Great Lakes Riparian Opportunity Assessment
Methodology
New York Natural Heritage Program
September 25, 2015

## OBJECTIVES

The goal of this analysis is to assemble a suite of riparian habitat quality indicators for the Great Lakes Basin. In accordance with the mission of the Trees for Tribs program, choice of indicators will be focused on those which most directly inform the optimal placement of vegetative riparian buffers. This document outlines a set of indicators and approach for assessing these indicators to accomplish this goal.

We are using a suite of indicators rather than just a single composite score to accommodate the different conservation priorities that may arise from collaborations with a diverse array of potential partners. While the calculation of a composite index will allow for fast and simple identification of the best and worst habitats, the individual indicators are also valuable. Riparian buffers can be used to improve several aspects of stream health, and a partner interested in using buffers to shade streams for trout habitat will need to focus on a different set of riparian areas than a partner interested in ameliorating the impact of upland agriculture.

## IDENTIFYING RIPARIAN HABITAT

The analysis will use the National Hydrography Dataset (high-resolution NHD) as the base stream layer. To identify riparian habitat, we will use the Riparian Buffer Delineation Model (Abood *et al.* 2012), to draw a variable width buffer based on 10 m digital elevation models and 50 year flood height. Variable width buffers take into account surrounding hydrology and can provide a more accurate delineation of riparian habitat than the more commonly used fixed width buffers (Lee *et al.* 2004, Polyakov *et al.* 2005), although they take longer to create.

## METHODOLOGY OVERVIEW

*Task I: Identify critical zones (sub-watersheds) for water quality and habitat quality management*

"Critical zones" will be identified at the scale of the sub-watershed (a hydrologic unit commonly referred to as "HUC 12"). Within the study area of the New York State portion of the Great Lakes Basin there are approximately 700 sub-watersheds (Figure 1). Layers for each of the habitat indicators (described in "Habitat Indicators" section below) will be created and the scores for all habitat within each sub-watershed will be aggregated to create a single score for the sub-watershed. Scores for each indicator will be normalized to a value between 0 and 1. The cumulative score will be calculated as the sum of the scores for each indicator, resulting in a composite score and several indicator scores for each sub-watershed.

The product of the analysis will be a GIS layer ranking sub-watersheds according to their cumulative score, as well as additional layers identifying rankings for each individual indicator. Areas with the highest cumulative scores represent those zones where the establishment of vegetative buffers may provide multiple services benefitting stream and habitat quality.

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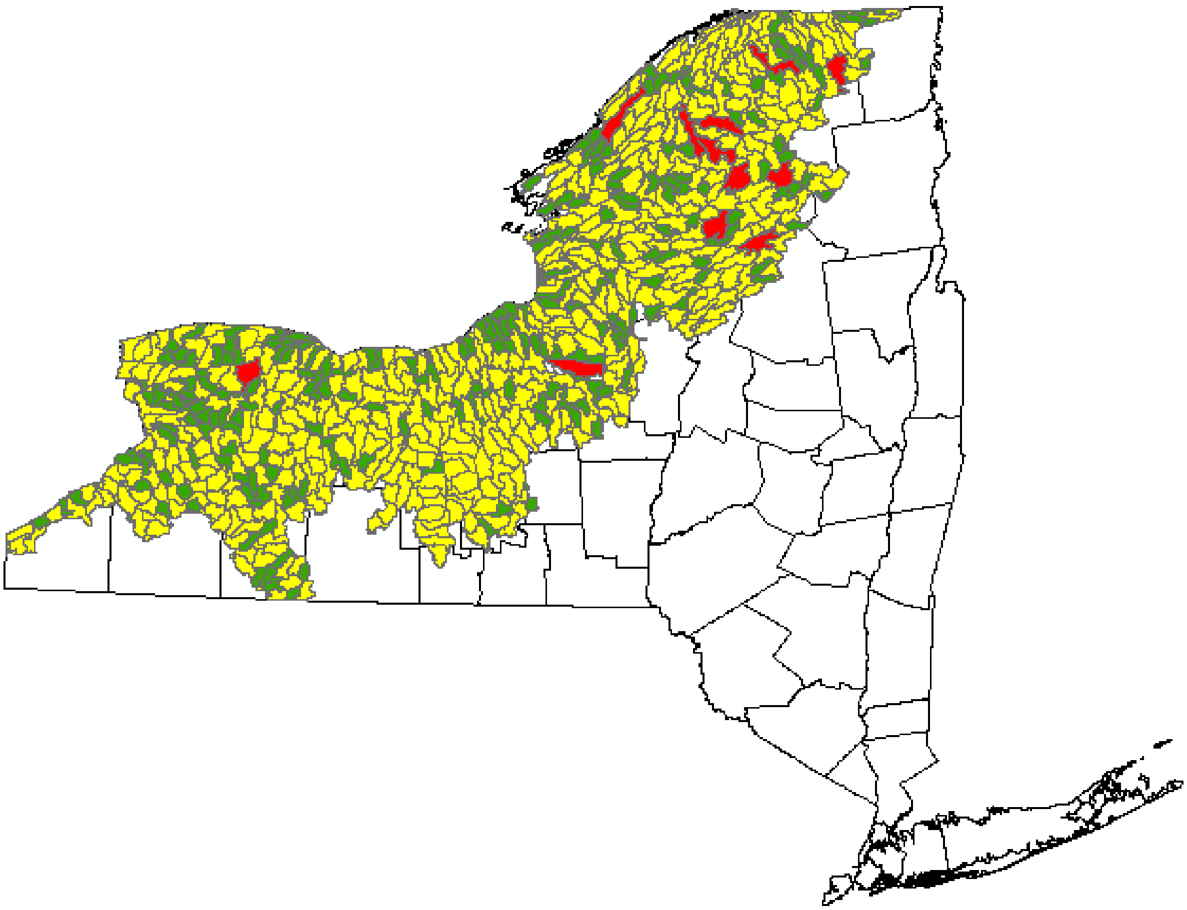

Figure 1: Example of the size and distribution of sub-watershed ("HUC 12") units for the study area. Each colored unit represents a single sub-watershed.

*Task II: Identify locations (catchments) within the critical zones where Trees for Tribs can have a tangible effect on improving water quality and habitat quality.*

This portion of the assessment will analyze habitat within each sub-watershed ("HUC 12"), to identify those areas within a critical zone where vegetative buffers can be most effective. "Locations" within the zone will be identified at the scale of the catchment. There is one catchment for every reach in a stream (Figure 2). Catchment size can vary depending on the length of the reach and surrounding topology, but in general it describes a very small area, allowing for fairly precise targeting of Trees for Tribs activities.

The same suite of indicators and methods of scoring that were used to classify critical zones in Task I, will be used to classify catchments within the sub-watershed for Task II. However, each catchment will only be ranked relative to other catchments in the same sub-watershed, not relative to every catchment in the NY Great Lakes Basin.

The product of the analysis will be a GIS layer with all stream catchments, their habitat indicator scores, ranked relative to the other catchments in their sub-watershed.

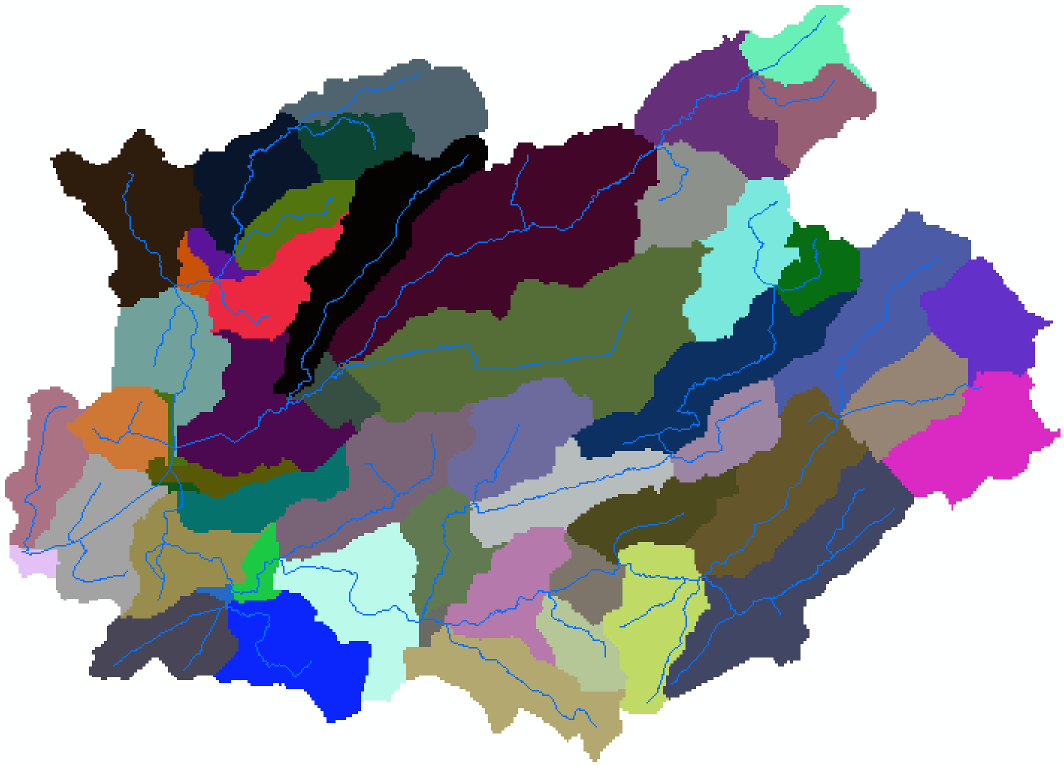

Figure 2: Example of the distribution of catchments and streams within a single sub-watershed, each colored unit represents a catchment. Blue lines represent streams.

Task III: Prioritize these locations

**Prioritizing by score:** Locations can be ranked according to their cumulative score, or the score of the habitat indicator of interest. Those locations with the highest cumulative score or high score for an ecological stressor indicator represent areas that may benefit the most from restoration activities. Locations with the lowest cumulative score, or the highest scores for ecological health indicators, will represent locations that may benefit from preservation.

**Prioritizing Locations with Plots:** A method that may prove useful for screening sub-watersheds to find the most critical locations for action, is through the use of "bubble plots" (Norton *et al.* 2009) This method provides more information than comparing the ranks of a single indicator of interest, and provides a different kind of assessment than would be gained from the composite index that incorporates all indicators. Scores are combined according to indicator quality (see "Habitat Indicators" below, indicator quality reflects if the indicator represents a sign of good habitat quality, or a source of stress), resulting in each watershed having two scores, one for ecological health, and one for ecological stress. Plotting the two indices against each other allows for the distinction of watersheds with good health and low stress (pristine), poor health and high stress (high need for restoration, although potentially low chance of success); and the intermediate classes of good health and high stress (good habitat at high risk) and poor health and low risk (moderately valuable habitat). This is especially useful for prioritizing areas of overall moderate habitat quality.

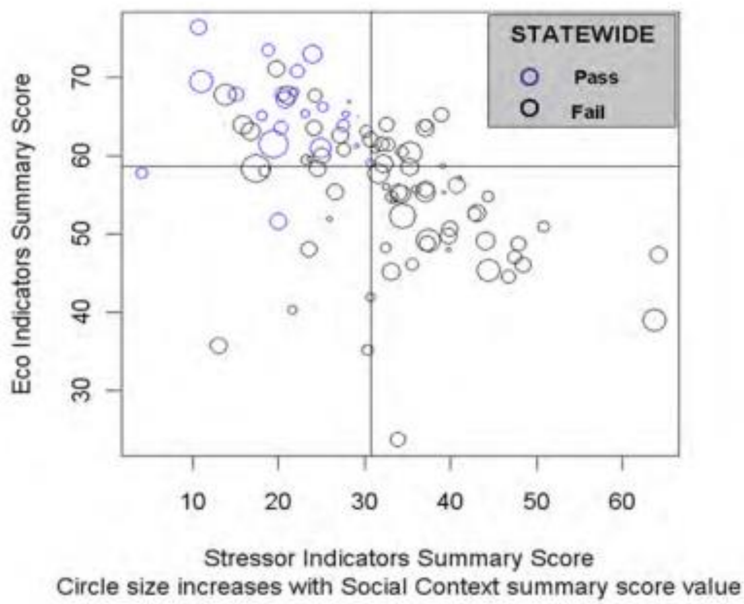


**Figure 4-30** Bubble plot of recovery potential screening of 94 non-tidal watersheds in Maryland. Colors signify whether watersheds passed the state's watershed bio-assessment. Although indicators were selected to compare recovery potential of impaired waters, the output also contrasts healthy watershed differences (e.g., social context and stressor levels) that have implications for protection priority-setting.

Figure 3: Example of a bubble plot used to prioritize watershed conservation in Maryland (US Environmental Protection Agency 2012).

Demonstrated in the example above, a third class of information can be included in this part of the analysis to incorporate the availability of collaborators, partnerships, or existing preservation activities in each region. In the example, the size of the bubbles relates to this "social context" score- which reflects the amount of existing activity at that site. In our analysis, the addition of data on existing partners and activities could allow us to prioritize based on watershed health, stress, and the presence of partners (which can be indicative of the likelihood of a successful project). The same analysis can also identify those areas of greatest ecological need for which there currently are no partners available.

HABITAT INDICATORS

Our research suggests the indicators summarized in Table 1 are most appropriate for this analysis. Each indicator is classified by category, quality, and scale of evaluation. Further detail about each indicator is provided below.

- Indicator category*:* The indicators can be grouped into 5 general characteristics of riparian habitat: landscape condition, hydrologic condition, biological condition, connectivity, and stream quality.

- Indicator quality: Ecological health indicators describe the distribution and abundance of key features for healthy, functional habitats. Ecological stressors describe the distribution and abundance of landscape modifications and impairments likely to damage habitat health.

- Scale of evaluation: Depending on the nature of the source data, some indicators will be scored twice, one score reflecting their abundance and distribution within the entire sub-watershed ("watershed"), and a separate score reflecting their abundance and distribution within the riparian zone ("riparian"). It is important to make this distinction because some landscape qualities, like land use, of both the upland and riparian zones can have significant influences on the quality of stream and riparian habitat. However, because habitat within the riparian buffer will impact stream and riparian quality more immediately and in a more localized manner than upland habitat, we think it is important to quantify the riparian habitat quality separately. Upland conditions still have significant impacts on stream health (Shandas and Alberti 2009), so watershed scale values are also included. This allows the scores to distinguish between a pristine buffer in a highly disturbed landscape, and a mediocre riparian habitat surrounded by forest. Some features, like all stream quality indicators, are by default, riparian qualities, and are only scored once.

*Landscape Condition:*

**Landscape Condition Assessment:**

The extent, quality, and distribution of alterations to the landscape surrounding a stream have profound impacts on the health of the habitat (Klein 1979). Runoff from agriculture can cause dangerous levels of sediments, nitrates, and phosphates to flow into rivers. Impervious surfaces, like roads and other paved areas, increase the speed and amount of runoff because water cannot be adsorbed into the soil. The Landscape Condition Assessment (LCA) incorporates a suite of landscape stressors which describe the distribution and abundance of transportation, urban, industrial, and agricultural land use. Areas with higher LCA scores correspond with more ecologically stressful landscapes.

Data source: New York Natural Heritage Program

**Canopy Cover:**

Streamside forests provide important ecosystem functions, protecting water quality by blocking pollutants, sequestering carbon, and metabolizing organic matter. Unforested streams experience higher maximum summer water temperatures than those under the shade of a full canopy (Sweeney and Newbold 2014). Streams with healthy canopy cover and low temperatures provide excellent habitat for trout (Barton *et al.* 1985). Distribution of areas with low canopy cover indicate areas where the addition of a vegetative buffer may have significant impacts on stream temperature.

Data source: National Land Cover Database

**Natural Cover:**

All vegetation, not just forest, can potentially protect water quality by intercepting sediment from disturbances in the watershed (Dosskey *et al.* 2010). This indicator describes the proportion of the landscape composed of non-crop, non-impervious surface land use classes, but not necessarily forest.

Data source: National Land Cover Database

*Hydrologic Condition:*

**Wetness Index (runoff)**: For the reduction of sediment and the amelioration of runoff, buffers will be most successful at slowing the speed of surface runoff when they are placed in areas where water collects from a large upslope area and moves across the riparian zone as a distributed flow, like a sheet. This wetness index targets these areas by identifying grid cells that both receive runoff waters from large upslope areas and have low slopes. Calculated as $W=\ln(A_s/\tan \beta)$, where As is the upslope contributing area and B is the slope. Calculation of upslope contributing area can be run using the TauDEM tool (Terrain Analysis using Digital Elevation Model) (Tomer *et al.* 2003).

Data source: National Elevation Dataset

**Erosion:** Highlights cells that receive runoff waters from large upslope contributing areas and have steep slopes, at greater risk for erosion adjacent to the stream bank (Tomer *et al.* 2003). Erosion indices will be weighted by soil erosivity, giving highest scores to areas with both soil types prone to erosion and hydrologic features with a high potential for erosion.

Data Source: National Elevation Dataset (NED), SSURGO soils

*Riparian Habitat Connectivity*

**Dams:**

Streams and rivers naturally meander, and progressive cycles of flooding lead to riparian habitat heterogeneity, making these areas of high diversity. Flow regulation can limit these flooding events. Without the disturbance cycle caused by flooding, there is a reduction in the input of nutrients and soil deposition, and upland species that otherwise would have been held in check by inundation of the shoreline, can begin to dominate, leading to a riparian zone indistinguishable from upland habitat. In addition to reduced diversity, these species are not adapted to flooding, making these areas potentially vulnerable to flooding risks from extreme weather related to climate change (Pringle 2001).

Data Source: NY State Dam Inventory

**Functional River Networks:**

Another method for estimating stream connectivity, the Functional River Network describes stream units which are unbroken by dams. This is a measure of longitudinal connectivity along streams, allowing for movement of organisms, water, sediment, and organic materials (Smith *et al.* 2008).

Data Source: New York Natural Heritage Freshwater Blueprint

**Forest Blocks:**

The connectivity of vegetation is an indicator of habitat health. Forest blocks describe units of contiguous forest, and riparian zones with a higher proportion of area composed of part of a forest block are likely to have better connectivity, and be more resilient to disturbance (Shandas and Alberti 2009).

Data Source: NY Natural Heritage Program

**Floodplain Complexes**

Floodplain complexes describe the connectivity of all wetland habitat, not just forest, and provide an indicator of vegetative connectivity independent of large tracts of forest.

Data Source: The Nature Conservancy

*Stream Quality:*

**WI/PWL status: "Impaired","Minor Impacts", or "Threatened":**

The New York Waterbody Inventory/Priority Waterbodies List is a statewide compilation of water quality information that assess overall water quality and sources of water quality impairment. Waters classified as "Impaired", "Waters with Minor Impacts", and "Threatened" are prioritized for intervention and restoration. "Impaired" waters have frequent and persistent water quality conditions which prevent, limit, or discourage the use of the waterbody. Waterbodies with "Minor Impacts" are considered stressed and have documented water quality impacts less severe than impaired waters. "Threatened" waters have no existing water quality problems but are included in the Priority Waterbodies List due to land use changes in the watershed that are known or strongly suspected to threaten water quality.

Data source: NYS Dept. Environmental Conservation

*Biological Condition:*

**Eastern Brook Trout Habitat Patches**

The confirmed presence of Eastern Brook Trout serves both as an indicator of healthy stream habitat, as well as a parameter of special interest for many potential partners whose work is focused on preserving fisheries.

Data Source: NYS DEC, Division of Fish and Wildlife

**Predicted Stream Invertebrate richness (EPT)**

Certain biological communities can be strong indicators of ecosystem health. The Stream Invertebrate richness index describes the species richness of different kinds of stonefly, mayfly, and caddisfly. Greater richness is usually an indicator of good water quality conditions. We modeled the relationship between environmental variables and observed EPT richness to yield predicted values of EPT richness for all stream reaches allowing a predicted score to be assigned to an unsampled location (White *et al.* 2011).

Data Source: New York Natural Heritage Program, NYS DEC Division of Water Stream Biomonitoring Unit.

**Predicted Biological Assessment Profile (BAP)**

The Biological Assessment Profile (BAP) is an overall water quality impact score obtained by plotting biological index values from five water quality indices. Predicted BAP values were modeled as part of the NYS Freshwater Blueprint Project (White *et al.* 2011) and will be incorporated as an indicator into this analysis.

Data Source: NY Natural Heritage Program, NYS DEC Division of Water Stream Biomonitoring Unit.

**Rare taxa presence:**

The presence within the riparian zone of rare taxa can be an indicator of a more functionally intact ecosystem. This indicator takes into account the presence of rare species and significant natural communities throughout the riparian zone, not just invertebrates.

Data Source: NY Natural Heritage Program

LITERATURE CITED

Abood, S. A., A. L. Maclean, and L. A. Mason. 2012. Modeling Riparian Zones Utilizing DEMS and Flood Height Data. Photogrammetric Engineering & Remote Sensing 78:259–269.

Barton, D. R., W. D. Taylor, and R. M. Biette. 1985. Dimensions of Riparian Buffer Strips Required to Maintain Trout Habitat in Southern Ontario Streams. North American Journal of Fisheries Management 5:364–378.

Dosskey, M. G., P. Vidon, N. P. Gurwick, C. J. Allan, T. P. Duval, and R. Lowrance. 2010. The Role of Riparian Vegetation in Protecting and Improving Chemical Water Quality in Streams1. JAWRA Journal of the American Water Resources Association 46:261–277.

Klein, R. D. 1979. Urbanization and stream quality impairment. Water Resources Bulletin 15:948–963.

Lee, P., C. Smyth, and S. Boutin. 2004. Quantitative review of riparian buffer width guidelines from Canada and the United States. Journal of Environmental Management 70:165–180.

Norton, D. J., J. D. Wickham, T. G. Wade, K. Kunert, J. V. Thomas, and P. Zeph. 2009. A Method for Comparative Analysis of Recovery Potential in Impaired Waters Restoration Planning. Environmental Management 44:356–368.

Polyakov, V., A. Fares, and M. H. Ryder. 2005. Precision riparian buffers for the control of nonpoint source pollutant loading into surface water: A review. Environmental Reviews 13:129–144.

Pringle, C. M. 2001. Hydrologic connectivity and the management of biological reserves: a global perspective. Ecological Applications 11:981–998.

Shandas, V., and M. Alberti. 2009. Exploring the role of vegetation fragmentation on aquatic conditions: Linking upland with riparian areas in Puget Sound lowland streams. Landscape and Urban Planning 90:66–75.

Smith, M. P., R. Schiff, A. Olivero, and J. MacBroom. 2008. The active river area: a conservation framework for protecting rivers and streams. The Nature Conservancy Eastern U.S. Freshwater Program, Boston, MA.

Sweeney, B. W., and J. D. Newbold. 2014. Streamside Forest Buffer Width Needed to Protect Stream Water Quality, Habitat, and Organisms: A Literature Review. JAWRA Journal of the American Water Resources Association 50:560–584.

Tomer, M. D., D. E. James, and T. M. Isenhart. 2003. Optimizing the placement of riparian practices in a watershed using terrain analysis. Journal of Soil and Water Conservation 58:198–206.

US EPA, O. 2012. Identifying and Protecting Healthy Watersheds. 296 pages.

White, E. L., J. J. Schmid, T. G. Howard, M. D. Schlesinger, and A. L. Feldmann. 2011. New York State Freshwater Conservation Blueprint Project, Phases I and II: Freshwater Systems, Species, and Viability Metrics. The New York Natural Heritage Program, Albany, NY. 85 pages.

Riparian Opportunity Assessment Metrics

| Indicator Name | Scale of Evaluation | Aggregation Method | Indicator Category | Indicator Quality | Source |
|---|---|---|---|---|---|
| Landscape Condition Assessment (LCA) | Riparian | Avg. value for cells in unit | Landscape Condition | Ecological Stress | NY Natural Heritage Program |
| Landscape Condition Assessment (LCA) | Watershed | Avg. value for cells in unit | Landscape Condition | Ecological Stress | National Land Cover Database |
| Canopy Cover | Riparian | Avg. value for cells in unit | Landscape Condition | Ecological Health | National Land Cover Database |
| Natural Cover | Riparian | % Natural cover (non-impervious, non-agricultural land use classes) | Landscape Condition | Ecological Health | National Land Cover Database |
| Natural Cover | Watershed | % Natural cover (non-impervious, non-agricultural land use classes) | Landscape Condition | Ecological Health | National Land Cover Database |
| Erosion Index | Riparian | Avg. value for cells in unit | Hydrologic Condition | Ecological Stress | Digital Elevation Model, SSURGO |
| Wetness Index (runoff) | Riparian | Avg. value for cells in unit | Hydrologic Condition | Ecological Stress | Digital Elevation Model |
| Dams | Riparian | # dams/cumulative stream length | Habitat Connectivity | Ecological Stress | NY State Inventory of Dams |
| Floodplain Complexes | Riparian | Proportion of area composed of Floodplain Complex | Habitat Connectivity | Ecological Health | NY Natural Heritage Program |
| Forest Blocks | Riparian | Proportion of area composed of Forest Blocks | Habitat Connectivity | Ecological Health | National Land Cover Database |
| Functional River Networks | Riparian | Proportion of stream length in Functional River Networks | Habitat Connectivity | Ecological Health | NY Natural Heritage Program |
| WI/PWL Status | Riparian | Proportion of stream length classified as "Impaired",”Threatened”, or with ”Minor Impacts” | Stream Quality | Ecological Stress | NY Priority Waterbodies Inventory |
| Eastern Brook Trout | Watershed | Sum of Patch Scores per Watershed | Biological Condition | Ecological Health | NY DEC, Division of Fish Wildlife |
| Biological Assessment Profile (BAP) | Riparian | Avg. value for cells in unit | Biological Condition | Ecological Health | NY Natural Heritage Program, NYS DEC Division of Water Stream Biomonitoring Unit. |
| Rare Taxa Presence | Riparian | # taxonomic groups with vulnerable aquatic species | Biological Condition | Ecological Health | NY Natural Heritage Program |
| Stream Invertebrate Richness (EPT) | Riparian | Avg. value for cells in unit | Biological Condition | Ecological Health | NY Natural Heritage Program, NYS DEC Division of Water Stream Biomonitoring Unit. |