the stratified overdraw. In the field, if the intended site was inaccessible or didn't meet our sampling criteria staff were prepared with alternate sites, usually another site from the random draw or an adjacent stream.

Macroinvertebrate stream surveys were completed at 20 sites with wadeable streams (Tasks 4 and 6) using a kicknet sampling protocol aligned with our previous water quality work, and methods used by NYS DEC (White et al. 2014, Henschell et al. 2018, NYS DEC 2019). Sites were simply point locations in a riffle section of a stream that were accessible for sampling (1 m depth or less). These point sample locations were associated in GIS with the NHD-defined stream reach that they fell on. Field data collected followed NYS DEC SBU's field data sheets, section 18.1 and 18.3 of SOP (NYS DEC 2019). Habitat condition assessments were performed at every site and benthic macroinvertebrates were collected using the traveling kick sampling method according to Stream Biomonitoring Unit protocol (NYS DEC 2019). A dip net was held downstream from the sampler, who disturbed the substrate and moved one meter per minute downstream on a diagonal transect for 5 meters. A habitat condition assessment of physical characteristics was completed by looking downstream and upstream of the area sampled.


Erin White performing kick-net sampling *by Amos Barnes*

To reduce variability in the invertebrate sampling, we limited our sampling between the months of July and September when similar invertebrate assemblages may be detected across sites and reduced oligochaetes are present compared to earlier season assemblages. We also followed NYS DEC protocol for selecting microhabitats for kick-net samples to optimize detection and reduce variability across sites (NYS DEC 2019).

Individual invertebrate sample containers were marked to identify collection date, sample collector and location. Containers were labeled using a waterproof label and pencil to prevent loss due to contact with sample preservative or water. Labels were placed inside the container with the sample. Sample containers required for preservation, transport, and storage of sample material were plastic with a screw top lid and a volume of approximately one quart. If sample containers were re-used, they were rinsed under regular tap water a minimum of three times.

All field staff followed travel and safety protocols outlined by the SUNY Research Foundation and SUNY ESF for travel during the COVID-19 pandemic, such as social distancing, hygiene, and mask wearing. To prevent the spread of invasive species among sites, all field staff (for all field components of this project) decontaminated boots and other gear using brushes and a dilute bleach solution in a hand-held pump pressure sprayer, and then rinsed gear using tap water. If problems occurred during sampling, corrective action was taken and documented in our reports to Lake Champlain Basin Program and NEIWPCC.

For Tasks 5 and 7, aquatic macroinvertebrate samples were sorted according to Behar and Cheo (2004), which consisted of a 100 organism sample. We completed sorting in a tray divided into six sections. A single section was randomly chosen to pick organisms from, then subsequent sections were sampled until at least 100 organisms were reached in the subsample. Each section must be fully picked once started. For example, if we reached 80 organisms, there were still 20 needed to meet subsample requirements, so another section was randomly chosen. There were cases where all organisms were picked from the entire sample, but due to low abundance at the site, the total was less than 100 organisms. Finally, we scanned the entire sample for large instars and new taxa not previously obtained in the subsample and included those. We then identified the sample to family level. Raw data collected was analyzed and the following metrics were calculated according to procedures of the Hudson Basin River Watch and using their benthic macroinvertebrate family level data sheets and calculators (Behar and Cheo 2004): Family richness, family EPT richness, Hilsenhoff family biotic index, PMA, and BAP.

Processed samples have been archived and are easily accessible for re-processing if needed. The remaining unprocessed sample material will be retained for at least one full calendar year. After one calendar year, all sample material may be discarded. Disposal consists of straining all alcohol from sample material and flushing it with copious amounts of water down a sink drain before disposing of all the material.

OBJECTIVE C. ESTIMATE POTENTIAL WETLAND CAPACITY TO INTERCEPT AND DESYNCHRONIZE FLOODWATER

After aggregating, preparing, and organizing wetland data and other data layers for analyses (Task 9), we modeled the New York portion of the Lake Champlain Basin using regionally-specific data layers produced by government agencies (e.g., NHD Plus HR), researchers working in the basin, and our previous research (e.g., Conley et al. 2018). Critical data features generated are outlined below in Roman numeral bullet points. Ecological systems and particularly wetlands are heterogenous and therefore express high levels of variability.

Section 1. Ranking wetland complexes by their opportunity and relative capacity to detain and desynchronize sheetflow and surface water flow.

Intercepting and detaining precipitation, snowmelt, and overland flow before it reaches surface water plays a crucial role in protecting water quality, recharging groundwater resources, and desynchronizing peak flow in streams and rivers (U.S. EPA 2015). Wetland context and composition also play important roles in determining wetland functional capacity. Ecological degradation compromises intrinsic functional capacity (water filtration, wildlife habitat, etc.), a threat that is particularly relevant for managing drinking water supplies, aquatic resources, and mitigating extreme storm events (e.g., U.S. EPA 2015). Factors such as adjacent upland buffer health and legacies of historical land use are reflected in the expressed wetland community we see today. For example, our previous research found that wetland ecological integrity scores reflect anthropogenic disturbance in space and time (Shappell and Howard 2018). Outlined below are a few factors assessed when ranking wetlands for this function:

i. Wetland size (Task 10). At a broad landscape scale, larger wetlands can absorb and detain larger volumes of water.
ii. Wetland cover type(s) (Task 10). Forested wetlands, for example, tend to have greater structural heterogeneity and higher rates of evapotranspiration compared to herbaceous marshes. We used data from National Wetland Inventory map codes to calculate coarse and fine scale "richness" of wetland assemblages that were merged to generate contiguous wetland polygons (e.g., the number of different wetland class or subclass polygon types that were merged together to create the wetland complexes).

iii. Geographically isolated wetlands (GIWs, Task 10). For modeling purposes, we defined geographically isolated wetlands as those >30 m from mapped surface waters (stream, lakes, ponds). Importantly, GIWs naturally detain overland flow from adjacent uplands. Although GIWs are surrounded by uplands, they are not functionally isolated as they still have hydrological, biological, and chemical connections to downstream systems (e.g., subsurface flow, groundwater recharge; (U.S. EPA 2015).

iv. Floodplain wetlands (Task 11). Building on our previous work (Conley et al. 2018, White et al. 2011), we generated a spatial layer of the floodplain identifying riparian base zones, wetflats, and material contribution zones. We also identified headwater wetland complexes along terminal- and lateral-source streams, which may co-occur with groundwater discharge zones (e.g., terminal source of coldwater streams (U.S. EPA 2015). *This output layer may also be used to identify priority areas for floodplain protection and restoration* (i.e., science-based technical tools useful for OFA Task I.C.1.b).

v. Interception opportunity relative to human land use cover types (Task 11). From an anthropogenic values perspective, wetlands downslope from impervious surface or agricultural lands are particularly important for intercepting and filtering upslope sheetflow and subsurface flow that may contain pollutants. However, ecological condition of the catchment draining into the wetland has an equally important role in protecting surface water quality. Employing methods developed by Shappell and Howard (2018), we generated discrete draining catchments ("wetland catchments") for all wetland complexes generated in Task 9, and calculated catchment metrics such as proportion of impervious surface, natural landcover, etc. for areas upslope of each complex.

vi. Wetland Watershed Condition (WWC) condition for mapped stream segments (Task 12). Land cover and the intensity of land use in the wetland catchment has important implications for the health of downslope ecosystems. For example, higher levels of impervious surface in the catchment reduce soil infiltration opportunity, instead causing horizontal sheetflow that more rapidly conveys water and pollutants downslope (or to a stormwater management system). Catchments with higher levels of impervious surface, for example, would contribute relatively more to the flashiness of a stream during a rain event. This is a metric for the catchment or stream segment, not wetland, but was calculated to help us understand the role of landscape composition on flow attenuation in the study area.

For Task 10, we created a master set of wetlands based on National Wetland Inventory polygons, excluding any NWI wetlands that were classified as Lakes, Ponds, or Rivers. Examination of the preliminary set revealed gaps in wetland areas caused by the omission of beaver-impacted wetlands (PABHb) from the initial subset, so we added all 'PABHb' attributed NWI wetlands to an updated wetland selection. The individual wetland polygons from the above selection were combined to create wetland complexes (contiguous wetland units) by uniting all wetlands within 30 meters of each other into a single complex.

We calculated metrics based on the NWI cover class and water regime codes for wetlands in each wetland complex. Wetland complexes were assessed based on their area in acres, the proportion of the complex that was covered by course cover classes, the diversity of water regimes, and richness of unique wetland types (as described by the NWI attribute code).

We created a subset of the NHD Plus HR flowlines for use in the identification of geographically isolated wetlands. This selection included NHD Flowlines, NHD Waterbody polygons and NHD Area polygons, according to the criteria outlined in Lane and D'Amico (2016). We also included FTYPE= "334" classified NHD Flowlines ("connectors") in the selection. These features were all buffered 30 meters and any wetland complex which intersected the buffered water features were considered to be connected to surface water, while those that did not intersect were geographically isolated.

We identified potential headwater wetlands by identifying all wetland complexes that intersected or came within 30 meters of a 1st order NHD Flowline. A Strahler stream order of 1 indicates a flowline which has no tributaries and is used by the NHD to indicate headwater segments. We removed from this initial group any wetlands that were also within 30 meters of higher order streams or waterbodies. This removed wetlands that fell along the intersection of a 1st order stream and a large lake or a larger river, which would not be considered a headwater wetland. The remaining wetlands were flagged in the attribute table as potential headwater wetlands (value = 1). We used the term potential because the wetlands flagged are not solely those located at the terminus of the 1st order streams, but anywhere along that flowline as long as it is not proximate to higher order streams or waterbodies. Time did not allow us to manually select only those wetlands at the stream terminus.

Crown Point Historical Area floodplain forest *by Greg Edinger*

In preparation for calculating landcover for the wetlands and wetland complexes, we reviewed landcover data for the entire Lake Champlain basin, developed from earlier LCBP projects and received from the LCBP (see https://www.lcbp.org/our-goals/clean-water/data-monitoring/lake-and-watershed-data/). The review revealed several areas where landcover classification and aerial imagery suggested the existence of wetlands, but no corresponding wetland existed in the NWI data set. For this reason, we decided to create a second "master" set of wetlands based directly upon the landcover classification. We created individual wetland polygons based on any areas that had been classified in the landcover raster as water, emergent wetland, shrub scrub wetland, or forested wetland. Wetland complexes were created, as with the NWI polygons, by combining all derived wetland polygons within 30 meters of each other. To control for a single pixel being treated as a wetland, we dropped any complexes smaller than 0.01 acre. We also removed water polygons greater than 2 hectares. The resulting remotely classified wetland complexes varied in size from 0.01 acre to over 83,000 acres and suffered from an abundance of misclassification in suburban areas, where pavement was classified as water, creating wetlands in many driveways.

We explored potential alternate representations of wetlands to select the best base unit for our wetland complexes from the data available. We had created a new set of wetland boundaries based on the land use classifications of the 1m land cover data, described above. The landcover-derived wetland polygons (available in the geodatabase "LakeChampLandcoverDerivedWetlands_LCBasin_NYNHP") represented significantly more habitat than those defined by NWI, including some wetland areas not included in the National Wetland Inventory data set. However, the extent of misclassification of non-wetland habitat as wetland in the landcover data made the resulting wetland units unreliable, and we made the decision to use the National Wetland Inventory polygons as our base data (Figure 2).

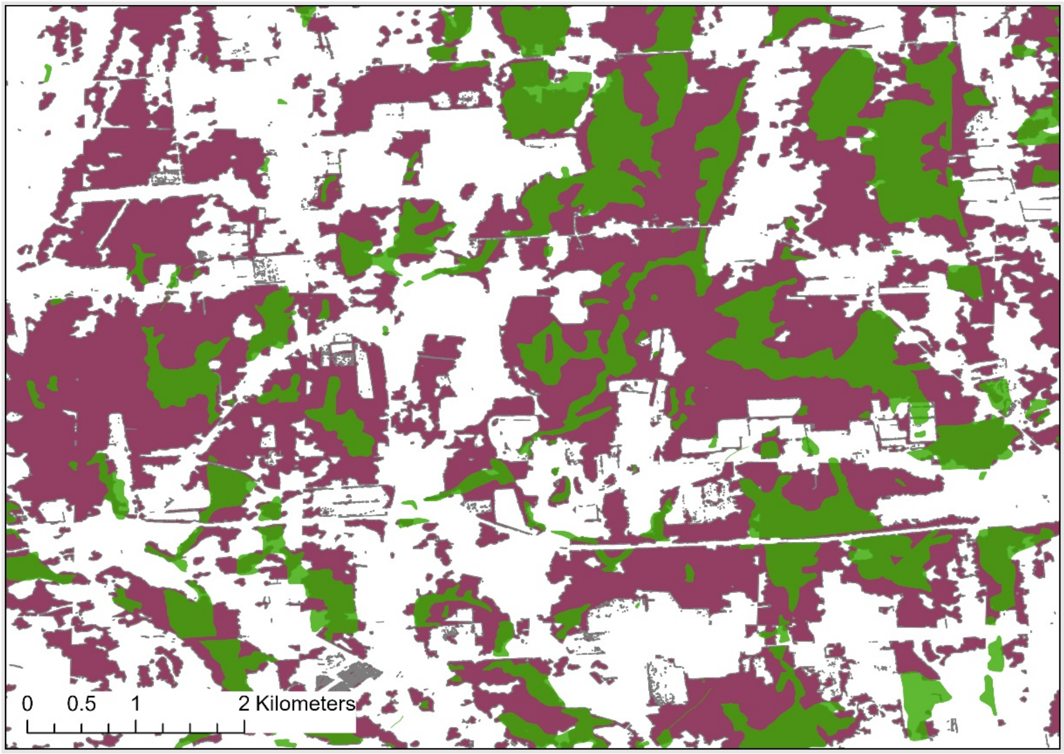


Figure 2. Comparison of wetland complexes as defined using high resolution landcover data (purple) or wetlands from the National Wetland Inventory (green).

For Task 11, our first step was to delineate the boundaries of floodplain complexes in the Lake Champlain basin necessary for calculating floodplain metrics for the wetland complexes. The Active River Area (ARA) spatial model provides an assessment of the boundaries of the riparian area, wetflats, and material contribution zones and is also the base data for identifying Floodplain Core Areas.

We recreated the ARA using our high resolution stream set and 1-meter digital elevation model following the methods used by The Nature Conservancy (TNC, Smith et al. 2008). We used the 1-meter digital elevation model for the Lake Champlain Basin to derive the necessary fine scale models of slope, flow direction, and flow accumulation. The ArcTool box provided by TNC for recreation of the ARA product is no longer functional, so we recreated the tool output manually as outlined in the ARA Three-Stream Class (3SC) Toolbox Documentation. The following is a list of the user inputs we used when following the toolbox protocol; for full details, consult the Active River Area Toolbox Documentation:

- Model inputs:
    - 1:24K stream network with stream order, we used the NHD Plus HR
    - Digital elevation model (DEM) – we used a 1-meter DEM of the Lake Champlain Basin
- Categorize streams and rivers by size class
    - The Active River Area protocol uses Cost Distance methods that are stratified by the size of the streams. Following the protocol, we divided streams into three classes,

determined by the assigned StreamOrder from the NHD Plus HR. The NHD uses Strahler stream order to assign StreamOrder based on the number of tributaries. Headwaters have a StreamOrder of 1, and order increases with increasing branching. Within the Lake Champlain Basin StreamOrder values for NHD Flowlines ranged from 1-10.

    i. Headwater/small stream class: 1st, 2nd, 3rd order streams
    ii. Medium rivers: 4th, 5th, 6th order streams
    iii. Rivers: 7th order and above

  - We also divided the waterbody polygons into the same classes based on the maximum stream order of flowlines intersecting the waterbody.

- Create Cost Distance, Slope, and Flow Accumulation Surfaces
  - The cost distance rasters were built following the protocol
    i. Slope: We derived a slope (degree) raster from the unfilled DEM
    ii. Flow accumulation: is a measure of accumulated flow in each cell, based on the accumulating the weight of all cells flowing into that cell. Areas of high flow accumulation are areas of concentrated flow, and can help identify stream channels, and areas of low accumulation represent local topographic highs and can help identify ridges.
    iii. Cost Distance: The least accumulative cost distance for each cell over a cost surface, based on Slope.
- Reclass Cost Distance Raster
  - Reclass the cost distance grids for each stream size class based on thresholds to create a base riparian zone raster
  - Following the ARA protocol, thresholds varied based on the stream size class and the average slope of the HUC12. The ARA toolbox provides four stream size classes for selecting appropriate thresholds, and after comparing the sizes of our large rivers with the descriptions, we did not use the thresholds for the largest river size group, so for our three size classes we used the ARA recommended thresholds for "Headwaters", "Small Rivers", and "Medium Rivers".
- Create Moisture Index to Build WetFlats
  - We generated a moisture index based on slope and flow accumulation to identify areas that are likely to be wet as a result of high groundwater and overland runoff from adjacent uplands. We calculated the focal mean of the moisture index according to the protocol. Based on comparison of the focal mean of the moisture index and mapped wetlands, we used a focal mean threshold of 500 for wetflats.
  - We identified all wetflat areas that overlapped with the riparian base zone and the wetflat grab zone (2 x the cost distance of the base riparian zone).
- Generated Non-Headwater Material Contribution Zones
  - We created a buffer of 100m around all streams to delineate material contribution zones and combined it with the base zone and wetflat zones.
- Combined Outputs for Final Active River Area
  - We followed the protocol to combine the riparian base zone, wet flats, and material contribution zones for all three stream size classes.

- The resulting Active River Area (ARA) product is a continuous raster with the final class values:
    i. Headwater riparian base zone, non-wetflat = 2
    ii. Medium rivers riparian base zone, non-wetflat = 5
    iii. Rivers riparian base zone, non-wetflat = 7
    iv. Headwater riparian base zone that occurs on wetflat cells = 22
    v. Medium rivers riparian base zone that occurs on wetflat cells = 55
    vi. Rivers riparian base zone that occurs on wetflat cells = 77
    vii. Headwaters non-headwater material contribution zones, non-wetflat = 200
    viii. Medium rivers non-headwater material contribution zones, non-wetflat = 500
    ix. Rivers non-headwater material contribution zones, non-wetflat = 700
    x. Headwaters non-headwater material contribution zones, wetflat = 222
    xi. Medium rivers non-headwater material contribution zones, wetflat = 555
    xii. Rivers non-headwater material contribution zones, wetflat = 777
- We created a subset of this to include only the riparian base zone (classes 2,5,7,22,55,77) (Figure 3).

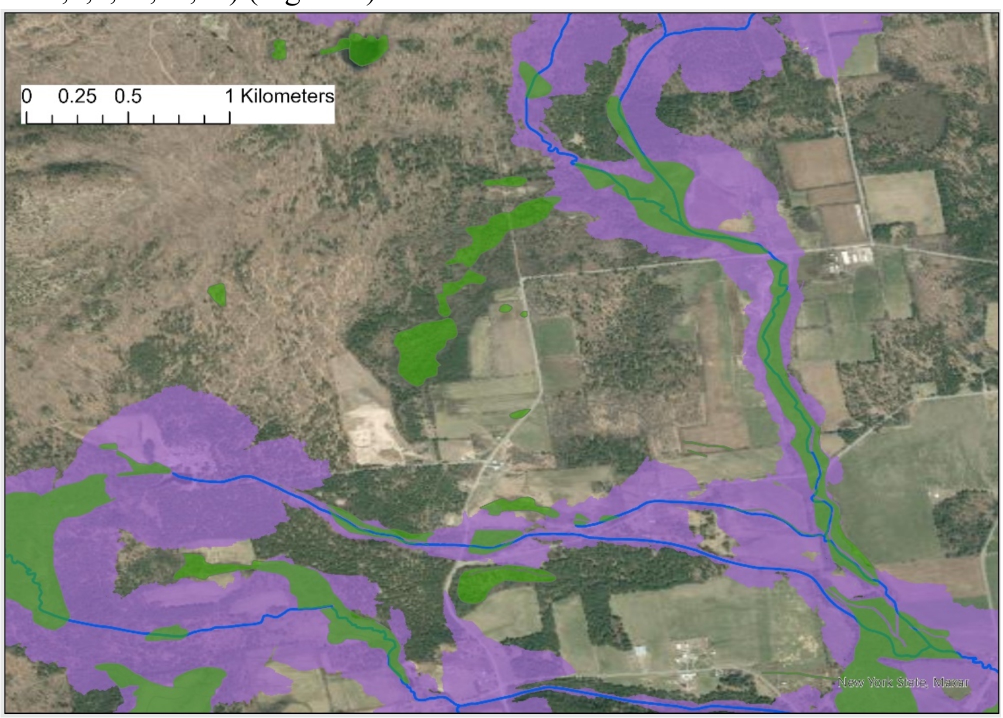


Figure 3. Example of the base riparian zones of the Active River Area for a portion of the project study area. Boundaries of the Active River Area are in purple, nearby National Wetlands Inventory wetlands are in green, and the National Hydrography Dataset flowline is in blue.

- Floodplain Cores: To create floodplain cores, we intersected the riparian base zone areas of the ARA with natural habitat classes from the Lake Champlain Land Use Classification (Water, Deciduous Forest, Coniferous Forest, Herbaceous, Shrubs, Emergent Wetlands, Scrub Shrub Wetlands, Forest Wetlands, and Barren Soil). The resulting areas described natural land within the riparian base zone. We divided these areas into contiguous patches. Patches that were greater than 150 acres were included as Floodplain Cores. Finally, we created a measure for each wetland complex reflecting the amount of complex falling within these floodplain cores by calculating the proportion of wetland complex area that was a part of the floodplain core, percent core floodplain (PCF).

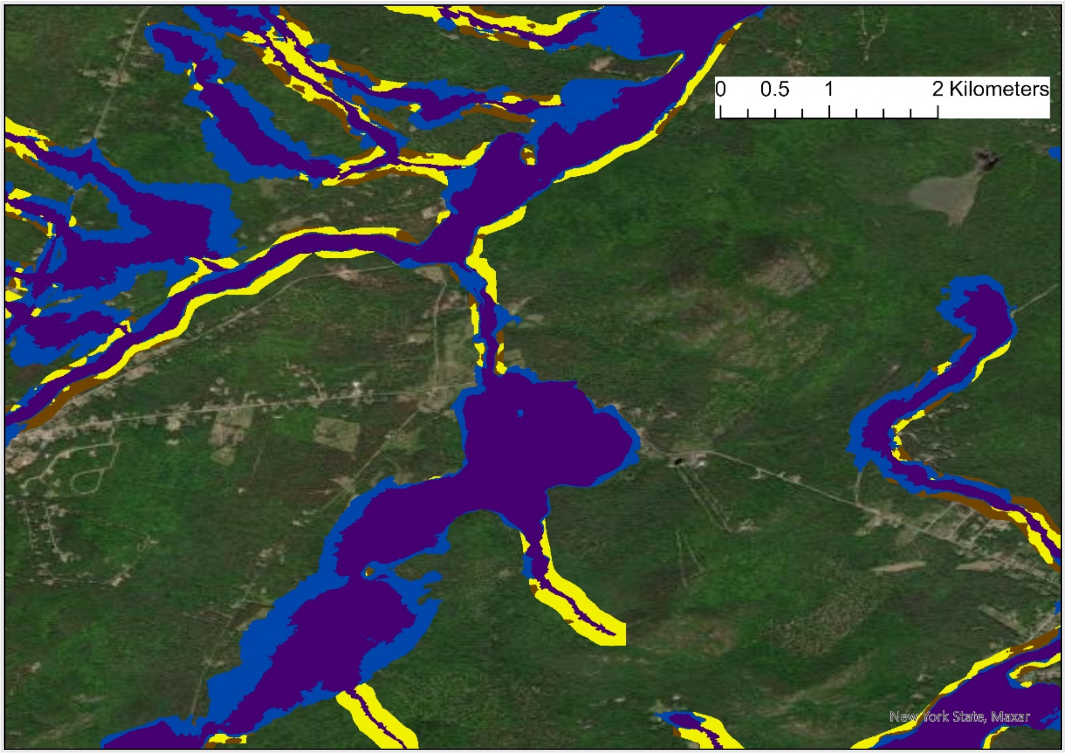


Figure 4. Active River Area: The active river area is composed of the main riparian zone in purple, riparian wet flats in blue, and material contribution zones: wet (brown) and dry (yellow).

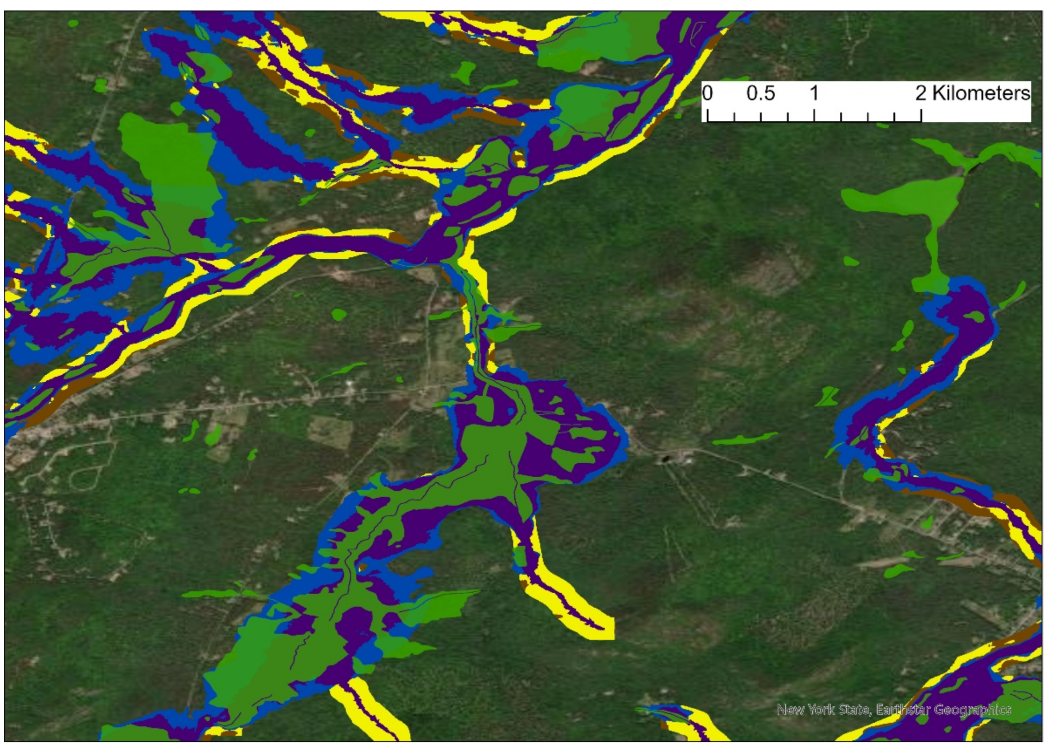


Figure 5. Active River Area with wetland complexes in green.

Building Wetland Catchments

We assessed the interception opportunity of wetlands (Task 11) using a method created earlier to delineate all the lands upslope from a target point (https://www.nynhp.org/epa-adjacent-areas). The original methods were modified to more accurately delineate the full extent of habitat upslope from each wetland and capitalize on the smaller study area and finer scale elevation model available for this project. Instead of only considering upslope areas within 1 kilometer of the wetland, we created a flow direction raster for the entire basin. In theory, this would allow the script to assess the entire upstream area for each wetland. However, initial tests of the new delineation methods showed that in the case of wetlands that intersected the flowlines of rivers and streams, the resulting upstream accumulation area included the accumulation area of the flowline as well as the wetland (Figure 6).

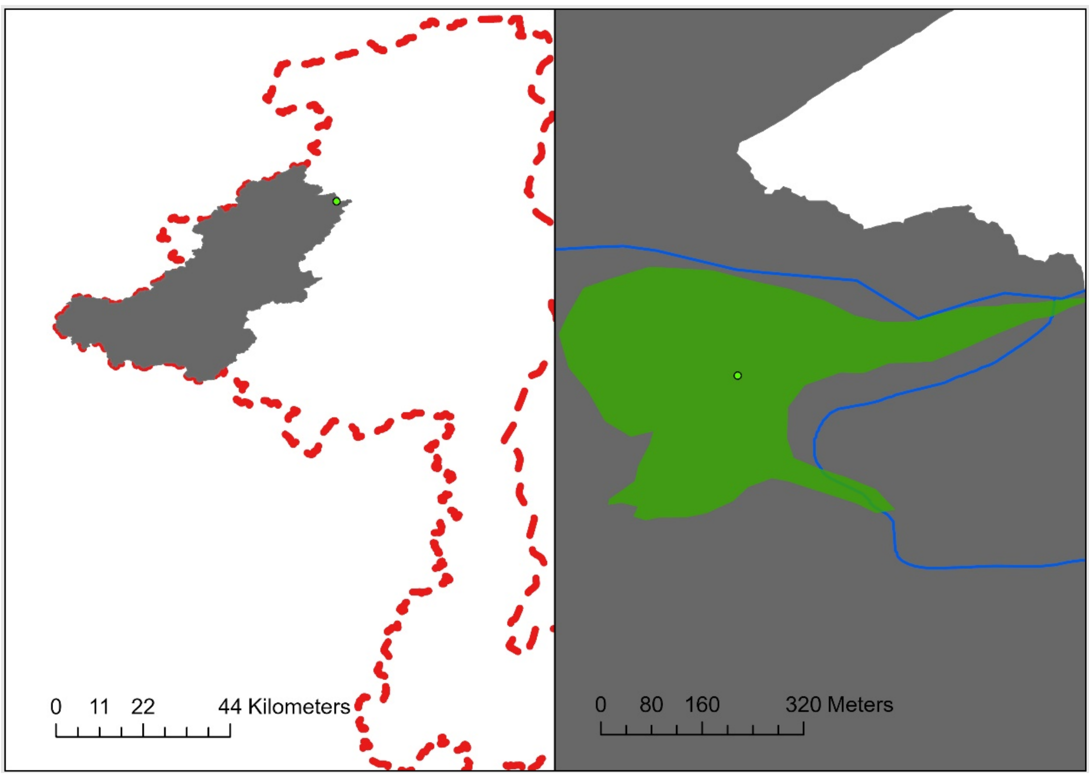


Figure 6. Left: Example of an overestimate of the upstream accumulation area (gray) for a single wetland (green dot). Study area is outlined in red line. Right: The source wetland (green) that intersects the flowines (blue) resulting in an upstream accumulation area that includes the entire stream watershed..

To calculate an upstream area that better reflected the interception opportunity of the wetland itself, rather than the extent of land that drains into the stream cutting through the wetland, we tested methods of restricting the pour points for the watershed function to eliminate the portion of the wetland that intersected the stream. Rather than submitting the entire wetland as a pour point, restricting pour points to the highest elevation in the outer 10 meters of the wetland (to avoid "hills" inside the wetland) was too restrictive for some wetlands and for flat wetlands, entirely ineffective. Restricting pour points to areas in the outermost 10 meters that were above the median height was an improvement, but still failed to fix the problem in some cases. Converting the outermost 10 meters to points and removing any that were within 20 meters of an NHD Flowline fixed the issue in many cases; however, in areas where the NHD stream representation did not match the digital elevation model precisely, the problem persisted. To get a better representation of flowlines that match the elevation model, we derived streamlines from the flow accumulation model developed as a part of the Active River Area procedure, then remove points that were within 2m of the derived flowlines (see Figure 7 and Figure 8 below). This seems to have made a marked improvement in the ability to automatically derive watersheds. This method was applied to calculate upstream accumulation area. The wetland complex itself was then erased from its watershed. The resulting polygons represent the upland area over which water may potentially flow into each wetland complex, or the "wetland catchment" (Figure 9).

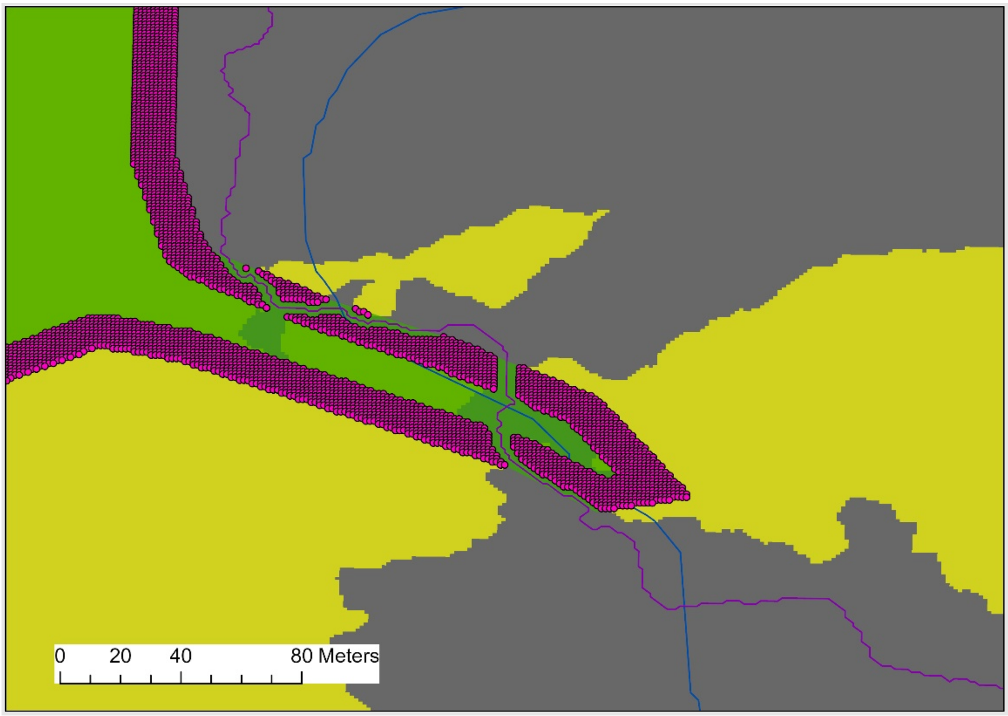


Figure 7. An NWI wetland in green. Blue lines show the NHD Plus HR flowlines, purple lines show the flowlines derived from the digital elevation model. Pink points represent potential pour points in the outer 10 meters of the wetland, with all points within 2 meters of the derived (purple) flowlines removed, to avoid delineating the watershed of the stream when calculating the wetland accumulation area. Yellow shows part of the newly calculated upstream accumulation area. Grey shows the original upstream accumulation area shown in Figure 6.

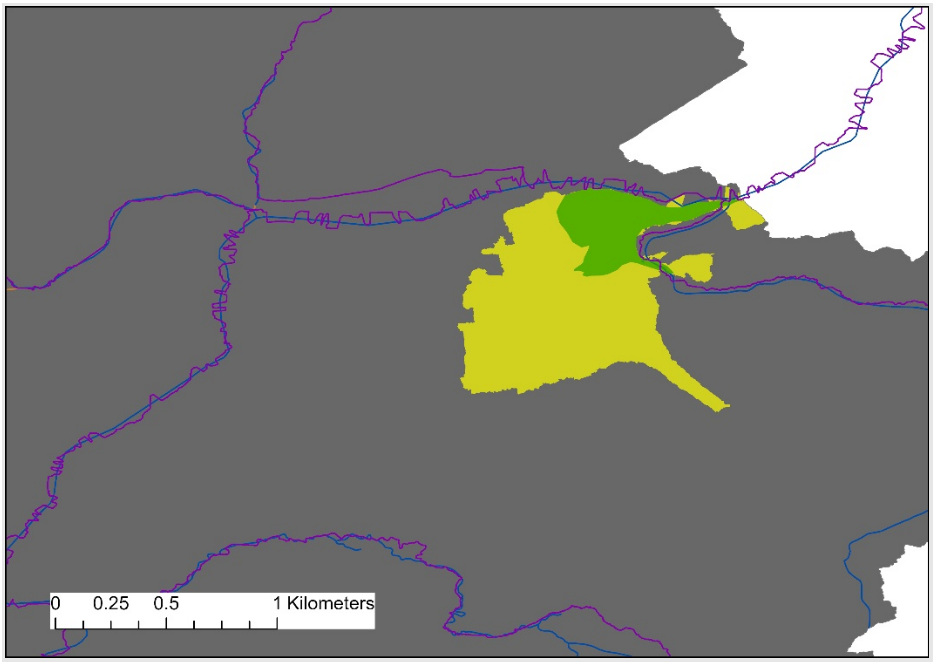


Figure 8. NWI wetland is in green, yellow area shows the complete extent of the upstream accumulation area of the wetland, calculated using the improved method. Blue and purple lines show NHD Plus HR and DEM-derived streams, respectively. Grey area represents the watershed calculated using the unmodified method.

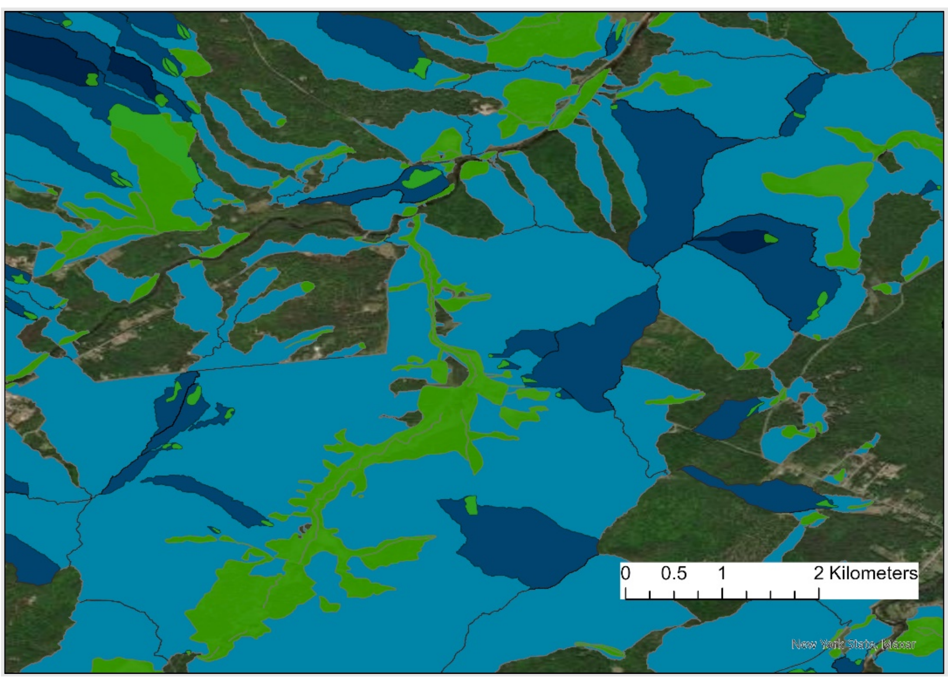


Figure 9. Boundaries for assessing upslope condition. Each polygon represents the contributing upslope contribution area for a single wetland complex. Areas with multiple overlapping contribution areas appear in darker shades of blue. Wetland complexes are in green.

After completing the delineation of the wetland catchment, we summarized the condition of the habitat within each using the ZonalStatistics2 tool in the ArcMap10 Supplemental Toolbox, which allows for calculations involving overlapping zones of interest. All data sets with original resolutions that were coarser than 1 meter were resampled to the same resolution using Nearest Neighbor assignment. This resampling did not change the underlying values, only subdivided them into smaller cells. We completed the assessment for the following environmental variables:

- Landscape Condition Assessment (version 2 and our "beta" version 3; New York Natural Heritage Program, 2021)
- Average % Canopy Cover (NLCD 2016 Tree Canopy)
- Average % Impervious Surface (NLCD 2016 Impervious Surface)
- % Natural Cover (Lake Champlain Land Cover)
- % Crop Cover (Lake Champlain Land Cover)
- % Riparian Zone (NYNHP Riparian Buffers)
- % Core Floodplain
- % Wetland Cover (NWI Wetlands)
- Average Slope in Degrees (Lake Champlain 1 m Digital Elevation Model)

We calculated these metrics independently for each wetland catchment, and also calculated cover within the wetland complex.

We calculated an upslope condition score to describe the quality of landcover in the wetland catchment. The four components were weighted, based on our experience with field collected wetland condition data, to reflect how they influence the ability of a wetland to absorb overland flow. Natural Cover and Canopy Cover are more likely to slow the flow of water over the surface of the catchment, reducing the strain on the wetland, while higher impervious surface and crop cover will increase the volume of runoff flowing into the wetland.

The Upslope Condition Score was calculated as follows:

- ((Percent Natural Cover *4) + (Average Percent Canopy Cover *4) + (Percent Crop Cover*(-3)) + (Average Impervious Surface *(-4)) + 800)/16)

To create a metric that described the relative size of the wetland complex compared to the wetland catchment, we calculated the ratio of the area of the wetland catchment to the area of the wetland complex. A small wetland with a much larger catchment might lack the capacity to absorb all the water running off such a large area of land. Conversely, a large wetland fed by a very small catchment would not have the opportunity to absorb significant amounts of runoff because of the relatively small upslope area. To distinguish wetlands that fell into a range of optimal opportunity for intercepting runoff, we needed a way to distinguish values in the middle, representing wetlands of a size relative to their catchments capable of absorbing the runoff. Using the log transformed ratio of the area of the wetland catchment to the area of the wetland complex, we scored highest those wetlands with a log transformed ratio of 2, representing wetland complexes with a catchment roughly 7 times their area. Wetland complexes that had ratios larger and smaller than this received lower scores. How the distribution of the final scores for this variable compare to the original values can be seen in Figure 10.

Sedge meadow at Putnam Pond *by Greg Edinger*

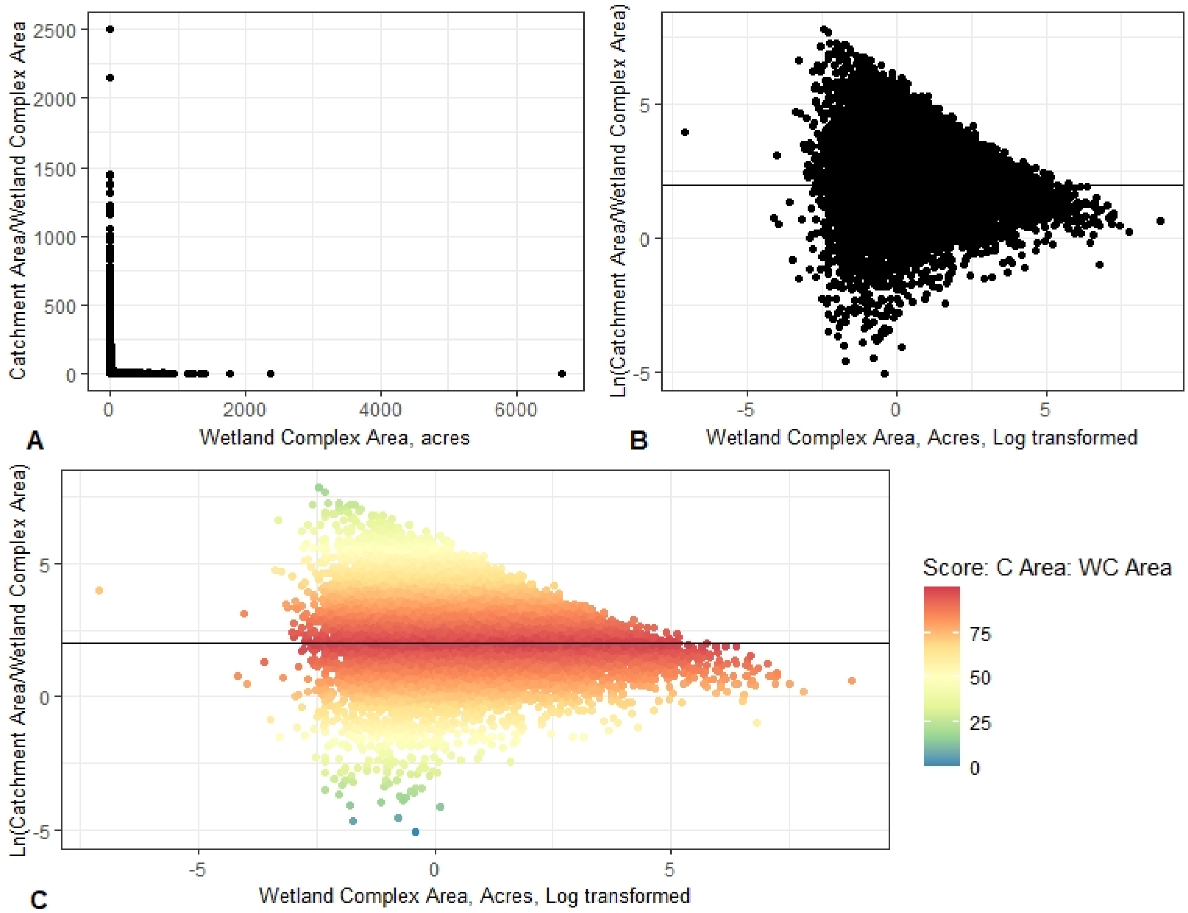


Figure 10. Calculation of the Score for Wetland Catchment Area relative to Wetland Complex Area. Fig A shows the area of each wetland complex plotted against the area of its respective catchment. Fig B shows these values log transformed to reduce skew. The horizontal line indicates value of log (ratio)=2. Wetlands closest to this value had catchments approximately 7 times their size. Fig C shows the same data as Fig B, with the color of the points representing the value of the score used in the Floodwater Desynchronization rollup metric.

To calculate an overall measure of a wetland's relative opportunity to slow and retain overland surface flows, we selected a subset of the metrics calculated in Task 10, Task 11, and Task 12 to combine into an overall Floodwater Desynchronization score (WFD). As we discovered in our sensitivity analysis, the values of our metrics exhibited slight to substantial skew. Because the goal of our "roll-up" metric was to more easily visualize differences between wetlands, we chose to transform the data to reduce skew before converting them to a common scale and combining them. Data with skewness of –0.5 to +0.5 are considered to have negligible skew. For each metric, the transformation that resulted in minimal skewness in the transformed data was chosen. The metrics used in the rollup variable were as follows:

- Wetland Complex Area (Acres) (Task 10)
  - i. Wetlands with larger area have greater capacity to absorb overland flows.
  - i. Unit: Wetland Complex
  - ii. Original Skew: 52.7
  - iii. Transformation: Natural Log transformation
  - iv. Skew of transformed data: 0.7
- Number of Unique Wetland Types (Task 10)

    i. Wetland Complexes with greater richness in wetland types will have more heterogeneity, providing greater capacity to absorb overland flow.
    ii. Unit: Wetland Complex
    iii. Original Skew: 1.9
    iv. Transformation: Natural log transformation
    v. Skewness of transformed data: 1.08
- Mean Percent Canopy Cover (Task 12)
    i. Wetland complexes with higher canopy cover have more woody plants and thus greater capacity to absorb floodwaters.
    ii. Unit: Wetland Complex
    iii. Original Skew: -1
    iv. Transformation: Cube transformation
    v. Skewness of transformed data: -0.1
- Upslope Condition Score (Task 12)
    i. Wetland Complexes with more intact areas upslope will have less overland flow entering the wetland and thus more capacity to mitigate other hydrologic issues.
    ii. Unit: Wetland Catchment
    iii. Original Skewness: -1.8
    iv. Transformation: Cube transformation
    v. Skewness of transformed data: -1.2
- Proportion of Catchment that is Wetland (Task 12)
    i. Higher proportion of wetlands in the catchment will slow the flow of water into the complex, increasing its capacity to retain the surface flow.
    ii. Unit: Wetland Catchment
    iii. Original Skew: 6.58
    iv. Transformation: Cube Root
    v. Skewness of transformed data: 1.4
- Wetland Complex Area relative to Wetland Catchment Area (Task 11)
    i. Wetland complexes have the greatest capacity to retain and slow overland flow when they are fed by a wetland catchment that is neither too small in area to generate significant runoff nor so large as to render the wetland insufficient.
    ii. Unit: Wetland Complex
    iii. Original Skew: 1.16
    iv. Transformation: Cube Root
    v. Skewness of transformed data: -0.19
- Average Canopy Cover in 50 meter buffer
    i. Wetlands with higher canopy cover in the 50 meters surrounded the wetland complex have a greater capacity to slow and retain overland flow.
    ii. Unit: 50 meter buffer around wetland
    iii. Original Skew: -1
    iv. Transformation: Cube transformation
    v. Skewness of transformed data: -0.15

The Floodwater Desynchronization score was calculated by taking the average value of all 7 sub-scores. While in theory the maximum value of the is score was 100, in practice the maximum observed score was 72, with a median score of 44.

Section 2. Stream-Floodplain connectivity (SFC) ranking: overbank flooding (flood pulse)

The goal of this section is to assess connectivity between floodplain wetlands and associated streams, particularly when streams reach peak flow, by examining a basic question: "When the river floods, are riparian and wetland land cover types intact and able to receive the flood pulse?" This function has the potential to desynchronize peak flows and lessen the impact of downstream flooding. However, natural ecosystem functions can be compromised by anthropogenic development/land use, fragmentation, dewatering modifications, and levees or berms/roads that restrict bidirectional surface flow; river-floodplain connectivity may also be compromised by severe undercutting. We developed the following measures as indicators of this function:

i. Floodplain wetland connectivity (Task 13). Vegetated wetlands help slow water velocity and increase deposition of suspended sediments, particularly during flood pulses.
ii. Proximity to surface water (Task 14). How near a wetland is to flowing water relates to its opportunity to receive lateral water flows from streams and rivers.
iii. Barrier detection between wetland and stream (Task 15). A large drop or high berm between a wetland and stream would reduce stream-floodplain interactions and the frequency at which a floodplain wetland would receive overbank flows. We will use LiDAR-derived elevation models to evaluate potential anthropogenic barriers between streams and associated floodplains.
iv. Proportion of riparian zone that is wetland (Task 16). Found to be an important factor associated with stream flashiness by Jayakaran et al. (2016); we also used a variant of this metric to produce a Wetland Resiliency Theme in our Trees for Tribs project (Conley et al. 2018).

We used the Near function in ArcGIS Pro to calculate the distance from each wetland complex to the closest NHD Flowline and NHD Waterbody polygon. The NHD flow network incorporates large waterbodies like lakes by placing a flowline directly down the middle instead of near the shore, which results in a distance to nearest flowline that is far greater than the distance to the waterbody, which is delineated by shoreline. To give the most accurate measure of distance to surface water, we assigned each wetland complex the minimum value of the distance to flowline and distance to waterbody metrics.

The goal of Task 15, barrier detection between wetland and stream, is to use LCBP's high-resolution elevation model (DEM) and look at the topography very close to each stream course. We developed a method, using information about how water flows along the surface of the ground (flow direction raster) to calculate the rise in elevation along each stream corridor. Concisely, the algorithm does this: at every 1 m raster cell along the edge of the stream, if that cell flows into the stream, calculate the elevation rise from the stream to that cell. Continue this for the next adjacent cells, for cells rising from the stream for 30 cycles such that an elevation profile is built for a corridor along the stream (Figure 11).

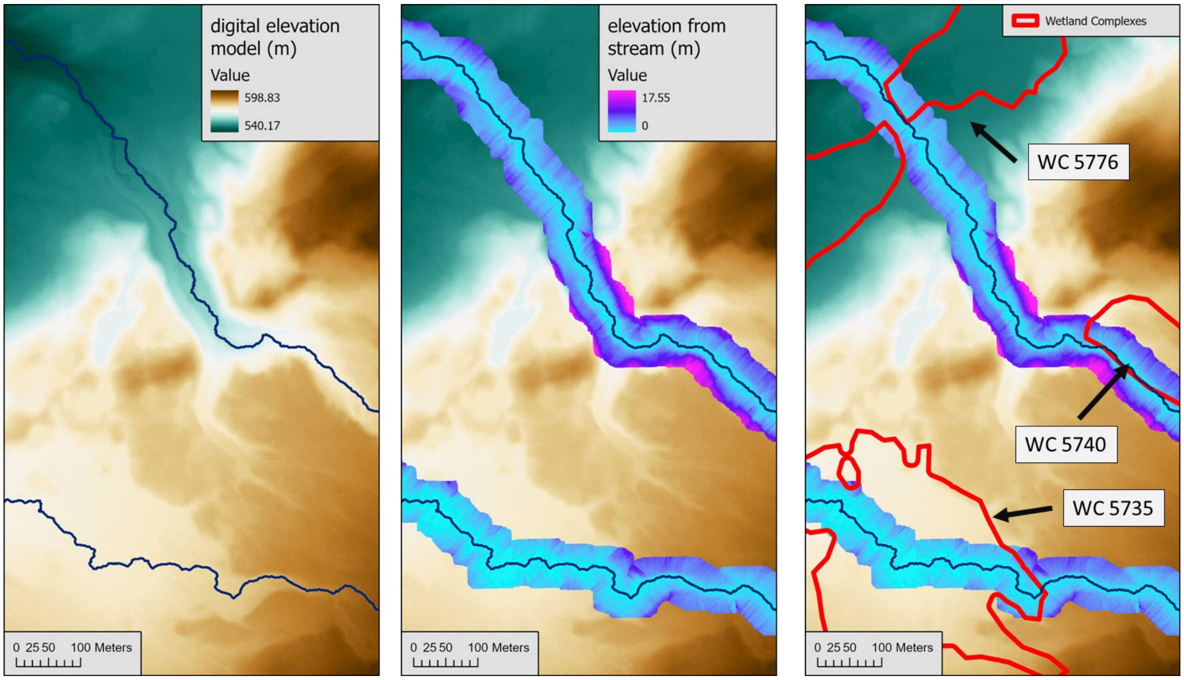


Figure 11. Wetland to stream connectivity example. Left panel: digital elevation model (DEM) and sections of two streams built with the DEM. The streams are tributaries to Frenchs Brook, which feeds into Union Falls Pond in the Saranac River Drainage. Middle panel: calculated elevations from the stream, based on flow direction of the slopes adjacent the stream. Right panel: the same layers as the middle panel with the borders of three wetland complexes (WC) added in red.

After the modeled corridor of elevations from the stream channel is created, we then captured elevation data for each two-meter band from the stream channel. As the goal was to assess the immediate connection to the stream channel, we limited this to eight bands, for a total of 16 meters from the channel. We then summarized the amount of rise from the stream channel within each band using the 10th percentile. As visualized in Figure 12, this allowed us to view how accessible the wetland is to flood waters. Wetlands with only small channels entering the wetland from the stream or with a high bank at the stream would have a rapid rise in the 10th percentile metric (e.g., WC_5740), while wetlands with no elevation barriers at the stream would show little to no increase the elevation along these sequential bands (e.g. WC_5735).

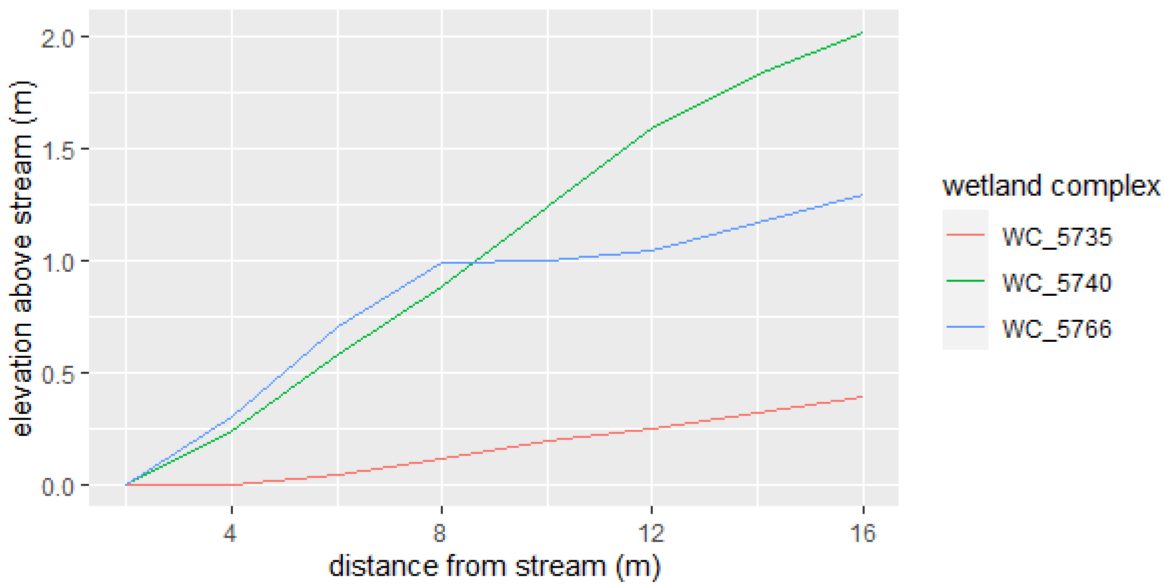


Figure 12. Elevation information for the three wetland complexes (wc) identified in Figure 11. For each band away from the stream corridor (0-2 m, 2-4 m, 4-6 m, etc., plotted at 2, 4, and 6 m, respectively), the 10th percentile of all cells in the band is plotted. Compare these cross sections to the right panel map of Figure 11.

To translate the elevation profiles of Figure 12 as a visualization into a metric that could be quantified, we estimated the area under the curve (AUC) using the trapezoidal rule in R (see https://en.wikipedia.org/wiki/Trapezoidal_rule). We normalized and rescaled these data to create the metric of stream to wetland connectivity for wetlands nearby streams. While all three wetlands depicted in Figure 11 and Figure 12 touch a stream, they differ in their ability to absorb rising water from the stream because of their elevation profiles. Based on this one metric, we would predict that WC_5735 would perform the best and WC_5740 would have the lowest function for this feature.

The high-resolution digital elevation model on which we developed these elevation profiles was aggregated from LiDAR data as a part of the LCBP-funded Land Cover mapping project (O'Neil-Dunne 2018), based on 2015 data, and provided to us by the LCBP in the fall of 2021. The actual dates or time of year for the LiDAR flights were not in the report or metadata for the DEM. To generate stream flowlines, we first generated a raster with holes "filled" (ArcGIS Fill tool) and also used this filled version of the DEM for this analysis. With a one-meter resolution, this input dataset is very high resolution and gives excellent information about existing stream channels and bank heights. However, because it is based on LiDAR data, which reflects at the water's surface, all wide streams will show up in this layer as flat, depicting the water surface, not the stream bed. This could potentially create some differences in barrier assessment due simply to water level differences at the time of the LiDAR flights, not based on real differences in the stream bank. Additional LiDAR flights with additional derivative DEMs, which are not available, could help us evaluate the sensitivity of this potential issue. However, we think the impact of this effect on our final scoring is likely to be very low. First, most streams are narrow and any additional channel depth would only be minimally picked up at this scale. Wider streams showing a flat surface do have a hidden channel profile, but our interest is in more than just the immediate channel rise from the channel bottom. In looking at the full area under the curve (AUC, Figure 12) for the full 16 meters from the modeled stream course we are examining the full profile and not depending on the small zone potentially submerged near the water line. Finally, comparisons are relative among wetlands, not based on absolute elevation rise values for stream water so if slightly higher (or lower) water levels are depicted in the DEM because of the day of LiDAR capture, wetlands along the same stream channel would be affected similarly and would still rank similarly.

For each wetland complex, we assessed what proportion of the riparian area in the upland accumulation area was composed of wetland (Task 16). For wetland complexes that had no riparian habitat in the upland accumulation area, this value was set to 0. We also calculated this at the level of the HUC 12, but this unit may be too large to be of use in the final calculation of condition.

The New York Natural Heritage program had previously developed a set of riparian buffers for streams throughout the state (https://www.nynhp.org/projects/statewide-riparian-assessment/). These buffers were designed to estimate the boundary of the 50-year floodplain based on gauge data and elevation. We used these buffers to define our basic riparian zone and intersected them with the wetland complexes to estimate connection to the riparian zone.

We use the Core Floodplain areas developed in Task 11 to calculate the proportion of the wetland that intersected with the Core Floodplain. Floodplain Cores were contiguous areas of the Active River Area base riparian zone that fell on natural habitat and were greater than 150 acres in size. The riparian buffers we used did not distinguish between, for example, developed riparian zones and natural riparian zones. However, this distinction is relevant for the capacity of the habitat in these areas to absorb overbank flooding. For this reason, we include Floodplain Cores cover as an indicator of which wetlands are located in sizable, natural portions of the floodplain.

We calculated these metrics independently and as a combined score that strives to estimate stream-floodplain functional connectivity. Our sensitivity analysis revealed, as with the metrics used to calculate the floodwater desynchronization score, these metrics were highly skewed. We transformed them to minimize skew and rescaled to a common scale before combining in the final score. The metrics used in the stream-floodplain functional connectivity score were:

- Distance to Surface Water
  - Wetland complexes that are closer to surface water are more connected to the stream and floodplain and better situated to absorb overbank flows.
  - Unit: Wetland Complex
  - Original Skewness: 1.7
  - Transformation: Cube root
  - Skewness of transformed data: 0.006
- Riparian cover in the Wetland Complex
  - Wetland complexes with more riparian cover are more connected to the stream and floodplain
  - Unit: Wetland Complex
  - Original skew: -3.3
  - Transformation: Exponential (on non-zero values) zero values were unchanged
  - Skewness of transformed data: -3
- Barriers between Wetland Complex and Streams
  - Wetlands that are separated from the stream by barriers are less connected and less capable of receiving overbank flooding
  - Unit: Wetland Complex
  - Original skew: 2.12
  - Transformation: Standardized Box Cox

    - Skewness of transformed data: -0.088
    - Data was rescaled to the range of 0-100 such that higher barriers received lower values
- Riparian cover in the Catchment
    - Wetland complexes with higher riparian cover will have less overland flow entering the wetland and thus greater capacity to mitigate overbank flooding issues
    - Unit: Catchment
    - Original Skew: 2.9
    - Transformation: Cube root
    - Skewness of transformed data: 0.8
- Core Floodplain Cover in the Wetland Complex
    - Wetlands with higher cover of core floodplain will have greater floodplain connectivity
    - Unit: Wetland Complex
    - Original skew: -2.24
    - Transformation: Non-zero values were power transformed (cube) and zeros were left as is.
    - Skewness of transformed data: 1.5

We took the average value of the 5 metrics to calculate the stream-floodplain connectivity score (CSW). The maximum possible score was 100, the maximum observed value was 100, with a median score of 32.

We decided not to combine the Floodwater Desynchronization Score and the Stream-Floodplain Connectivity Score into a final score because we felt that, especially with the skew of the data despite all efforts to minimize it, a combined score might obscure more than it informed. We instead incorporated a set of filters into our Interactive Map that allow users to view only wetlands that had the top scores for both the ability to detain overland surface flows and to absorb flood pulses.

Objective D. Model ecological condition for all wetland units across the NY portion of the Lake Champlain Basin and validate these estimates with field sampling

Our three-tiered wetland assessment framework for NYS has demonstrated strong, significant correlations between our remote "Level 1" Landscape Condition Assessment model (LCA), rapid condition assessment ("Level 2": NY Rapid Assessment Method, NYRAM), and intensive vegetation plot surveys including floristic quality metrics ("Level 3"; Shappell and Howard 2018: www.nynhp.org/epa-adjacent-areas). Our work has shown wetlands with good floristic quality scores (Level 3) or condition scores (Level 2) tend to have comparable LCA scores (Level 1). Recent funding from EPA supported an update to the LCA statewide model that was completed by the summer 2021 ("LCA3"), just in time for use in this project. However, because we do not yet have reference benchmarks for LCA3 we are also including scores from our previously published "LCA2" model (Feldmann and Howard 2013).

We first estimated the condition of wetlands remotely (Level 1 assessment, Task 17) using the LCA (Appendix A). The LCA spatial layer estimates the cumulative effects of anthropogenic stressors at a given location based on a sigmoid decay function. Stressor types are weighted relative to their intensity and extent, for example, a four-lane highway has a larger zone of impact compared to an unpaved road. We evaluated including methods from Shappell and Howard (2018) to improve our assessment of wetland condition. The original version and development documentation of our Landscape Condition Assessment ("LCA2") model is available here: https://nynhp.org/data#LCA.

For each contiguous wetland complex we generated average Landscape Condition Assessment (LCA) scores, where lower scores indicate lower levels of anthropogenic stressors in the surrounding landscape. Based on our previous work, we used benchmarks to develop LCA "bins" that were used to stratify the random sample draw (Figure 13), helping ensure our sites were representative of our target sub-basins (Shappell et al. 2016, Shappell and Howard 2018). We selected the Lake Champlain and Mettawee sub-basins (HUC 8) in which to focus our wetland assessment field surveys (Figure 14, right panel). These sub-basins capture a wide range in the basin spatially as well as a wide range in ecological condition (Figure 14, left panel).

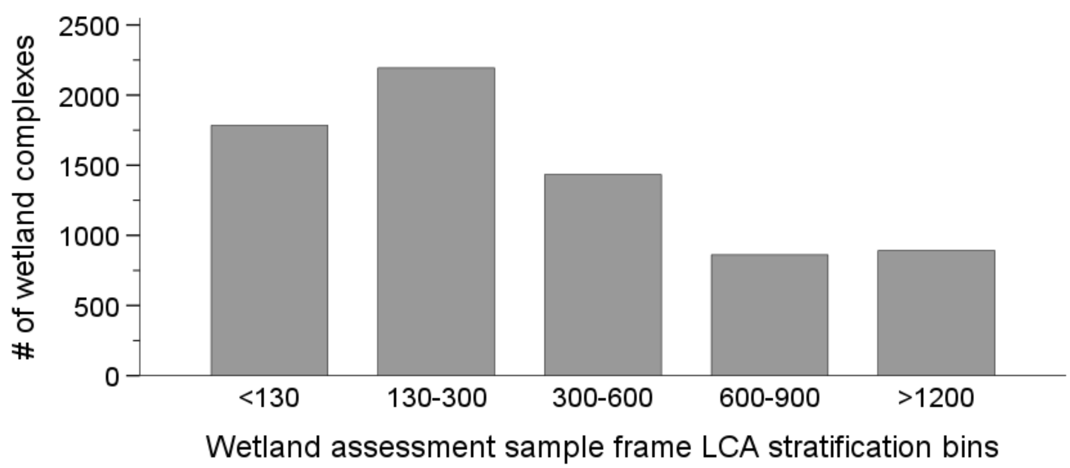


Figure 13. Histogram of the five LCA bins used to stratify the randomized sample draw used for wetland assessment surveys. Scores <130 typically represent sites that are least disturbed by anthropogenic development; score >1200 are typical of urbanized or heavily developed areas. This histogram includes all modeled wetland complexes in the Lake Champlain Basin (n = 13,772).

Data analysis methods modified after our previous work are cited above. Our analysis procedures were scripted for transparency and repeatability. Final scripts will be available to other researchers on request.

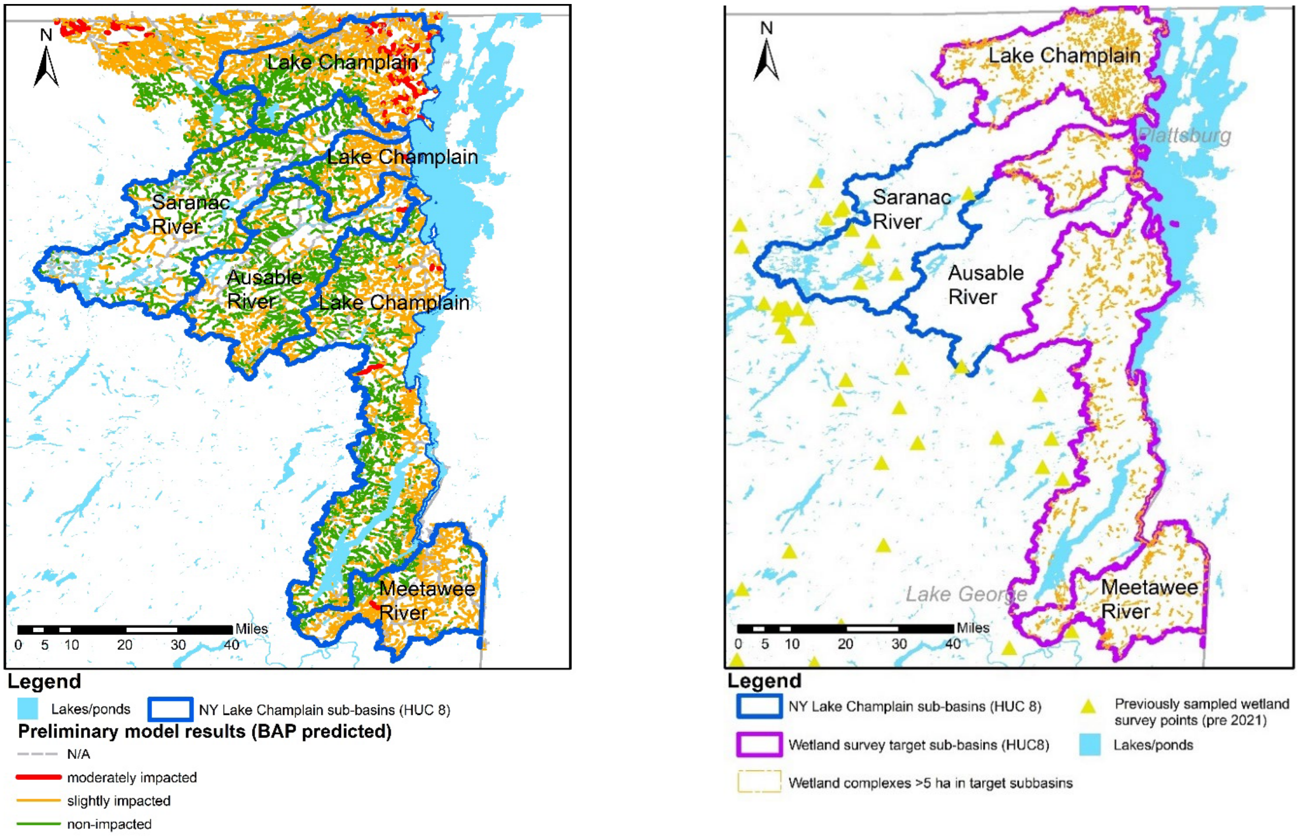


Figure 14. Preliminary stream model results (left) and targeted survey sub-basins (right) for ecological wetland sampling.

We contacted over 80 private landowners for permission to sample at selected sites and secured access to 20 sites that were a mix of private and public lands. We conducted field surveys (Tasks 19 and 20) at targeted wetlands to assess ecological condition and functional traits and conduct model validation of the LCA scoring. A primary goal of our wetland field surveys was to validate the relationship between Level 1 estimated condition (mean LCA; Task 4-1) and Level 2 observed field condition using our NY Rapid Assessment Methodology (NYRAM, Appendix B). We provide a map of the sampled sites below (Figure 24) in the Deliverables section and our Level 3 protocol in Appendix C. Field teams were prepared with backup sites to visit (usually another site in the random draw) in the event that the site intended to be visited was not accessible for any reason at the time of the visit.

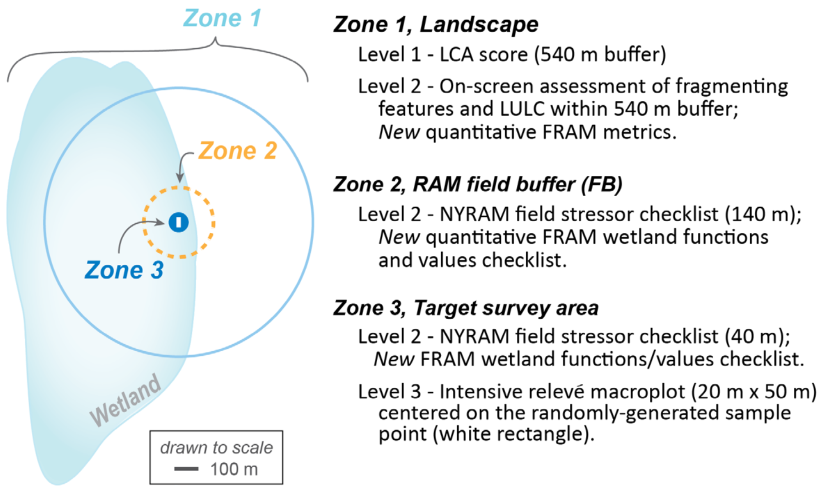


Figure 15. Schematic of the evaluation areas used in our three-tiered wetland assessment protocols. Please see appendices for detailed descriptions of our assessment protocols. FRAM is our Functional Rapid Assessment Methodology, explained in Appendix D.

The center of our NYRAM Survey Areas ("SA", 40-m diameter focal area) were at least 50 meters from the wetland edge to reduce edge effects and where applicable within 140 meters of surface water (NYRAM Field Buffer is 140-m diameter). For narrow wetlands, we used a modified (rectangular) NYRAM layout that requires a minimum Survey Area width of 20 meters. We also collected validation data on wetland cover types (Task 10), and where applicable, surface water proximity and floodplain health (Tasks 13-15). Prior to field work, we inspected field equipment for use, chose sites for study, corresponded with landowners for permission to access properties, acquired permits, and prepared for data collection (Task 18).

Finally, we completed vegetation plot surveys (Level 3) at eight exemplary sites that could serve as sentinel monitoring locations (i.e., "exemplary" per standard NYNHP natural community ranking methodology, and preliminary benchmarks by Shappell and Howard (2018). Floristic quality scores generated from these targeted surveys were assessed relative to comparable ecological communities in our database (e.g. Edinger et al. 2020) as well as broader statewide benchmarks (e.g., Shappell and Howard 2018).

Laura Shappell completing vegetation plot in a rich sloping fen at Miller Mountain/Grant Brook *by Greg Edinger*

Field notes were documented in our field computers using our NYNHP data entry application as outlined below. Following standard NYNHP survey protocols, general survey site information included a unique surveyor code (12 digit alphanumeric), we documented surveyor names, Managed Area Name (if applicable), site code, and natural community classification (per Edinger et al. 2020). We collected plant specimens (Tasks 19 and 20) into a plastic bag and affixed them with mailing labels containing all the same information. We pressed plant specimens in a plant press at the end of every field day (pressed with their detailed labels). We retained specimens until the identification was confirmed, after which specimens were discarded in the trash, or if rare or challenging to identify, given to NYNHP's Chief Botanist for processing. In addition, moss expert Tom Phillips reviewed additional plant specimens.

Data acquisition for our wetland field sampling (Tasks 19, 20) consisted of visiting each site and documenting the plant species, stressors, condition indicators, and other physical characteristics of the site. The metrics we collected were designed to integrate environmental effects over space and time. In this way, we sampled each site once, providing the opportunity to sample more sites (extensive sampling) rather than sample one site multiple times (intensive sampling). All data collected were integrated into metrics that help us characterize ecological condition of the site and allow comparisons of condition among sites.

We expected variability at each sampling level. The primary concerns were variability in wetland quality that we could not detect with the metrics used, and conversely, variability in our metrics for wetlands of equal condition. The main ways we alleviated these concerns were to assess wetlands at multiple levels, as we did with L1, L2, and L3, and sample multiple wetlands across the expected range of our selected metrics, with multiple samples at similar conditions as well. We intentionally sampled wetlands such that we collected a range in condition metrics and functions/values. We expected these efforts to maximize our detection of any signal notwithstanding the variability inherent in field assessments.

OBJECTIVE E. PROVIDE AN INTERACTIVE TOOL TO DECISION MAKERS AND THE PUBLIC FOR VIEWING AND USING THESE DATA

Data Contained in the Online Interactive Map and Data Explorer ("Interactive Map") and in geodatabase format:

1. We created a stream feature class containing the predicted values for our three best performing stream quality models (EPT, BAP, HBI). Only flowlines that are coded in the NHD Plus HR as "Stream" (FTYPE 460) will contain a predicted score. We did not model scores for connectors, pipelines, or artificial path flowlines. These appear as a grey hashed line.
2. We combined the results of all metrics calculated as a part of Tasks 9-16 into a single feature class with 84 metrics describing the wetland complex and wetland catchment attributed to the level of the wetland complex polygon. The full attribute table of this feature class includes both the original data, the transformed scores, the rollup scores, as well as any data metrics calculated for the wetlands that were not included directly in the final scores. It is also available as a Microsoft Excel Workbook.
3. We included as a separate polygon feature class the extent of wetland catchments (the boundaries of the upslope accumulation areas calculated in Task 12.)
4. We created a 1m resolution raster of the final Active River Area product created as a part of Task 11. To simplify interpretation, the zones for each stream size class are grouped together, reducing the number of unique categories from 12 to 4 and focusing on function. The categories displayed are: riparian base zone, riparian base zone wetflats, material contribution areas, and material contribution area wetflats.

5. As a part of preparing the Interactive Map, we also gathered additional data layers to serve as reference data and provide additional context for map users. These include a copy of the National Hydrography Dataset, Urban Areas and Urban Clusters from the 2010 Census, and a set of New York State administrative boundaries. These data are feature services provided by outside sources and are available in the viewer only.

Design of the Interactive Map

We developed the tool with the goal of facilitating exploration and understanding of the data. We wanted users to be able to quickly visualize wetland complex scores for both the floodwater desynchronization metric and the floodplain and surface water connectivity metric. To achieve this, we presented the wetland complex polygon feature class as two separate layers, one displaying the values of the floodwater desynchronization score, and the second displaying the values of the floodplain and surface water connectivity score.

We wanted to be able to provide as much context as possible for these layers within the Interactive Map, in an easily consumable fashion, without overwhelming or confusing the viewer with irrelevant data. To facilitate this, we designed informative popup windows linked to the display layers. Clicking on a wetland of interest displays a new window with a brief description of the wetland in terms of size and National Wetland Inventory cover types. The precise score for the associated metric, floodwater desynchronization or floodplain and surface water connectivity is prominently displayed, along with the maximum value observed in the dataset to allow users to consider the score in context. We included a bar chart to allow users to see, at a glance, the scores for each of the metrics that went into building the rollup score; providing a visual means of understanding why a wetland may have scored high or low. Beneath the plot is a more detailed explanation of the rationale for how the score was calculated, along with data tables that describe additional relevant data metrics.

As we included several metrics describing the land cover or condition of the wetland catchment, it was important that we allow users of the Interactive Map to clearly visualize the catchments. Because boundaries of wetland catchments can overlap, when all the catchments are made visible displaying the entire layer at once is inelegant and confusing. For this reason, we designed a filter for the catchment layer. All catchments are hidden until their wetland complex has been selected by the user. Once a wetland complex has been selected using the select tool, its associated catchment becomes visible. Multiple complexes can be selected at one time to visualize multiple catchments as well. We felt this was the best way to allow the catchments to be explored without overwhelming the map.

We also wanted users to easily focus their use of the tool on wetlands relevant to their interests. We built a series of filters into the left-hand panel of the Interactive Map that use simple sliders to remove from view any wetland complexes that do not meet user's criteria. Users can focus on wetlands of a certain size by manually entering the desired minimum and/or maximum area (in acres) into the Size Selector. Users can turn on or off the visibility of wetlands that are greater than 30 meters from surface water. And users can use sliders to select wetlands based on how they score in the two roll-up metrics. By raising the minimum values of both the Floodwater Desynchronization slider and the Wetland Complex Connectivity slider, users can limit the display of wetlands to just those that score the highest on both metrics.

Quality Assurance Tasks Completed

Quality Objectives and Criteria for Measurement Data

Objectives. The project data-quality objectives discussed below are for developing analytical spatial models and collecting and analyzing valid field data to support those models and our understanding of the ecological health of the New York portion of the Lake Champlain Basin. These objectives ensured our ability to collect, maintain, analyze, display, and document valid locational data pursuant to the project's deliverables. The primary use of the data is to provide the Lake Champlain Basin with a fine-scale, fully attributed stream dataset, including newly modeled water quality, wetland functional capacity, and ecological condition metrics for prioritization of conservation and management actions.

The monitoring information that was collected to support stream biomonitoring and wetland assessment met the quality assurance objectives outlined in this section. We also received data from trusted sources which performed vetting for quality. Data quality was measured in terms of accuracy and precision, completeness, representativeness, comparability, sensitivity, and the required detection limits for the analytical methods.

Software required to complete this project included ArcGIS by ESRI (we used version 10.7 or newer). We also utilized the statistical software R Statistics (we used version 4.0.3 or newer). Desktop computer workstations were the only hardware required for all the GIS and statistical analyses conducted throughout this project. We used a variety of Dell workstations to complete these tasks.

Our tasks included data compilation and field sampling. Some of the data quality measures are relevant. We discuss those below.

Precision

Precision is the measure of agreement among repeated measurements. With the DEC water quality data used for Task 2, the unit of measure was the stream reach and the measurement was samples that were taken along that stream reach. We were interested in the most current measurement of a certain location and so we could not evaluate precision using multiple observations at the same location. We could, however, evaluate sample variability if multiple observations were made along a single reach. We expected very few cases of this, but if we did not detect multiple recent observations of a single metric for individual reaches, we evaluated the sampling methodology, the date sampled, and the relative equivalence (precision) of the samples. If the samples differed by an order of magnitude or more, we chose, by random, one sample as representative of the reach; if the samples were within the same order of magnitude, and all other comparisons are relatively equivalent, we averaged the samples.

- We found six reaches (NHDPlusID units) with multiple sample events for which stream quality metrics had been calculated. For two of these units, (NHDPlusID 60000200062817 and 60000200026965) the duplicate samples came from different years, and we chose the most recent observation to represent the metric values for that unit and dropped the older value.

Chemical data were not collected as part of the field validation for this project.

We do not perform repeat measurements in our field sampling for stream condition validation (Tasks 4, 6) nor for our wetland field surveys (Tasks 19, 20).

For Task 2, the sample frame included all stream reaches in which there were recent observations. Our measurement was a comparison of the predicted values against the measured values in sets of observations held out for external validation through a jackknifing procedure. As the measurements and predictions were continuous measures, we expected to use regression analysis to compare measured vs. predicted. Regression statistical metrics such as goodness of fit (R^2) and statistical significance of the estimated parameters were our metrics for model performance.

- We created models for Biological Assessment Profile (BAP); Ephemeropta, Plecoptera, and Trichoptera richness (EPT), Hilsenhoff Biotic Index (HBI), Percent Model Affinity (PMA), and total species richness (SPP) metrics. The goodness of fit varied, but was as might be expected for real biological data. Here are the R2 values and the significance (p-value) for each model:
    - BAP: 0.259 ($p < 0.0001$)
    - EPT: 0.218 ($p < 0.0001$)
    - HBI: 0.328 ($p < 0.0001$)
    - PMA: 0.255 ($p < 0.0001$)
    - SPP: 0.086 ($p = 0.00071$)

For Tasks 5 and 7, a second subsample was analyzed for at least 5% of all samples. This was to assess the precision of subsampling procedures. Repeated subsamples must contain at least 75% or greater of the same macroinvertebrate orders.

- Two subsamples were analyzed from a single site in 2021, site 43, 5% of 10 samples. The similarity among macroinvertebrate orders was 81.6%, thus passing validation. In 2022, two subsamples were analyzed from site 77 and the similarity was 79.9%, also passing validation.

Bias

In Task 2, bias may arise when there is more than one sample point for a stream reach and there are not clear rules about which sample to use as an input for modeling. We avoided this bias with clear rules that emphasized using the most recent sample. When samples were taken during the same (most recent) season, we combined samples as discussed in the Precision section, above.

- Four reaches (NHDPlusID units) had multiple samples (2 each) that were taken on the same date. We compared the methods and metric values for each pair and found that in all cases the sampling methods were the same, and the calculated metrics were within an order of magnitude. We used an average of the two values for each unit as inputs in the model.

Perlid stonefly larvae *by Erin White*

During water quality field sampling (Tasks 4, 6), bias could be introduced by setting up kicknet locations inconsistently or arbitrarily. To ensure this is minimized, we carefully followed the

DEC protocols (NYS DEC 2019) developed specifically for this sampling procedure and used to collect the samples on which our initial models were based.

- For each of the 20 stream reaches sampled, we followed the NYS DEC 2019 protocol for determining kicknet location within the reach. This can be found in section 9.4.1. of the Standard Operating Procedure on kicknetting for benthic macroinvertebrates. Essentially, this involves selection of a location with hard bottom with 5 m of riffle and rock, rubble, gravel, sand substrate and flow >=40 cm/sec (high gradient). On many occasions flow was estimated rather than measured due to rocks in the stream bed inhibiting flow measurement. Kick-netting is done for 5 minutes downstream for 5 m and digging with feet into the substrate 2 inches, on a diagonal transect (when possible given the stream width). July-September sampling was completed to also follow their procedure to avoid high numbers of naidid worms occurring in the spring. We used a GPS or Samsung tablet to obtain coordinates and document the location where the samples were taken along the reach.

For our ecological wetland condition sampling (Tasks 19, 20), bias could be introduced through a variety of factors, including sampling location within the wetland and experience of the person doing the sampling. We strove to minimize bias by being very explicit in our sampling protocols about where and how each wetland should be sampled, by always having more than one person involved in sampling, and by ensuring all involved personnel are trained on the procedures outlined in our QAPP. The hierarchical assessment methodology (L1 through L2 assessments) provides a cross-check on sampling bias and gave us an opportunity to qualitatively assess sampling bias by comparing results among levels. Similarly, the fact that we implemented NYRAM both remotely and on-site allowed us to check for indicators of sampling bias in the field. Species identifications were made by the ecologist on the field team; unknowns were identified by our Chief Botanist or by other knowledgeable NYNHP staff and contractors.

For Task 2, our methodology for attributing partner biomonitoring data to stream reach included QC checks for duplicate records per reach and for record locations that were far enough away from any stream reach such that they could not be clearly attributed. Careful QA/QC intervention in these cases applied to the above procedures.

- Data from the stream biomonitoring unit was assigned to the nearest reach ("reach" = smallest stream unit in the NHD Plus HR data set, identified by a unique NHDPlusID) using the NEAR function in ArcGIS. Of the 281 sites in the SBU data, 181 sites had at least one of the metrics (BAP, EPT, HBI, PMA, SPP) calculated and could be used as input into the model, 2 of these sites were greater than 100 meters from the nearest flowline and were not used.

Representativeness, Accuracy and Comparability

Representativeness, accuracy, and comparability applied to both of our field sampling efforts: the water quality validation and the ecological wetland condition sampling.
For the water quality validation sampling (Tasks 4, 6) the selected site must be representative of the targeted stream segment. To ensure this, sampling locations were located in areas which maximize the upstream distance to which the assessment interpretation of the water quality data is considered valid. As such, the recommended procedure for placing water quality sampling locations along Waterbody Inventory segments is to choose the most downstream suitable location. Suitable

locations had the most representative physical characteristics in comparison to the remaining upstream portion of stream segment; this should include stream width, depth, substrate composition and embeddedness, velocity, and overhead canopy cover among others. If the most downstream location was considered significantly different from the majority of the upstream reach, the site location was either moved further upstream or an additional site was added to capture the transition in habitat characteristics. Site representativeness at the location was achieved by sampling in the mainstream, rather than peripheral areas. For kick sampling, the sampling location was a riffle with a substrate of rock, rubble, gravel, and sand. Depth was less than one meter but high enough to flow into the sampling net.

With regards to where sampling sites are throughout the basin, we ensured that sites chosen were representative of varying degrees of quality or metric scores based on model predictions. Our goal was to ensure a sampling design that is representative of the desired environments to be sampled and complete enough to ensure adequate samples to effectively evaluate the models generated. To accomplish this, we built a stratified sampling design, using the Generalized Random Tessellation Stratified (GRTS) methodology (Stevens and Olsen 2003, 2004, Kincaid and Olsen 2011). We stratified our stream samples by the best performing metric, HBI. Our sampling design encompassed greater than 75% of the range of successfully modeled metrics (BAP, EPT, HBI, Table 4), exceeding QA compliance. Finally, we ensured our Task 4 and 6 samples were comparable among each other by sampling consistently and carefully following sampling procedures as defined by NYS DEC (2019).

For the wetland condition assessment sampling (Tasks 19, 20), we assessed accuracy by comparing the condition assessment at each Level with results from other Levels, although we certainly did not expect correlation between every metric at one Level and those of the Levels above. High correlation supposes high accuracy. Our project's goal, to evaluate wetland condition and functions, requires an assessment of the relationship between Levels and, more specifically, between the indicator metrics and the wetland assessments. We provided regression plots to highlight the stronger relationships that we find (Figure 26). Our sampled wetlands represented wetlands of our target vegetated palustrine population (Emergent Marsh-EM, Shrub Swamp-SS, Forested Swamp (deciduous)-FO1, and Forested Swamp (evergreen)-FO4) with water depths <1 meter.

The methods for the wetland condition assessments of Tasks 19 and 20 are well vetted from previous projects and apply a consistent methodology among sites, ensuring comparability in metrics collected among the sites sampled.

- Wetland sites were selected using a spatially balanced random sampling framework, developed by US EPA, which we have used in our previous projects. As with our previous projects, wetland complexes in our sample frame were stratified along a stressor gradient (i.e., Landscape Condition Assessment) to ensure our sample sites reflect the range of anthropogenic development in the basin. Our survey sites ranged from an urban Red Maple-Hardwood Swamp in urban Glens Falls to a pristine Sedge Meadow in Pharaoh Lake Wilderness. Using our established three-tiered assessment methods makes data from this study comparable to data in our statewide wetland assessment dataset (n > 250).

For both field sampling efforts (Tasks, 4, 6, 19, 20), we used GPS units to document our location. Accuracy of our GPS units was related to how "true" the position recorded by the GPS was, in relation to the real location on the ground. We collected GPS points at carefully specified points in each sampling protocol. When these points were used to locate our samples within or nearby a specific wetland in New York State, then the point coordinates simply needed to be within 20 to 50 meters of the true position. When these points were used to compare with remote sensing information at the same location, the point coordinates would ideally be within 10 meters of the true position. The GPS units we used, both imbedded within the data collection tablets and the stand-alone GPS devices exceeded these standards and more regularly reported an accuracy of 3-5 meters. Nevertheless, we collected accuracy information along with location information as reported by the GPS and we used position averaging to increase our accuracy when collecting point data. We used an average of at least 120 positions.

Accuracy of specimen identifications, both for plants and insects, is important because the identifications form the core of many of the assessment metrics. This is the primary reason we collected and vouchered specimens because then identifications conducted by field staff can be confirmed by experts and revisited if new taxonomic or identification information comes to light. The accuracy criteria for macroinvertebrate identifications from the field sampling will be to family level for aquatic macroinvertebrate groups. These families are listed in Table 18.12 of (NYS DEC 2019). Thus, our QC for identification accuracy consisted of identification confirmations by taxonomic experts and vouchering specimens for revisiting any questions and revising as necessary.

Representativeness

For Task 2, we evaluated representativeness of our stream samples by comparing the mean, standard deviation, and other statistics between our samples and the stream samples provided by NYS DEC Stream Biomonitoring Unit (Table 4).

Table 4. Comparisons of stream condition metrics calculated from the Stream Biomonitoring Unit (SBU) samples, our field samples (NHP), and the predicted values for all appropriate reaches throughout the basin (pred). The number of samples (n), mean, standard deviation (sd), median, minimum (min), maximum value (max), first quartile (Q1), and third quartile (Q3) are provided for these indices: Biodiversity Assessment Profile (BAP); Ephemeropta, Plecoptera, and Trichoptera richness (EPT); and Hilsenhoff Biotic Index (HBI).

Metric	Recs	n	mean	sd	median	min	max	Q1	Q3
BAP	SBU	180	7.3	1.4	7.7	2.6	9.9	6.8	8.3
BAP	NHP	17	5.8	1.2	5.9	2.2	7.7	5.3	6.3
BAP	pred	9572	6.9	0.8	7.1	3.7	8.8	6.3	7.5
EPT	SBU	180	7.9	2.2	8.5	0.0	10.0	6.8	10.0
EPT	NHP	17	8.0	2.4	8.3	0.0	10.0	7.5	10.0
EPT	pred	9572	7.1	1.1	7.2	2.7	9.6	6.3	7.9
HBI	SBU	180	7.9	1.3	8.0	2.9	10.0	7.3	8.7
HBI	NHP	17	6.9	1.4	6.6	2.2	8.7	6.5	7.7
HBI	pred	9572	7.5	0.7	7.7	4.9	9.5	7.1	8.1

Accuracy

For Tasks 5 and 7, to ensure accuracy of all macroinvertebrate identifications, a reference collection was maintained. NYNHP worked with NYS DEC to determine unknown IDs and verify a reference collection.

- A reference collection was maintained and was verified by NYS DEC SBU experts following the identification of 2022 samples.

Comparability

For Task 2, our measure was the ability of our model to generate a probability network for relevant stream reaches. We were able to make metric predictions for 7918 stream reaches.

For Task 3, our measure was the range in predicted values for each condition metric within the sample frame in comparison to the range in predicted values within the entire study area. This is presented in Table 4 and shows that the sample metrics and estimates and range for the predicted values are similar and comparable.

Mud Brook, Keeseville *by Erin White*

Completeness

Field surveys. We expected 100% completeness in our field surveys. We strove to collect Level 2 NYRAM field data at 20 sites in 2022 and Level 3 vegetation plot data at two "exemplary" wetlands. For both NYRAM and the stream biomonitoring surveys we set our determination of compliance at 80% (i.e. a minimum of 16 sites per survey type). Because we couldn't say for sure how many exemplary sites would exist ahead of time, we set a lower threshold of 50% for Level 3 plot data (i.e., one site).

- We completed stream sampling at 20 stream reaches, meeting our 2021 and 2022 goals.
- We completed rapid assessment for wetland condition and function at 20 sites and completed Level 3 vegetation sampling at eight exemplary sites; we met and exceeded our goals, respectively.

Spatial data. We expected 100% completeness in our modeling efforts. For stream condition estimates we expected to model condition metrics for every stream reach within the modeled size classes in the study area (the NY portion of the Lake Champlain Basin). Similarly, we expected to be able to calculate Level 1 scores for all wetland units (as defined by the spatial wetland data set that we use) in the study area. To accommodate unforeseen circumstances, we set our determination of compliance at the standard 80% for these modeling efforts.

- At this stage, we have calculated metrics based on remotely sensed data for all 13772 wetland complex units. There have been some wetland complexes with particularly small or complicated geometries that have occasionally caused calculation errors when attempting to calculate summary statistics, but those have been limited to under 10 complexes and efforts to recalculate have been successful. Also, because of the differences in resolution between boundaries at the basin and watershed level and the catchments developed by the high-resolution DEM, some of the wetland catchments extended outside the study area, making it impossible to calculate final catchment scores for 29 catchments. We chose to keep these wetlands with incomplete scores in the dataset rather than dropping them so that the other metrics could be available for use. If we count these wetland complexes, we have 99.8% completeness.

For Task 2, our measures were the number of observations successfully assigned to a stream reach and the number of stream reaches for which we could make a model prediction.

- 179 of 180 sites with metrics data provided by the SBU were successfully assigned to a reach. Two sites were farther than 100 meters from the nearest flowline and could not be used for model input. After correcting for multiple sites associated with the same reach, 174 unique stream reaches with metrics were usable for input into the model. Model predictions were created for 9572 NHDPlusID units.

For Tasks 5 and 7, the goal of this project was to process at least 20 of the total site samples collected. The criterium for completeness was considered to be met if 90% of the completeness goal was achieved, e.g. 18 sites.

- All 20 stream macroinvertebrate samples were processed and identified to family level, reaching 100% completeness.

Sensitivity

Sensitivity refers to the lowest detection limit of the method or instruments employed. With respect to our aquatic invertebrate sampling (Tasks 4, 6), very low densities of invertebrates in the stream bed may not be detected by our sampling methodology. Thus, consistency in methods is critical to ensure our approach has equivalent sensitivity (and comparability, as noted above) to the DEC data set we are comparing it to. Our approach was to apply the exact same sampling methods, using the same protocols as DEC to ensure equivalent detection (NYS DEC 2019).

We evaluated the sensitivity of our functional assessment metrics in Objective C by evaluating the range of each metric and how they compared and aligned with measurements made on site and via onscreen evaluation in GIS. For example, a large wetland in a basin setting that lacks a connection to surface water would have a greater capacity to detain water and thereby desynchronize stream flows compared a small flat riparian wetland. We developed similar metrics for our statewide Trees for Tribs Project (Conley et al. 2018) including a “Wetland Resiliency Theme”. The purpose of the theme was to identify areas along streams with greater flood capacity due to the presence of intact wetland habitat. We compared the riparian buffers to the National Wetlands Inventory (NWI) dataset and estimated the relative contribution of wetlands to the area of buffer. The least resilient basins would be those with fewer wetlands in the riparian zone. Conversely, the most resilient basins would be those with the highest proportion of wetlands in the stream corridor. Compared to statewide data, the data available for the Lake Champlain Basin is high resolution, so we expected greater sensitivity for this project compared to our statewide outputs (Conley et al. 2018).

- Before conducting a complete analysis comparing the results of the completed field ecology sampling with the remotely sensed metrics, we conducted an exploratory data analysis of the remotely sensed metrics. We assessed the range and distribution of each metric individually to evaluate their suitability as indicators of wetland condition, and we also compared the ranges of the full data set (13772 wetland complexes) with the ranges of the sampled wetlands visited this summer (20 wetland complexes). Comparing the ranges visually can help us to assess how robust inferences using that particular metric can be. Sensitivity analyses of this kind often use boxplots to compare the distributions of data. However, upon examination of the data we found that several of our remotely sensed metrics had non-normal distributions (Figures 17-19), which can make boxplots misleading because they do not distinguish between cases in which most of the values are clustered around the median and cases where most values are clustered around the minimum and the maximum with very few scores in the middle. We used violin plots to examine the data. Violin plots are mirrored density plots, they extend from the minimum observed value to the maximum observed value, and are widest around areas where values are clustered.

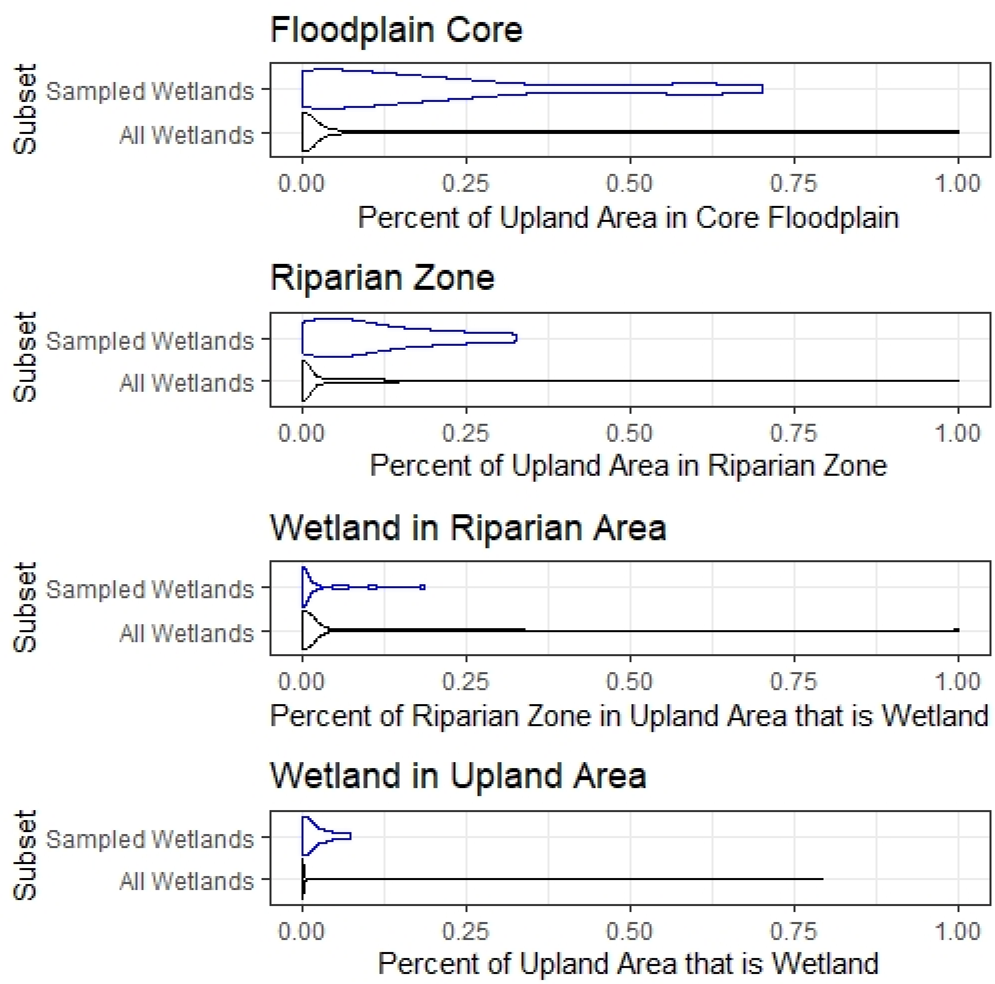


Figure 16. Wetland Catchment Metrics 1: Floodplain Connectivity Data. Comparison of data distribution for remotely sensed metrics among sampled wetland complexes (n=20) and all wetland complexes in the Lake Champlain Basin (n=13772). “Upland area” or “wetland catchment” refers to the immediate upslope drainage area that we generated for all wetland complexes.

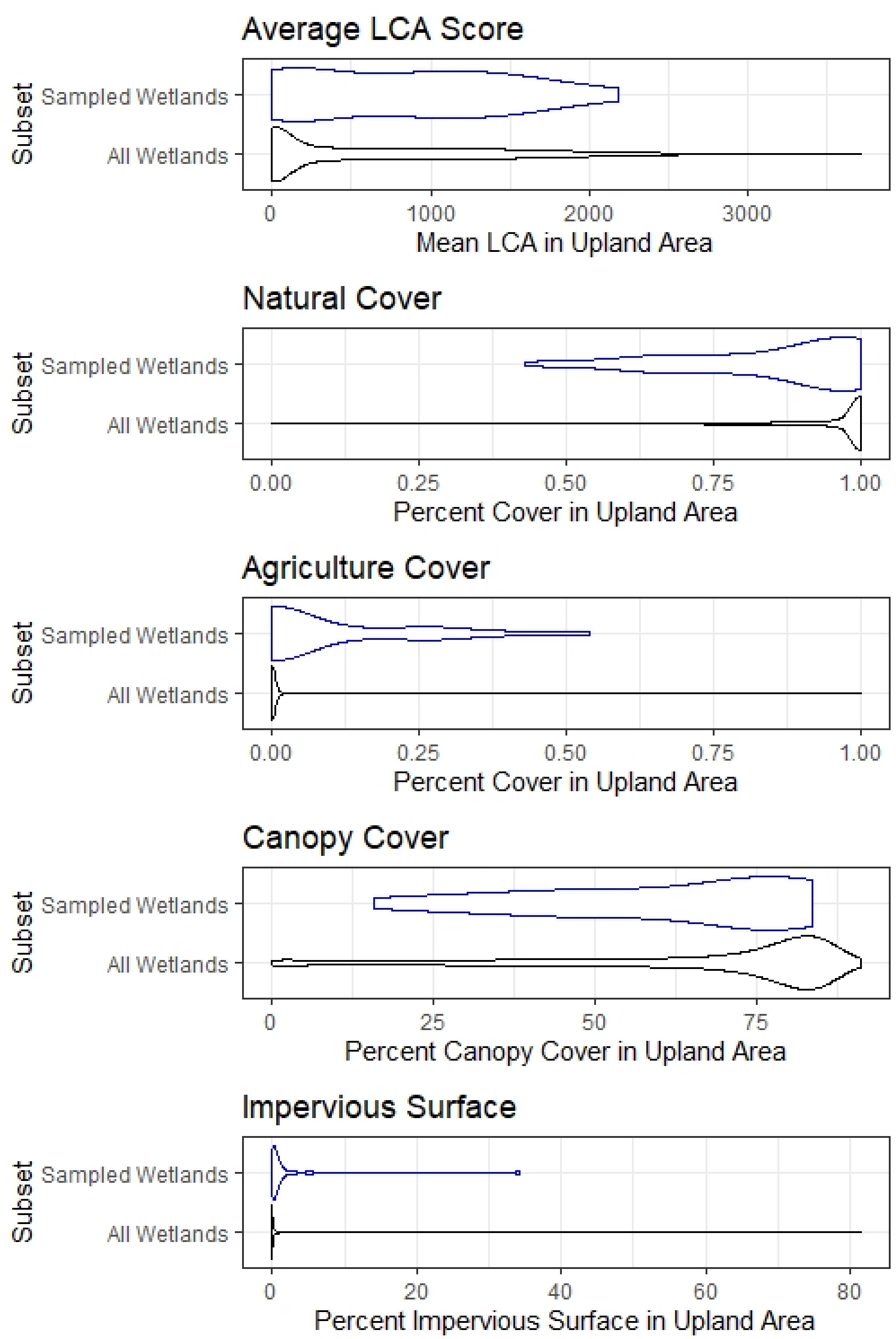


Figure 17. Wetland Catchment Metrics 2: Landcover Data Comparison of data distribution for remotely sensed metrics among sampled wetland complexes (n=20) and all wetland complexes in the Lake Champlain Basin (n=13772). Upland area refers to the contributing upland area that flows into the wetland, the wetland catchment.

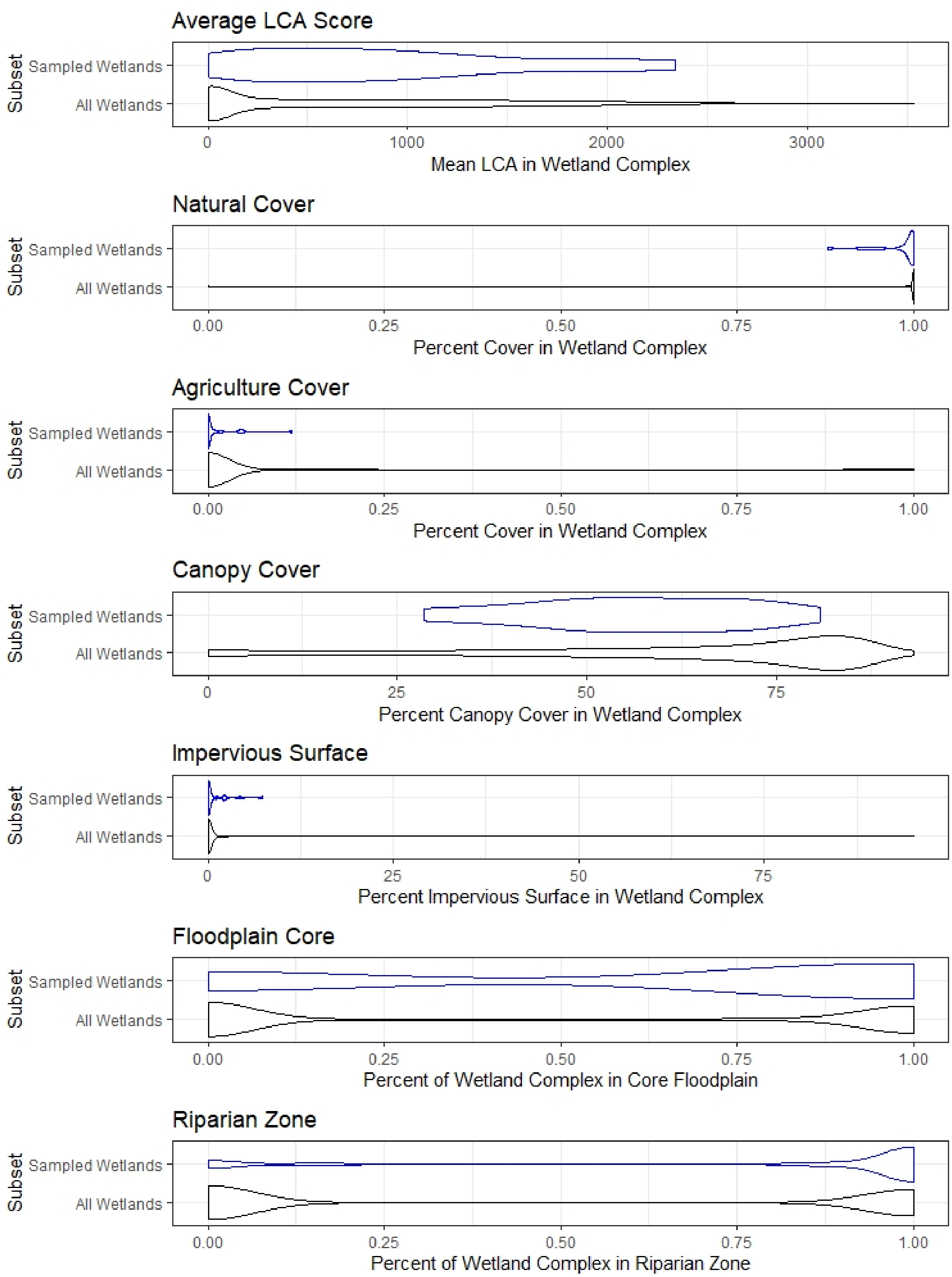


Figure 18. Wetland Complex Metrics: Floodplain Connectivity and Landcover Data. Comparison of data distribution for remotely sensed metrics among sampled wetland complexes (n=20) and all wetland complexes in the Lake Champlain Basin (n=13772).

Results of the sensitivity analysis give us a better understanding of the ability of individual metrics to provide sufficient information to be useful as measures of wetland function, or the limits of extrapolation (Table 5). For example, the percent impervious surface inside the wetland complex has a large range, but values are so clustered around 0 that it may, in practice, be of limited use when differentiating between wetlands. The impact of the upland accumulation area may be more useful, as metrics calculated at that unit did not tend to have distributions clustered around the minimum and maximum values, which complicates interpretation. For binary variables, for example, if a wetland complex is connected to surface water or not, we did not evaluate the range of the metric. We used our understanding of the remotely sensed metrics when developing combined condition scores based on their relationship with the field data collected at the sampled wetland complexes.

Table 5. Summary of the distributions of remotely sensed metrics for wetland complexes in the Lake Champlain basin. Metrics include Landscape Condition Assessment (LCA), Proportion Natural Cover (prop Natural), proportion agricultural cover (prop Ag), mean percent canopy cover (% canopy), mean percent impervious surface (% imperv), percent floodplain core (%FP), percent riparian zone (% Riparian), percent of riparian zone that is wetland (% Wet Riparian) and percent wetland (% Wet). The unit of comparison (Unit) includes the Wetland Complex (WC), wetland catchment (upland accumulation area, UA), and the subwatershed (HUC12). The set of records (Recs) and sample size (n) assessed included the full dataset (F) and the wetland complexes sampled in the field (visited, V). For each set, we compare the mean, median, minimum (min), maximum (max), first quartile (Q1), third quartile (Q3), and the interquartile range (IQR).

Metric	Unit	Recs	n	mean	median	min	max	Q1	Q3	IQR
LCA3	WC	F	13772	719	515	0	3533	3	1251	1248
LCA3	WC	V	20	880	785	0	2342	335	1204	869
LCA3	UA	F	13772	682	437	0	3714	7	1203	1196
LCA3	UA	V	20	813	816	0	2187	136	1369	1233
prop Natural	WC	F	13772	0.93	1.00	0.00	1.00	1.00	1.00	0.00
prop Natural	WC	V	20	0.98	1.00	0.88	1.00	0.99	1.00	0.01
prop Natural	UA	F	13772	0.87	1.00	0.00	1.00	0.87	1.00	0.13
prop Natural	UA	V	20	0.87	0.95	0.43	1.00	0.73	0.99	0.26
prop Ag	WC	F	13772	0.07	0.00	0.00	1.00	0.00	0.00	0.00
prop Ag	WC	V	20	0.01	0.00	0.00	0.12	0.00	0.01	0.01
prop Ag	UA	F	13772	0.10	0.00	0.00	1.00	0.00	0.05	0.05
prop Ag	UA	V	20	0.10	0.00	0.00	0.54	0.00	0.16	0.16
% Canopy	WC	F	13772	62	71	0	93	48	82	34
% Canopy	WC	V	20	56	56	28	81	47	69	22
% Canopy	UA	F	13772	65	76	0	91	52	83	31
% Canopy	UA	V	20	61	72	16	84	47	79	31
% Imperv	WC	F	13772	0.51	0.00	0.00	95.12	0.00	0.00	0.00
% Imperv	WC	V	20	0.94	0.11	0.00	7.39	0.00	0.61	0.60
% Imperv	UA	F	13772	1.21	0.00	0.00	81.44	0.00	0.43	0.43
% Imperv	UA	V	20	2.50	0.44	0.00	34.16	0.13	1.10	0.97
% FP	WC	F	13772	0.46	0.10	0.00	1.00	0.00	1.00	1.00
% FP	WC	V	20	0.62	0.96	0.00	1.00	0.00	0.99	0.99
% FP	UA	F	13772	0.15	0.00	0.00	1.00	0.00	0.17	0.17
% FP	UA	V	20	0.19	0.11	0.00	0.70	0.00	0.25	0.25
% Riparian	WC	F	13772	0.44	0.00	0.00	1.00	0.00	1.00	1.00

Metric	Unit	Recs	n	mean	median	min	max	Q1	Q3	IQR
% Riparian	WC	V	20	0.79	1.00	0.00	1.00	0.89	1.00	0.11
% Riparian	UA	F	13772	0.10	0.00	0.00	1.00	0.00	0.10	0.10
% Riparian	UA	V	20	0.10	0.08	0.00	0.33	0.02	0.16	0.13
% Wet Rip	UA	F	13772	0.03	0.00	0.00	1.00	0.00	0.00	0.00
% Wet Rip	UA	V	20	0.23	0.00	0.00	0.19	0.00	0.02	0.02
% Wet Rip	HUC12	F	78	0.36	0.33	0.06	0.87	0.25	0.45	0.21
% Wet	UA	F	13772	0.01	0.00	0.00	0.79	0.00	0.01	0.01
% Wet	UA	V	20	0.02	0.01	0.00	0.07	0.00	0.03	0.03

The current published version of our Landscape Condition Assessment (LCA v2, Feldmann and Howard 2013) effectively captures a wide range of scores representing an urban-rural stressor gradient, with minimally developed areas having low scores and urban areas having high LCA scores (Appendix A). Our previous work by Shappell and Howard (2018) has demonstrated strong correlations between our "Level 1" LCA model scores and our "Level 2" NY Rapid Assessment Method for wetland condition (NYRAM). Building on our updated LCA model (LCA ver 3 currently in prep under EPA WPDG CD-9626530-0), we added variables that have been demonstrated to have ecological significance, such as forest cover in the adjacent buffer and historical land use (Shappell and Howard 2018). For Objective D, we evaluated the sensitivity of the new ecological condition model developed in this project by comparing its range and variation to that of the similar LCA v3 model as well as regressing a spatial sampling of scores from each and evaluating a statistical regression of the new model on LCA v3. We also evaluated the sensitivity of the new model by comparing its ability to distinguish Level 2 scores from sites we have sampled during this project (e.g., scatterplot graph). Compared to our LCA stressor-based model, we expected the new ecological condition model to exhibit a stronger correlation with our Level 2 scores and therefore more accurately reflect ecological condition (i.e., have greater sensitivity).

For Task 2, our sensitivity measure was the distance used for automatically assigning observations to stream reaches.

- Observations were assigned to the nearest flowline. Sample sites that were greater than 100 meters from the nearest NHD Plus HR flowline (n = 2) were considered too far to be accurately attributed to the stream, and were omitted from model input.

Inspection Acceptance of Supplies and Consumables

All supplies and consumables for field and laboratory activities were inspected for compliance with the acceptance criteria by qualified staff prior to use. Supplies or consumables not meeting the acceptance criteria upon inspection were not used. For newly arrived supplies and consumables, all materials must be in their original packaging and free of noticeable damages. For materials already obtained and about to be used no noticeable defects were allowed. Any equipment determined to be in an unacceptable condition was replaced. Supplies and consumables were stored in accordance with identified storage requirements of each item.

- All stream sampling equipment was inspected prior to use. This included ethanol, kick sample jars, kick net, sieve, white tray, data sheets, waders, shoes, 5 gallon bucket, and GPS unit.

- All wetland field equipment was inspected prior to use. Equipment we used and inspected: backpacks, muck boots, waders, hiking boots, measuring tapes, pin flags, plant press, GPS, Samsung Tablet, Hori Hori Soil Knife, and compass.

Deliverables Completed

Objective A. Develop a detailed Quality Assurance Project Plan

We developed a detailed QAPP, which was finalized and approved on April 14, 2021.

Objective B. Build and validate a spatial model estimating stream water quality in the NY portion of the Lake Champlain Basin

We developed a spatial model estimating stream water quality on the NY side of the Lake Champlain Basin. We provide the predicted water quality scores by stream reach in an online data viewer, Online Interactive Map and Data Explorer, available at the project's Interactive Map. Once at the Interactive Map, choose the "layers" icon in the upper right, then Additional Models – Stream Water Quality Models, as in Figure 19.

Figure 19. Interactive Map screen capture with the layers dialogue open to show where and how to turn on the stream water quality models.

The predicted water quality scores are also available in the feature class called "Stream_condition_model_results" in the "NHDFlowlines_LCBasin_NYNHP_condition_models.gdb" geodatabase available on our webpage. The high-resolution NHD flowlines are also available in "NHDFlowline_LakeChampBasin." The 205 environmental variables we created are available in the two tables (Accumulation_attributes, Catchments_Attributes) located in the same geodatabase, each can be joined to either flowline featureclass using the NHDPlusID field. The column names for both tables are described in the spreadsheet "NHDFlowlines_added_Attributes_Definitions.xlsx", also available for download on our webpage.

These predicted scores were validated through field sampling. We provide a map of the sampled sites as well as site coordinates below (Figure 20 and Table 6).

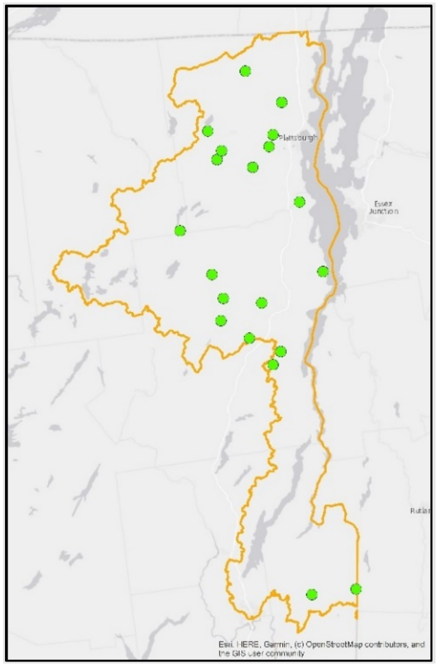


Figure 20. Stream sites sampled (kicknet sampling) for stream quality validation (green dots). Twenty sites were sampled over 2021-2022.

Table 6. Coordinates sampled for stream quality validation and the date each point was sampled.

UTM E	UTM N	Date Sampled
616736.5	4881546.5	2021-07-27
626927.0	4803050.7	2021-09-09
613214.8	4948000.6	2021-07-28
607644.6	4941334.7	2021-07-28
594829.8	4943659.3	2021-07-28
641232.3	4804651.1	2021-09-09
610893.4	4897454.5	2021-07-29
616262.1	4961377.6	2021-08-21
605825.5	4970962.5	2021-08-21
630164.4	4906820.7	2021-07-29
605839.9	4889113.4	2022-08-24

UTM E	UTM N	Date Sampled
612927.1	4876884.7	2022-08-24
597932.6	4899059.7	2022-09-01
595469.0	4905644.7	2022-09-01
597378.9	4947011.6	2022-07-20
614796.9	4950790.6	2022-07-21
601420.2	4892649.3	2022-09-01
584013.4	4915693.7	2022-07-21
591302.9	4951880.3	2022-07-21
624972.1	4931024.0	2022-07-22

We retained a reference collection of specimens collected for each macroinvertebrate family that was verified by experts from the Stream Biomonitoring Unit of the NYS DEC. We also will retain curated aquatic insect presence data for the sampled sites, available upon request.

We completed a validation (comparison of predicted scores from models to measured scores from sampling) using the field survey points from 2021 and 2022 (Task 8). It turns out that three of our samples occurred in small headwater streams, which require different calibration and calculations unavailable to us at the family level. Thus, we used 17 samples in this analysis. We used the three best-performing metrics from model creation (HBI, BAP, EPT, see Table 3) for this validation assessment. Our invertebrate identifications were to the family level and we converted the HBI and EPT sample scores to family level scores based on directions from page 87 of the Standard Operating Procedure (NYS DEC 2019).

The following graphs (Figure 21) show the predicted (modeled) score of stream reaches versus the sampled score for these indices.

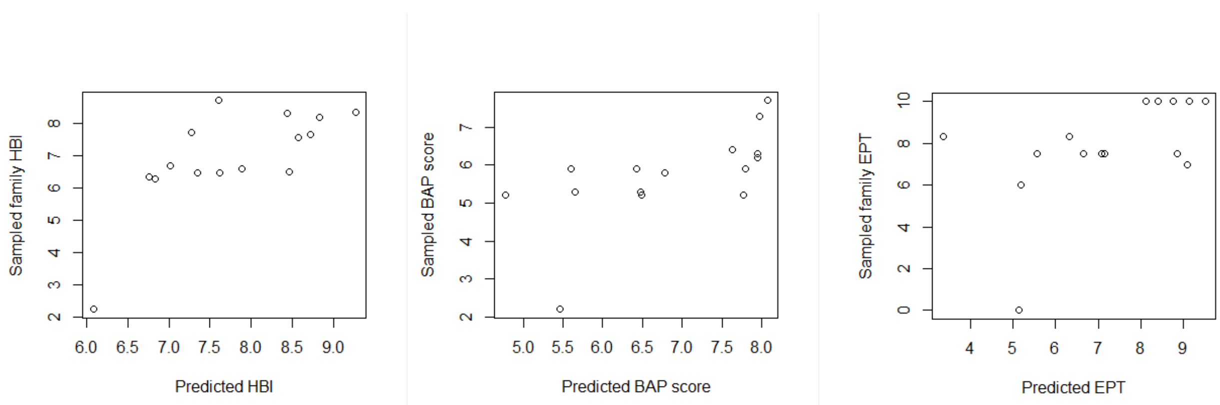


Figure 21. Predicted stream condition scores plotted against sampled scores for the same reach. HBI is the Hilsenhoff Biotic Index, BAP is the Biodiversity Assessment Profile, and EPT the index for diversity of the taxonomic groups Ephemeroptera, Plecoptera, and Trichoptera.

In both comparisons in Figure 21, we see the trend that streams with lower predicted condition tended to have lower sampled condition. This trend is statistically significant for HBI (linear model, $p = 0.003$, adjusted $R^2 = 0.47$) and BAP (linear model, p=0.011, adjusted R2=0.36) and nearly significant with EPT (linear model, p=0.0503, adjusted R2=0.021).

As the validation, especially of HBI, was successful, we provide these model results as a deliverable. A map of HBI for modeled streams is shown in Figure 22.

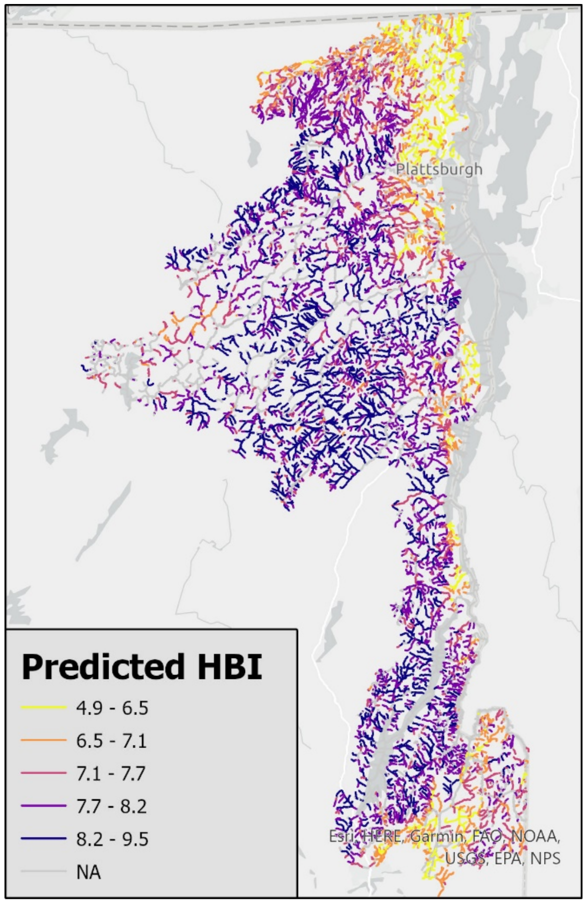


Figure 22. Predicted stream condition, based on HBI, for stream reaches in the NY side of the Champlain Basin.

OBJECTIVE C. ESTIMATE POTENTIAL WETLAND FUNCTIONAL CAPACITY TO DESYNCHRONIZE FLOODWATER

We calculated wetland metrics including wetland size, wetland cover types, and geographically isolated wetlands (GIW), floodplain metrics and interception opportunity, and upslope condition. We rolled-up these metrics into a combined desynchronization score (relative opportunity to desynchronize flood pulses by slowing and retaining overland surface flow from precipitation and snow melt) available in our Interactive Map (link) as the layer "Wetland Complex Overland Flow Interception". An overview of using the Interactive Map is below, but to quickly access and view this layer after entering the Interactive Map, choose the 'Layers' button in the upper right and then turn on "Lake Champlain Wetland Complexes – Wetland Complex Overland Flow Interception" (Figure 23). GIW are available as the "30 meters from mapped surface water" layer.

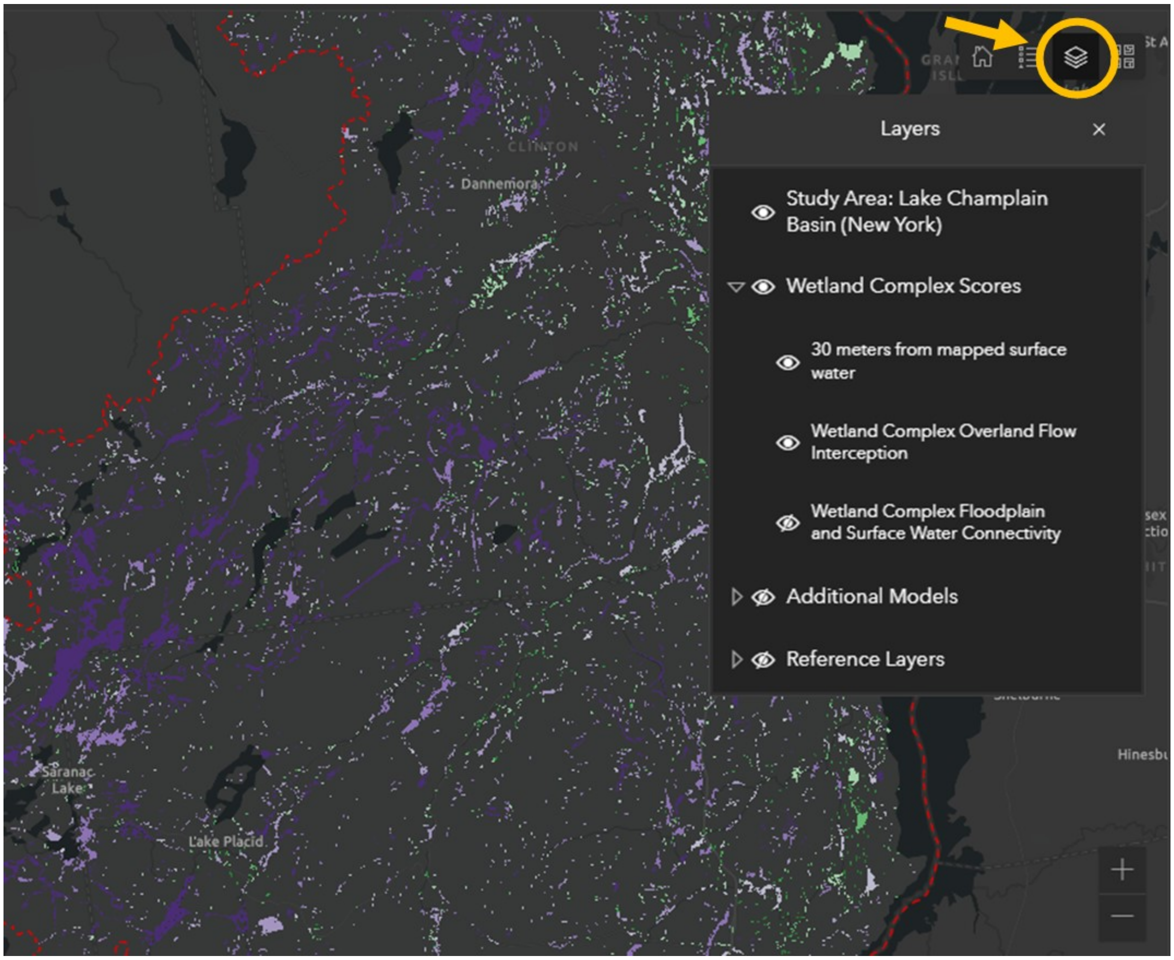


Figure 23. Interactive Map screen capture with the layers dialogue open to show where and how to turn on the layers depicting wetland complexes.

This is also available in our geodatabase on our webpage as attributes in the layer called "Wetland_Complex_Scores" (within Wetland_Complex_Polygons_LCBasin_NYNHP.gdb) for those wanting to view in a GIS. Attribute definitions are available in the Excel workbook "WetlandComplexScores.xlsx".

We also assessed wetland connectivity to streams, wetland proximity to surface water, and the proportion of the riparian zone that is wetland as well as detected barriers between wetland and streams. We calculated these metrics independently and as a combined score that strives to estimate *stream-floodplain functional condition*, providing insight into a stream reach's ecological health. View these data in the Interactive Map similarly to the other wetland complex metric (Figure 23). They are rolled up a combined score available in the Interactive Map as layer "Wetland Complexes Floodplain and Surface Water Connectivity". They are also available in the geodatabase on our webpage as attributes in the layer called "Wetland_Complex_Scores" (within Wetland_Complex_Polygons_LCBasin_NYNHP.gdb) for those wanting to view in a GIS. Attribute definitions are available in the Excel workbook "WetlandComplexScores.xlsx".

Objective D. Model ecological condition for all wetland units across the NY portion of the Lake Champlain Basin and validated these estimates with field sampling

Small Bur-reed (*Sparganium natans*) *by Kimberly Smith*

This section begins by focusing on our 20 ecology sites where we deployed wetland condition and functional assessment protocols. Our spatially balanced randomized sampling method focused on the Lake Champlain and Metawee River subbasins (HUC 8) ensuring sites were distributed along an urban-rural gradient, ranging from good to poor ecological condition. Wetland data from this study are discussed relative to scoring trends from our statewide wetland assessment database and reference benchmarks we developed in Shappell and Howard (2018). From our in-house database we gleaned another 10 Lake Champlain Basin sites that were surveyed for previous EPA- and State-funded projects (2013-2021); all 10 have vegetation plot data, seven have NYRAM data. These additional sites were in the western portion of the Lake Champlain Basin (Figure 24).

Wetlands visited during this project ranged in size from 13 to 656 ac (116 ± 38 ac; 47 ± 15 ha, n = 20). By contrast, sites from our database ranged in size from 3 to 6,674 ac (1391 ± 611 ac; 563 ± 247 ha, n = 10). Half of our 20 sites were forested wetlands, and included the following natural community types: floodplain forest (S2S3), red maple-hardwood swamp (S3S4), northern white cedar swamp (S2S3), and silver maple-ash swamp (S3). At least one of the deciduous forest wetlands is likely a rare Champlain Valley wet clayplain forest community type that has not yet been described in NY, but is described in VT (S2). Native-dominated herbaceous wetlands (shallow emergent marsh and sedge meadow, both S3 conservation rank) comprised 25% of sites. We encountered one marsh co-dominated by *Phragmites australis*, but the very high abundance of remnant poison sumac (*Toxicodendron vernix*), a calciphile, indicates the wetland is ground-water fed and was likely a fen community. The remaining sites were scrub shrub, including Alder-dominated shrub swamps (S3S4) and a medium fen (S2S3). The final site of note had a rare natural community type, rich sloping fen (RSF; S1 = Critically Imperiled in NY, G3 = Globally Vulnerable), that persisted in a power line right-of-way and in smaller natural patches in a matrix of a sloping variant of a northern white cedar swamp. This RSF site is now the northern most occurrence of this natural community in NY.

Sedge meadow (foreground) and alder shrub swamp (background), Penfield Pond *by Lydia Sweeney*

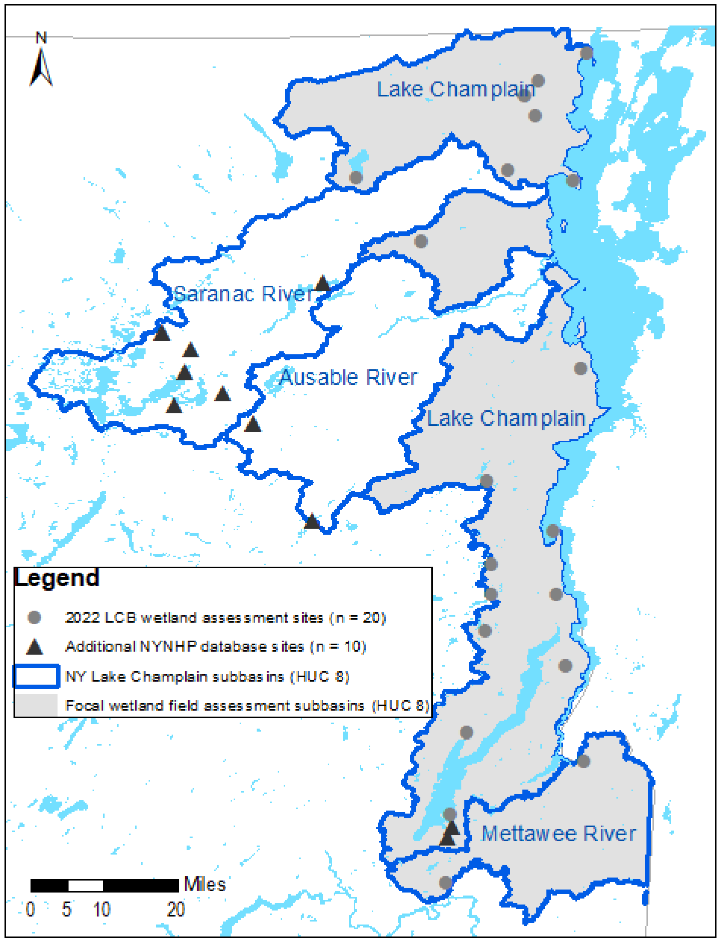


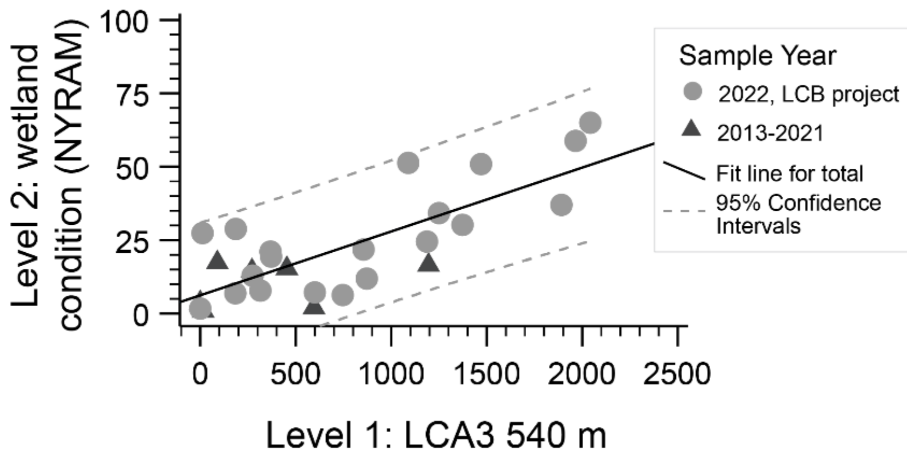
Figure 24. The above map shows the distribution of our 2022 wetland ecology assessment sites (n = 20) and sites in our database from previous projects/collaborations (n = 10, 2013-2021).

Level 3: Vegetation macroplots

We completed detailed vegetation macroplot surveys at eight of our wetland assessment sites and completed an addition two detailed observation points. During our 2022 surveys we identified >200 plant species, including Small Bur-reed, *Sparganium natans*, a state listed rare plant (NYNHP species guide). Plant species richness ranged from 26 to 100 species per 1,000 m^2 macroplot (60 ± 7), with nonnative invasive species comprising 6% (± 2) of the flora. Floristic quality scores (weighted mean coefficient of conservatism) ranged from a low of 3.9 ("fair" condition) to 5.9 ("good"; 4.7 ± 0.3, n = 8), which is within the expected range for most of the natural communities we surveyed in 2022. The additional sites are all fen or bog communities that have specialized plant species, making floristic quality scores markedly higher as expected for those community types (7.6 ± 0.2, n = 10). Live canopy tree basal area in our 2022 forested wetlands ranged from 16.1 to 41.7 m^2/ha (26.8 ± 4.3 m^2/ha, n = 5). Crown Point Historic Area Floodplain had the highest basal area, with the largest trees measuring >60 cm diameter at breast height (>23.5").

Levels 2 and 1: Rapid Assessment Methods (NYRAM, FRAM) and Modeled Landscape Condition Assessment (LCA)

Rapid wetland condition assessment scores (NYRAM, Level 2), based on field and onscreen assessment evaluation, ranged from a low score of 1.7 (excellent condition) to a high of 65 (poor condition), with an average of "good" ecological condition for our randomized 2022 data set (26 ± 4, n = 20). Approximately half (55%) of these sites appear to be in good or excellent condition based on their NYRAM score and their modeled landscape condition score calculated as an average score within 540 m of the sample point ("LCA 540 m", Level 1; Figure 25). Two sites are in "poor" condition and the remainder are in "fair" ecological condition. By contrast, the additional points from our database ranged from 0.8 to 17, with an average of "excellent" condition (10 ± 3, n = 7). A primary cause of the two-fold difference in NYRAM scores between the two data sets can be attributed to a ten-fold difference in wetland complex area. Very large and intact wetlands, such as those from our database, tend to act as their own buffer compared to the smaller wetlands surveyed in 2022. This size difference is also reflected in the Level 1 scores (Figure 25).



$p < 0.001$, rs = 0.673, n = 27

Figure 25. Cross validation of our rapid field condition assessment score (NYRAM) and average landscape condition score (LCA 540 is average score within a 540-m radius buffer around the sample point). Unlike other metrics used in this project, high scores for NYRAM and LCA indicate worse ecological condition.

Ecology three-tiered condition assessment & Spatial analytic metric performance

Our wetland assessment field metrics aligned well with some of the wetland complex spatial analytic metrics, particularly Connectivity to Surface Water (CSW) and Percent Core Floodplain (PCF). As core floodplain area increased, wetland condition increased, as did functional assessment "roll up" scores (SA score: $p = 0.007$, rs = -0.505, n = 27; $p = 0.028$, rs = 0.491, n = 20, respectively; note: high NYRAM scores indicate worse condition, hence the negative correlation coefficient).

As wetland condition decreased, we saw scores for modeled Wetland Floodwater Desynchronization Capacity (WFD) decrease ($p = 0.007$, rs = -0.508, n = 27). High functional assessment scores were positively associated with high connectivity scores, which we would expect given the design of Functional Rapid Assessment Methodology (FRAM) (e.g., wetlands connected to surface water support downstream fish and perform functions that are unique to floodplain and headwater systems; SA: $p = 0.028$, rs = 0.491, n = 20). FRAM protocol is available in Appendix D. Our Level 1 wetland assessment metric was negatively correlated with both CSW and WFD ($p < 0.035$, rs >-0.405, n = 30), illustrating potential connections between wetland ecological health and modeled functional capacity. We also saw a decrease in modeled water quality (HBI) as stressors in the landscape increased (Level 1: LCA3 540m; $p = 0.002$, rs = -0.587, n = 26). Overall, our field metrics aligned as expected with key spatial analytic metrics.

Ecology site water quality metrics & Spatial analytic metrics

To examine connections between our wetland-based spatial analytic metrics (see Appendix E for examples) and our water quality model we selected all streams within 50 m of 20 wetland complexes surveyed by our ecology team for this project and an additional 10 sites from our internal database. Seven of the complexes were not adjacent to modeled streams (e.g., lakeside, lacked throughflow), therefore 23 wetlands were used for this analysis. The number of stream segments associated with each of these wetlands ranged from 1 to 32 (mean = 5 segments, SEM = 1), with total modeled stream length averaging 8.1 mi (13 ± 2 km; range: 1.5 – 80.1 km) for each wetland complex.

There was a strong, positive, partial correlation between modeled water quality (HBI) and some of our spatial analytic metrics, controlling for number of modeled stream segments and total segment length. Wetland Catchment Condition (WCC) and the potential for a wetland to intercept and desynchronize overland and surface water flows (wet desync) were significantly correlated with mean HBI scores (Figure 26).

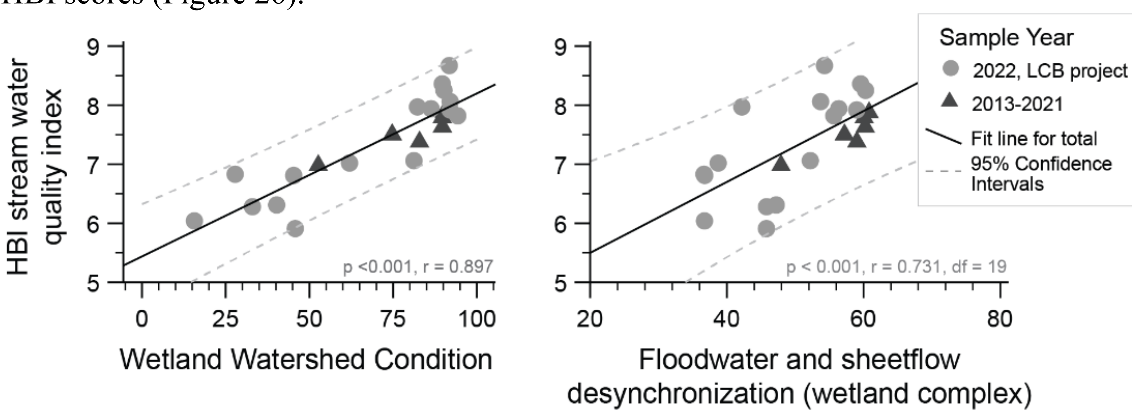


Figure 26. The HBI water quality index was positively correlated with wetland catchment condition (left) and wetland surface water desynchronization metrics (right). This analysis was applied to sites where we had wetland field assessment data and nearby water quality indices (n = 21).

Spatial analytics: modeling wetland condition

Anthropogenic development in the Lake Champlain Basin is one of extremes, from minimally disturbed to wetlands in urban landscapes. We applied our LCA model to all of the wetland complexes we generated in Task 10 and summarized the data as an average LCA score for each of the 13,772 complexes. As established above and in our previous work (Shappell and Howard 2018, Shappell et al. 2016), LCA is a useful tool for estimating ecological condition remotely. Through this project we've developed Wetland Watershed Condition (WWC) scores that when examined with LCA, show that decreases in catchment condition (lower scores) correlate with reduced wetland condition (Figure 27). Lower wetland condition may also correspond with reduced functional capacity relative to a wetland's capacity to intercept, detain and desynchronize floodwaters and upslope sheet flow.

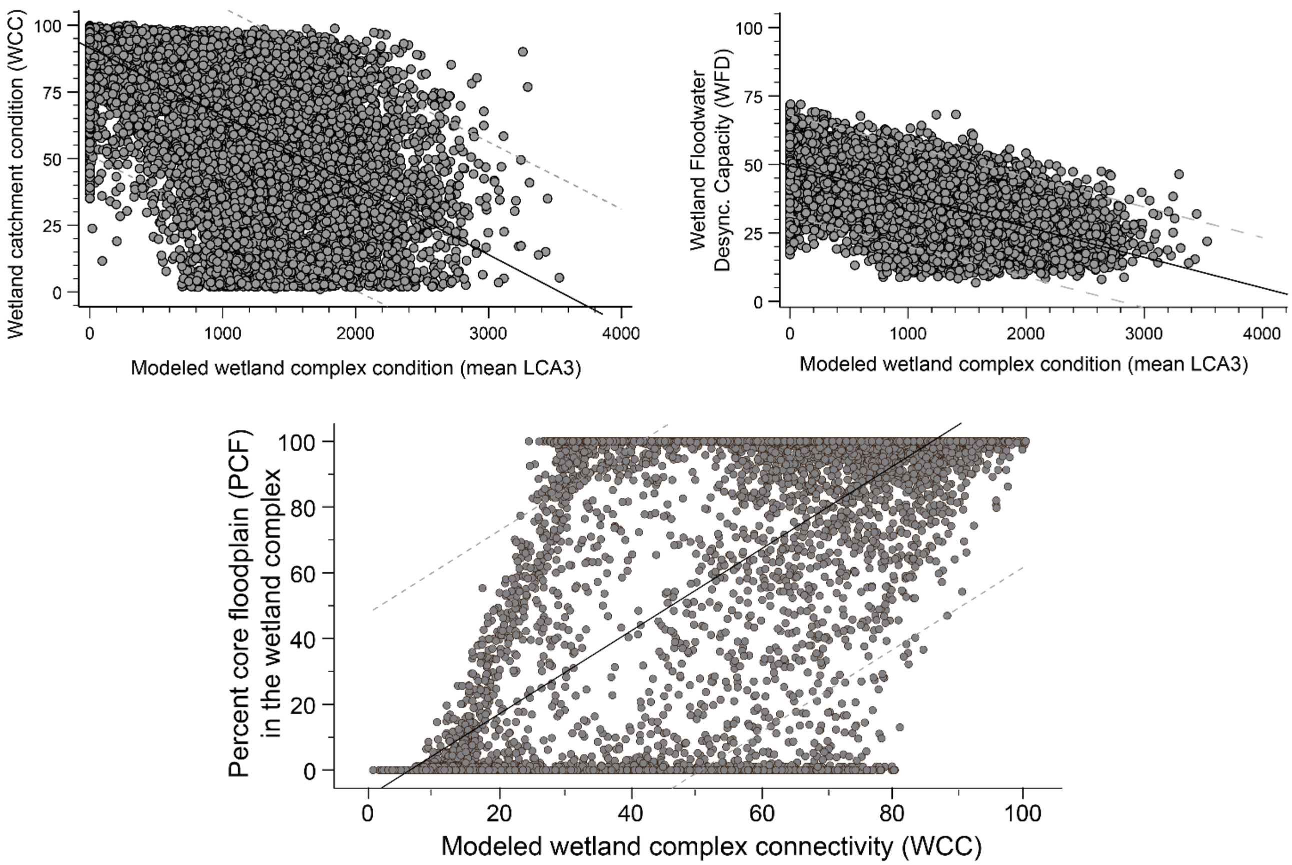


Figure 27. Intuitive results from our spatial models indicates that: Upper left: wetlands in poor condition co-occur where the upslope catchment is in poor condition, too ($p<0.001$, rs=-0.704, [n=13772 for all]). Upper right: Functional capacity in the form of WFD may be compromised by ecological condition of the wetland ($p<0.001$, rs = -0.633). Lower graph: Wetlands with a greater percentage of core floodplain area have greater modeled connectivity scores ($p<0.001$, rs=0.763).

OBJECTIVE E. PROVIDE AN INTERACTIVE TOOL TO DECISION MAKERS AND THE PUBLIC FOR VIEWING AND USING THESE DATA

Specific access and views of specific layers are noted in the other sections, above, but we provide a short overview of the Online Interactive Map and Data Explorer. The URL for the Interactive Map is:
https://nysdec.maps.arcgis.com/apps/dashboards/5043979934914f8e86fa2bc27ec5cb3f

It is technically an ArcGIS online "Dashboard" with four panels (Figure 28). A short overview is provided in the text at the top (Panel B). Filtering the types or condition of wetland viewable in the map view (Panel C) is controlled by the selectors in the lefthand sidebar (Panel A). A legend of visible layers is provided on the right (Panel D).

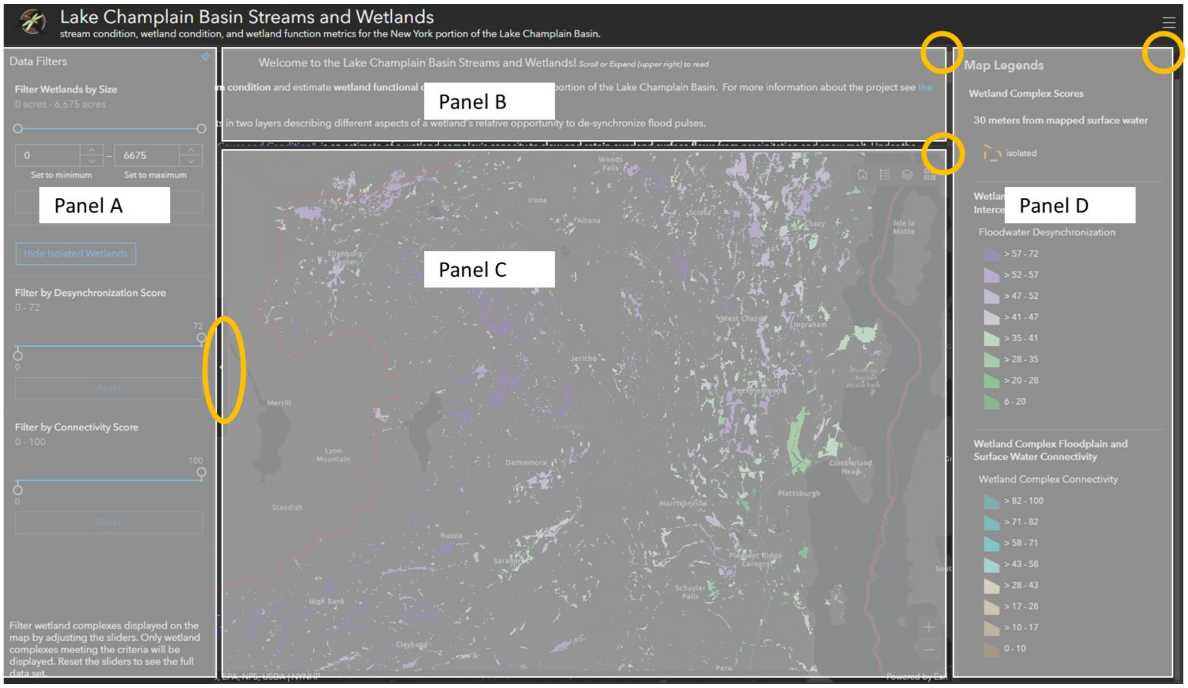


Figure 28. General layout of the Interactive Map. The four panels are shown with the boxes and making each viewable is controlled by buttons at the circled locations.

Notes on best use practices for the Interactive Map:

- Each of the four panels in the Interactive Map can be expanded by clicking on the expand icon in the upper righthand corner of each box. This can be useful for more easily reading the introductory text box, or for giving the user more room to explore the map.

- The Map Layers
    - The legend describing the symbology of all currently visible layers is permanently displayed in the right-hand box (Panel D in Figure 28). However, the legend can also be accessed from within the map box itself by clicking on the legend icon in the upper righthand portion of the map window which may be useful if the user has the map expanded.
    - When multiple layers are on, scrolling may be necessary to see the full data in the Legend Box.
    - Layers can be turned on and off by clicking on the layer stack icon in the upper righthand portion of the map window (Panel C in Figure 28) to reveal the layer selector window. Clicking on the icon again will hide the window.
    - The layers are organized into groups. The layers displaying the calculated scores for the wetland complexes are under the “Wetland Complex Scores” heading. Any additional models that were created for the project (the wetland catchment polygon, the stream water quality models and the Active River Area raster) are located under the “Additional Models” heading. “Reference Data” provides the ability to view other layers that may help users (a full copy of the NHD Plus HR, Urban Areas and Clusters, and administrative boundaries) but were not created for this project and are hosted by third parties.

- Several layers have zoom control, meaning they will not display at all scales. If a layer's name in the layer window appears in grey, it means that the current zoom level is either too close or too far to display it. For example, the Active River Area will not display if zoomed in too close, and the NHD will not display if zoomed out to the full extent of the map, the user must zoom in one level down.

- Accessing Data about Wetland Complex Scores
  - Two layers have pop-up windows designed to display additional data relevant to the wetland: "Wetland Complex Overland Flow Interception" and "Wetland Complex Floodplain and Surface Water Connectivity".
  - Wetland Complex Overland Flow Interception Popup Data
    - i. Displays the Floodwater Desynchronization Score
    - ii. General information about wetland size and its NWI types. Also flags whether its wetland is within 30 meters of mapped surface water.
    - iii. A chart of the component scores used to calculate the Floodwater Desynchronization Score. Hovering over the bars will reveal the name of the associated score and the value.
    - iv. A summary of what the score represents and the rationale behind how it was calculated.
    - v. Table: Floodwater Desynchronization Data. Lists the raw data values and the transformed score values for each of the elements of the Floodwater Desynchronization Scores.
    - vi. Table: Catchment Condition Score. Lists the raw data values and transformed scores used in calculating the sub score for Catchment Condition.
    - vii. Table: National Wetland Inventory Cover Data: Provides the percent cover for each of the coarse wetland types and the percent cover by water regime type.
  - Wetland Complex Floodplain and Surface Water Connectivity Popup Data
    - i. Displays the Wetland Connectivity Score
    - ii. General information about wetland size and its NWI types. Also flags whether its wetland is within 30 meters of mapped surface water.
    - iii. A chart of the component scores used to calculate the Wetland Connectivity Score. Hovering over the bars will reveal the name of the associated score and the value.
    - iv. A summary of what the score represents and the rationale behind how it was calculated
    - v. Table: Connectivity to Floodplain and Surface Water Data. Lists the raw data values and the transformed score values for each of the elements of the Floodplain and Surface Water Connectivity score.
- Visualizing Catchments
  - The Wetland Catchments layer is turned off when the map is loaded, to reduce lag when exploring the map. If a user wishes to view the catchments, the first step is to open the layers window in the map box, click on "Additional Models" and check the eye symbol next to "Wetland Catchments". The catchments will not appear, but the layer will be visible.

- Ensure that the “Wetland Complex Overland Flow Interception” layer is on. It is the default layer open when the Interactive Map is loaded. For fastest results, turn off the “Wetland Complex Floodplain and Surface Water Connectivity” layer.
- Click on a wetland of interest.
- Look at the popup window. If multiple layers are active when a wetland is clicked, the pop-up window will display left and right arrows in its upper right corner and indicates that multiple layers with popups are visible with text “1 of 2”. Clicking on the arrows will move through the pop-ups. Ensure that the title of the pop-up is “Wetland Complex Overland Flow Interception”. In the top bar of the pop-up window, click on the icon of a box with a + sign that says select. The wetland catchment should appear in grey.
- To view the catchments of multiple wetland complexes at once, or to quickly view catchments without using the pop-up window, with the “Wetland Complex Overland Flow Interception” and “Wetland Catchments layers on, click on the select tool located in the upper left hand window of the map. It should turn blue, and the cursor will change from an arrow to a point selector. Then click on a wetland complex with the point cursor. The complex will be selected and the catchment should appear on the map in grey. You can display the catchments for multiple wetland complexes at the same time by using the drop-down menu next to the select tool to change the selector from point to lasso or rectangle. Drag the new selector tool around the map to select multiple wetland complexes and see their catchments. If any selections have been made, a second tool icon will appear next to the select tool in the upper left corner, with a zoom icon and an “X”. Clicking on “X” will clear all selections made on the map. Clicking on the Select tool again will turn the tool off, the tool icon color will change from blue to grey, and the cursor will change from a point selector to an arrow. The arrow cursor is necessary to explore the pop-up boxes for the Wetland Complex Floodplain and Surface Water Connectivity layer, so it is recommended to turn the Select tool off when exploring data on the map.

* Using filters to focus on wetlands of interest
    - The Filter panel (Panel A in Figure 28) is a collapsible box. When collapsed, it can be made to reappear by clicking on the black button with a right-arrow in the center of the left-hand border of the page. This will make the Filter Panel slide out, partially obscuring the map and text box. It can be tucked away again by clicking on the button with a left-arrow on the right border of the Filter panel. Clicking on the blue pin icon in the top-right of the Filter Panel box will affix the Filter panel to the left side of the dashboard, and the other panels will re-size themselves so that no data is obscured. Clicking on the pin again restores the ability to hide the window.
    - The Size selector allows filtering of wetlands by their area in acres. Users can input minimum and maximum sizes directly into the boxes.
    - The Isolated Wetlands category selector will turn on or off wetlands that are greater than 30 meters from mapped surface water.
    - The Filter by Desynchronization Score selector uses sliders to adjust values for minimum and maximum desired Floodwater Desynchronization Score.

- The Filter by Connectivity Score selector uses sliders to adjust values for minimum and maximum desired Connectivity to Surface Water Score.
- Hitting Reset will restore the default settings of the filters, where all wetland complexes are visible.
- Any filter will act on both the Wetland Complex Overland Flow Interception layer and the Wetland Complex Floodplain and Surface Water Connectivity layer.

Conclusions

Project accomplishments

The importance of understanding the components of stream and wetland condition and function *and* how these factors vary over the landscape cannot be overstated, especially for land managers with a stake in minimizing the detrimental effects of flooding and increasing biodiversity. The ultimate goal of this project was to support managers and other conservation practitioners with data and tools that help prioritize where to work, whether that be land acquisition, wetland and stream restoration, or other activities.

Our accomplishments include the development of:

- 205 local and landscape metrics related to each stream segment of the mapped streams (NHD Plus HR) in the NY portion of the Lake Champlain Basin.
- Validated stream condition models for streams throughout the NY portion of the Lake Champlain Basin.
- The Active River Area framework (Smith et al. 2008) applied to the high resolution mapped streams (NHD Plus HR) of the NY portion of the Lake Champlain Basin.
- Wetland complexes, grouped adjacent wetlands, defined and assembled throughout the NY portion of the Lake Champlain Basin.
- 74 metrics calculated for the wetland complexes, each related to different aspects of wetland condition or function.
- Summary metrics related to floodwater desynchronization and wetland connectivity.

We have made all of these products available to researchers and conservation practitioners, in the form of GIS data sets and integrated into an online mapping data viewer, the Online Interactive Map and Data Explorer. With the tools developed through this project, conservation practitioners can now, for example, find high-performing and low-performing wetlands, understand the factors integrated into the scoring, and use that information to best design a strategy for conservation, restoration, and management.

Lessons learned and possible future work

East Branch Ausable River *by Erin L. White*

A perpetual problem for all landscape analyses such that those undertaken here is the range in scales of the input data. The best available GIS data set may be perfectly adequate for most uses but then turn out to lack the precision needed to apply to our use-case. One example of this would be the National Wetland Inventory (NWI), the data set we used as our primary source of wetland delineations. While the NWI is a tremendous resource that is constantly improving (and also better than any other alternative, see Figure 2), it still has its limits when, for example, the wetland boundaries cross stream segments such that 'watersheds' for the wetlands can be grossly overestimated. We quickly learned we needed to cut streams out of our watershed calculations (Figure 7, Figure 8), *and* that the stream we cut out needed to be the stream channel calculated from the high-resolution digital elevation model (1 meter DEM) because of the discrepancies between this and the mapped streams of the National Hydrography Dataset (NHD Plus HR).

Another "lesson learned" follows directly from this. Ideally, streams calculated from flow accumulation (depicted in Figure 7) should be extracted from culvert-modified (Fareed and Wang 2021) DEMs so that stream-road crossings are accurately depicted. While a version of this appears to be available for Vermont (link), we do not know of a comparable product for the New York side of the Champlain Basin and creating this (a culvert and bridge modified 1 m DEM) was far too time intensive for us to accomplish as part of this project. The result was that in a few places, the streams calculated via flow accumulation did not pass under roads in the correct location. This is one area in which future work could improve both the data inputs (the DEM) and some of the derived products developed in this project.

Similarly, a flood inundation data set has been built for the Vermont portion of the basin (link), but not the New York side. These topographically-defined floodplains categorize the areas adjacent streams by flood zone (Diehl et al. 2022) and thus have a different focus and application to the elevation profiles we developed with the high-resolution DEMs. However, applying this approach and extracting the relevant information to get stream bank profiles may increase the efficiency of the barrier score we estimated here.

Other aspects of this project could also benefit from future work. There are additional freshwater invertebrate datasets in the Champlain Basin, particularly one built by Luke Myers at SUNY Plattsburg (e.g., Myers et al. 2011). These data could be added to the DEC data and, while a fair amount of preparatory work would be required to align these data sets, it would allow us to build and validate a more robust stream condition model.

Further, expanding our wetland sampling would result in better wetland condition and function validation as well as provide a better understanding of the different function metrics and possibly provide additional remote assessment metrics to our arsenal.

In all, the intermediate products, final synthesis products, and the tools developed from this project provide land managers with data and tools that can be used to help prioritize conservation and protection work within the Lake Champlain watershed. The landscape in the basin, however, is continually changing, as are the analytic resources available for these types of assessments. We look forward to finding opportunities to make this an iterative product that improves and better fits the needs of resource managers with each iteration.

Acknowledgements

We wish to thank the Lake Champlain Basin Program for contracting with NY Natural Heritage to coordinate and manage this project. This project was funded by an agreement awarded by the United States Environmental Protection Agency (EPA) to NEIWPCC in partnership with the Lake Champlain Basin Program. We thank Mae Kate Campbell of LCBP and Heather Radcliffe of NEIWPCC for technical and administrative oversight of this project. Thanks to NYNHP staff, J Evans and Fiona McKinney, for their administrative support of this project and Greg Edinger and Lydia Sweeney for their assistance with field surveys and observations. Thanks to Matt Buff for creating and posting content on a project webpage. We also thank SUNY ESF student Amos Barnes for assisting with three days of stream sampling in 2021 as part of an internship program through the Adirondack Ecological Center in Newcomb, NY.

Thanks to Rich Ring and Tom Phillips for verifying plant identifications. We thank our partner NYS DEC Stream Biomonitoring Unit for sharing their stream quality data with us and for verifying our macroinvertebrate reference collection. Specifically we thank Bryan Duffy, Keleigh Reynolds, Makenzie Garrett, Evan Joneson, Charles Stoll, and Zach M. Smith. Thanks to Luke Myers of Lake Champlain Research Institute of SUNY Plattsburgh for sharing macroinvertebrate data with us.

We offer thanks to the many landowners who provided us access to wetlands sampled for Objective D of the project.

Many thanks to Tim Daly for his assistance and guidance for serving and displaying our data in an online format and helping to make our data accessible to the public.

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Appendices

Appendix A. Landscape Condition Assessment (LCA ver. 2) for New York. Albany, NY. New York Natural Heritage Program. October 2013.

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

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

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

where *x* is 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).

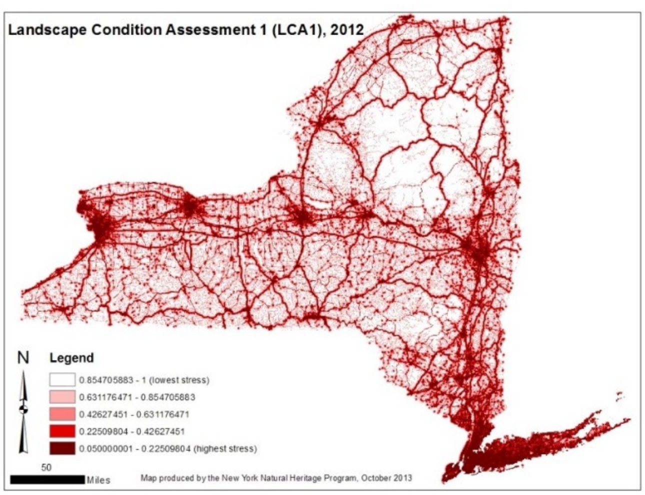

Figure 1. Statewide Landscape Condition Assessment model, version 1 (LCA1).

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

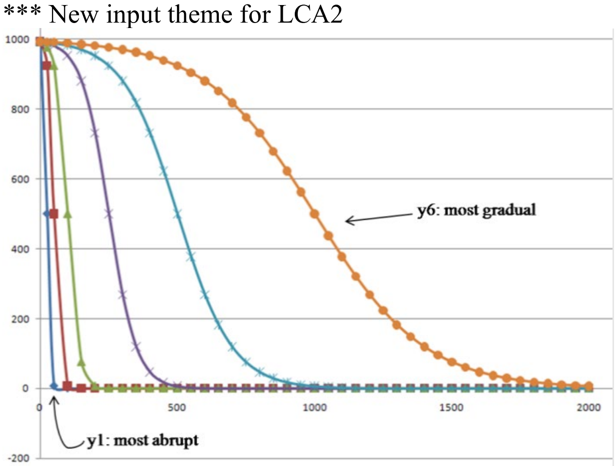

Figure 2. Sigmoid decay curves used to model the attenuation of ecological effects away from the footprint of a stressor. For stressors modeled with the y1 curve, impacts dropped off rapidly with distance (e.g., unpaved trails); stressors associated with the y6 curve had impacts that were assumed to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

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

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:

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

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).

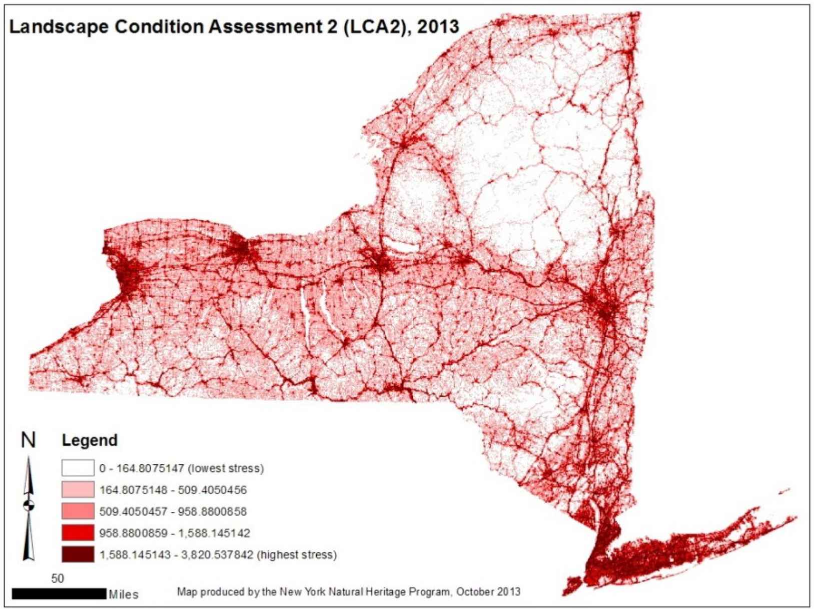

Figure 3. Statewide Landscape Condition Assessment model, version 2 (LCA2).

Notable improvements, LCA1 to LCA2:

1. Addition of agricultural lands, significantly improved stressor assessments in central and western NY.
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.

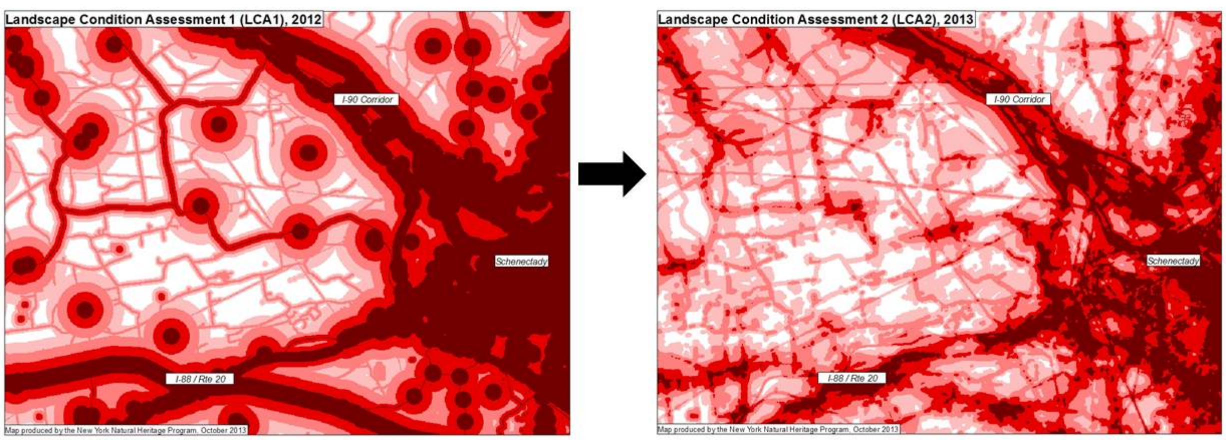

Figure 4. Depiction of landscape stress west of Schenectady, New York from the LCA1 model (left) and the LCA2 model. Sigmoid modeling of stressor reduction and cumulative (instead of maximum) stressor scoring produces a more natural, less stylized stress assessment.

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APPENDIX B. LEVEL 2 RAPID ASSESSMENT METHOD

New York State Wetland Condition Assessment

Level 2 Rapid Assessment Method
NYRAM Version 5.3, December 2021

User's Manual and Data Sheets

Developed By New York Natural Heritage Program

Laura J. Shappell, Ph.D.

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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NYRAM Field Manual

Project scope ... 67
Method development ... 67
Development of NYRAM ... 67
Sampling effort ... 68
Part A ... 68
Part B ... 68
Overview of the NYRAM sampling design ... 68
Site vetting and establishment ... 69
Sample Area ... 69
Digital resources for the field (Part B) ... 70
Part A: Onscreen assessment example ... 71
Materials & resources ... 71
Methods for determining % LULC type ... 72
Worked example: Figure 4 ... 73
Works cited ... 75
Appendix: Wetland Condition Level 2 Rapid assessment scoring forms
Part A: Onscreen rapid assessment ... 77
Part B: Wetland stressor field worksheet ... 79
Wetland stressor checklist ... 80
Qualitative condition rating ... 82
Part B field data summary ... 85
Part B cumulative score ... 85
NYRAM Level 2 Grand Score: ... 85

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 (http://www.nynhp.org/wetlands). 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, Shappell et al. 2016, Shappell and Howard 2018). Most of the 54 survey sites used to calibrate NYRAM ver. 4.2 fell within the Lower Hudson River and Susquehanna River watersheds; a few additional points were located in the Adirondack Park. **NYRAM ver. 5** scoring was recalibrated in 2018 based on an expanded urban-rural dataset with greater coverage across NYS (n = 140; Shappell and Howard 2018).

Following recalibration, NYRAM ver. 5 (“NYRAM5”) scores are more robust and correlate strongly with floristic quality scores (Shappell and Howard 2018). The new method provides an option to automate the onscreen assessment portion of NYRAM (“Part A”), but we’ve retained the original manual form, with updated scoring, as an option for users (NYRAM5-m). Regardless of whether users automate or manually complete Part A, the final scores are comparable (Figure 29). Users can use either the automated of manual versions of NYRAM Note: landscapes that have been recently developed or are heavily logged may not be accurately scored by the LCA model since it was developed using the 2011 National Land Cover Dataset – in these landscapes, consider using the manual option for Part A for best results.

Limitations of NYRAM

To capture subtle or short-term (<10 year) shifts in vegetation composition please consider using our floristic quality and ecological integrity metrics outlined in Shappell and Howard (2018). NYRAM was developed for non-tidal palustrine wetlands and does not include stressors unique to lacustrine, tidal, brackish, or estuarine environments (e.g., tidal flow restrictions). Caution should be used when applying NYRAM to non-target wetland systems because appropriate stressors have not been identified and evaluated during the development of this protocol. We have tested NYRAM in a handful of estuarine wetlands and it appears to perform okay, but it is not designed to capture stressors such as slumping, decreased vegetative cover, etc.

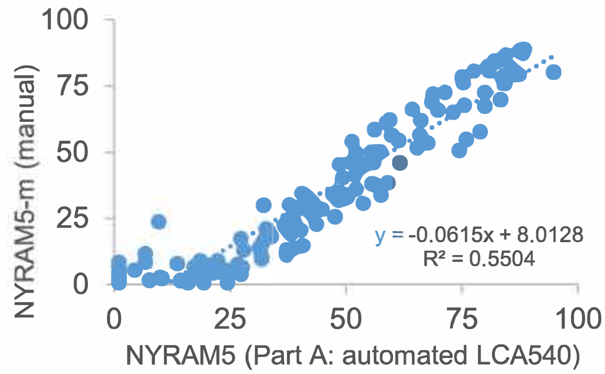

Figure 29: New for NYRAM ver. 5 users can generate a site's Part A score using a modified LCA540 metric ("automated") or complete Part A manually. Final NRAM5 scores are generally comparable between the two methods (n = 140). See sampling effort notes for exceptions.

Sampling effort

Part A: The onscreen portion of this method assesses the 540 m Landscape Buffer centered on the target Sample Area (see figure below). Following recalibration of NYRAM5, users now have the option of automating this step, using the "Zonal Statistics" tool in ArcGIS to calculate the mean (average) LCA score for a 540-m buffered area generated around the center of your Survey Area. More information about the rasterized LCA model and download information are available at nynhp.org/data. In NYRAM5-m, part A can be completed manually based on air photo interpretation using ArcGIS, Google Earth, or other air photo sources. Depending on landscape complexity and observer experience, manual completion of Part A may take 15-60 minutes. scores produced by NYRAM5 and NYRAM5-m are generally comparable with a few exceptions. The manual version should be used in areas where subtle differences in land use may not have been captured by the LCA model (e.g., silviculture or logging), or where development has occurred relatively recently (<10 years old). Tips for manually completing this portion of the assessment are outlined below.

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 ≥2.5 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 540-m buffer around the center of the SA, is assessed in Part A of NYRAM ver. 4.5 through basic air photo interpretation. The field survey assesses stressors within the SA and surrounding 100-m Field Buffer "doughnut" (Part B; Figure 30).

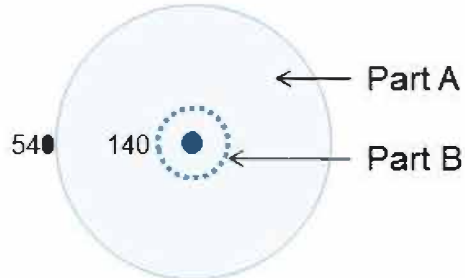

Figure 30: Schematic of the standard Level 2 rapid assessment survey design that includes Landscape Buffer stressors (Part A), and a meander field survey (Part B). Site surveys are centered on the target Survey Area (SA), a 40-m (44 yard) radius circle (0.5 ha), signified here as a dark blue circle or "doughnut hole". To ensure ≥90% of the SA land cover is wetland, linear, or small, irregularly-shaped wetlands may require non-standard SAs dimensions (e.g., 20 m x 50 m rectangle) and range in size from 0.1 ha (0.25 ac) to 0.5 ha (1.24 ac). Part B field meander surveys are conducted in the SA, and a 100-m buffer around the SA (i.e., the dash "doughnut" pictured above). Field stressor surveys therefore cover a 140-m radius area (6.15 ha/15.21 ac) around the center of the targeted survey area.

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 (www.google.com/earth), Google Earth Pro (includes advanced functions, GIS file import: (Google Earth Pro: Importing GIS data), or via online maps (e.g., Bing Maps: www.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 71.

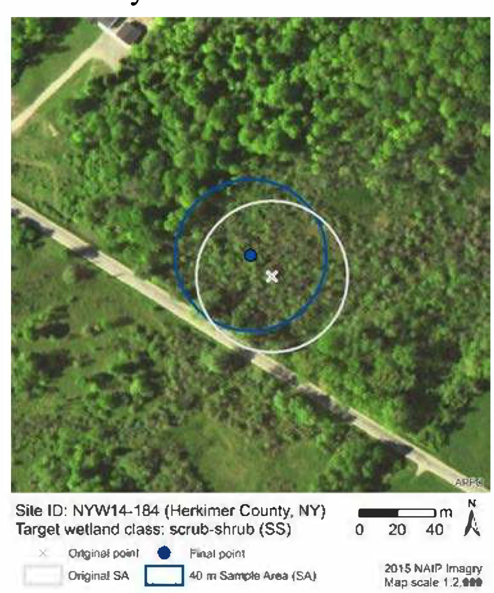

Figure 31: Sample Area around original random point included a road and some forested area (>10% non-target), so the point was moved ~15 m northwest

Additional mapped data such as topography, USDA NRCS SSURGO2 soils (SSURGO website), 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.

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

<u>≤10% of the total SA</u> 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**, and you are using a <u>random</u> sample point, try moving the point ≤60 m (e.g., Figure 31). Point movement is only restricted to 60 m if you are following a random survey design.

SA size & shape

<u>Standard SA:</u> accommodates a 40-m radius plot 0.5 ha (5,025 $m^2 \approx$ 1.24 ac), while maintaining the above composition criteria.

<u>Non-standard SA:</u> 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 32 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

<u>Ownership</u> – 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.

<u>Physical obstructions</u> – 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.

Figure 32: The original SA was <90% emergent, the target class for this survey, so a smaller nonstandard SA was established (0.1 ha)

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 random 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 random point or wetland.]

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 32 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

This step can be conducted before or after 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

Automated Part A (NYRAM5) - Landscape Condition Assessment

Generate a 540-m buffer around the center of your survey area (point) in ArcGIS using the "buffer" tool. Using the rasterized LCA data layer (download from nynhp.org/data), use the "zonal statistics as table" tool to calculate the average (mean) LCA score within your target 540-m buffer (polygon). Your zonal statistics will be exported as a table – the average (mean) LCA value is what you're looking for, this is what we use for our landscape scale "Level 1" metric referred to as "LCA540". Use the following equation to transform your LCA540 score and calculate your NYRAM5 Part A score. Note: some stressors associated with land use history such as logging may not be captured by the LCA model and in such settings, it's best to crosscheck your automated score with a manual onscreen review.

$$\textbf{NYRAM5 Part A}: \log_{10}(\mathrm{LCA540} + 1) \times 15$$

Manual Part A (NYRAM5-m) - Aerial imagery

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

US EPA, "WATERS GeoViewer": epa.gov/waterdata/waters-geoviewer
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 for manual onscreen assessment (optional)

Wetland, hydrography, and soils

NWI data published by US Fish & Wildlife Service (USFWS) - Interactive mapper, GIS & Google Earth data downloads: 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: nhd.usgs.gov/data.html

USDA soils:

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

GIS data: gdg.sc.egov.usda.gov/ or via interactive downloader: ArcGIS SSURGO downloader

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): gis.ny.gov/gisdata

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

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

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

Methods for determining % LULC type (NYRAM5-m only)

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 34). 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 34), 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 34). [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.

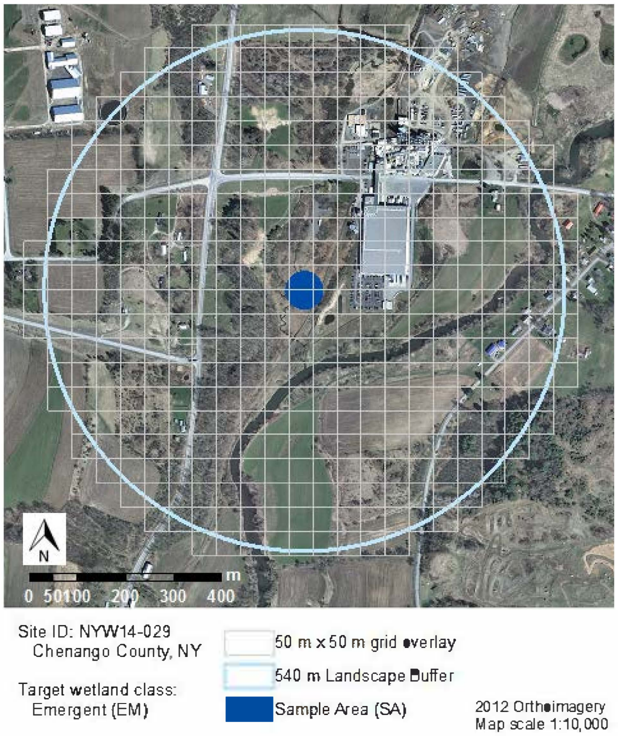

Figure 34: NYRAM5m part A assess the Landscape Buffer that extends 540 m from the center of the Sample Area. An overlay grid aids percent cover estimates of LULC types.

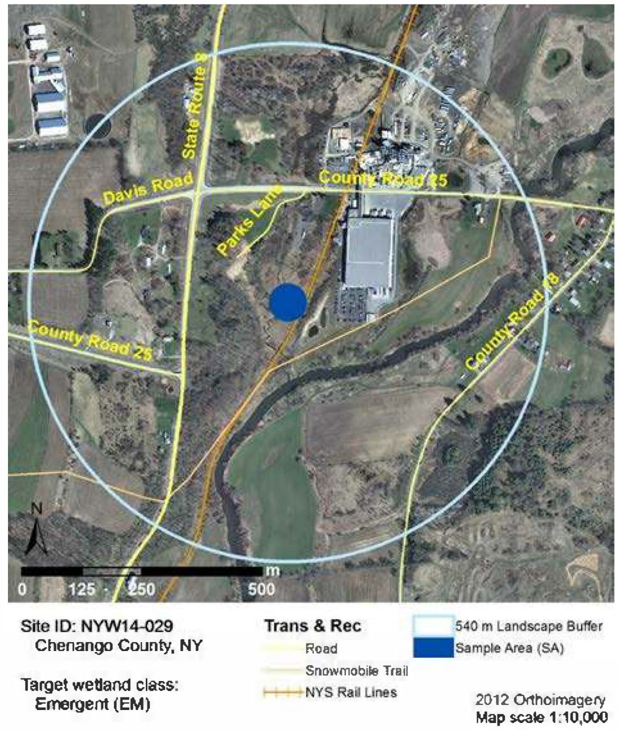

Figure 33: Fragmenting feature tally example. This site includes three categories of features: 2-lane roads, railroad, and an unpaved trail.

Worked example: Figure 34

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 34 (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.

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 34). 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, railroads, 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 65 for weights and calculation). Total LULC scores produced form Table 7 averaged 17.6 (± 1.2).

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; percent 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

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), the Landscape Buffer includes one (1) unpaved trail (snowmobile), one (1) railroad, and five (5) continuous named roads.

NYRAM Works cited

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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.

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WETLAND CONDITION LEVEL 2 RAPID ASSESSMENT SCORING FORMS

New York Rapid Assessment Method (Level 2) Field Worksheets

Developed by New York Natural Heritage Program
625 Broadway, 5th Floor, Albany, NY 12233-4757 (518) 402-8935 Fax (518) 402-8925 www.nynhp.org/wetlands

Part A: Onscreen rapid assessment

Area of focus: the Landscape Buffer, a 540-m buffer around the center point.
Note: If the sample point will likely be moved in the field, complete this portion after the field survey.

Site description

Observer(s) ______________________ Date of onscreen assessment ____________

Site name ______________________ Site code ______________________

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

Option 1 (automated, beta ver.): Use zonal statistics in ArcGIS, calculate the mean LCA score for a 540-m buffer around the center point ("LCA540" score), and then use the calculation outlined below in Option 1.

Option 2 (manual*): Complete the following LULC and fragmenting features tables.
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 lawn, timber, 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

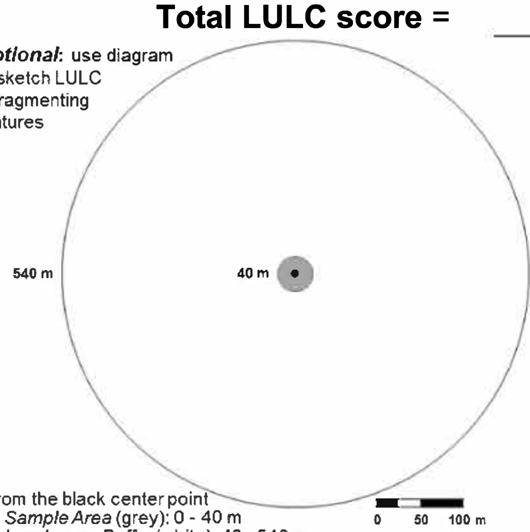
Tally the number of fragmenting features in each category found in Landscape Buffer.
GIS tip: add New York State road, railroad, hiking & snowmobile trail layers

	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 or maximum score of 40]

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

Option 2 (manual)
LULC + frag scores or **max of 50 pts**: ________
*Manual is suggested for landscapes with recent development within 10 years or where logging is present

Option 1 (automated, beta ver.)
$\log_{10}(\text{LCA540} + 1) \times 15$ ________

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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 ______________________ Sourcecode Sarracen1a(optional) ______________________

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)

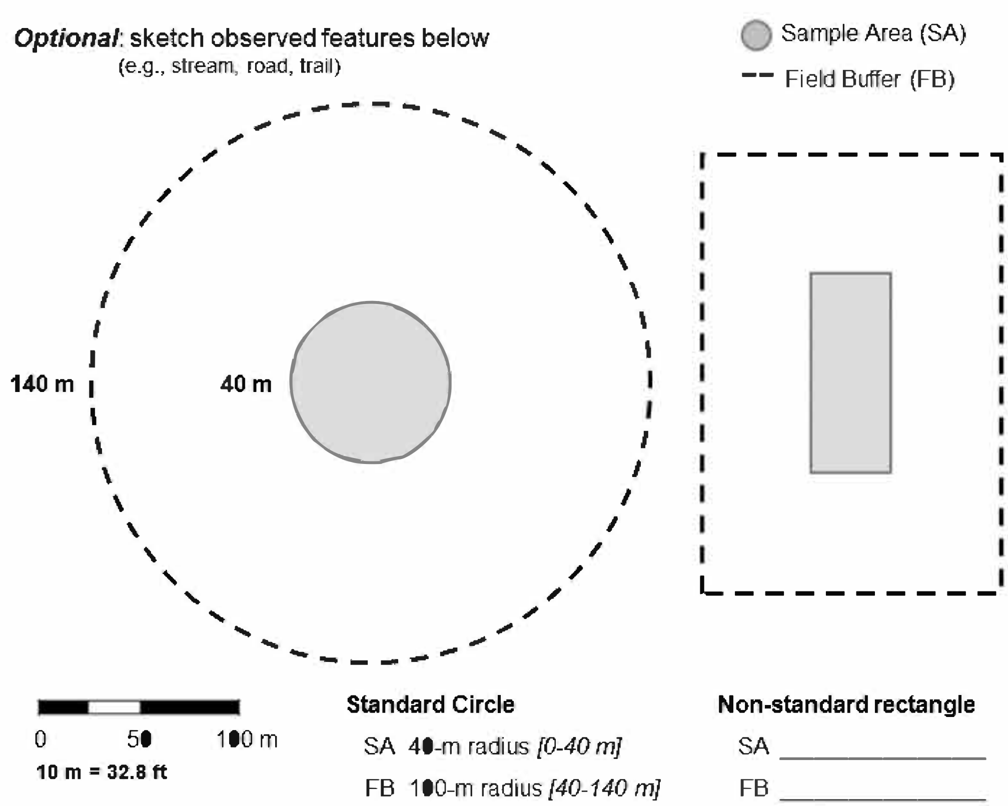
☐ CIRCLE - 40-m radius

SA dimensions determined by (circle one): GPS 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



NYRAM 5.3 - Part B

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)	SA	FB	Abs
Absent (circle one if applicable): SA FB Both	------	------	
Uncommon (Present, < 20% cover) – List species in the invasive survey (see end)			------
Abundant (Present, 20-75% cover) – List species in the invasive survey (see end)			------
Pervasive in SA (>75% relative cover)		------	

V3. Other vegetation alterations (e.g. woody debris removal)	SA	FB	Abs
______________________________			

HYDROPERIOD MODIFICATION

H1. General hydroperiod alterations	SA	FB	Abs
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	SA	FB	Abs
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)

Site code: ____________ Date: __________

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

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	____	____	____
History of tilling (e.g., uniform upper soil profile typical of tilled farm land)	____	____	____
Livestock tracks	____	____	____
H3. Other indicators of topographic modification (e.g. high temperature discharge, dead/dying standing trees)			
	____	____	____

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	____	____	____

 Site code: ____________ Date: ___________

	SA	FB	Abs
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:	___	___	___

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

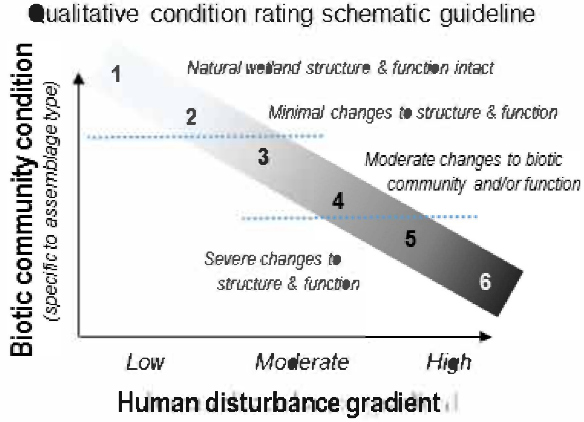
After completing the survey, describe overall site quality (SA + FB) as it relates to the level of human-mediated disturbance.

Circle the number that best describes the site:

Least disturbed 1 2 3 4 5 6 Highly disturbed

Ranking notes (optional):

Qualitative condition rating schematic guideline



NYRAM 5.3 - Part B

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
Acer platanoides	Norway maple	ACPL		
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 spp.	Swallowwort (black, pale or white)	CYNAN		
Daucus carota	Queen Anne's lace	DACA6		
Dioscorea oppositifolia	Chinese yam	DIOP		
Dioscorea polystachya	Chinese yam	N/A		
Elaeagnus umbellata	Autumn olive	ELUM		
Epipactis helleborine	Broadleaf helleborine	EPHE		
Euonymus alatus	Burning bush/Winged euonymus	EUAL13		
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		
Hydrocharis morsus-ranae	Common frogbit	HYMO6		
Hypericum perforatum	Common St. Johnswort	HYPE		
Iris pseudacorus	Yellow iris	IRPS		
Ligustrum vulgare	European privet	LIVU		
Lonicera japonica	Japanese honeysuckle	LOJA		
Lonicera spp.	Shrub honeysuckles (nonnative)	LONIC		
Lysimachia nummularia	Creeping Jenny, moneywort	LYNU		
Lythrum salicaria	Purple loosestrife	LYSA2		
	Sum of unique species observed on this page			

NYRAM 5.3 - Part B

Site code: ____________ Date: __________

Invasive & nonnative species richness survey

Scientific name	Common name	USDA Code	SA	FB
Microstegium vimineum	Japanese stiltgrass	MIVI		
Murdannia keisak	Marsh dewflower	MUKE		
Myosotis scorpioides	True forget-me-not	MYSC		
Myriophyllum spicatum	Eurasian water-milfoil	MYSP2		
***Persicaria hydropiper* (syn. *Polygonum hydropiper*)**	Water-pepper smartweed	PEHY6 (POHY)		
Persicaria perfoliata	Mile a minute	POPE10		
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		
Salix alba	White willow	SAAL2		
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

Scientific name	Common name	SA	FB
Adelges tsugae	**Hemlock Wooly Adelgid (HWA)**		
Agrilus planipennis	Emerald Ash Borer (EAB)		
Anaplophora glabripennis	Asian Longhorned Beetle		
Cipangopaludina* spp *aquatic snails	Invasive Aquatic Snails		
Cryptococcus fagisuga + Neonectria spp.	Beech Bark Disease		
Dendroctonus frontalis	Southern Pine Beetle		
Halyomorpha halys	Brown Marmorated Stink Bug (BMSB)		
Orconectes rusticus	Rusty Crayfish		
Lymantria dispar	Gypsy Moth (caterpillar)		
Lycorma delicatula	Spotted Lanternfly		

Additional species observed, but not listed above

______ ______

______ ______

Site code: ______________ Date: ____________

INVASIVE & NONNATIVE SPECIES RICHNESS SURVEY

Sum of unique species observed on this page ______________

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. (Invasive score = zero if no invasive were observed in the SA or FB.)

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
Pervasive in SA (>75% relative cover)	15	---

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 ______________

[1]Invasive richness for scoring is capped at 14 spp.

QUALITATIVE CONDITION RATING

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

Condition rating ______________

Part B cumulative score ________

[Part B is capped at a maximum of 70 points. If Part B>70, use 70 when calculating your final score.

Stressors score + Invasives cover score + Invasive richness[1] + Condition score.

NYRAM5 Score: ______________

$$\left(\frac{\text{Part A (max 50 pts)} + \text{Part B (max 70 pts)}}{135}\right) \times 100$$

Scores range from a minimum of 1 to a maximum of 100.

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

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-a-likes: 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 habitats for Michigan

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

Pennsylvania's field guide to aquatic invasive species

https://docs.wixstatic.com/ugd/bd649e_f616c128088e4a46b27b0f4a0b4f5290.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

nyimapinvasives.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/

APPENDIX C. WETLAND ASSESSMENT LEVEL 3 PROTOCOLS

NYNHP Wetland Assessment

Level 3 protocols

Draft ver. 1.0

DECEMBER 2021

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Introduction

Sampling methodology and plot placement

Using plot-based sampling for vegetation study involves two broad considerations: 1) the method by which plots are placed in the study area, and 2) how the data on plant species cover are collected in the plot. Both of these factors are influenced by the objectives and requirements of the study.

Methods of plot placement can be separated into two general categories, subjective and objective. NYNHP wetland surveys conducted for EPA-funded projects primarily use objective stratified random sampling.

- **Subjective** (non-random): Plot locations are carefully chosen within each sample stand/target community so that the data from the plot represent attributes of the stand as a whole. Subjective plot placement may be used in studies whose goal is to describe or characterize vegetation for developing plant community classifications or developing detailed natural community maps, for example.
- **Objective** (random): Plots are placed either randomly or at regular intervals (i.e., systematically) across the entire study area, or alternatively the study area is divided into general units according to broad vegetation types (e.g., Cowardin et al. wetland class), groupings of dominant species, substrate types, management units, or other general criteria and plots are placed randomly or systematically within these units; the latter are examples of *stratified random* or stratified systematic sampling. Objective placement of plots is generally used in experimental (rather than descriptive) studies, where the goals of the study require that the data collected be treatable with probability statistics.

Our wetland program database has both objective and subjective plot data, so recording placement method is important for analysis.

Target wetland community types

Is it a wetland?

Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. Following Cowardin et al. (1979) classification, wetlands must have *one or more* of the following three attributes:

1) at least periodically, the land supports predominantly hydrophytes;

2) the substrate is predominantly undrained hydric soil;

3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year (≥3 weeks).

Target wetland communities

Broadly, the target population for NYNHP's wetland assessment work includes is tidal and nontidal wetlands, including certain farmed wetlands not currently in crop production. The wetlands have rooted vegetation and, when present, open water **less than 1 meter deep**. Specific projects may narrow the target community specifications or adjacent land use types to meet the project's objectives (e.g., nontidal palustrine systems).

Community classification follows Edinger et al. (2014).

Evaluating random points remotely and in the field

Our site evaluation protocols follow those developed by EPA for National Wetland Condition assessment 2016, as outlined in their Site Evaluation Guidelines ("SEG"), and are briefly summarized below.

The primary purpose of site evaluation is to determine whether a random sample point selected by the random sample design ("sample draw") is a wetland in the target population for the project and is accessible and sampleable by a field crew. There are four main steps involved in this process (see SEG Figure 1):

1) Locate the sampling point on an aerial image, topographic and/or similar map and determine whether the point is within or very near (within 60 meters of) a wetland that is in the target population for the project.
2) Determine if the point is accessible.
3) Verify that the point is sampleable or can be shifted (up to 60 meters) to a nearby location that is.
4) Sample the point OR replace with an alternate point.

Vegetation plot sampling

Level 3 macroplot protocols modified after Peet et al. (1998)

When conducting objective surveys, our default macroplot orientation is North-South, or alternatively East-West. We do this for consistency and easy of set up, but occasionally sites call for non-cardinal orientation due to sampling concerns (e.g., to capture heterogeneity, fit in a narrow space, avoid open water, or a stand of poison sumac).

Plot setup

Our standard wetland assessment macroplot is 20 m by 50 m, and divided into ten 10 m x 10 m subplots AKA modules (Figure 1, left). Subplots are numbered 1-10 in a “U” pattern; in Figure 1 subplot 1 is directly below the word “plant” and subplot 10 is below the word “richness”. We intensively sample four subplots, unusually following the “standard” layout (i.e., blue shaded subplots [2,3,8,9] in Figure 1, left). However, for heterogeneous sites I will randomly select intensive modules (usually using the old stopwatch start-stop method).

GPS points (n = 3): Taken at 0 m, 25 m, and 50 m of the macroplot using waypoint averaging.

Plot photos (n = 12): Main axis – taken at 0 and 50 m looking along the 50-m tape; subplot photos – photograph all subplots, preferably with the 50-m tape in view for reference. These photos are meant to capture the overall feel of the macroplot and may serve as a reference back at the office or if someone wishes to revisit the survey area.

Intensive subplots: what’s measured?

<u>Species x strata</u>: raw percent cover is estimated for each species and unvegetated category type in *each* stratum (see vegetation strata section below); in a 10 m x 10 m plot 1% cover means the leaf area would fill a 1 m x 1m area. Note: Cover estimates are rounded to the nearest whole number, with <1% recorded as 0.01%. To assign Coefficient of Conservatism scores we often need a subspecies or variety level determination (e.g., ssp. or var.) per NY Flora Atlas Taxonomy.

<u>Strata cover + height</u>: Estimate total cover for each stratum present in the subplot, assess strata height in meters. For tree height we use a Biltmore stick. One edge of the Biltmore stick is marked with a Merritt hypsometer used to estimate tree height.

<u>Diameter at Breast Height</u> (at 1.3 m): The diameter of all woody stems >10 cm are recorded in cm as follows: Separate DBH measurements with a comma and note whether the tree is dead. Example: plot includes four red maple boles: one is 20 cm DBH, two multi-stemmed trunks [split below DBH] at 14 and 16 cm, and one snag at 30 cm. These data should be recorded as: 20,(14,16),30=dead. (Note: for restored sites or tree recruitment is a concern you may way to go down to 2.5 cm).

<u>Litter and duff depth</u>: representative for the plot, recorded to the nearest half centimeter, and you may optionally note the predominate leaf litter type (“maple leaves”, “pine needles”, “sedge leaves”, etc.).

Standing water depth: deepest observed standing water depth in the subplot
Hummock hollow range (optional): we don't officially record this, but sometimes we note the range in centimeters if it is pronounced.
Coarse woody debris decomposition (optional): NYNHP's Wetland Ecologist, Laura Shappell, just started recording this in 2019, particularly for sites with CWD >30 cm in diameter, noting the highest decay class observed. Decay classes follow Maser et al. 1979.
Note: Unlike Peet et al. (1998) we do not use smaller subplots within the 10 m x 10 m modules (we've considered doing so for mosses, but haven't, yet). We do not follow Peet's soil sampling – see references below.

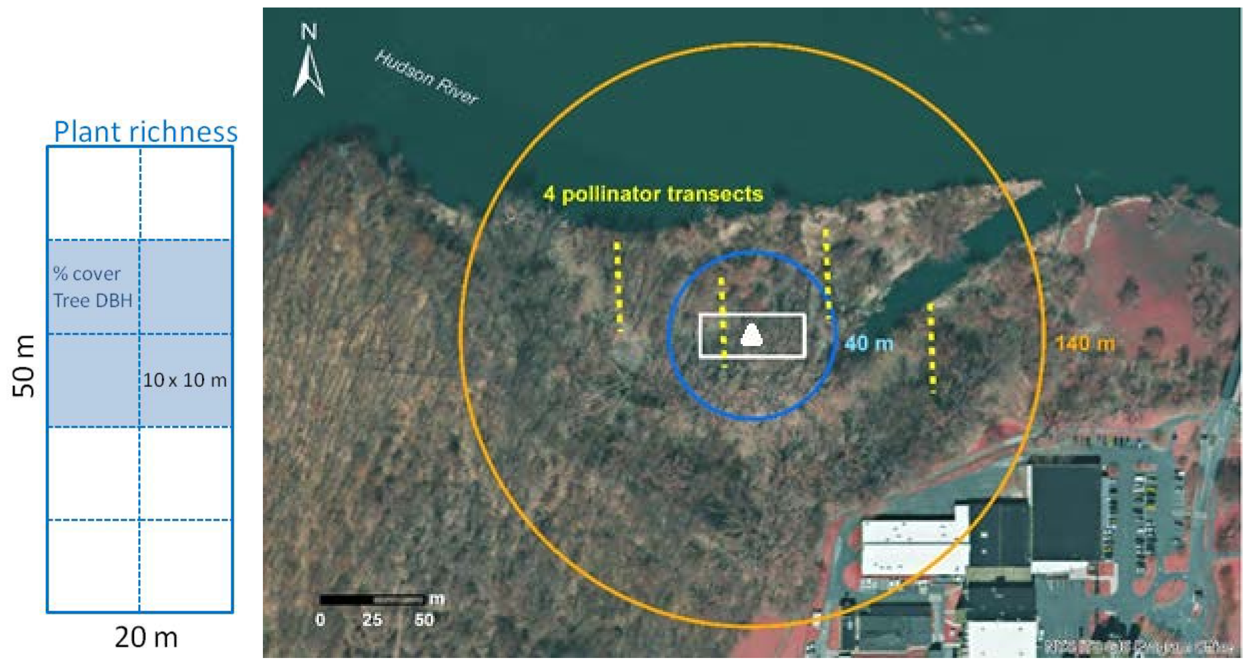


Figure 1: Left – schematic of the 20 m x 50 m macroplot. Right - Example placement of an East-West macroplot (white rectangle), centered around a random point (white triangle). That is, the point is the 25 m mark of the macroplot. At this site, 0 m is at the western end of the macroplot and 50 m is at the eastern end. Blue and orange circles represent survey areas covered during the Rapid Assessment Method survey(s). This figure also demonstrates how pollinator bowl transects may be laid when completing the intensive Empire State Native Pollinator Survey protocols (i.e., four transects within the wetland habitat); Note: pollinator transects do not need to be placed parallel no are they likely to be perfectly spaced. Pollinator sampling is not part of our standard wetland assessment sampling protocols.

Macroplot: what's measured?

Residual plant species: These are *novel* species not previously captured in the four intensive subplots. Percent cover should be estimated at the 20 m x 50 m *macroplot* scale (i.e., at 1,000 m^2, 1% = 10 m^2). Height and strata cover can be recorded for residuals, particularly if the strata is also novel. DBH is not recorded for residual tree species.

Soils: We typically just conduct soil profiles at one representative location in the macroplot. See Minnesota DNR field manual (2013, p. 15) for a good deception of **soil profile** methods along with how to use the **von Post** decomposition scale for organic soils. For each soil layer, note hydric indicators as described in the NWCA 2016 Field Operations Manual (EPA NWCA 2016, section 6.6), also briefly described by MN DNR (2013, p. 18). Additional traits described in the MN DNR manual: **Soil drainage classes** (p. 19).

General site characterization

NYNHP ecological system (e.g., Palustrine) and wetland community name(s) per Edinger et al. 2014.
Topographic Context (MN DNR 2013, p. 14)
Hydroperiod (*sensu* Cowardin et al. 1979)
Physiognomic group variables (MN DNR p. 30 – "woody plants" and "herbaceous plants")

Vegetation strata

Current vegetation strata codes are outlined below in Figure 2 and Table 1.

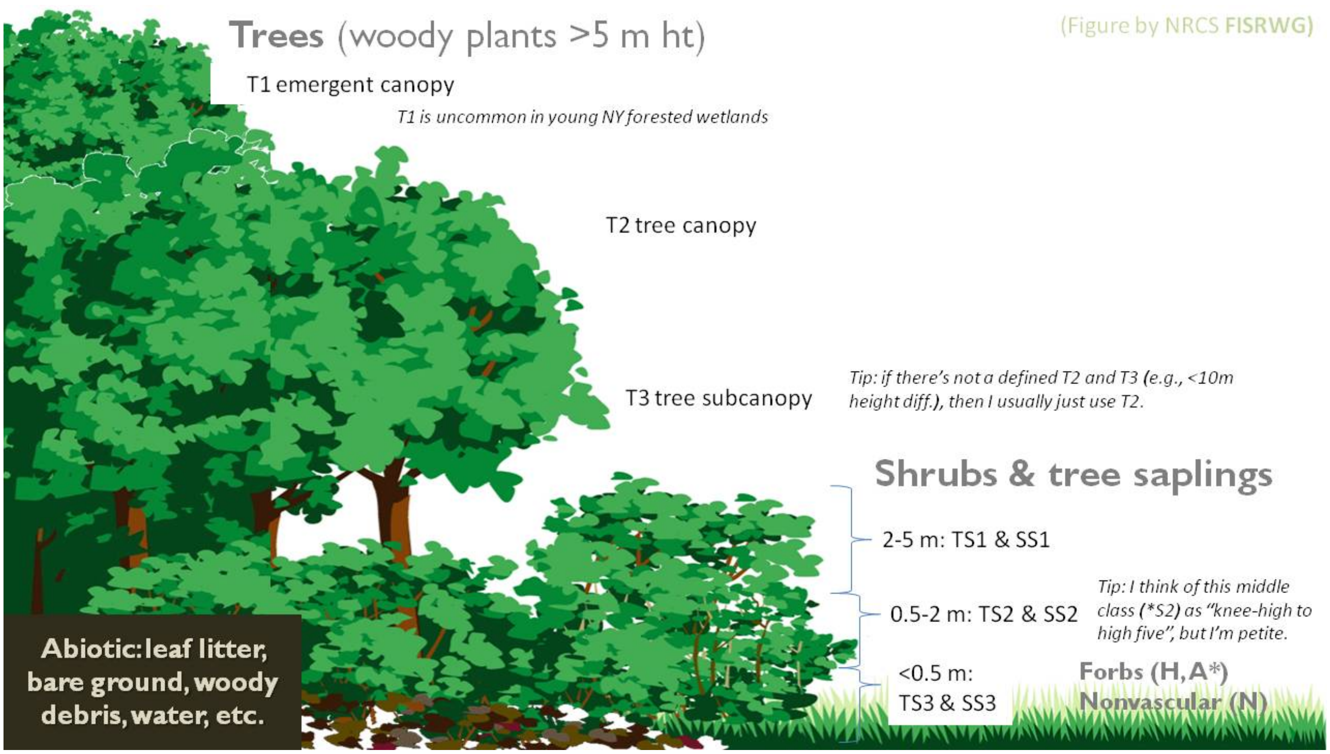


Figure 2: Schematic diagram illustrating some of the vegetation strata assessed in NYNHP's "intensive" subplots. Note: aquatic strata examples are not illustrated.

Table 1: Quick guide to NYNHP strata codes and unvegetated categories. Note unvegetated size classes for rocks and woody debris.

Code	Strata/life forms			Unvegetated categories (reference)
T1	Emergent tree (>5m)	V1	Tall Vine/liana >5m)	Bedrock | Very large rocks >1m
T2	Tree canopy (>5m)	V2	Short Vine/liana <5m)	Lg rocks >10cm | Sm rocks <10cm
T3	Tree sub-canopy (>5m)	H	Herbaceous	Sand <2mm | Bare soil | Litter & Duff
TS1	Tall sapling (2m - 5m)	N	Non-vascular	Wood: CWD >7.5cm | FWD <7.5cm
TS2	Med sapling (<2m - 0.5m)	E	Epiphyte	Water | Wrack | Trash | Other
TS3	Short sapling (<0.5m)	A1	Emergent aquatic	
SS1	Tall shrub (2m - 5m)	A2	Floating-leaved aquatic	
SS2	Med shrub (<2 - 0.5 m)	A3	Submerged aquatic	
SS3	Short shrub (<0.5m)	U	Unvegetated (duff, soil, etc.)	

Citations:

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. Office of Biological Services, Fish and Wildlife Service, U.S. Dept. of Interior, Washington, D.C.

Edinger, G. J., D. J. Evans, S. Gebauer, T. G. Howard, D. M. Hunt, and A. M. Olivero (editors). 2014. Ecological Communities of New York State. Second Edition. A revised and expanded edition of Carol Reschke's Ecological Communities of New York State. New York Natural Heritage Program, New York State Department of Environmental Conservation, Albany, NY.

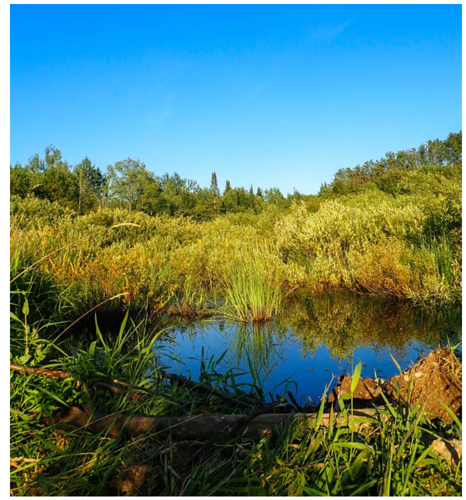
Minnesota Department of Natural Resources. 2013. A handbook for collecting vegetation plot data in Minnesota: The relevé method. 2nd ed. Minnesota Biological Survey, Minnesota Natural Heritage and Nongame Research Program, and Ecological Land Classification Program. Biological Report 92. St. Paul: Minnesota Department of Natural Resources.

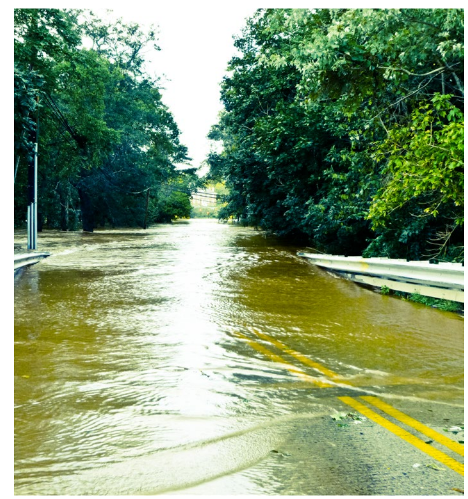
Peet, R. K., T. R. Wentworth, and P. S. White. 1998. The North Carolina Vegetation Survey protocol: A flexible, multipurpose method for recording vegetation composition and structure. Castanea 63:262–274.

U.S. EPA. 2016. National Wetland Condition Assessment 2016: Site Evaluation Guidelines. EPA-843-R-15-010. U.S. Environmental Protection Agency, Washington, DC.

APPENDIX D. FUNCTIONAL RAPID ASSESSMENT METHODOLOGY (FRAM)

Functional Rapid Assessment Methodology (FRAM)
for palustrine nontidal wetlands in New York State, *ver. 2.0*

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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Acknowledgments
Funding for the "beta" version 1.0 of our functional assessment protocol was provided by US EPA Wetland Program Development Grants. Results from our first two years of piloting this method in NY's Mohawk and Allegheny basins are outlined in the following technical report:

> Laura J. Shappell, Lydia M. Sweeney, and Tim G. Howard. 2022. Developing methods, cultivating engagement, and creating end-user tools for wetland functional assessment. EPA Wetland Program Development Grant. Final Report. New York Natural Heritage Program (NYNHP), Albany, NY.

Special thanks to all biologists who provided feedback on this protocol, which we continue to refine in support of New York's wetland program, and to private land owners who allowed us to survey on their properties. To learn more about NYNHP's wetland program please visit nynhp.org/wetlands. You can also find us on iNaturalist.org: NYNHP Wetlands Projects.

Suggested citation: Shappell, Laura J. and Lydia M. Sweeney. 2023. Functional Rapid Assessment Methodology (FRAM) for palustrine non-tidal wetlands in New York State. Version 2.0 working draft dated 01/19/20223. New York Natural Heritage Program. Albany, NY.

Please note:
The FRAM method and scoring system presented here is ***actively being revised*** and has only been tested on 70 wetlands. FRAM ver. 1.0 inculded in the 2022 report is the first published copy of this protocol, which we are actively revising and updating as we gain feedback from collaborators, users, and our own field experience. Therefore, we consider this protocol and scoring to be a "beta" draft. If you're interested in providing feedback or learning about the most current version of this protocol please message Dr. Laura Shappell at laura.shappell@dec.ny.gov or ljshappe@esf.edu.

Cover photos (clockwise from far left): Adirondack wetland boardwalk on Ferd's Bog Trail by J. Kwiatkowski; Highbush Blueberry fruit (*Vaccinium corymbosum*) by L. Shappell; Shallow Emergent Marsh on the downstream side of a beaver dam in Lewis County by L. Shappell; Raritan River flooding its banks and a road following Hurricane Irene, New Brunswick, NJ by L. Shappell; and Perplexing Bumble bee (*Bombus perplexus*) on Spotted Joe-Pye Weed (*Eutrochium maculatum*) in Chautauqua County by L. Shappell

Introduction

This method is applied at three spatial scales (see figure right). The Survey Area (SA) and Field Buffer (FB) are centered on a target sample point; at least 90% of the SA should be wetland (biological definition, not jurisdictional). If needed, the SA and FB shape can be changed but the area within each Evaluation Area should match the original: SA = 0.5 (1.25 ac) ha and FB = 6.15 ha (15.2 ac).

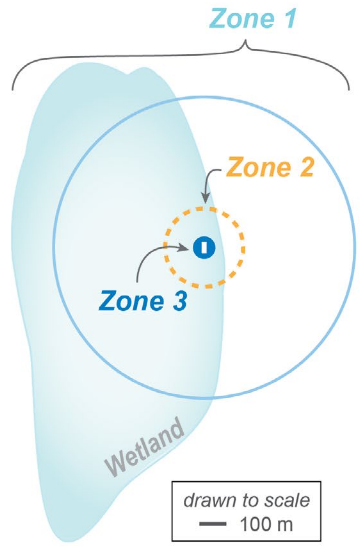
Data collection & final summary "roll-up" scoring

On-screen evaluation: Suggested spatial data layers are outlined in our Shappell et al. (2022) technical report, some of these data are available via NYS DEC's Interactive Maps web-page (https://www.dec.ny.gov/pubs/42937.html).

The field portion of the form has eight broad function and value categories as outlined in Table 1 and includes >170 indicators or ranking options. Indicators relevant to each category guide the user's final ranking for that category. If an indicator has a dash through an evaluation area, it's not applicable at that scale and users should simply move on to the next check-box or field.

Category ranking: We've developed minimum guidelines for ranking, but the rater has the option to upgrade or downgrade by one degree if they think the suggested rank is not representative. When individual ranks are combined or "rolled-up" onto a summary score, users can gain a general understanding of an evaluation area's overall functional value (Table 1). Given the data requirements for this metric it is only applicable to the SA and FB, not the contiguous (WH) wetland. Points are associated with each category rank – more points for higher ranks – "very high" = 4 points, "high" = 3 points, "moderate" = 2 points, and "low" = 1 point. The summary roll-up score is calculated by summing all category points (Table 1), dividing by total possible points (35) and multiplying by 100, then round to nearest whole number. The lowest possible score is 23 and the highest is 100.

Table 1 (right): Points are associated with each category rank – more points for higher/better ranks. All categories but hydrologic health and natural community development follow this scoring: Very High = 4 points, High = 3, Moderate = 2, and Low = 1 point. *Pollution: High = 4, Moderate = 3, Low = 2. Natural Community development scoring is as follows: Excellent = 7, Very Good = 6, Good = 5, Fair = 3, Poor = 1. Hydrologic "health" scoring: None or none apparent = 4, Recovered = 3, Recovering = 2, Recent or no recovery/ongoing = 1. The right column is a workspace for you to summarize data for this site.



Zone 1, Landscape and Contiguous wetland

On-screen evaluation - Sub-basin water quality and habitat connectivity characterization.

Contiguous/whole wetland ("contig" or "WH") - Indicator checklist (field and on-screen).

Indicators more appropriately evaluated at smaller spatial scales are excluded from this evaluation area. Similarly, some indicators are only applied at this scale.

Zone 2, RAM field buffer (FB)

Level 2 - Field indicator checklist (140 m radius).

Zone 3, Focused Survey Area (SA)

Level 2 - Field indicator checklist (40 m radius).

Level 3 (optional) - Intensive releve macroplot (20 m x 50 m) is centered on the target sample point that the SA and FB are centered around.

Category	Max points	This site
Flood and storm water control	4	
Hydrologic "health"	4	
Erosion control	4	
Subsurface and groundwater resource protection	4	
Natural community development	7	
Pollution*	4	
Wildlife	4	
Values	4	
Total points in the SA or FB:	35	

Summary roll-up scores for this site: SA = __________ FB = __________

Site information and Landscape setting - remote on screen evaluation

Select all that apply.

Site name		**Site code/ID**		**Observer(s)**	
Survey date		**Sourcecode (NYNHP)**			
Natural community notes		**Latitude/UTM** (SA center point)		**Longitude/UTM**	
Major basin name (HUC 8)		**HUC 8 code**		**HUC 12 code**	
Where in the major river basin does the wetland lie?	Lower Mid Upper (circle 1)	Landscape position (based on Tiner 2014)	☐ Terrene	☐ Lentic ☐ Lotic	

Contiguous wetland size (ha or ac)

Size class (check 1)

- ☐ <30 ha (<74 ac)
- ☐ 30-70 ha (74-173 ac)
- ☐ >70 ha (>173 ac)

Is contiguous wetland *entirely* contained within the targeted Survey Area (SA)?

☐ No ☐ Yes.

Wetland associated with perennial or intermittent watercourse?

☐ **NO**. Wetland is "geo-graphically isolated".

☐ **YES**. *Direct surface water connection present, including periodic overbank flooding or ephemeral streams.* Answer the following:

Flow determination made: ☐ In the field ☐ Aerial photo/map

Water flow path (check all that apply): ☐ Inlet ☐ Outlet ☐ Throughflow (unidirectional) ☐ Bidirectional (perm. lake/river) ☐ Tidal

Modifiers*: ☐ None observed ☐ Watercourse is a ditch ☐ Restricted outlet ☐ Restricted inlet

* Includes anthropogenic restrictions to water movement such as culverts, and natural restrictions such as beaver dams.

Intensity of surrounding land use (check one)

- ☐ Very low. 2nd growth or older forest, wildlife area, etc.
- ☐ Low. Old field (>10 yrs), shrub land, young second growth forest
- ☐ Moderately high. Residential, pasture, park, new fallow field
- ☐ High. Urban, industrial, row crops, construction, clear cut forestry

Average width of natural buffer (check one)

- ☐ Undeveloped. Buffers average ≥200 m (≥656.2 ft)
- ☐ Very wide. Buffers average 100 to <200 m (328.1 to <656.2 ft)
- ☐ Wide. Buffers average 50 to <100 m (164 to <328.1 ft)
- ☐ Medium. Buffers average 25 to <50 m (82 to <164 ft)
- ☐ Narrow. Buffers average 10 to <25 m (32.8 to <82 ft)
- ☐ Very narrow. Buffers average <10 m (<32.8 ft)

On screen evaluation: sub-basin water quality and connectivity

The following apply to the contiguous wetland area and its potential to protect surface, subsurface and groundwater water resources. This portion of the assessment may be completed remotely either before or after the field survey, using digital mapping software such as ArcGIS, Google Earth, or NYS DEC's Environmental Resource Mapper (https://www.dec.ny.gov/animals/38801.html). ***Check all that apply.***

1) Water quality and water resource security: In the drainage area contributing to the wetland (upstream, upslope) there are:

- ☐ Potential sources of stormwater/wastewater/agricultural runoff
  (e.g., agriculture, impervious surface, municipal wastewater discharge etc.)
- ☐ Potential sources of excess <u>sediments</u>.
  Agriculture, forestry, construction, etc.
- ☐ Potential sources of excess <u>nutrients</u>.
  Nitrogen and/or phosphorous sources; agriculture, golf courses, septic systems, etc.
- ☐ Potential or known sources of toxicants or chemicals.
  Contaminants, pollutants, pesticides, etc.
- ☐ Highly porous upland soils or surficial geology.
  Sandy or gravel soils, karst, moraine etc.
- ☐ Sheet-flow, potential to intercept
  Contiguous wetland may intercept surface and subsurface flows that may contain pollutants and/or suspended sediments. Steep slopes, impermeable upslope/upland soils, or large amounts of impervious surface (>10%) occur upstream or upslope of the wetland (e.g., runoff to the wetland); or upslope/upstream has inadequate or limited flood storage features/capacity (natural or constructed).

2) Water quality and water resource security: Downstream or near the contiguous wetland there are:

- ☐ Water wells, known public/private wells [groundwater]
  e.g., single household or real property parcel (excluding commercial properties)
- ☐ Water wells, potential for public/private wells [groundwater]
  e.g., single household or real property parcel (excluding commercial properties)
- ☐ Water source, public/private [groundwater, subsurface, or surface]
  e.g., *Water Source Protection Area, surface drinking water supply for more than one household or parcel, includes commercial properties.*
- ☐ Groundwater or subsurface recharge or discharge
  Assumed present if contiguous wetland coincides or is near a confined or unconsolidated aquifer (high- or mid-yield unconfined), primary or sole source aquifers. (Consult NYS DEC or USGS spatial aquifer resources online.)
- ☐ Impaired or stressed waters [surface or groundwater]
  Wetland potentially contributes to the protection of surface water quality. Applies to adjacent and downstream water bodies.
- ☐ Between surface water & human land use [surface or groundwater]
  Potential point or non-point sources of sediment, nutrients, toxic substance, etc. runoff may be intercepted by the wetland, which is associated with permanent, seasonal, or ephemeral surface water such as streams, lakes, reservoirs. e.g., includes wetlands with <90% natural buffer or upslope septic tank(s).
- ☐ Valuable property/resources/recreation in/near the 100-year floodplain

3) Connectivity: The following connectivity attributes relate to habitat connectivity and heterogeneity in the local landscape. For example, being connected or near other greenspace (public or private) or open water is crucial for wildlife that may use wetland resources for all or part of the year.

- ☐ Connected: Same class within 800 m (0.5 mi)
  Hydrologically connected to other wetlands of the same dominant class. (e.g., marsh site is 500 m upstream from another marsh)
- ☐ Connected: Different class w/in 1.6 km (1 mi)
  Hydrologically connected to other wetlands of a different dominant class or open water.
- ☐ No surface connection: Difference class within 400 m (1/4 mi)
  Not hydrologically connected, but other wetland classes or open water are nearby.
- ☐ Connected or not: permanent open water within 400 m (1/4 mi)
  1.2 ha (3+ ac) permanent water nearby. Includes natural and created ponds, lakes, reservoirs.

Wetland hydrology: Water source(s), Flooding depth/duration, and Open water cover.

Water source

Rank the top three water sources in the SA on a scale of 1 to 3, with "3" representing the greatest influence (Fewer than 3? Just rank 1 or 2 and add a comment). Use check-boxes to indicate all water source present in a given evaluation area. Precipitation is only ranked in the SA if it is a primary water source.

Location/Evaluation Area	SA Pres	Rank	☐ FB	☐ WH	= N/A Flag
Stream inflow *Typically unidirectional, includes permanent, intermittent, and ephemeral surface water*	☐	___	☐	☐	___
Overbank flooding *Water that has escaped the banks of a river or lake, may be periodic or infrequent*	☐	___	☐	☐	___
Perennial surface water (lake or pond)	☐	___	☐	☐	___
Precipitation, not primary source *i.e., rain, snow, sleet, or hail that falls to the ground*	☐	----	☐	☐	___
Precipitation, primary source (ombrotrophic)	☐	___	☐	☐	___
High pH groundwater *Natural groundwater fed systems where pH typically ranges from 7.0 to 9.0. Note: freshwater salinization (e.g., road salt runoff) may artificially cause high pH.*	☐	___	☐	☐	___
Other groundwater, springs/seeps *pH is circumneutral (pH typically ranges 5.0 to <7.0) e.g., subsurface, seeps, headwater, toe-slope, etc.*	☐	___	☐	☐	___
Tidal: freshwater *Salinity <0.5 ppt, specific conductance <800 uMhos. Nanotidal: <0.3 m (≤1 ft); micro: >0.3 to <2 m (>1 ft to <6.6 ft); meso: 2 m to <4 m (6.6 ft to <13.1 ft)*	☐	___	☐	☐	___
Tidal: estuarine or marine *Ocean-derived salts ≥0.5 ppt. Nanotidal; micro; meso.*	☐	___	☐	☐	___

Comments/Flags:

References

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

U.S. Army Corps of Engineers (ACOE). 2011. Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region (Version 2.0), ed. J. S. Wakeley, R. W. Lichvar, C. V. Noble, and J. F. Berkowitz. ERDC/EL TR-12-1. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

Flooding duration

Select one or double check and average for each evaluation area. Hydroperiod definitions follows Cowardin et al. 1979.*

Location	Permanent	Semi-perm	Seasonal	Saturated: Seasonal	Saturated: Semi - Perm.	Flag
SA	☐	☐	☐	☐	☐	___
FB	☐	☐	☐	☐	☐	___

Comments/Flags:

Maximum surface water depth

Select one per location. The Rater does not need to directly observe maximum water depth, the presence of primary and secondary hydrology indicators may be used per ACOE (2011). Less than 40 cm includes saturated wetlands. Select "upland" if <10% of the FB is wetland. *No checkbox? Some indicators don't apply to all evaluation areas.*

Location	>70 cm (≥27.6 in)	40-70 cm	<40 cm (<15.7 in)	Upland	Flag
Survey Area (SA)	☐	☐	☐	----	___
Field Buffer (FB)	☐	☐	☐	☐	___

Comments/Flags:

Open water, mud or sand flat community cover

The following apply to wetland units associated with open water and/or mudflats where emergent and woody vegetation cover is <30% (floating and submerged aquatic veg may be >30%). *Select one per eval area.*

Location	SA	FB	WH	Flag
None observed/Not applicable	----	☐	☐	
Absent/Trace: <0.05 ha (0.12 ac) *<10% of SA; <1% of the FB or WH*	☐	☐	☐	___
Low: 0.05 to <1 ha (0.12 to 2.47 ac) *≥10% of SA; 1-20% of FB*	☐	☐	☐	___
Moderate: 1 to <4 ha (2.5 to 9.88 ac) *20% to <60% of FB*	----	☐	☐	___
High: ≥4 ha (≥9.88 ac) *≥60% of FB. (Includes riverine and lacustrine.)*	----	☐	☐	___

Comments/Flags:

Wetland hydrology: Surface water connectivity, Interception, Retention, and Disturbances

Riparian or floodplain communities

The following apply to wetlands associated with open water (lakes, reservoirs, through-flowing perennial streams, or ponds. Alluvial processes are present and soils are likely Fluvaquents or Fluvents, or soils with Fluvaquentic subgroups. (First three apply to contig.) *Select all that apply.*

- ☐ **Floodplain wetland unit**
  >10% of wetland receives overland through-flow or bidirectional surface water flow in 100-yr flood or more frequently, or major beaver influence in headwater wetlands.
- ☐ **Headwater wetland unit,** may be terrene or assoc. with streams <3 order
  Surface water is primarily unidirectional, flowing to an intermittent or perennial outlet (e.g., stream source).
- ☐ **Non-floodplain/headwater wetland unit**
  No perennial or intermittent/seasonal surface water inlet or outlet associated with the wetland. Wetland does not fringe a lake, pond, or watercourse.

None observed/Not applicable	☐	☐	☐	
Floodplain Indicators (FI) Location	**SA**	**FB**	**WH**	**Flag**
Sinuous perennial stream present *Associated with a sinuous or diffuse low-velocity watercourse.*	☐	☐	☐	___
Vegetation fringing open water (intermittent or perennial surface water) *≥90% of open water boundaries are fringed by a band of vegetation ≥10 m (33 ft) wide. [e.g., supports aquatic fauna by providing cover/refuge, shading (water temp.), allochthonous organic inputs.]*	☐	☐	☐	___
Streambank/shore stabilization, woody *Developed woody root masses stabilize streambanks against undercutting.* (No "WH" here because unlike the above indicator, this can be difficult to discern from aerial photos/maps.)	☐	☐	----	___
Depositional environment present *All wetland types: includes potential upslope surface water runoff. In floodplains, e.g. sediment/drift deposits, siltation, debris, flood wrack, trash, etc. Includes ephemeral streams.*	☐	☐	☐	___
Floodwater drainage patterns *Backwater sloughs/ponding areas, back- channels, ephemeral streams, etc.*	☐	☐	☐	___
Ice scour marks/evidence (marks at tree bases, etc.)	☐	☐	☐	___

Comments/Flags:

General Overland Obstruction Indicators (GOOI): Surface water retention and dispersion

Select all general indicators that apply. The following indicate a wetland's capacity to obstruct or slow overland flow of surface water or desynchronize surface water flows. Obstruction may be performed at a higher level if any of the following indicators are present. The Rater may check few of the following, yet still score the function as high or moderate.
No check-box? Some indicators don't apply to all evaluation areas.

None observed/Not applicable	☐	☐	☐	
Gen. Surface Indicators Location	**SA**	**FB**	**WH**	**Flag**
Overland flow input *Wetland receives and retains flow from upslope or upstream, and/or overbank flooding.*	☐	☐	☐	___
Surface water dispersion *Wetland lacks a steep slope and exists in a relatively flat area or basin.*	☐	☐	☐	___
Shows signs of **variable water levels** or seasonal ponding/flooding *(Stained leaves, water lines, moss lines, etc.)*	☐	☐	----	___
Lacks an outlet, or if present, has a *constricted* outlet (i.e., slows outflow rate). *Human-made or naturally-occurring (e.g., beaver dam).*	----	----	☐	___
Dense persistent vegetation *Applies to areas ≥10 m from open water, or lacking open water. Herbaceous or woody zone ≥6 m (20 ft) wide, with ≥40% plant cover.*	☐	☐	☐	___
Vegetated hummocks or tussocks *Hummocks cover >1 m² per 100 m². Including microtopography resulting from raised tree/shrub based, sedge/fern tussocks, etc.*	☐	☐	----	___
Veg. hummocks or tussocks, abundant *>25% of the wetland, includes moss hummocks. If selecting this indicator, do not select the above indicator.*	☐	☐	----	___
Woody hummocks, tree or shrub bases *Includes any rooted woody vegetation.*	☐	☐	----	___

Comments/Flags:

Wetland Function: Hydrology - Alterations to the wetland's hydroperiod.

Hydrological disturbances and disconnection from surface water continuum

Select all that apply. If disturbance indicators are present, related inherent wetland functions may be less effective (i.e., functional capacity reduced); these disturbances are often directly or indirectly caused by anthropogenic actions. Indicators related to a wetland's disconnection from the surface water continuum is relevant for wetlands associated with surface water (streams, waterbodies, overland flow), including permanent or ephemeral waterbodies.

None observed/Not applicable	☐	☐	☐	
Hydrologic Dist. Indicators (HDI)	**SA**	**FB**	**WH**	**Flag**
Stormwater input or Point source *e.g., impervious surface, source pipe, respectively*	☐	☐	☐	___
Artificial dewatering features *Ditches, drains, land grading, etc.*	☐	☐	☐	___
Water inflow <u>reduced</u> *Barriers present between wetland and surface or subsurface water inputs (permanent or ephemeral). Examples: dam / weir / culvert; including perpendicular roads, railroad beds, and parallel features that may reduce surface or subsurface flow into the wetland (e.g., reduce toe-slope discharge).*	☐	☐	☐	___
Artificial levee <u>parallel</u> to surface water *Reduction in surface water dispersion in wetland, or stream/floodplain interaction (road, railroad bed, rail trail, etc.).*	☐	☐	☐	___
Stream channel banks degraded *Banks are steep, eroding, have abundant bank slides or slumps, have <50% cover of roots, or are unvegetated (excludes bedrock).*	☐	☐	☐	___
Incised stream channel *Results in reduced over-bank flooding during peak/high velocity flows. (Also check above degraded indicator.)*	☐	☐	☐	___
Hardened stream channel *e.g., riprap, gabions, concrete, etc.*	☐	☐	☐	___
Straightened stream channel and/or moved to toeslope *(meanders eliminated).*	☐	☐	☐	___
Invasive knotweed thickets *This includes Japanese knotweed (*Reynoutria japonica*), giant knotweed (*R. sachalinensis*), and bohemian knotweed hybrid (*R. ×bohemica*) present and covering >100 m^2 or 3 linear meters (9 ft) along a perennial or seasonal watercourse/water body. These species grow/spread rapidly and decrease bank/shoreline stabilization.*	☐	☐	☐	___

Hydrologic Dist. Comments/Flags:

Hydro disturbance indicators continued... N/A	☐	☐	☐	
Location	**SA**	**FB**	**WH**	**Flag**
Presence of dead forest or dead shrubs *Areas in sufficient amounts to result in diminished evapotranspiration, nutrient uptake, etc.*	☐	☐	☐	___
Current use in wetland results in disturbance(s) that compromise natural wetland hydroperiod, surface water interception, groundwater discharge/recharge. *e.g., over-grazed pasture >50% bare soil; annually-tilled crops lack winter plant residue or cover crops.*	☐	☐	☐	___

Hydrologic "health", general rank

Rank the wetland's current status/response to direct or indirect **<u>anthropogenic</u>** disturbance(s). Select one or double check and average. The Rater may check one or several of the possible hydrologic disturbance indicators listed above, yet still determine their impact is minimal and wetland has "recovered" or there is no apparent alteration relative to the area's overall function. Add comment if FB is >90% upland and leave those check-boxes blank.

	SA	**FB**	
None or none apparent (undisturbed)	☐	☐	___
Recovered *Evidence of past disturbance, but community and hydrology has largely recovered (i.e., not dominated by ruderal plant species), native perennials that reflect the current hydroperiod.*	☐	☐	___
Recovering *Wetland vegetation may be in a state of conversion (succession) due to the anthropogenic disturbance(s). Ruderal or nonnative species may be common, or if drier, greater abundance of facultative upland plants.*	☐	☐	___
Recent or no recovery/ongoing *May apply to wetlands where disturbance(s) or degraded condition (e.g., dewatering structures, filling) are ongoing and extensive enough to significantly alter a wetland's natural hydroperiod.*	☐	☐	___

Hydrological Health Comments/Flags:

Wetland Function: Microtopography, Flood/storm water desynchronization.

Microtopography & edaphic indicators

These structural features are important for fauna, but they may also positively influence a wetland's capacity to retain and slow surface water flows. : If present, only select one CWD prompt*, otherwise select all that apply.

None observed/Not applicable	☐	☐	
Location	**SA**	**FB**	**Flag**
Tip-up mounds/upturned tree root wads and pits *(Different from vegetation hummocks)*	☐	☐	
Shallow flooded hollows or fish-less pools *Seasonal, semi-permanent, or permanent. May appear as sparse concave surfaces when water levels are low - often showing secondary hydric indicator(s).*	☐	☐	
Coarse woody debris/material* *≥10 cm diameter, >1 m long, fully on the ground in wetland.*	☐	☐	
Coarse woody debris, abundant* *>3% cover of wetland evaluation area.*	☐	☐	
Soil organic matter accumulation *≥20 cm (8 in) depth of organic soils within given evaluation area. This includes peat, muck & mucky peat.*	☐	☐	
Leaf litter and duff layer *Abundant leaf litter, bare ground typically <5%.*	☐	☐	

Comments/Flags:

Overall microtopographic complexity

In wetlands lacking a dense, movement-inhibiting shrub layer, this metric can often be quickly estimated by considering the need to pay attention to balance while walking through the wetland. Select one for each evaluation area. Note: If FB is >90% upland add a comment and leave those check-boxes blank.

	SA	**FB**	**Flag**
Low: <3% *Most surveyors can walk freely though the wetland without looking at the ground.*	☐	☐	
Medium: 3-40% *Most surveyors must pay attention to their footing but can still move through the wetland unhindered.*	☐	☐	
High: >40% *Most surveyors need to slow down, pick their footing with care, and be mindful of their balance.*	☐	☐	

Comments/Flags:

Flood and storm water control, general rank

This score reflects the evaluation area's capacity for flood attenuation, dispersion of surface flows/desynchronization, and surface water/runoff storage capacity. Ranking should be informed by Rater's answers in related sections (GOOIs, microtopography, and disturbances). Select one per evaluation area.

Not applicable	----	☐	☐	
Location	**SA**	**FB**	**WH**	**Flag**
Very High *Wetland lacks a steep slope and contains micro-topography features that help slow surface water, exists in a relatively flat area, or is a basin that has flood storage potential. No significant Hydrologic Disturbance Indicators (HDI) present (if any), typically HDI tally <3. Minimum criteria for SA & FB: At least two "microtopographic indicators" and "microtopographic complexity" is medium or high; OR has ≥6 GOOIs; WH: ≥3 GOOIs and ≥4 FI.* *Note: If eval. area is 1 pt short of these criteria rater may use best professional judgment to rank "very high" - explain reason in comments section. Some wetlands may meet this minimum criteria for WH, but rater may choose to rank as "high" or "moderate" if pervasive hydrologic disturbances present.*	☐	☐	☐	
High *SA & FB: As "Very High", but may have minor HDI or landscape position that excludes "very high" (e.g., floodplain not in a relatively flat area, lower storage potential). SA & FB: ≥4 GOOIs, Microtopography complexity may be "low", but wetland still interacts with floodwaters or receives surface or subsurface flows from adjacent upland or wetland (e.g., may include "flashy" rivers); WH: ≥3 GOOIs OR ≥3 FIs.*	☐	☐	☐	
Moderate *SA & FB: ≥3 GOOIs, may have ≥2 HDI; WH ≥2 GOOIs.*	☐	☐	☐	
Low *HDI(s) present and strongly impacting hydrology in the eval. area (no GOOI minimum). Note: if HDIs are limited to a discrete area or wetland edge then "low" likely does not apply. For example, any of the following: Wetland occurs on a slope; receives little overland flow from uplands and none from surface water.*	☐	☐	☐	

Comments/Flags:

Wetland Function: General ranking - Erosion Control, Subsurface and groundwater.

Erosion control, general rank

Select one ranking per evaluation area. Use your answers in related sections to inform your overall ranking of the wetland's functional capacity.

Location	SA	FB	WH	Flag
None Applicable	----	☐	☐	
Very High *Permanent or semi-permanent surface water present. SA & FB: ≥4 Floodplain Indicators (FI) and ≥4 GOOIs. Hydrologic Health score is "recovered" or "none apparent"; WH: ≥4 FI and ≥3 GOOIs*	☐	☐	☐	___
High *SA & FB: As "Very High", but Hydrologic Health score is "recovered" or better, only 2-4 FI and ≥3 GOOIs or ≥1 Floodplain Indicators and ≥5 GOOIs; WH: ≥3 FI and ≥3 GOOIs. Includes vegetated headwater wetlands with a surface water outlet.*	☐	☐	☐	___
Moderate *SA/FB/WH: At least one of the following: ≥2 GOOIs; ≥1 FI; or lacks an outlet but fringes a permanent pond/lake >0.8 ha (2 ac).*	☐	☐	☐	___
Low *SA/FB/WH: Wetland is a narrow riparian corridor whose associated permanent stream channel is hardened or stream channel is strongly incised. Or wetland is predominately open water, has minimal natural upland buffer (<30% w/in 25 m), and rooted emergent vegetation fringes <30% of the pond/lake edge.*	☐	☐	☐	___

Comments/Flags:

Subsurface and ground water resources, field observations

Select all that apply. Only check present if observed in the field.

	SA	FB	WH	Flag
None observed	☐	☐	☐	
Field observation: Signs of groundwater or subsurface **recharge or discharge** *(e.g., seeps, springs, toe-slope discharge, base flow levels during drought, water temperature, or water pH).*	☐	☐	☐	___
Field observation: **Permeable soils or rock present** *Well drained to excessively drained sands, gravels, or karst is present in the wetland or adjacent upland.*	☐	☐	☐	___

Comments/Flags:

Subsurface and groundwater, general rank

Select one or double check and average. Use your answers in related sections to inform your overall ranking of the wetland's functional capacity.

Location	SA	FB	WH	Flag
None observed/Not applicable	----	☐	☐	
Very High *Example indicators: fairly stable year round water levels, seeps, water pH ≥6 in communities not dominated by* Sphagnum, *circumneutral plant species present (e.g., skunk cabbage, golden ragwort, buttonbush, poison sumac,* Carex lasiocarpa *etc.). Or spatial data review indicating any one of the following, occurs in or adjacent to: ground water resource protection area, unconfined aquifer, principal or primary aquifer, or potentially supports water wellheads. Note: floodplain wetlands on large rivers may meet the above criteria, but the rater may choose "high" or "moderate".*	☐	☐	☐	___
High *Example indicators: seeps, water pH ≥5 in communities not dominated by* Sphagnum, *circumneutral plant species present (skunk cabbage, golden ragwort, buttonbush, royal fern,* Carex lacustris, C. lasiocarpa *etc.)*	☐	☐	☐	___
Moderate *Does not meet the criteria for "low", but no groundwater or subsurface indicators observed.*	☐	☐	☐	___
Low *Wetland underlain by impermeable rock or fragipan and wetland lacks a surface water outlet (including ephemeral).*	☐	☐	☐	___

Comments/Flags:

Wetland function: Wetland community heterogeneity/habitat diversity.

Wetland assemblage types/classes present

Check each community present within each evaluation area; only count areas ≥0.1 ha or ≥1000 m[2] (0.247 acres). Starting in the SA, assign a score of 0 to 3, ranking up to three types dominant in the SA (if only one type, score it as a 3). Working your way outward from the SA, note all types present in the other areas.

Location	SA	FB	WH	Flag
Not applicable	----	☐	☐	
Forested *Dominated (30%) by tall woody vegetation >6 m (20 ft). Characterized by an overstory of trees and often containing an understory of young trees and shrubs and an herbaceous layer, although the young tree/shrub and herbaceous layers can be largely missing from some types of forested wetlands.*		☐	☐	
Shrub *Dominated (≥30%) by woody vegetation <5 m (16.4 ft) tall. Plants include true shrubs, young trees, or trees/shrubs that are small or stunted b/c of environmental conditions. This class may be a successional stage or be a relatively stable plant community.*		☐	☐	
Shallow emergent marsh *Herbaceous wetlands dominated by erect, rooted, herbaceous hydrophytes (excluding mosses/lichens), that persists for most of the growing season in most years. Associated community names: marsh, wet meadow, sedge meadow, & herbaceous fens. Hydrology: often saturated to seasonally-flooded.*		☐	☐	
Deep emergent marsh *Often occurring next to open water, this semi-permanent to permanently-flooded wetland is dominated by erect or floating, rooted, vascular hydrophytes with persistent and non-persistent vegetation present for most of the growing season in most years. Common plants: cattail, wild rice, water or pond lily, green arrow-arum, broadleaf arrowhead, bulrush, and bladderwort.*		☐	☐	

Types/classes present, *continued*

Location	SA	FB	WH	Flag
Not applicable	----	☐	☐	
Aquatic bed Wetlands and deepwater habitats where plants grow principally on or below water surface (i.e., submergent or floating-leaved), and are the uppermost form layer with ≥30% areal coverage (e.g., PAB*, R1AB). Floating aquatic species like duckweed (*Lemna* spp., *Spirodela* spp.) are excluded from the definition of "aquatic bed."		☐	☐	
Mud, sand, or gravel flats *Equivalent to "unconsolidated bottom" (e.g., PUB3/4, R1UB3/4, E1UB3/4) described in Cowardin et al. (2016), includes areas characterized by seasonally/permanently exposed or shallowly inundated substrates with vegetative cover <30%.*		☐	☐	
Open water/deep water *Areas of permanent water generally deeper than 1 m (3.25 ft).* *Note: Rater should default to open water if communities are identified remotely and data are not available to confirm the community is a mudflat, just document your reasoning in the comments box below.*		☐	☐	
Upland inclusion *Includes upland "islands" in wetlands and the outer wetland/upland boundary. Per SA protocol, upland inclusions should comprise <10% of your survey area, so maximum SA score for this category is 1 (i.e., for "standard" SA (0.5 ha), upland area should be <500 m[2] (0.12 ac). Note: Here we are using an "ecological"* definition of wetland - that is, the evaluation area lacks all three wetland indicators: no hydric soils[1], no hydrology field indicators (primary or secondary[2]), and dominate hydrophyte species <50% (OBL, FAW, FAC).*		☐	☐	

Comments/Flags:

[1]USDA NRCS. 2018. Field Indicators of Hydric Soils in the United States, Version 8.2. L.M. Vasilas, G.W. Hurt, and J.F. Berkowitz (eds.). USDA, NRCS. <link>
[2]USACE. 2012. Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region. Version 2.0. ERDC/EL TR-12-1 <link>

Wetland function: Wetland structure - Modifications, Composition.

Vegetation structure & habitat modification (VMod)

Select all that apply for each evaluation area.

Location	SA	FB	Flag
None observed/Not applicable	☐	☐	
Excessive to moderate wildlife herbivory *E.g., deer (low seedling recruitment, visible browse line, remaining (unpalatable) plants species, etc.), geese, insects, etc.*	☐	☐	
Livestock grazing, *≥25% bare soil.*	☐	☐	
Mowing *Low intensity lawn, residential lawn, or hay.*	☐	☐	
Golf course or highly maintained turf	☐	☐	
Right-Of-Way (ROW): cleared *Brush cutting, chemical, etc. (power lines/roads)*	☐	☐	
ROW: no maintenance w/in past year	☐	☐	
Logging, *selective or clearcut within past 2 years*	☐	☐	
Annual agricultural row crops *(w/in 2yrs)*	☐	☐	
Plantation or orchard, *managed or abandoned Conversion from natural tree species.*	☐	☐	
Dumping, excessive trash	☐	☐	
Nutrient enrichment *e.g., algal bloom*	☐	☐	
Historical land use *Evidence of past use such as cut tree stumps, stone walls, skidder tracks, ditching, historical aerial imagery, etc.*	☐	☐	
Other notable habitat features or species observations *(specify):*	☐	☐	
VMod tally sums:			

Comments/Flags:

Invasive plant species abundance

Select one per evaluation area.

Location	SA	FB	Flag
Not applicable	----	☐	
Absent *None or <1% cover observed by Rater in area.*	☐	☐	
Uncommon *Present, <20% cover.*	☐	☐	
Abundant *Present, 20-75% cover.*	☐	☐	
Pervasive *>75% cover.*	☐	☐	

Comments/Flags:

Wetland vegetation alteration

This question evaluates the “intactness” of the natural habitat relative to the type of wetland being evaluated. Select one per evaluation area or double check and average.

Location	SA	FB	Flag
Not applicable	----	☐	
None or none apparent *There are no disturbances or no disturbances apparent to the Rater.*	☐	☐	
Recovered *Area appears to have recovered from past disturbances (e.g., human, beaver, fire, invasive insect such as Emerald Ash Borer).*	☐	☐	
Recovering *Recovering from past disturbance.*	☐	☐	
Recent or no recovery *Disturbance(s) recently occurred, are ongoing, and/or the wetland has not recovered from past disturbances.*	☐	☐	

Comments/Flags:

Wetland function: Wetland community development, Pollution treatment.

Natural community development, general rank

Select one per evaluation area or double check and average the points when calculating a score. If the contiguous wetland is entirely contained in the SA check "not applicable" for the FB.

Location	SA	FB	Flag
Not applicable	----	☐	
Excellent *Wetland appears to represent the best of its ecoregional type or class. Forested wetlands: Old growth trees likely present, tree recruitment good in all strata. No vegetation structure/habitat modifications observed, of if present, modification is minor and only along wetland fringe.*	☐	☐	
Very good *Very good but lacks characteristics that would make it "excellent" (e.g., a few nonnative plants or minor anthropogenic disturbances near the wetland edge).*	☐	☐	
Good *Past or present disturbances, successional state, invasives, or other factors present. Nonnative plant cover <20%. Forested wetlands have mature canopy trees with at least some seedling recruitment.*	☐	☐	
Fair *Moderately good example of its type/class, but because of past or present disturbances, successional state, etc. it is not "good". Seedling recruitment of native trees in forested wetland may be low due to over-browsing.*	☐	☐	
Poor Wetland may be heavily invaded (>75% nonnative plants), have past or present land use(s) that altered hydrology and/or soils.	☐	☐	

Comments/Flags:

Pollution treatment, general rank

Select one per evaluation area. This question addresses an evaluation area's overall potential to serve as biologic and chemical oxidation basins. Human disturbances such as dewatering may reduce a wetland's potential capacity to provide this function.

"Pollution" as defined by Article 24 includes the presence in the environment of man-induced conditions or contaminants in quantities or characteristics which are or may be injurious to human, plant or wildlife, or other animal life or to property. This includes point and non-point source pollutants such as suspended solids/organic matter/sediment, road salt runoff, pesticides, agriculture pollutants (e.g., row crop amendments, animal waste, sediment, pesticide), municipal sewer overflow, septic system(s), thermal changes (e.g., discharge warm water), etc.

Location	SA	FB	WH	Flag
Not applicable	----	☐	☐	
High *Wetland is in a human-dominated landscape (>25%) and is at least seasonally flooded. Primary or secondary water source is lake/pond, stream inflow, overbank flooding, or tidal.*	☐	☐	☐	
Moderate *Does not meet the criteria for "low" or "high". Wetland may lack a surface water outlet, but is in a human-dominated landscape (>25%),* ***or*** *within 175 m (190 yards) of a road/industrial property/mine/logging,* ***or*** *wetland is riparian/floodplain and has ≥2 HDIs.*	☐	☐	☐	
Low *For example, wetland may be saturated and lack surface water outlets; has dewatering features that significantly reduces flood duration (retention time) and/or depth. Wetland is oligotropic and precipitation is the wetland's primary water source.*	☐	☐	☐	

Comments/Flags:

Wetland function: Wildlife guilds - Birds, Invertebrates, and Mammals.

Select all that apply. Sub-guilds: Presumed present if it supports or has habitat support a given sub-guild. Many of the habitat traits important to each animal group such as wetland size, buffer width, water levels, and habitat heterogeneity are captured in other sections of this assessment.

Birds[1], *Supports or has habitat to potentially support:*

	SA	FB	WH	Flag
None observed/Not applicable	☐	☐	☐	
Location	**SA**	**FB**	**WH**	**Flag**
Aquatic habitat *Water depth/duration necessary for waterbird foraging, breeding (ponds, perennial streams, etc.).*	☐	☐	☐	___
Waterfowl breeding *Potentially supports 1+ breeding pair/broods.*	☐	☐	☐	___
Wading bird breeding *Nest site, nest site buffer, or feeding habitat.*	☐	☐	☐	___
Other migratory wetland-dependent birds *1+ pair for nesting, feeding, roosting, etc.*	☐	☐	☐	
Migrating water birds *Potential resting/feeding/roosting habitat.*	☐	☐	☐	___
Birds of prey *(hawks, falcons, & owls)* *1+ pair for nesting, feeding, roosting etc.*	☐	☐	☐	___
Uncommon species *(RT&E, SGCN, S1-S3)* *1+ breeding pair for nesting, feeding, etc.*	☐	☐	☐	___
Other notable features/observations (specify).	☐	☐	☐	___

Comments/Flags:

Invertebrates

	SA	FB	WH	Flag
None observed/Not applicable	☐	☐	☐	
Location	**SA**	**FB**	**WH**	**Flag**
Aquatic or wetland-dependent/associated invertebrates *Mollusks, fingernail clams, crayfish, Odonates, etc.*	☐	☐	☐	___
Pollinators *Supports native bees, butterflies, moths, flies, beetles, etc. Floral resources present in the spring and/or summer (>25%), or potential nesting resources present (e.g., sandy soils, woody debris/snags, or hummocks above the mean high water line).*	☐	☐	☐	___
Uncommon species *(RT&E, SGCN, S1-S3)*	☐	☐	☐	___

Comments/Flags:

Mammals, *Supports or has habitat to potentially support:*

	SA	FB	WH	Flag
None observed/Not applicable	☐	☐	☐	
Location	**SA**	**FB**	**WH**	**Flag**
Semi-aquatic mammals *Aquatic otters, beavers, muskrat, or mink.*	☐	☐	☐	
Beaver dam/lodge, muskrat lodge *Includes active and abandoned.*	☐	☐	☐	___
Medium/large mammals *Provides or has potential to provide important feeding habitat for black bear or bobcat based on regional occurrence, assessment of use, and/or proximity to contiguous natural area patch area >275 ha (≥680 ac).*	☐	☐	☐	___
Other carnivores *Foxes, coyotes, wolves etc.*	☐	☐	☐	___
Ungulates, White Tailed Deer	☐	☐	☐	___
Ungulates, Moose	☐	☐	☐	___
Bats *Potential feeding (marshes, forests, forested edges etc.) or roosting habitat (e.g., trees or snags with shaggy bark or cavities).*	☐	☐	☐	___
Small terrestrial mammals *Rodentia, Insectivora, etc.*	☐	☐	☐	___
Uncommon species *Habitat supports or potentially supports any RT&E, SGCN, or S1-S3 mammal.*	☐	☐	☐	___
Other notable habitat features or species observations *(specify):*	☐	☐	☐	___

Comments/Flags:

[1]Bird guild examples: Waterfowl: ducks, geese, swans; Wading birds: herons, egrets, bitterns, rails, sandhill crane, etc.; Migratory wetland-dependent birds: Virginia rail, common snipe, marsh wren, sedge wren, swamp sparrow, American bittern, northern water thrush, northern harrier, spruce grouse, Cerulean warbler, and loons; Other wetland-dependent migratory birds: alder flycatcher, belted kingfischer, red-headed woodpecker, etc.

Wetland function: Wildlife guilds - Amphibian, Reptile, and Fish.

Select all that apply. Many of the habitat traits important to each animal group such as wetland size, buffer width, water levels, and habitat heterogeneity are captured in other sections of this assessment.

Amphibians and reptiles

Location	SA	FB	WH	Flag
None observed/Not applicable	☐	☐	☐	
Amphibians - significant populations *Potentially supports large populations of native amphibians (common or rare species).*	☐	☐	☐	
Reptiles - significant populations *Potentially supports large populations of native reptiles (common or rare species).*	☐	☐	☐	
Vernal pool habitat *Fish-less pools may support species requiring seasonally flooded pools for breeding (includes pools within wetland complexes).*	☐	☐	☐	
General habitat *Wetland and/or adjacent watercourse provides or has potential to provide basking (large rocks/logs), breeding, feeding, or cover habitat (e.g., shallow littoral zones with emergent vegetation, physical structures such as rocks, debris dams, and hummock/hollow topography provide microhabitat).*	☐	☐	☐	
Uncommon species (RT&E, SGCN, or S1-S3) *Potentially supports breeding/nesting, buffer for a nest site, or feeding habitat.*	☐	☐	☐	
Other notable habitat features or observations (specify):	☐	☐	☐	

Comments/Flags:

NRCS: General habitat requirements of North American reptiles and amphibians https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_022220.pdf

Freshwater and marine fish

Location	SA	FB	WH	Flag
None observed/Not applicable	☐	☐	☐	
Fish present *Native fish are present (natural or stocked) in the target wetland area or adjacent watercourse or waterbody.*	☐	☐	☐	
Supports downstream fish *Wetland and adjacent tributary may not contain fish, but provides cooler water, and/or allochthonous materials/food sources to a downstream watercourse/body that does.*	----	----	☐	
General habitat *(provides or potentially does)* *Wetland and/or adjacent watercourse/body provides spawning, nursery, feeding, or cover habitat (e.g., assoc. with deep or shallow marshes, or seasonally flooded wetlands associated with streams and rivers.)*	☐	☐	☐	
Winter habitat *Retains some open water during winter and/or size sufficient to support fish; if riverine, defined channel present and bankfull width >15 m (>50 ft) and/or depth ≥1m (>3 ft).*	☐	☐	☐	
Brackish/estuarine/marine habitat *E.g., tidal marsh, mud flats, eelgrass beds, and/or essential fish habitat as defined by Magnuson-Stevens Fishery & Conservation Act 1996 amendments are present in or adjacent to the wetland.*	☐	☐	☐	
Uncommon species (RT&E, SGCN, or S1-S3) *Supports or potentially supports.*	☐	☐	☐	
Other notable habitat features or observations (specify):	☐	☐	☐	

Comments/Flags:

Wetland function: Wildlife.

Select all that apply. Habitat traits important to each animal guild are captured in other sections of this assessment, too.

General habitat indicators (GHI)

None observed/Not applicable	☐	☐	☐	
Location	**SA**	**FB**	**WH**	**Flag**
Wetland dependent animals *Evidence of use by wetland-dependent species.*	----	----	☐	
Standing dead trees (snags) *>25 cm (10") diameter and 137 (4.5') tall*	☐	☐	☐	
Abundant standing dead trees (snags) *≥25 cm (10") diameter and ≥1.4 m (4.5') tall, ≥3 snags/0.4 ha (1 ac). If present in a given evaluation area also check the above indicator. That is, there should be two checks.*	☐	☐	☐	
Supports higher trophic levels *Wetland or associated surface water supports prey for higher tropic levels.*	----	----	☐	
Fruiting plants present *≥30% total cover of flowering plants (dicots and monocots, e.g., oaks, maple, blueberry, cattail, etc.)*	☐	☐	----	
Adjacent greenspace *≥50% surrounding land is forest, agriculture, old field, or open land within 100 m of the wetland.*	----	----	☐	
Habitat heterogeneity *3+ wetland vegetation classes*	☐	☐	☐	
Surface water: watercourse, pond, lake *Field observation: direct surface water connection (watercourse, lake, pond, overbank flooding, etc.).*	☐	☐	☐	
Remote, aerial imagery observation: *If only observed remotely check here*	----	☐	☐	
Other notable features or observations:	☐	☐	☐	

Lower functional capacity (LFI), potential indicators

Any of the following can be negated by evidence of wildlife or fish use.

None observed	☐	☐	☐	
Location	**SA**	**FB**	**WH**	**Flag**
Small and isolated by development *Vegetated wetlands <5 ha (<12.4 ac), surrounding develop. limits wildlife access/use.*	----	----	☐	
Frequent anthropogenic disturbance *Current use results in frequent cutting, mowing, herbicide treatment, etc.*	☐	☐	☐	
Supports few wetland dependent spp. *Applies to sites where hydrology is at the drier end of the scale (saturated).*	☐	☐	----	
Fragmentation within wetland *Roads, railroads etc. fragment what was once a contiguous wetland. Check if any fragmenting features are present in a given evaluation area.*	☐	☐	☐	
Aquatic connectivity barrier(s) *Present in evaluation area (SA, FB) or surface water associated with the contiguous wetland (WH). Dam or culvert, beaver dam, water fall, road, etc.*	☐	☐	☐	
Invasive plant abundance >75%, all strata *Native cover ≤25% in all strata. For example: Phragmites marsh should receive a check, but a floodplain forest with >25% native canopy cover does not.*	☐	☐	☐	
Other notable features or observations:	☐	☐	☐	

Comments/Flags:

Wildlife habitat and biodiversity, general rank

Select one for each evaluation area. If wetland is entirely contained within the SA leave FB and WH blank and write a comment.

Very High. *Natural Community Development is "very good" or better; moderate or high interspersion (heterogeneity). Open water/mud/sand flat ranking is Low in SA or moderate/high in FB/WH, and/or permanent watercourse present and has a ≥10 m vegetated buffer. All guilds present in evaluation area. LFIs if present are not pervasive and ideally limited to the wetland edge.*	☐	☐	☐	
High. *Natural Comm. Devel. is "good" or better. SA: If LFI present, not pervasive, SA ≥4 guilds; FB and WH = 5 guilds. Typically ≥4 GHIs present.*	☐	☐	☐	
Moderate. *If LFI present, not pervasive, SA ≥3 guilds; FB and WH ≥4 guilds. Upland natural buffer tends to be ≤100m (see on-screen eval).*	☐	☐	☐	
Low. *LFI present and pervasive, SA ≤3 guilds; FB and WH <5 guilds. Wetland Vegetation Alteration typically Recovering or Recent/No recovery, or Invasive Plant Species cover is Abundant or Pervasive, or Natural Community Development is poor*	☐	☐	☐	

Wetland values

Recreational value considers the effectiveness of the wetland and associated watercourse to provide consumptive and non-consumptive recreational opportunities. Functional category is present and likely to be significant if any of the following are present. Select all that apply.

Recreation value and economic benefit

Location	SA	FB	WH	Flag
None observed/Not applicable	☐	☐	☐	
Preserved land *Property ownership allows for consumptive and non-consumptive activities and is open to the public or conservation-oriented membership group (e.g., sportsman club).*	☐	☐	☐	___
Proximity to potential visitors *Potential recreation site is accessible and in, or nearby, populated cities and towns.*	☐	☐	☐	___
Visible to the public, recreation/aesthetics *Whether on preserved land or viewable from the road, a scenic overlook, etc.*	☐	☐	☐	___
Recreational activities, non-consumptive *Contributes to or has potential to support activities by private or public entities (e.g., hiking, boating, wildlife viewing etc.).*	☐	☐	☐	___
Recreational activities, consumptive *Provides habitat for fish/wildlife/flora that can be fished/hunted/trapped/foraged under state law.*	☐	☐	☐	___
Provides economic benefits *e.g., attracts visitors to local area, users pay entrance fees, hunting/fishing permits, etc.*	☐	☐	☐	___

Comments/Flags:

Open space and aesthetics

Location	SA	FB	WH	Flag
None observed/Not applicable	☐	☐	☐	
Important open space *e.g., municipal, regional, or state plan*	----	----	☐	___
Scenic river or byway proximity *Hydrologically connected to a state or federally designated scenic river or scenic byway*	☐	☐	☐	___
Visible to the public, open space *Whether on preserved land or viewable from the road, a scenic overlook, etc.*	☐	☐	☐	___
Aesthetics, <u>Heterogeneity</u>. Contains 2+ wetland classes, or is dominated by emergent marsh or open water	☐	☐	☐	___
<u>Color</u>. Contains flowering plants, plants that turn vibrant colors in different seasons, or a diversity of vegetative species	☐	☐	☐	___
<u>Contrast</u>. Visible surrounding land use form contrasts with wetland, appears undeveloped from viewing area and/or relatively unobstructed sight line exists through wetland.	☐	☐	☐	___
Other notable values *(specify)*	☐	☐	☐	___

Comments/Flags:

Education and research

Location	SA	FB	WH	Flag
None observed/Not applicable	☐	☐	☐	
Preserved land, *owned or leased* *Public or non-profit entity dedicated to education, research, and/or stewardship.*	☐	☐	☐	___
Accessibility *Accessible or potentially so with the addition of trails and/or off-road parking.*	☐	☐	☐	___
Group Education, *known or potential* *Within safe walking distance or short drive to schools and/or off-road parking accommodates 1+ passenger van or school bus.*	☐	☐	☐	___
Scientific Research *past or present* *Known to be a study site for research.*	☐	☐	☐	___

Comments/Flags:

Wetland values: Uniqueness and Special wetlands.

These functions are valuable wetland attributes relative to aspects of public health, recreation, and habitat diversity. Functional category is present and likely to be significant if any of the following are present. Select all that apply.

Uniqueness

Location	SA	FB	WH	Flag
None observed/Not applicable	☐	☐	☐	
Rare, Threatened, & Endangered, *known State or Federally listed species*	☐	☐	☐	____
RT&E habitat, *known or potential*	☐	☐	☐	____
Species of Conservation Concern, *known*	☐	☐	☐	____
SCC habitat, *known or potential*	☐	☐	☐	____
Historic RT&E or SCC *Last observed/documented ≥20 years ago*	☐	☐	☐	____
Migratory birds. *Significant migratory song bird/waterbird potential habitat or use.*	☐	☐	☐	____
Habitat "island" *Urban, exurban, and agriculture >25%*	☐	☐	☐	____
Urbanization/Development *Development >25%, but agriculture <25%. Urban or exurban areas should check Habitat "island" above as well as here (2 checks).*	☐	☐	☐	____
Tribal, archaeological, or historical relevance *known or potential*	☐	☐	☐	____
Wetland currently supports culturally-significant native plants *that have unique values to regional First Peoples. e.g., Native sweetgrass* (Anthoxanthum spp.), cattail (Typha spp.)	☐	☐	☐	____
Unusual geological feature which is an excellent representation of its type. e.g., karst map,	----	----	☐	____

Comments/Flags:

Special wetlands

A special wetland type should be marked present even if it does not apply to the entire evaluation area. See Appendix A for rare/uncommon natural community ranking specifications.

Location	SA	FB	WH	Flag
None observed/Not applicable	☐	☐	☐	
Bog or Fen	☐	☐	☐	____
Rare natural community *Any other comm. ranked S1, S1S2, or S2*	☐	☐	☐	____
Uncommon natural community *Any other comm. ranked S2S3 or S3*	☐	☐	☐	____
Old growth forest *[e.g., ADK upland BA ~33.7 m2/ha (McGee)]*	☐	☐	☐	____
Mature forested wetland *[e.g., avg canopy tree DBH >30 cm (>11.8 in)]*	☐	☐	☐	____
Lacks historical land use *No evidence of historical land use w/in 75 yrs*	☐	☐	----	____
NYS DEC Class I wetland See Environmental Resource Mapper. More info on Class scoring is here Article 24.	----	----	☐	____

Comments/Flags:

Unique and Special rating summary

Summarize scores on this page in the space below. Zero means none observed. If the wetland is fully contained within the SA leave FB and WH blank and write a comment.

Location	SA	FB	WH	Flag
Uniqueness indicators tally *Scale: 0 to 11.*	____	____	____	____
Special wetlands indicators tally *Scale: 0 to 7.*	____	____	____	____

Comments/Flags:

SCC: Species of Conservation Concern includes NYS DEC's Species of Greatest Conservation Need & Species of Potential Conservation Need, & NYNHP S1-S3

Urban/Devel: In urban areas/clusters, or rapidly developing areas (with past 20 years), or occurs in an area where past wetland loss rates are high.

Hist. land use: historical air photos or records indicate the wetland has not been cleared, logged, farmed, or used for pasture. No field indicators observed such as rock walls, foundations, fence posts, ditches, homogeneous soil profile. If historical land use is lacking in the FB then it would automatically also be lacking in the SA.

Wetland values

Functional category is present and likely to be significant if any of the following are present. Select all that apply.

General value indicators (GVI)

Check all the apply.

	Location	SA	FB	WH	Flag
None observed/Not applicable		☐	☐	☐	
Off-road public parking *presence/potential Within 400 m (1/4 mi) of wetland edge.*		----	----	☐	___
Handicap accessible *For recreation, education, or stewardship.*		☐	☐	☐	___
Watercourse adjacent/abutting *Potential to support valued actives.*		☐	☐	☐	___
Valuable wildlife habitat		☐	☐	☐	
Wildlife/habitat enhancement efforts *e.g., bird/bat box, or stewardship (e.g., invasive plant management).*		☐	☐	☐	___
Local significance *Wetland contains biological, geological, or other features that are locally rare/unique.*		☐	☐	☐	___

Comments/Flags:

Potential indicators of lower functional capacity

User may mark these Lower Value Indicators (LVI) as present and still choose a general value score of high or moderate if the impact is small/localized relative to the evaluation area.

	Location	SA	FB	WH	Flag
None observed/Not applicable		☐	☐	☐	
Unpleasant odors, loud noises, trash/ debris, or signs of disturbance *Noticeable from primary viewing areas.*		☐	☐	☐	___
Safety/health hazards *Known hazards that could significantly reduce the utility of the wetland for recreation or education exist within the site.*		☐	☐	☐	___
Wetland is small, heavily degraded, inaccessible, and not w/in public view		☐	☐	☐	
Other *(specify)*		☐	☐	☐	___

Comments/Flags:

Value rating summary

Summarize the value scores below. Zero means none observed. The "Not applicable" check-box applies if the wetland is fully contained within the SA.

	Location	SA	FB	WH
Not applicable		-----	☐	☐
Value category tally *Summarize the presence of the five value categories: Education and research, Special wetlands, Uniqueness, Recreation value and economic benefit, and Open space and aesthetics - If at least one box is checked present in a categories' evaluation area then that category should be counted as "present". Scale: 0 to 5.*		___	___	___
General value indicator tally *Two or more "general value indicators" were selected. Scale: 0 to 6.*		___	___	___

Comments:

Value score, general rank

Use answers from the detailed value categories and general value indicators to inform your overall value ranking below.

	Location	SA	FB	WH	Flag
Not applicable		-----	☐	☐	
Very High, meets all of the following criteria: *All 5 value categories present (applies to SA or FB only), ≥3 Uniqueness types, and ≥3 Special wetland types.*		☐	☐	☐	___
High, meets all of the following criteria: *All 5 value categories present (applies to SA or FB only), ≥3 GVI, [≥2 special wetland types OR ≥3 Uniqueness types], and LVI if present is not pervasive.*		☐	☐	☐	___
Moderate *≥1 Education/research indicator + ≤4 Recreation indicators + ≤3 Open space.*		☐	☐	☐	___
Low *<3 GVI or <3 Recreation + <3 Open space indicators or ≥1 pervasive LVI.*		☐	☐	☐	___

Comments/Flags:

Appendix A.

A quick guide to significant palustrine natural community specifications for New York State (2021)

by Laura Shappell and Greg Edinger
New York Natural Heritage Program (NYNHP)

Coarse community specifications

This guide was created to help users identify potential wetlands of statewide significance relative its natural community type and conservation status rank (S-rank). Visit our website for more information on wetland community types: https://guides.nynhp.org/. Use the minimum size and maximum invasive plant cover values below to help you quickly determine the natural community's S-rank and if your wetland area of interest meets the minimum size and invasive plant cover to be potentially significant. Many other variables are variables are factored in when NYNHP officially ranks a given community occurrence, but we use size and invasive plant dominance as part of our "first cut". Please check NYNHP's natural community guide to ensure the S-rank has not changed since this document was developed in December 2021.

NYNHP wetland communities are organized into three broad classes per Cowardin et al. (1979): palustrine emergent (PEM), palustrine scrub shrub (PSS), palustrine forested (PFO), palustrine moss-lichen (PML), palustrine rock bottom (PRB). For communities that can occur as more than one class, the alternative subclass is noted in brackets. Cowardin et al. (1979) salinity and alkalinity modifiers are applied to geographically-restricted communities.

Palustrine Emergent, unless noted		Min. size		
Natural community type	**S-rank**	**ha**	**ac**	**Inv %**
Deep Emergent Marsh	S3	8	20	<20%
Cobble Shore Wet Meadow *or 500 linear ft (150 m)*	S2	0.2	0.5	<20%
Floodplain Grassland[1]	S3	4	10	<20%
Inland Calcareous Lake Shore *or 1000 linear ft (305 m)*	S3	0.4	1.0	<20%
Patterned Peatland	S1	4	10	<10%
Pine Barrens Vernal Pond	S2	0.2	0.5	<10%
Rich Sloping Fen [PEM/PSS]	S1?	0.10	0.25	<25%
Rich Graminoid Fen	S1	0.20	0.5	<50%
Riverside Ice Meadow[1] *or 500 linear ft (150 m)*	S1	0.2	0.5	<20%
Shallow Emergent Marsh	S3	8	20	<20%
Sedge Meadow	S3	6	15	<2%

[1]Confirm hydric indicators - this community can present as wetland or terrestrial.

Scrub Shrub, unless noted		Min. size		
Natural community type	**S-rank**	**ha**	**ac**	**Inv %**
Dwarf Shrub Bog	S3	4	10	<2%
Highbush Blueberry Bog Thick	S3	4	10	<2%
Inland Poor Fen [PSS/PEM]	S3	4	10	<2%
Medium Fen [PSS/PEM]	S2S3	2	5	<5%
Perched Bog	S1	0.04	0.1	<5%
Rich Shrub Fen	S1S2	0.2	0.5	<50%
Shrub Swamp	S3S4	4	10	<15%

Appendix A, continued: Forested (left) and geographically-restricted (right) palustrine wetland communities

Forested		Min. size		
Natural community type	**S-rank**	**ha**	**ac**	**Inv %**
Black Spruce-Tamarack Bog	S3	4	10	<5%
Floodplain Forest	S2S3	4	10	<40%
Hemlock-Hardwood Swamp	S3	2	5	<5%
Inland Atlantic White Cedar Swamp	S1	0.2	0.5	<40%
Northern White Cedar Swamp	S2S3	4	10	<25%
Perched Swamp White Oak Swamp	S1S2	0.4	1	<25%
Pitch Pine-Blueberry Peat Swamp	S1	0.4	1	<5%
Red Maple-Blackgum Swamp	S2	4	10	<15%
Red Maple-Hardwood Swamp	S3S4	8	20	<10%
Red Maple-Swamp White Oak Swamp	S2	0.4	1	<30%
Red Maple-Sweetgum Swamp	S1	0.4	1	<40%
Red Maple-Tamarack Peat Swamp	S2S3	2	5	<15%
Rich Hemlock-Hardwood Peat Swamp	S2S3	2	5	<20%
Silver Maple-Ash Swamp*	S3	20	50	<10%
Spruce-Fir Swamp	S3	10	25	<2%
Vernal Pool	S3	0.008	0.02	<5%

*If Ash tree canopy has been lost due to Emerald Ash Borer this community can still be classified as a SMAS if Silver Maple canopy cover is at least 15% and, ideally, total canopy cover is >30%.

Geographically-restricted communities

Several of NYS' rare wetland communities are restricted to particular regions of the state, such as the coastal plain (Long Island and New York City Metro), Adirondack High Peaks[2], or unique geologic features. We've included the global conservation rank (G-rank) in this section because they may be Vulnerable (G3), Imperiled (G2), or Critically Imperiled (G1) on a *global* scale.

	Rank		Min. size		
Coastal Plain	**S**	**G**	**ha**	**ac**	**Inv %**
Coastal Plain Atlantic White Cedar Swamp [PFO4]	S1	G3G4	0.20	0.5?	<30%?
Coastal Plain Pond Shore [PEM1]	S2	G3G4	0.20	0.5?	<30%?
Coastal Plain Poor Fen [PEM1/PSS1]	S1	G3?	0.04	0.1?	<50%?
Pine Barrens Shrub Swamp [PSS3/1]	S3?	G5	0.40	1.0?	<30%?
Sea Level Fen [PEM1t/i]	S1	G1G2	0.40	1.0?	<30%?

	Rank		Min. size		
Non-Coastal Plain	**S**	**G**	**ha**	**ac**	**Inv %**
Alpine Sliding Fen[2] [PML1]	S1S2	G3G4	0.04	0.10?	<5%?
Inland Salt Marsh[3] [PEM18/7]	S1	G2	0.04	0.10?	<60%?
Marl Pond Shore [PRB1i/PEM1i]	S1	G3G4	0.005	0.01?	<60%?
Marl Fen[4] [PEM1i]	S1	G1	0.04	0.10?	<60%?

[2]Marl fen: Known occurrences are present in the Great Lakes Plain ecoregion and eastward to Warren County.
[3]Inland salt marsh: Great Lakes Plain

This Appendix was developed by Laura Shappell and Greg Edinger, December 2021.
Suggested citation for this appendix: Shappell, Laura J. and Greg J. Edinger. 2021. A quick guide to significant palustrine natural community specifications for New York State (2021). In L. J Shappell and L. M. Sweeney, Functional Assessment Method for New York State Wetlands (ver. 2.0). New York Natural Heritage Program, Albany, NY.

Appendix B. Newly in development as of December 2021.

Native wetland plant species used by regional First Peoples.

This draft list is in development and intended to be informative, but is by no means exhaustive. Taxonomy follows New York State Flora Atlas and regional National Wetland Plant List (NWPL) rankings by US ACOE as of December 2021. Where only a genera is listed the status applies to multiple native species. Example uses: food/medicine (f/m) or other (oth) uses such as cordage for rope/weaving, dye, building supplies, and technology.

Common name	Scientific name	NWPL	Example use codes
Balsam Fir	*Abies balsamea*	FAC	f/m, oth
Red Maple	*Acer rubrum*	FAC	f/m
Single-Vein Sweetflag	*Acorus calamus*	OBL	f/m
Speckled Alder	*Alnus incana*	FACW	f/m, oth
Eastern Serviceberry	*Amelanchier canadensi*	FAC	f/m, oth
Sweetgrass	*Anthoxanthum* spp.	FACW	oth
Groundnut	*Apios americana*	FACW	f/m
Birch	*Betula* spp.	FACU-OBL	f/m, oth
Yellow Marsh-Marigold	*Caltha palustris*	OBL	f/m
Bitter-Nut Hickory	*Carya cordiformis*	FAC	f/m, oth
Dogwood	*Cornus spp. (C. amomum, C. canadensis, C. racemosa, C. sericea)*	FAC/ FACW	f/m, oth
Common Boneset	*Eupatorium perfoliatum*	FACW	f/m, oth
Black Ash	*Fraxinus nigra*	FACW	f/m, oth
Spotted Touch-Me-Not	*Impatiens capensis*	FACW	f/m
Tamarack	*Larix Laracina*	FACW	f/m, oth
Ostrich/Fiddlehead Fern	*Matteuccia struthiopteris*	FAC	f/m
Mint	*Mentha* spp. (e.g., *M. arvensis, M. spicata, M. x piperita)*	FACW	f/m
Pond Lilly	*Nuphar* spp. (e.g., *N. advena, N. variegata)*	OBL	f/m
Sensitive Fern	*Onoclea sensibilis*	FACW	f/m, oth
Black Spruce	*Picea mariana*	FACW	f/m, oth
Swamp Oak	*Quercus bicolor*	FACW	f/m
Willow	*Salix* spp.	FACW	f/m, oth
Broad-leaved Arrowhead	*Sagittaria latifolia*	OBL	f/m, oth
Black Elder	*Sambucus nigra*	FACW	f/m, oth
Bullrush	*Schoenoplectus, Scirpus* spp.	OBL	f/m, oth
Skunk- Cabbage	*Symplocarpus foetidus*	OBL	f/m, oth
Northern White Cedar	*Thuja occidentalis*	OBL	f/m, oth
Cattail	*Typha* spp.	FACW	f/m, oth
Elm	*Ulmus americana, U. rubra*	FACW/ FAC	f/m, oth
Blueberries, Cranberry	*Vaccinium spp. (e.g., V. corymbosum, V. macrocarpon, V. myrtilloides, V. oxycoccos)*	FACW/ OBL	f/m
Nannyberry	*Viburnum lentago*	FAC	f/m
Wild Rice	*Zizania aquatica, Z. palustris*	OBL	f/m

References

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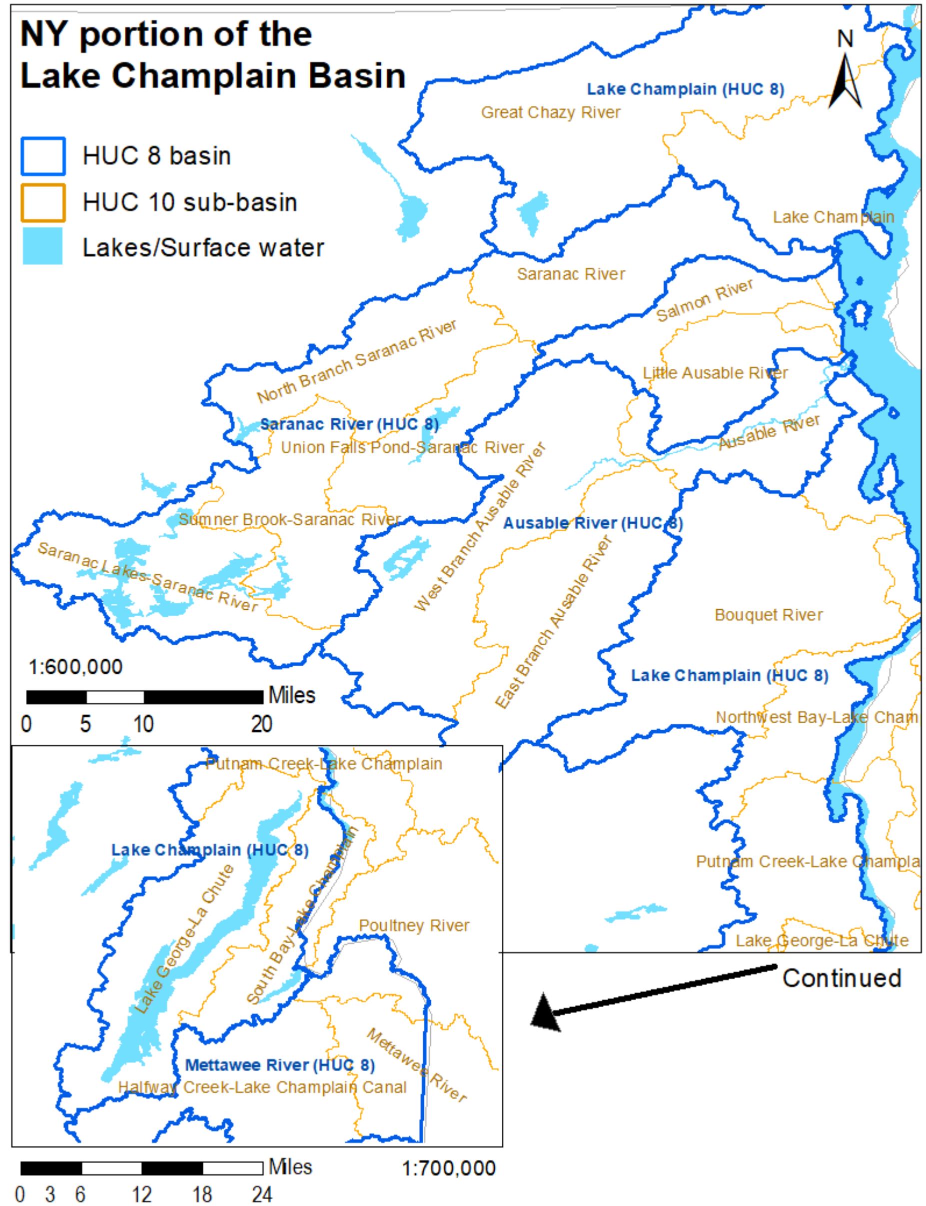
Appendix E. Remote Assessment Score for HUC 10 Watersheds

Appendix E

This appendix presents average scores for some of our spatial analytics metrics at the small HUC 10 scale. Scores presented below are averages for the HUC 10, divided into scores for wetland complexes and wetland catchments. Refer to the below map for HUC 10 names.

Wetland complex (wc)	
# of wetland complexes	Total wc in HUC 10
Area_Acres (ac)	wc area (ac)
Largest wc (ac)	Largest wc in HUC 10
M2_natural_wc	% Natural land cover in wc
M6_pCFP_wc	%Core Floodplain
M3_crop_MEAN_wc	Average crop cover
M1_LCA2_MEAN_wc	Average LCA2 in wc
M1_LCA3_MEAN_wc	Average LCA3 in wc
RU3	Floodwater Desynchronization (WFD)
RU4	wc connectivity (CSW)
Wetland catchment	
M4_canopy50buff	% canopy in 50 m buffer around the wc
wet catch_acres	Catchment area (ac)
M1_LCA2_MEAN	Average LCA2
M1_LCA3_MEAN	Average LCA3
M11_Slope	Catchment slope
M2_Natural	% Natural land cover
M4_canopy_MEAN	% canopy cover
M7_riparian	% Riparian cover
RU3_UpslopeCondition	Wetland Catchment Condition



Sub-basin (HUC 8): Saranac River

HUC 10:	North Branch Saranac River	Saranac Lakes-Saranac River	Saranac River	Sumner Brook-Saranac River	Union Falls Pond-Saranac River
Wetland complex					
# of wetland complexes	525	549	666	330	340
Area_Acres (ac)	16.58 ± 2.75	33.91 ± 13.41	7.42 ± 0.89	15.13 ± 3.69	15.79 ± 3.95
Largest wc (ac)	605.59	6674.21	288.87	841.64	1141.18
M2_natural_wc	100 ± 0	99 ± 0	96 ± 1	98 ± 1	100 ± 0
M6_pCFP_wc	216 ± 17	301 ± 21	900 ± 29	564 ± 40	136 ± 14
M3_crop_MEAN_wc	0 ± 0	0 ± 0	3 ± 1	1 ± 1	0 ± 0
M1_LCA2_MEAN_wc	92 ± 9	203 ± 14	467 ± 21	338 ± 26	53 ± 8
M1_LCA3_MEAN_wc	216 ± 17	301 ± 21	900 ± 29	564 ± 40	136 ± 14
RU3	49 ± 0	45 ± 0	41 ± 0	46 ± 1	49 ± 1
RU4	37 ± 1	38 ± 1	43 ± 1	26 ± 2	37 ± 2
M4_canopy50buff	73 ± 1	65 ± 1	61 ± 1	69 ± 1	73 ± 1
Wetland catchment					
wet catch_acres	121.1 ± 13.74	129.3 ± 25.97	66.01 ± 4.81	101.87 ± 13.43	103.03 ± 14.69
M1_LCA2_MEAN	82 ± 7	176 ± 13	475 ± 22	310 ± 24	53 ± 8
M1_LCA3_MEAN	180 ± 14	269 ± 19	881 ± 30	518 ± 37	131 ± 13
M11_Slope	7.6 ± 0.2	8.6 ± 0.2	5.8 ± 0.1	9.2 ± 0.2	7.6 ± 0.2
M2_Natural	98 ± 0	97 ± 0	89 ± 1	94 ± 1	99 ± 0
M4_canopy_MEAN	77 ± 1	75 ± 1	61 ± 1	72 ± 1	80 ± 0
M7_riparian	88 ± 0	86 ± 1	71 ± 1	83 ± 1	90 ± 1
RU3_UpslopeCondition	525 ± 0	549 ± 1	666 ± 1	330 ± 1	340 ± 1

Sub-basin (HUC 8): Lake Champlain

HUC 10:	Bouquet River	Great Chazy River	Lake Champlain	Lake George-La Chute	Little Ausable River	Northwest Bay-Lake Champlain	Putnam Creek-Lake Champlain	Salmon River	South Bay-Lake Champlain
Wetland complexe									
# of wetland complexes	1340	2125	1216	920	374	302	552	308	396
Area_Acres (ac)	6.69 ± 0.7	9.72 ± 1.5	10.74 ± 1.3	5.95 ± 1.6	9.04 ± 3.2	3.73 ± 0.5	7.17 ± 1.0	9.25 ± 1.2	6.34 ± 1.2
Largest wc (ac)	545.1	2365.96	813.32	1337.76	895.9	102.8	388.49	170.16	387.85
M2_natural_wc	89 ± 1	92 ± 1	90 ± 1	99 ± 0	95 ± 1	96 ± 1	97 ± 1	96 ± 1	97 ± 1
M6_pCFP_wc	584 ± 18	792 ± 16	1095 ± 21	461 ± 22	519 ± 32	633 ± 40	448 ± 28	825 ± 46	483 ± 31
M3_crop_MEAN_wc	11 ± 1	7 ± 0	10 ± 1	0 ± 0	4 ± 1	4 ± 1	2 ± 0	3 ± 1	3 ± 1
M1_LCA2_MEAN_wc	309 ± 11	338 ± 10	513 ± 14	289 ± 16	189 ± 15	332 ± 23	182 ± 14	329 ± 26	266 ± 20
M1_LCA3_MEAN_wc	584 ± 18	792 ± 16	1095 ± 21	461 ± 22	519 ± 32	633 ± 40	448 ± 28	825 ± 46	483 ± 31
RU3	43 ± 0	41 ± 0	36 ± 0	48 ± 0	43 ± 1	43 ± 1	47 ± 0	40 ± 1	44 ± 0
RU4	39 ± 1	44 ± 1	37 ± 1	40 ± 1	36 ± 2	39 ± 2	40 ± 1	47 ± 2	49 ± 1
M4_canopy50buff	65 ± 1	62 ± 1	52 ± 1	75 ± 1	68 ± 1	68 ± 1	72 ± 1	60 ± 1	70 ± 1
Wetland catchment									
wet catch_acres	71.86 ± 3.9	61.58 ± 3.1	60.91 ± 3.8	65.7 ± 4.5	74.1 ± 11.2	77.08 ± 6.4	85.3 ± 6.36	84.31 ± 8.3	89.04 ± 7.9
M1_LCA2_MEAN	275 ± 10	352 ± 10	547 ± 14	244 ± 15	196 ± 15	291 ± 21	159 ± 13	359 ± 26	230 ± 18
M1_LCA3_MEAN	523 ± 17	792 ± 16	1121 ± 22	393 ± 20	504 ± 32	557 ± 38	389 ± 25	833 ± 46	423 ± 29
M11_Slope	10.4 ± 0.1	3.6 ± 0	3.8 ± 0.1	11.5 ± 0.1	6.8 ± 0.2	11.3 ± 0.3	9.7 ± 0.2	5.5 ± 0.2	12 ± 0.2
M2_Natural	88 ± 1	84 ± 1	80 ± 1	96 ± 0	89 ± 1	90 ± 1	93 ± 1	90 ± 1	95 ± 1
M4_canopy_MEAN	69 ± 1	60 ± 1	51 ± 1	79 ± 0	68 ± 1	71 ± 1	75 ± 1	60 ± 1	77 ± 1
M7_riparian	77 ± 1	68 ± 1	60 ± 1	88 ± 1	76 ± 1	78 ± 1	83 ± 1	71 ± 1	85 ± 1
RU3_UpslopeCondition	1340 ± 1	2125 ± 1	1216 ± 1	920 ± 1	373 ± 1	302 ± 1	552 ± 1	308 ± 1	396 ± 1

Sub-basin (HUC 8): Ausable River (left) and Mettawee River (right)

HUC 10:	Ausable River	East Branch Ausable River	West Branch Ausable River	Halfway Creek-Lake Champlain Canal	Mettawee River	Poultney River
Wetland complexe						
# of wetland complexes	401	500	852	870	865	341
Area_Acres (ac)	8.68 ± 1.82	6.83 ± 1.63	11.56 ± 1.95	6.31 ± 0.84	2.95 ± 0.24	6.97 ± 1.35
Largest wc (ac)	456.82	766.7	931.86	557.87	99.3	299.4
M2_natural_wc	93 ± 1	93 ± 1	97 ± 0	84 ± 1	80 ± 1	79 ± 2
M6_pCFP_wc	40 ± 2	672 ± 33	421 ± 20	1232 ± 25	1174 ± 22	1187 ± 38
M3_crop_MEAN_wc	6 ± 1	6 ± 1	2 ± 0	16 ± 1	19 ± 1	21 ± 2
M1_LCA2_MEAN_wc	389 ± 25	337 ± 19	229 ± 13	603 ± 18	522 ± 15	609 ± 28
M1_LCA3_MEAN_wc	775 ± 40	672 ± 33	421 ± 20	1232 ± 25	1174 ± 22	1187 ± 38
RU3	42 ± 1	43 ± 0	46 ± 0	32 ± 0	33 ± 0	33 ± 1
RU4	38 ± 2	44 ± 1	40 ± 1	41 ± 1	35 ± 1	34 ± 1
M4_canopy50buff	62 ± 1	65 ± 1	70 ± 1	45 ± 1	47 ± 1	46 ± 1
Wetland catchment						
wet catch_acres	76.44 ± 7.75	88.54 ± 7.03	101.61 ± 8.61	76.33 ± 4.07	54.7 ± 2.81	82.04 ± 7.3
M1_LCA2_MEAN	365 ± 25	259 ± 17	208 ± 13	595 ± 18	464 ± 13	537 ± 25
M1_LCA3_MEAN	700 ± 39	537 ± 29	379 ± 19	1210 ± 25	1094 ± 20	1098 ± 36
M11_Slope	8.9 ± 0.3	12.6 ± 0.3	10.3 ± 0.2	7.4 ± 0.2	8.8 ± 0.1	8.3 ± 0.2
M2_Natural	89 ± 1	92 ± 1	95 ± 0	71 ± 1	75 ± 1	75 ± 1
M4_canopy_MEAN	66 ± 1	70 ± 1	73 ± 1	47 ± 1	52 ± 1	53 ± 1
M7_riparian	75 ± 1	80 ± 1	84 ± 1	52 ± 1	57 ± 1	57 ± 2
RU3_UpslopeCondition	401 ± 1	500 ± 1	852 ± 1	870 ± 1	865 ± 1	341 ± 2