Regional Aquatic Research

March 14, 2013

Mark Anderson, Arlene Olivero Sheldon, Erik Martin
The Nature Conservancy Eastern Regional Office

U.S. FISH & WILDLIFE SERVICE

The Nature Conservancy
Protecting nature. Preserving life.™

NEAFWA

Projects To Date:

Aquatic Habitat Classification

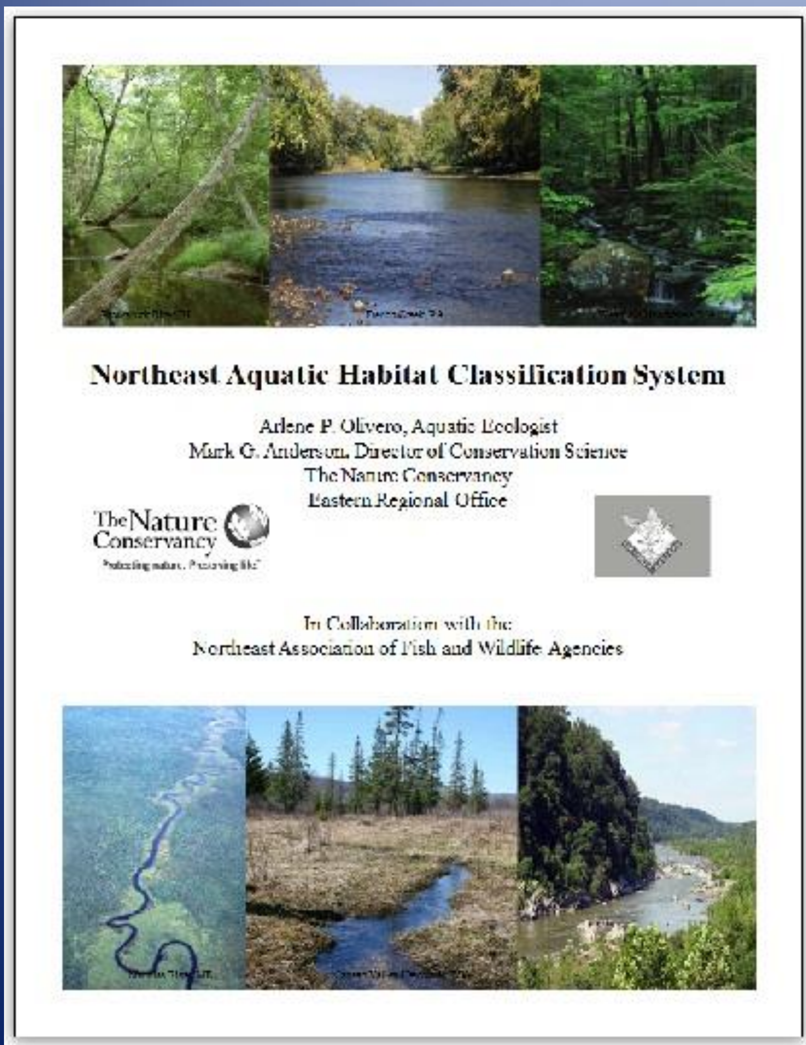
1. Northeast Aquatic Habitat Classification
2. Northeast Aquatic Habitat Guide + Linked Revisions
3. A Stream Classification System for the Appalachian Landscape Conservation Cooperative
4. Southeast Aquatic Classification

Aquatic Condition

1. Conservation Status Report
2. Geospatial Habitat Condition Assessment
3. Northeast Aquatic Connectivity Assessment
4. Southeast Aquatic Connectivity Assessment

Aquatic Resilience to Climate Change

1. Northeast Aquatic Habitat Classification System



Product: Developed a standard regional stream and river classification to consistently represent flowing water habitat types across the region.

Process: Workgroup of representatives from all states and some federal partners (>30 participants) worked together for 2 years

- Used monthly workgroup calls to review state classification, potential variables, testing, and thresholds in these variables.

Funding: NEAFWA + TNC

Completed Sept. 2008

http://rcngrants.org/spatialData

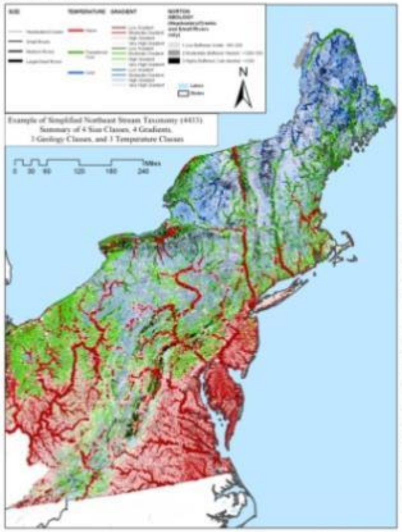
Northeast Aquatic Habitat Classification System

Mark G. Anderson Ph.D. Director of Conservation Science. The Nature Conservancy. Eastern North America Division. manderson@tnc.org 99 Bedford Street, Boston, MA 02111.
Arlene Olivero Sheldon M.S., Aquatic Ecologist/GIS Manager. The Nature Conservancy. Eastern North America Division, arelene_olivero@tnc.org 99 Bedford Street, Boston, MA 02111.

Abstract

This project developed a standard Northeastern Aquatic Habitat Classification (NAHCS) and GIS map for 13 northeastern states (ME, NH, VT, MA, RI, CT, NY, PA, NJ, DE, MD, VA, WV, and DC.) that are part of the Northeast Association of Fish and Wildlife Agencies (NEAFWA). This classification and GIS dataset was designed to consistently represent the natural aquatic habitat types across this region in a manner deemed appropriate and useful for conservation planning by the participating states. This product was not intended to override state classifications, but is meant to unify state classifications and allow for looking at aquatic biodiversity patterns across the region. The NAHCS habitat classification is based on a biophysical aquatic classification approach (Higgins et al. 2005) and uses four primary classification attributes to define habitat types. These variables include size, gradient, geology, and temperature. Ecologically meaningful class breaks within each of the four variables were developed and the resultant variables and classes combined to yield a regional taxonomy with 259 stream types. The full types can be simplified using recommended prioritization and collapsing rules. It is anticipated that these Northeastern Aquatic Habitat Classification (NAHCS) products will allow each state to identify and map aquatic habitat types consistently across state lines and provide opportunities for new understandings of aquatic biota, aquatic habitat conditions, and aquatic priority habitats.
The data and report can be downloaded from http://rcngrants.org/node/38

Example: Stream Type Taxonomy Using 4 Sizes, 4 Gradients, 3 Geology, and 3 Temperature Classes. This taxonomy yields 96 stream types in the region.



Example: Mapping a single stream type. "High gradient acidic cold headwater streams"

High gradient acidic cold headwater stream.
Type 1b511:
Size Class (1b): Northeast Headwaters
Gradient Class (5): High
Geology Class (1): Low Buffering Capacity, Acidic
Temperature Class (1): Cold

Linked State Name: MA Small Streams, VT Cold headwater acidic streams, NY Coldwater Stream, CT Coldwater Stream.

Habitat Description: Cascade and step-pool habitats where channels are narrowly confined, bed materials of bedrock, boulders, and cobbles, coldwater habitats with fast moving water; low elevation coastal variants rare

Linked Biota
Fish: Brook trout, Brook-trout Slimy sculpin, Blacknose dace
Macroinvertebrates: acid tolerant leaf shredders, low species diversity Caddisflies (*Parapsyche, Palagapetus*)-Stoneflies (*Capniidae*)-Non-biting midges (*Eukiefferiella*), Mayflies (*Eurylophella*) Other preferential taxa Caddisflies (*Rhyacophila*), Stoneflies (*Leuctridae, Taeniopteryx, Chloroperlidae, Peltoperlidae*), Water strider (pools). Possible taxa Alder flies, Beetles (*Psephenidae*), Mollusca (*Elliptio*), Mayflies (*Heptageniidae*).
Plants: acid tolerant bryophytes, algae, macrophytes

Combining Variables into Stream Types

The workgroup agreed that the four variables and their thresholds were primary in determining stream type: Size (7 classes), Gradient (6 classes), and Geologic Buffering Capacity (3 classes), and Temperature (4 classes). Of the 312 possible combinations possible given these variables, 259 unique combinations actually occurred in the 13 state region. Because of the large number of stream types, we developed some consistent ways to reduce the number of aquatic habitat types for specific purposes.

Variable Prioritization: Certain variables were deemed more important than others in terms of structuring aquatic habitats and biological communities in the northeastern U.S. Certain variables were also considered more constant and unalterable by humans and thus of more utility in a basic classification to address the expected natural aquatic habitat distributions in the northeast. The team recommends the following prioritization rules: 1st importance = stream size, 2nd importance = gradient, 3rd importance = geology, and 4th importance = expected natural water temperature. With this guidance, a user could for example display the aquatic habitats by a combination of the two most important variables, stream size classes (7) and gradient classes (6) to yield a simpler number of types (e.g. 7 size classes x 6 gradient classes = 42 possible types).

Within Variable Collapsing Rules. Each of the four major variables is divided into multiple classes. Although the breaks are useful in many applications, for some applications users may want to group variation within a given variable into a smaller number of classes. The team developed recommendations of how to collapse each of the four classification variables. For example, size, geology, and temperature, the team developed collapsing rules independent of other variables. For the gradient variable, the workgroup preferred using different collapsing rules for the gradient variable within streams (size 1a and 1b) vs. within rivers (size 2+) due to variation in the original distribution of gradients in streams vs. rivers.

Remove Biotically Insignificant Combinations: Certain combinations of variables were deemed likely biologically insignificant. For example, although larger rivers can occasionally have higher gradient sections and waterfalls, workgroup members felt in many cases the few high gradient large river reaches mapped in the classification were potentially data errors given the scale of the reach hydrography. Although members did not want to eliminate these types until further "on the ground" investigation, they felt these types should be viewed with skepticism until their unique high gradient habitat could be verified.

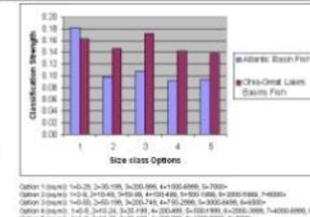
Defining Aquatic Habitat Types

The aquatic habitat types were structured after the "macrohabitat" level of classification which defines individual stream reach types based on variables that influence aquatic communities at the reach scale and that can be modeled in a GIS. **Our process focused on a review of potential variables by the team to reach consensus on the most important variables and define meaningful ecological breaks to represent aquatic habitat patterns across the eastern region. The resultant four primary habitat variables and classes are described below.** The individual stream segments can be further described using the 100+ other "habitat descriptors" compiled during the course of this project. These include variables such as stream order, channel elevation, estimated mean-annual flow and velocity, air temp, precipitation, catchment land cover, catchment geology, average baseflow index, average catchment slope, catchment landform types, and downstream connectivity type.

1. Size: Stream size is a critical factor determining aquatic biological assemblages. The well known "river continuum concept" describes how stream ecosystems change with an increase in physical size from small headwater streams to large river mouth.

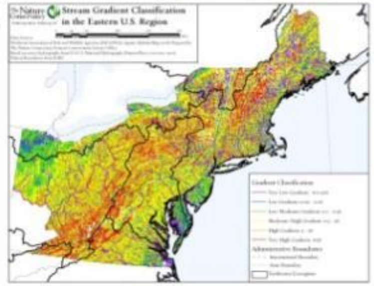
Results: 7 agreed upon classes
1) Headwaters (<4 sq. mi.)
2) Creeks (4-40 sq. mi.)
3) Small River (40-200 sq. mi.)
4) Medium Tributary Rivers (200-100 sq. mi.)
5) Medium Mainstem Rivers (1000-4000 sq. mi.)
6) Large Rivers (4000 – 9600 sq. mi.)
7) Great Rivers (over 9600 sq. mi.

Pennsylvanian fisheries data tested against stream size breaks within the Ohio-Great Lakes Basin and Atlantic Basin. The classification strength chart below compares between class similarities and within class mean similarities as a relative measure of a classification's ability to distinguish patterns (VanSickle 1997). The five stream size classification options tested had classification strengths ranging between 0.09 and 0.18. Option 1 which is very similar to the final regional stream size thresholds chosen in this NEAFWA project had high classification strengths for fish communities in both the Ohio – Great Lakes Basins (1976 sites, 76 species) and the Atlantic Basin (4284 sites, 61 species).

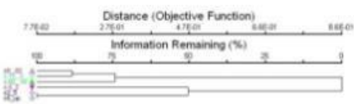


2. Gradient: Stream gradient influences stream substrate and grain size, stream bed morphology, flow velocity, and sediment transport/deposition.

Results: 6 agreed upon classes
1) Very low 0-0.02%
2) Low 0.02-0.1%
3) Moderate 0.1-0.5%
4) Moderate-High 0.5-2%
5) High 2-5%
6) Very High 5%

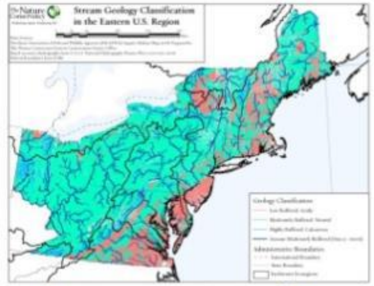


The relationship of stream biota to gradient classes. A cluster analysis using 6672 points representing 317 Heritage tracked species of fish, mussels, snails, amphibians, and aquatic insects was used to test gradient classes. Tested gradient classes are listed on the left . The "information remaining" scale provides a measure of the "similarity" between the classes based on the information lost at east step in the hierarchical cluster analysis. As groups are fused, the amount of information decreases until all groups are fused and no species information remains different between the groups to further classify. The magnitude of the information remaining at each steps gives the reader a way to measure how distinctly different the groups are in terms of their species composition.



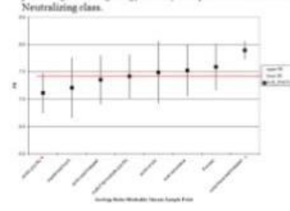
3. Geology: Aquatic organisms need water pH to be within a certain range for optimal growth, reproduction, and survival. Water chemistry parameters such as pH and acid neutralizing capacity (ANC) are strongly influenced by the minerals and ions that leech out of underlying bedrock and surficial material.

Results: 3 agreed upon classes
1) Acidic, low buffer (100-200*)
2) Neutral, moderate buffer (200-300*)
3) Calcareous, highly buffered (300+*)
* = Norton geology index of acid neutralizing capacity for upstream watershed



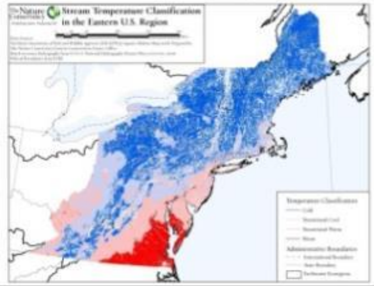
Map of Bedrock and Deep Surficial Sediments.

Average stream pH by underlying geology type (EPA wadeable stream assessment chemistry data, mean and two standard deviations). The percentages of geology classes within the upstream watershed of each reach were transformed into a "Norton Index Value" by multiplying the percentage of each geology class by its equivalent Norton Acid Neutralizing class.



4. Temperature: Stream temperature sets the physiological limits where stream organisms can persist. To map the expected natural water temperature class of each stream or river, we developed a CART model relating differences in water temperatures to differences in stream sizes, stream gradients, air temperatures, and groundwater inputs.

Results: 4 agreed upon classes
1) Cold
2) Transitional Cool
3) Transitional Warm
4) Warm



Each headwater and creek reach was assigned to an expected natural water temperature based on the following matrix. If the reach fell within cumulative air temperature class 1-5 or 10 (across), its water temperature class was assigned simply by what gradient class it fell within (down). If the reach fell within cumulative air temperature class 6-9, its water temperature class was based on an initial stratification of those reaches < or >= 40% baseflow index. The expected natural air temperature for these reaches was then assigned based on variations in the gradient class (upper table for those <40% baseflow index, lower table for those >40% baseflow index). Please note a separate model was used to assign rivers to the four water temperature classes.

RESULTS

4 Major Variables

7 size classes
6 gradient classes
3 geology classes
4 temperature classes

= 259 combinations of the above 4 variables occur

Example:
headwater, very high gradient, acidic, cold

Size Class	**Description**	**Definition (sq.mi.)**
1a	Headwaters	0<3.861
1b	Creeks	>=3.861<38.61
2	Small Rivers	>= 38.61<200
3a	Medium Tributary Rivers	>=200<1000
3b	Medium Mainstem Rivers	>=1000<3861
4	Large Rivers	>=3861<9653
5	Great Rivers	>=9653
Gradient Class	**Description**	**Definition (slope of stream channel (m/m) * 100)**
1	Very Low Gradient	<0.02%
2	Low Gradient	>= 0.02 < 0.1%
3	Moderate-Low Gradient	>= 0.1 < 0.5%
4	Moderate-High Gradient	>=0.5 < 2%
5	High Gradient	>=2 < 5%
6	Very High Gradient	>5%
Geology Class	**Description**	**Definition (index based on cumulative upstream geology; only applied to size 1a, 1b and 2 rivers)**
1	Low Buffered; Acidic	100-174
2	Moderately Buffered; Neutral	175-324
3	Highly Buffered; Calc-Neutral	325-400
Temperature	**Estimated Natural Temperature Regime**	**Definition**
1	Cold	Complex rules; see CART analysis and final rules on Temperature Metadata worksheet
2	Transitional Cool	
3	Transitional Warm	
4	Warm	

2. Aquatic Habitat Guide

Objective: Simplify the classification to ~50 major types and create a guide to the Northeast Aquatic Habitat Classification System. For each type include: description, distribution, picture, associated species, associated natural communities, etc.

Funding: NEAFWA , TNC, NA LCC

Due Date: Streams Sept. 2013, Lakes Dec. 2013

Scope of Work

1) **Simplify the Stream Classification, Add Tidal, Add Lake Classification, Explore River Confinement Class**

   With steering committee, hold web-ex conference calls to come to consensus regarding the simplification and revisions to the aquatic habitat types.

2) **Habitat Guide**

Develop a simple report format for each habitat type and populate it with:

- Description of stream type
- Distribution Map
- Environmental Setting
- Associated Fish and Mussels
- Crosswalk to SWAP types
- Photo

3) **Review**

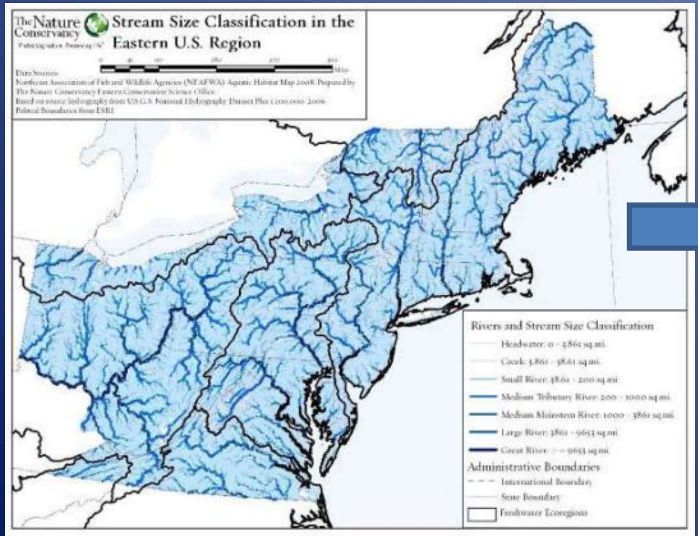
Input and review from the committee and others will be critical

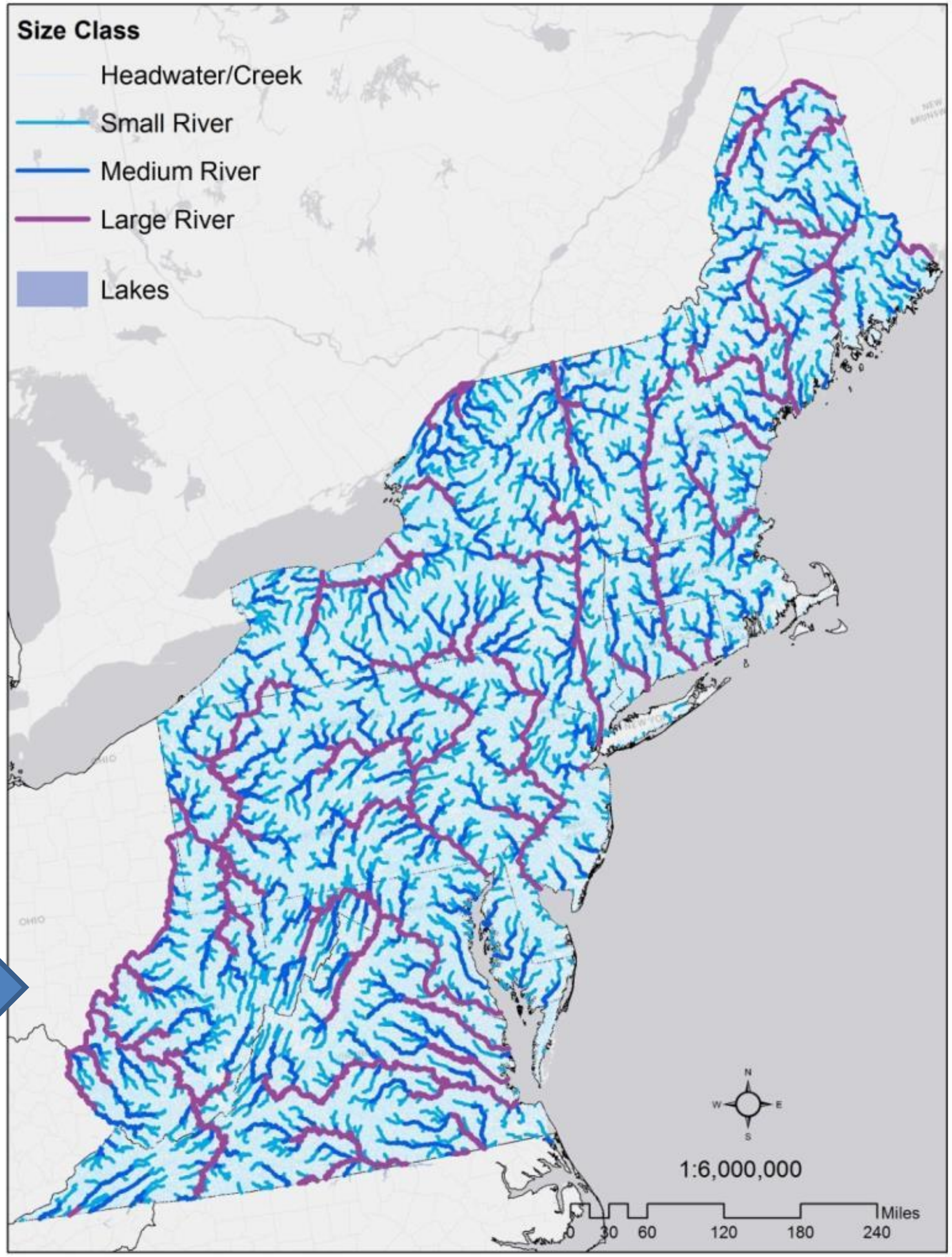
Size

From 7 to 4 suggested classes

1) Headwaters (1<3.861 sq.mi.)
 and Creeks (>= 3.861<38.61 sq.mi.)
2) Small River (>=38.61<200 sq. mi.)
3) Medium Rivers
 (>=200<1000 sq.mi.)
4) Large Rivers
 (>=1000<3861 sq.mi.)

(measure = upstream drainage area)



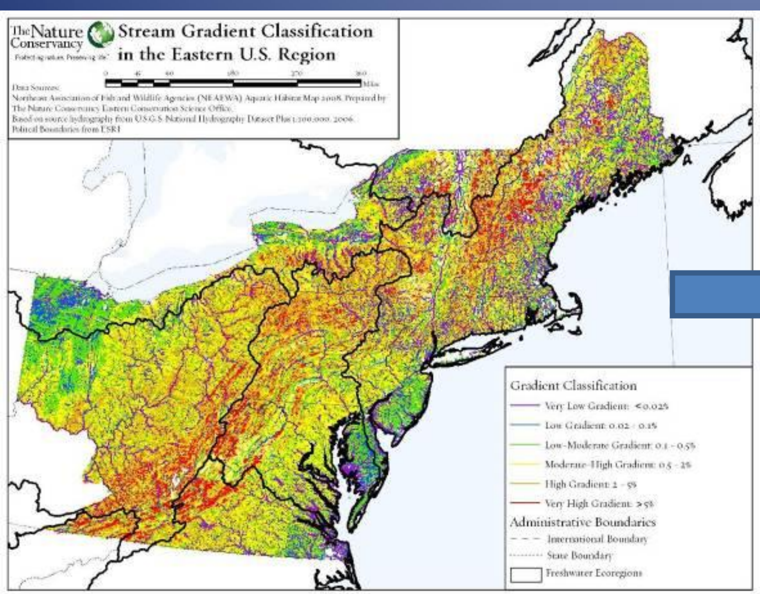


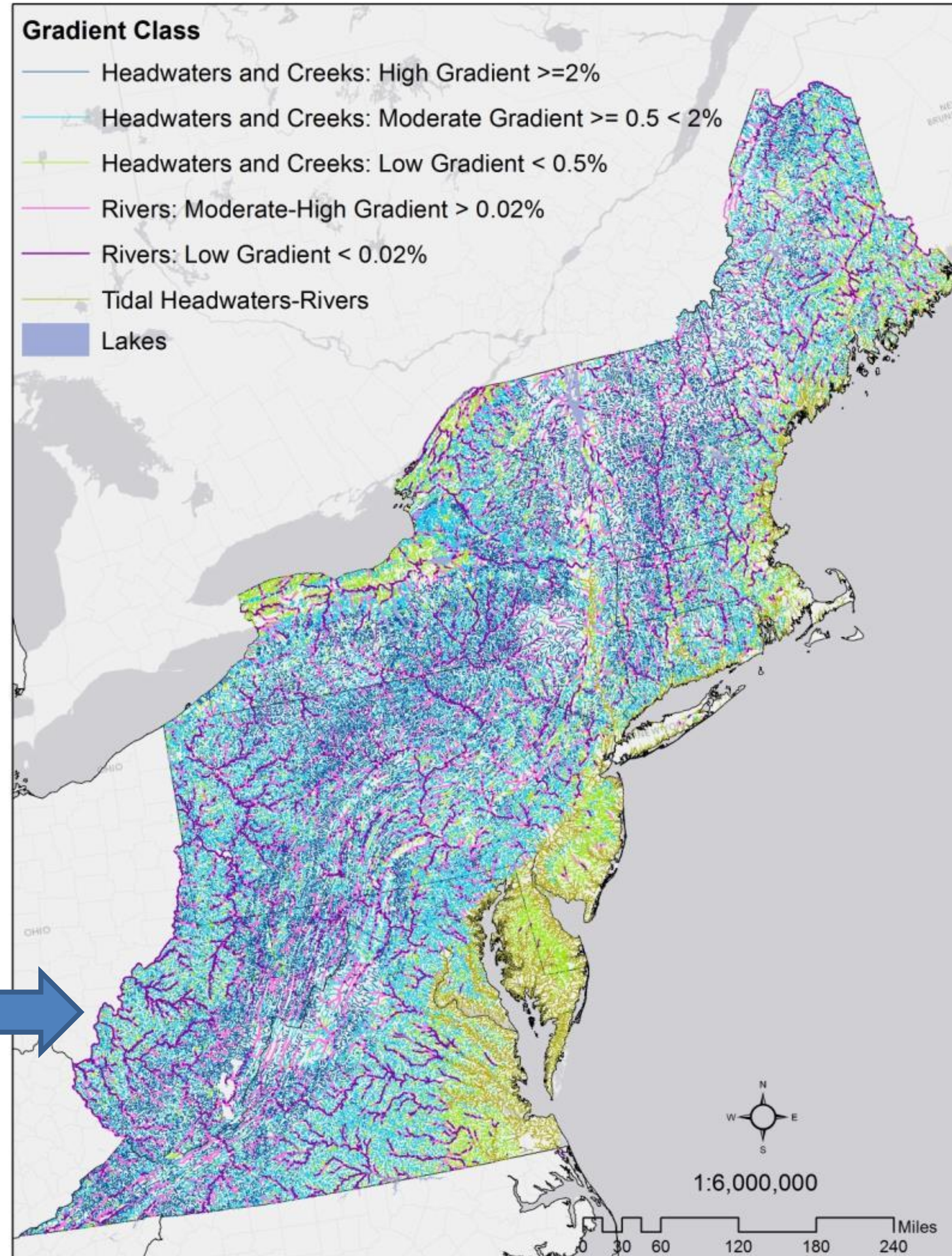
Gradient

Results: From 6 classes to

3 Classes for Headwaters/Creeks
1) High >= 2%
2) Medium >= 0.5 <2
3) Low <0.5

2 Classes for Rivers (small-large)
1.High >= 0.02%
2.Low < 0.02%





Geology

3 Classes for headwaters, creeks, and small rivers.

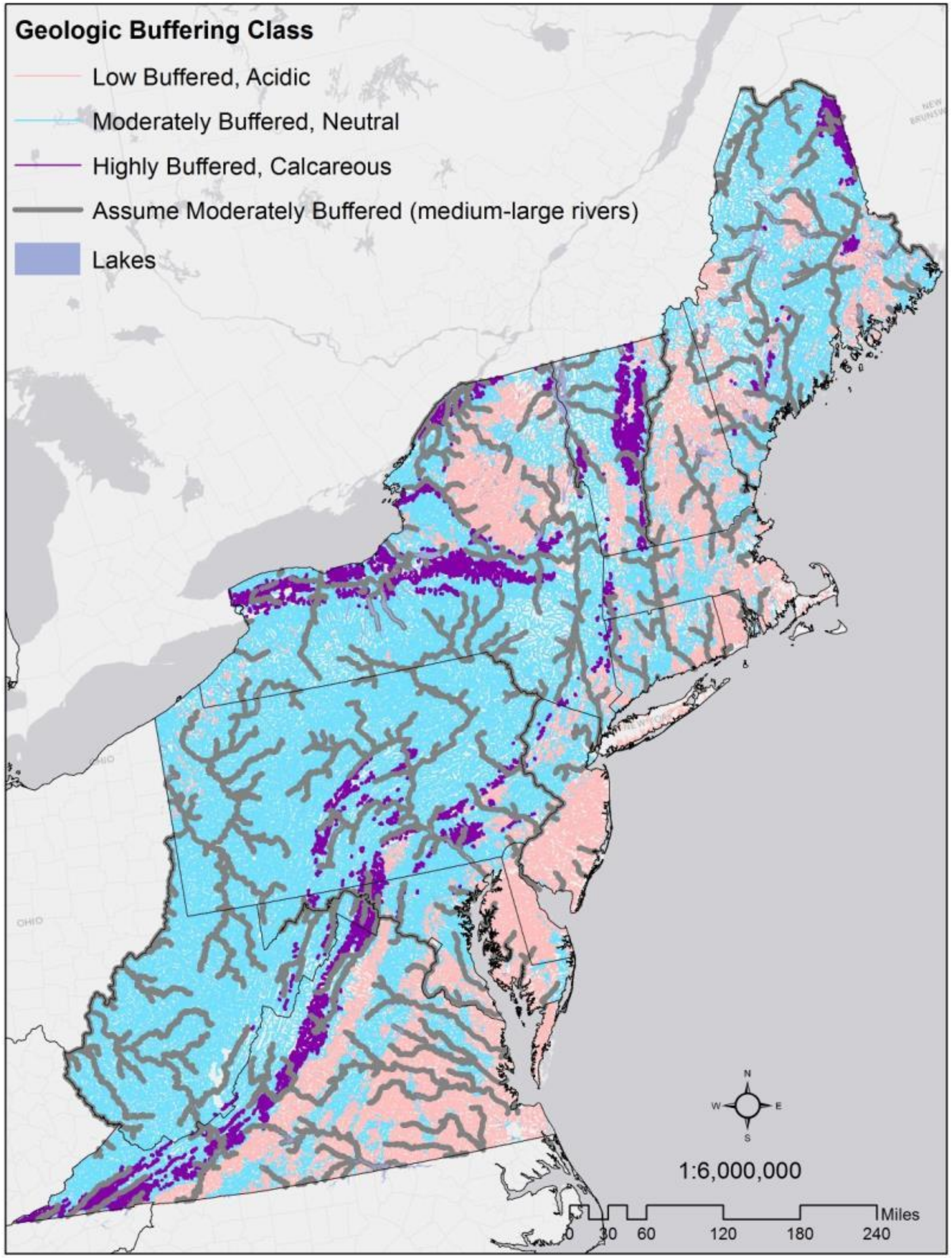
1)Low buffering capacity, Acidic (100-200*)

2) Moderate buffering capacity, Neutral (200-300*)

3) Highly Buffered, Calcareous (300+*)

Note this attribute was not modeled for medium-large rivers. All medium-large rivers were assumed to have neutral chemistry.

measure = Norton buffering capacity index value of upstream geology in the watershed.

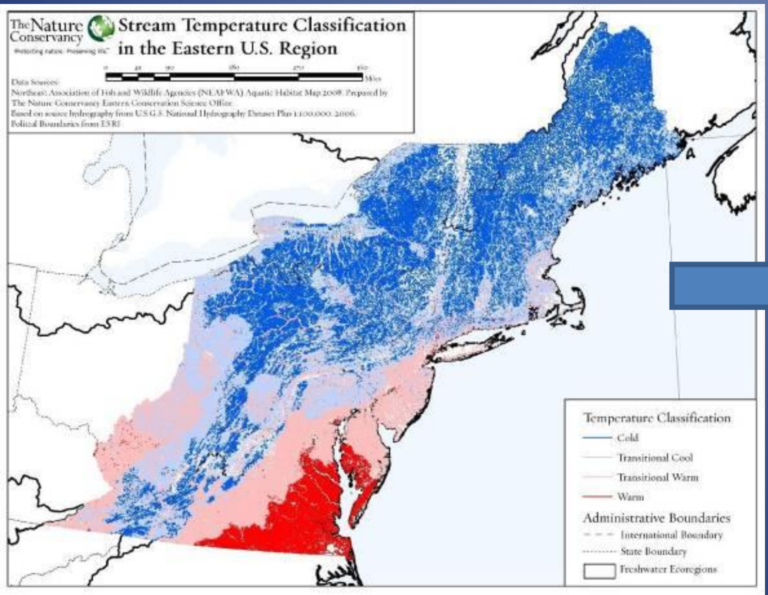


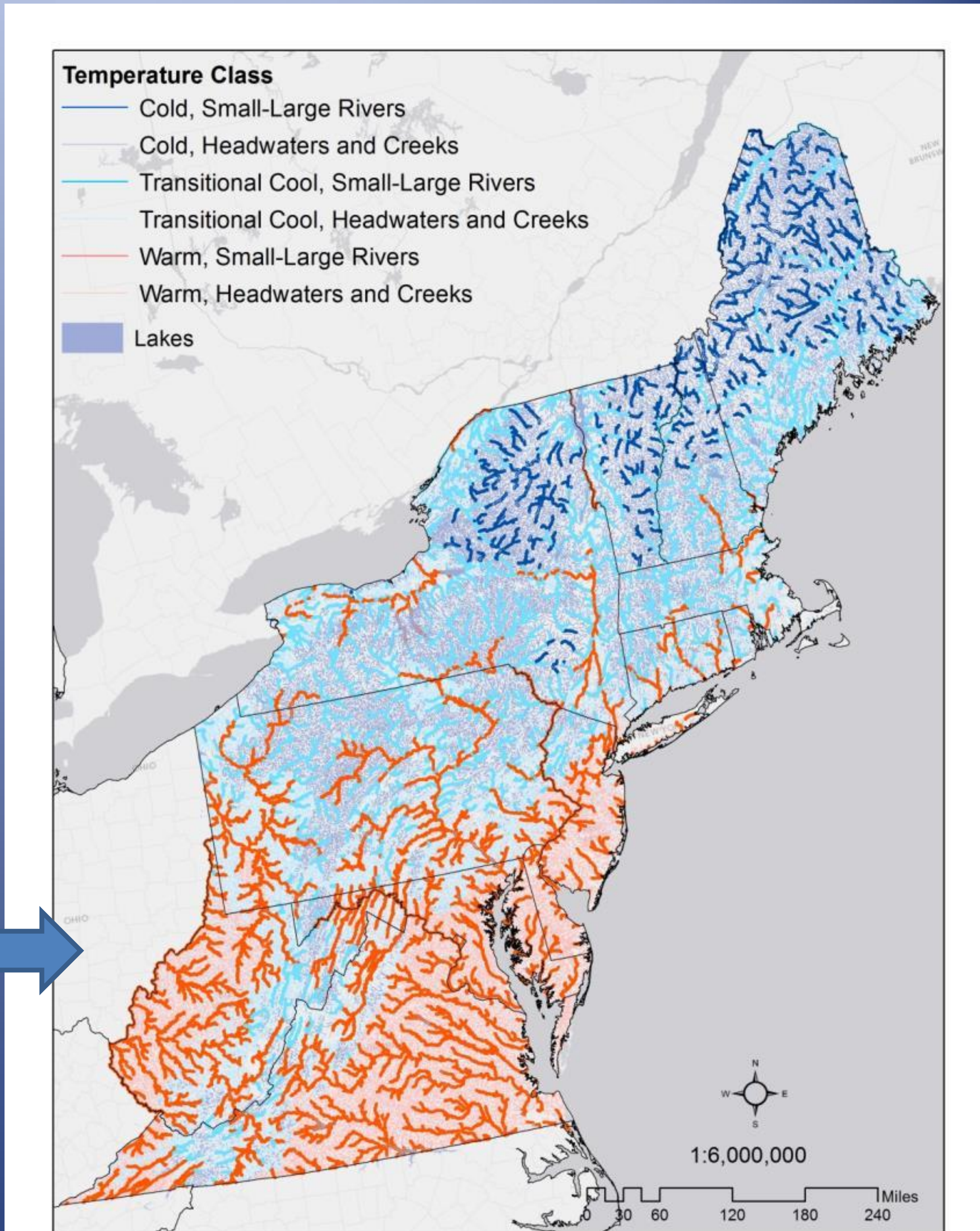
Temperature

Natural Expected Water Temperature

From 4 classes to 3
1) Cold
2) Transitional Cool
3) Warm

measure = based on CART Statistical model predicting class based on using the following variables of stream size, cumulative air temperature, stream gradient, baseflow index.





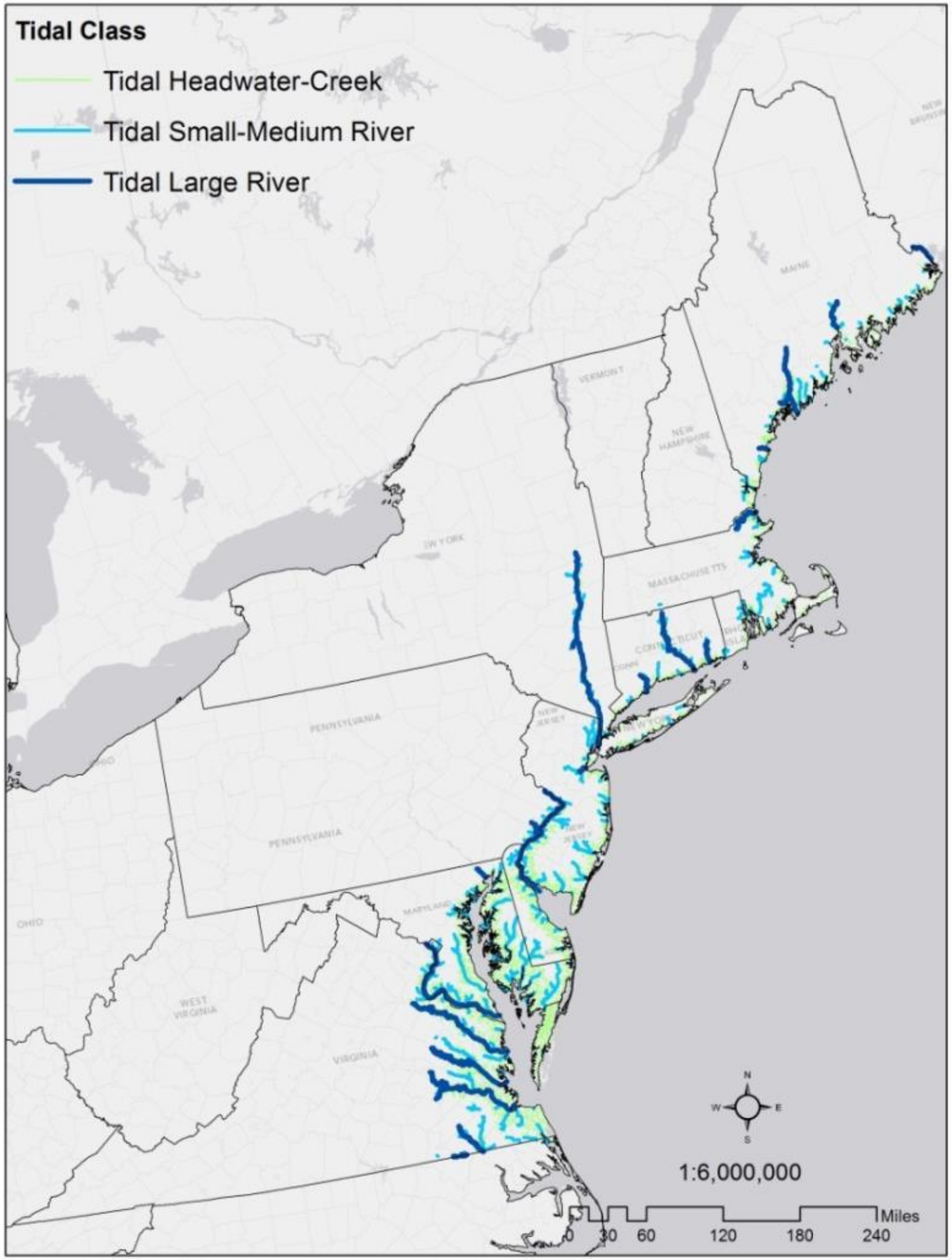
Tidal

3 classes

1)Headwater-Creek (size 1a and 1b): *Alewife, Blueback Herring*

2)Small-Medium River (size 2, 3a): *Alewife, Blueback herrring, American Shad, Hickory Shad, some Alewife and Blueback*

3)Large River (size 3b-4): *Striped Bass, Sturgeon*



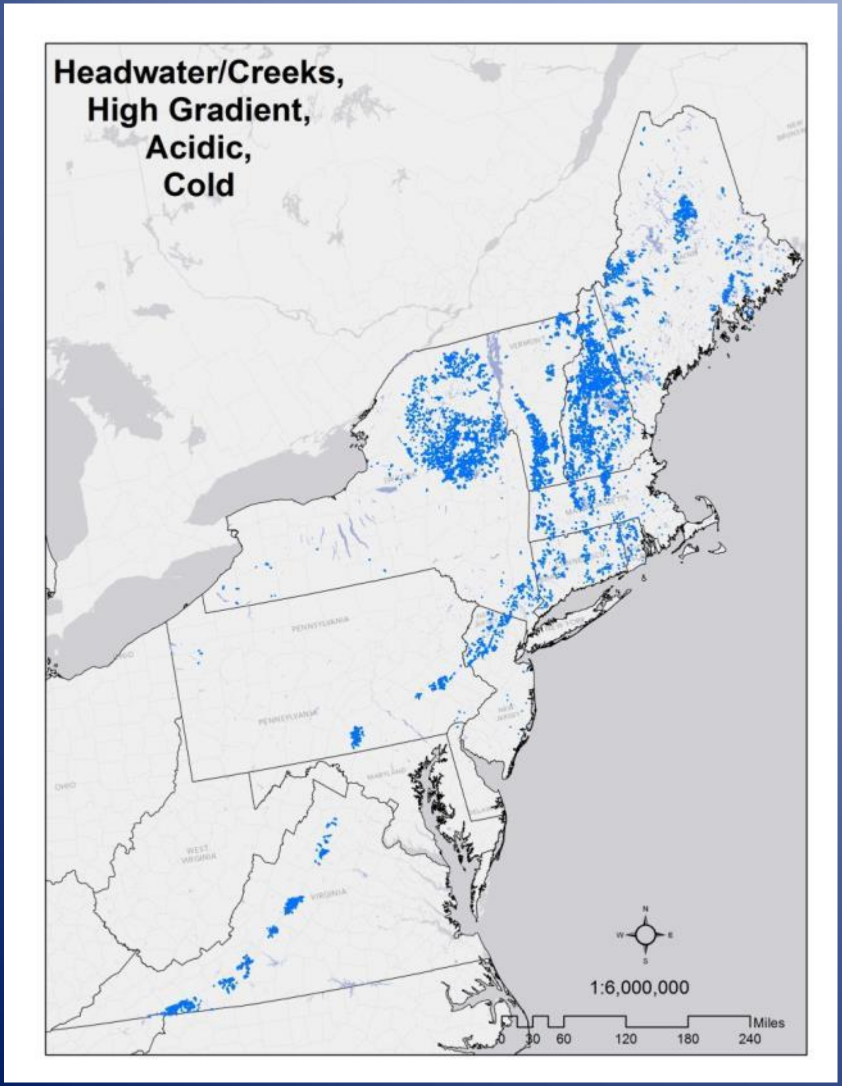
Simplification Results: 58 Types

27 Headwater/Creek
18 Small River
6 Medium River
4 Large River
3 Tidal

DRAFT: January 2013

Major Type	# Sub Types	Total Miles	ME	NH	VT	MA	CT	RI	NY	NJ	PA	MD	DE	DC	VA	WV
Headwater/Creek	27	165,029	12	13	12	13	15	10	21	21	23	19	11	4	24	21
Small River	18	19,645	10	9	12	5	4	4	13	8	12	8	4	1	12	5
Medium River	6	9,185	6	6	5	4	4	2	6	2	4	2	2	0	2	2
Large River	4	5,361	2	4	4	4	2	0	4	2	2	2	0	0	2	2
Tidal	3	14,881	3	2	0	3	3	2	3	3	3	3	3	3	3	0
TOTAL	**58**	**214,101**	**33**	**34**	**33**	**29**	**28**	**18**	**47**	**36**	**44**	**34**	**20**	**8**	**43**	**30**

Example: Cold, Acidic, High Gradient, Headwater/Creeks



Headwater/Creek, High Gradient, Acidic, Cold														
Total Miles	ME	NH	VT	MA	CT	RI	NY	NJ	PA	MD	DE	DC	VA	WV
6,337	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y		Y	

Example: Headwater-Creek, High Gradient, Acidic, Cold

Habitat Description:

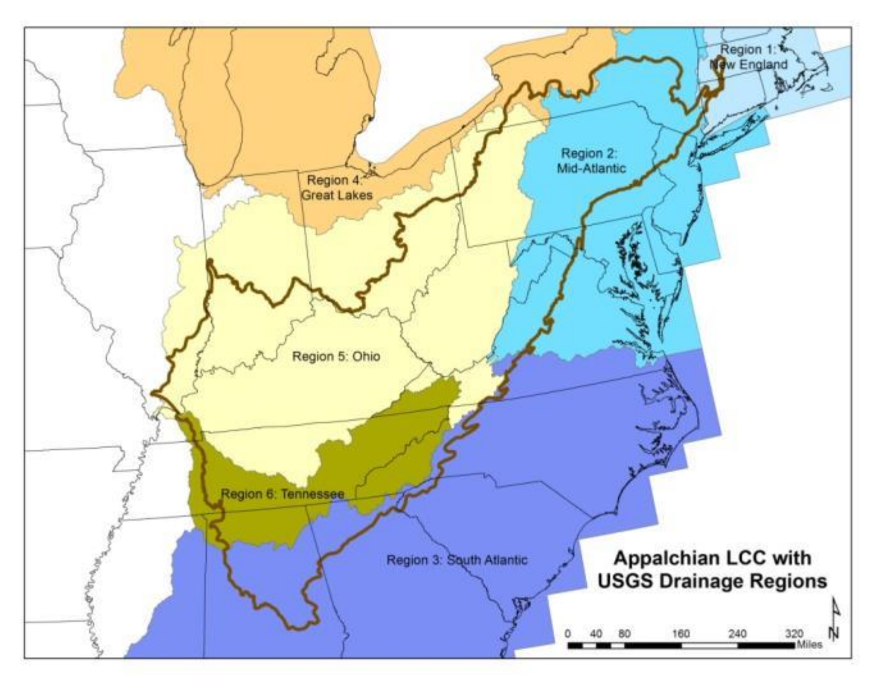
- Cascade and step-pool habitats where channels are narrowly confined; bed materials of bedrock, boulders, and cobbles; coldwater habitats with fast moving water; low elevation/coastal variants rare, common for headwaters <10sq mi to have closed canopy, leading to more dominance by plecoptera and det shredders in general, fewer macro algae shredders, more scrappers.

Associated Animals and Plants

- **Fish:** Brook trout; Brook-trout with Slimy sculpin, Blacknose dace
- **Crustacea and Mollusca:** Given the low ph and alkalinity very few crustacea and mollusca except for crayfish, cambarus bartoni.
- **Other Macroinvertebrates:** acid tolerant leaf shredders, low species diversity:
- **Plants:** acid tolerant bryophytes, algae, macrophytes

Associated State Community Names: VT Cold headwater acidic mountain stream, subset of MA Small Streams, RI Upper Perennial, NY Coldwater Stream, CT Coldwater Stream, PA Atlantic Basin Fish Coldwater Community, MD Coldwater

3. A Stream Classification System for the Appalachian Landscape Conservation Cooperative



Funding: APP LCC + TNC

Website:
http://applcc.org/projects/aquatic-habitat-classification

Due: Nov. 2014

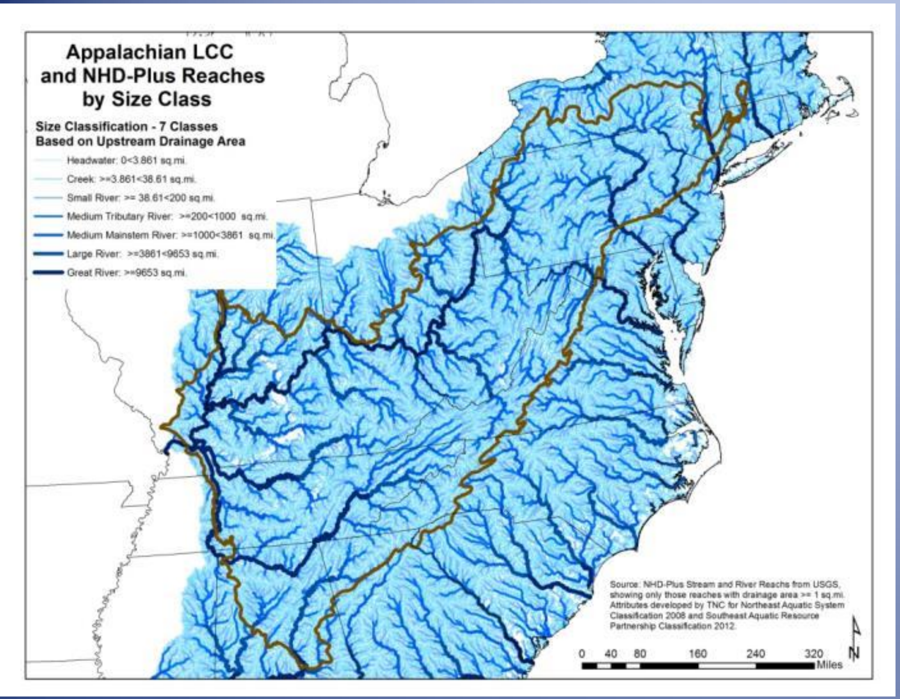
The goal of this project is to develop a hierarchical classification for stream and river systems within the Appalachian Landscape Conservation Cooperative (LCC). Guided by workgroup of state representatives.

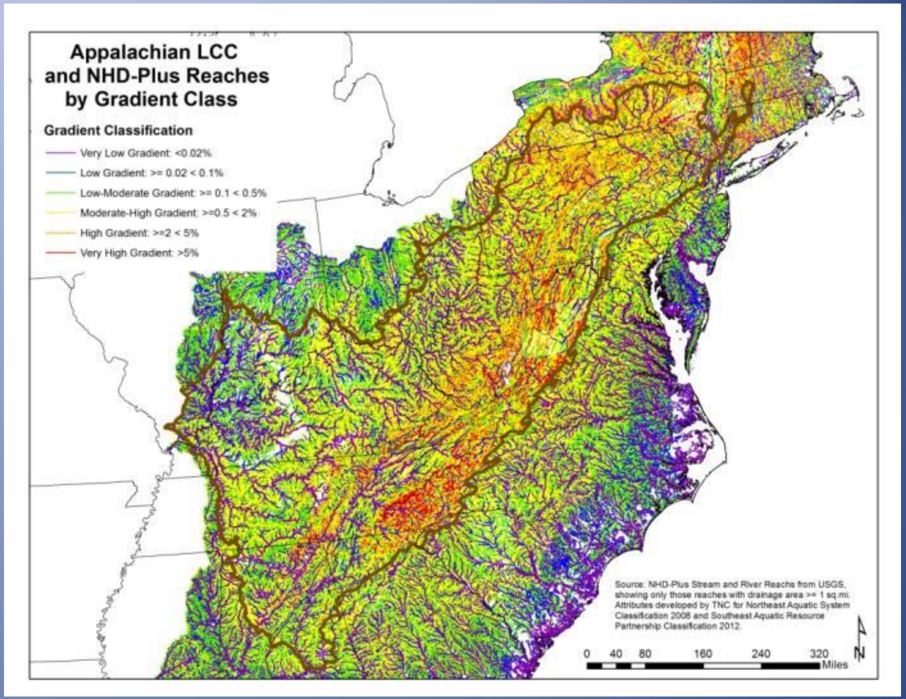
Final products will include:

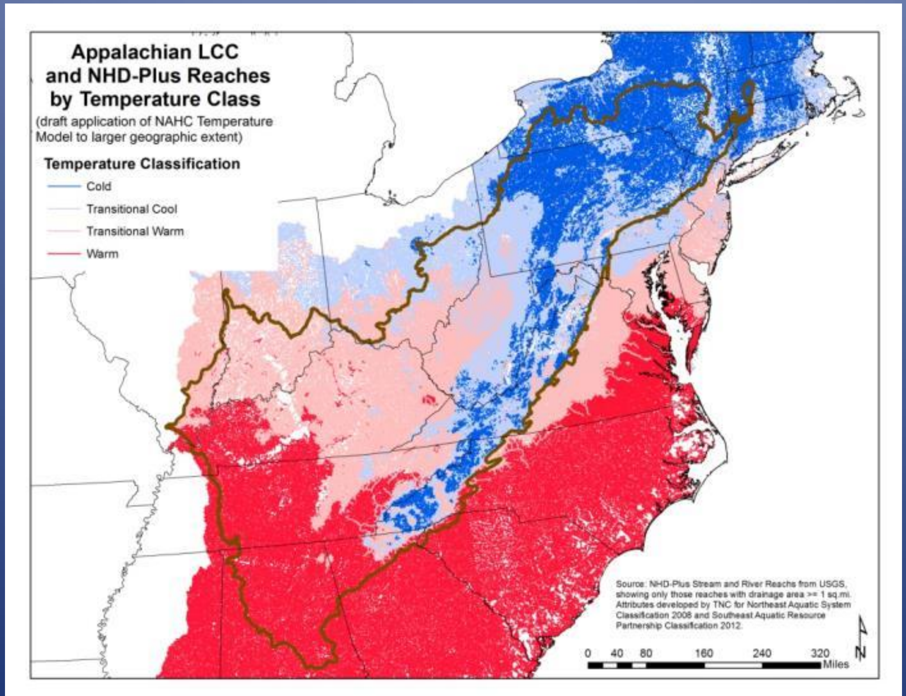
1) a GIS stream data set based on the NHD+ medium resolution stream reaches attributed with the selected classification variables such as stream size, gradient, geology and pH, temperature, and hydrologic class.
2) Report describing the method used to develop the classification,

Process

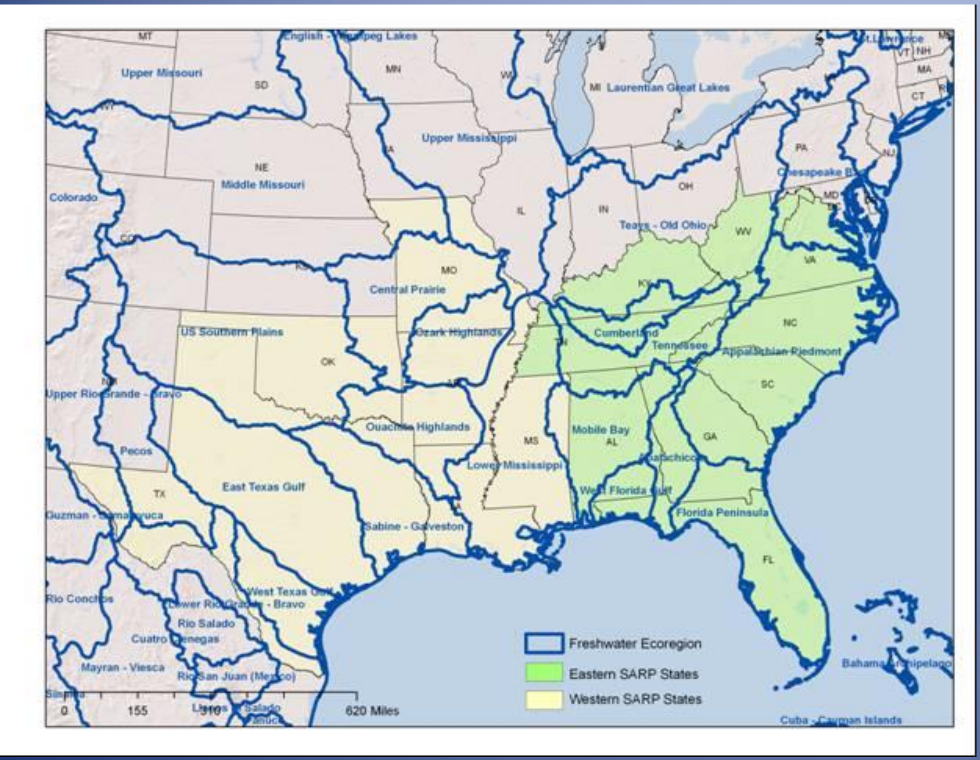
- Month 1-3: Develop a steering committee of aquatic ecologists and hydrologists from the Appalachian LCC states. Develop contract with Ryan McManamay for Hydrologic classification and model.
-
- Month 1-6: Compile existing classification reports and GIS data for the region, and collect literature on approaches to hydrologic, geomorphic, and temperature classifications.
-
- Month 3-22. Initiate monthly conference calls with steering over to develop consensus regarding the classification approach , key variables, and to review modeled GIS outputs.


Appalachian LCC
and NHD-Plus Reaches
by Size Class
Size Classification - 7 Classes
Based on Upstream Drainage Area
Headwater: 0<3.861 sq.mi.
Creek: >=3.861<38.61 sq.mi.
Small River: >= 38.61<200 sq.mi.
Medium Tributary River: >=200<1000 sq.mi.
Medium Mainstem River: >=1000<3861 sq.mi.
Large River: >=3861<9653 sq.mi.
Great River: >=9653 sq.mi.
Source: NHD-Plus Stream and River Reachs from USGS, showing only those reaches with drainage area >= 1 sq.mi. Attributes developed by TNC for Northeast Aquatic System Classification 2008 and Southeast Aquatic Resource Partnership Classification 2012.
0 40 80 160 240 320 Miles
N


Appalachian LCC
and NHD-Plus Reaches
by Gradient Class
Gradient Classification
Very Low Gradient: <0.02%
Low Gradient: >= 0.02 < 0.1%
Low-Moderate Gradient: >= 0.1 < 0.5%
Moderate-High Gradient: >=0.5 < 2%
High Gradient: >=2 < 5%
Very High Gradient: >5%
Source: NHD-Plus Stream and River Reachs from USGS, showing only those reaches with drainage area >= 1 sq.mi. Attributes developed by TNC for Northeast Aquatic System Classification 2008 and Southeast Aquatic Resource Partnership Classification 2012.
0 40 80 160 240 320 Miles
N


Appalachian LCC
and NHD-Plus Reaches
by Temperature Class
(draft application of NAHC Temperature Model to larger geographic extent)
Temperature Classification
Cold
Transitional Cool
Transitional Warm
Warm
Source: NHD-Plus Stream and River Reachs from USGS, showing only those reaches with drainage area >= 1 sq.mi. Attributes developed by TNC for Northeast Aquatic System Classification 2008 and Southeast Aquatic Resource Partnership Classification 2012.
0 40 80 160 240 320 Miles
N

4. Southeast Aquatic Classification

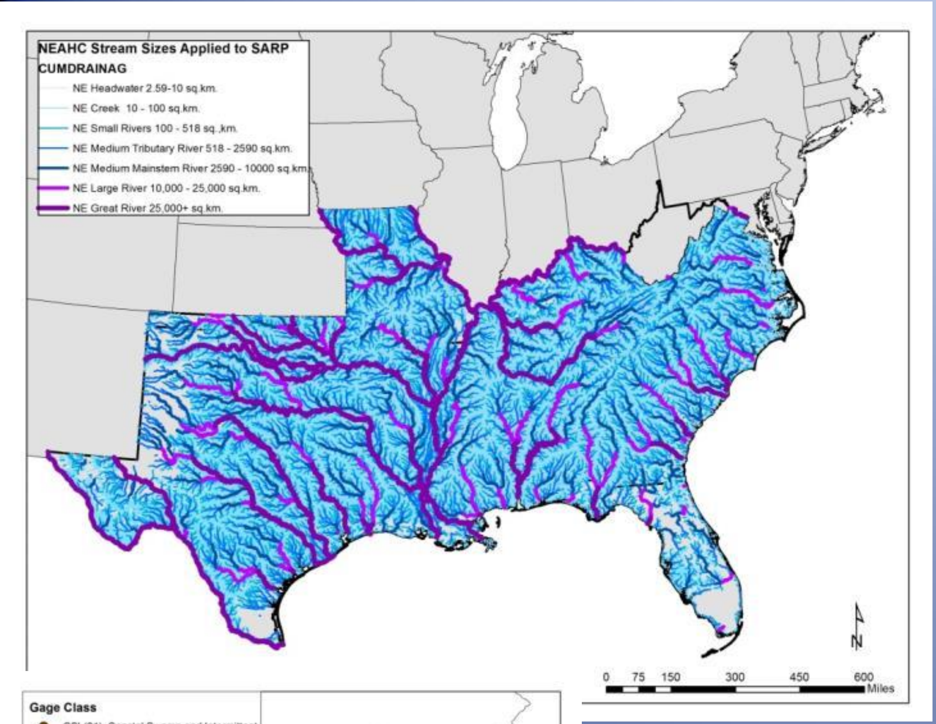


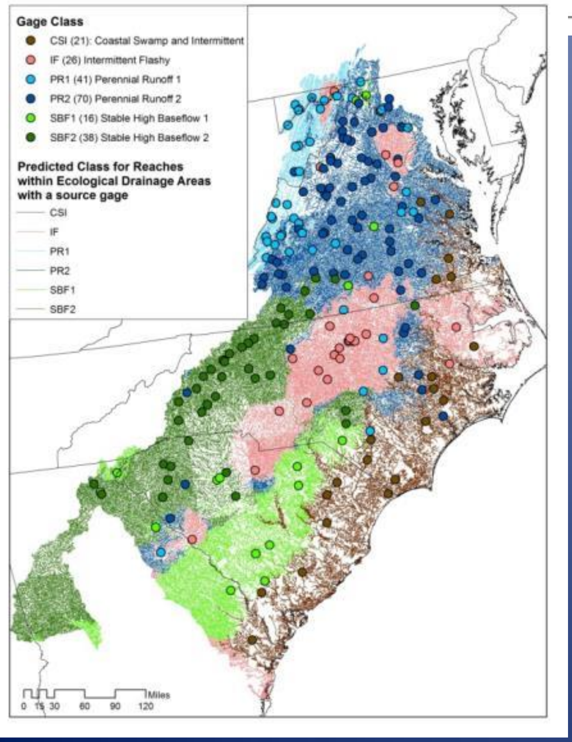
- The objective is to develop some basic stream classification attributes for the entire SARP region and to provide more detailed attributes in the eastern section of the SARP geography where additional data and modeling capacity is readily available.

- This final product is a mapped data set of information that can be used to classify stream reaches. This product has been reviewed/developed with help of a small steering committee and will be considered an <u>initial draft classification system</u> which should be refined in the future by further research and application by SARP users.

- http://sifn.bse.vt.edu/sifnwiki/index.php/SIFN_Classification_Expert_Review

Due March 30, 2013





Attributes:

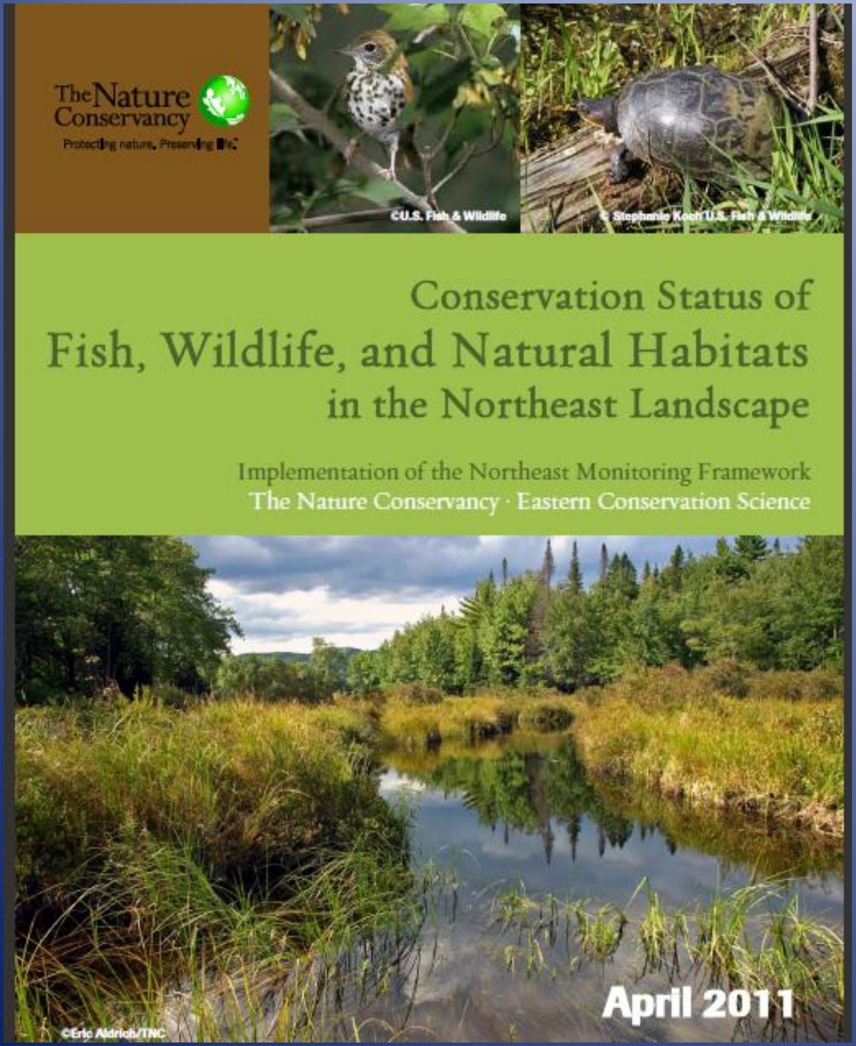
Entire Region:

Size Class: drainage area and mean annual flow
Unit Runoff Coefficient
Gradient Class
Ecological Drainage Unit
Freshwater Ecoregion

Additional Reach Catchment Variables for Eastern Region

Baseflow Index
Northeast Temperature Class Applied
Available Water Capacity (SSURGO)
Soil Organic Carbon (SSURGO)
% Sand
% Silt
% Clay
% of 13 Landforms
% of NLCD 2006 Land Cover
Modeled Hydrologic Class

Condition Analyses
1. Conservation Status Report



River and Stream Metrics

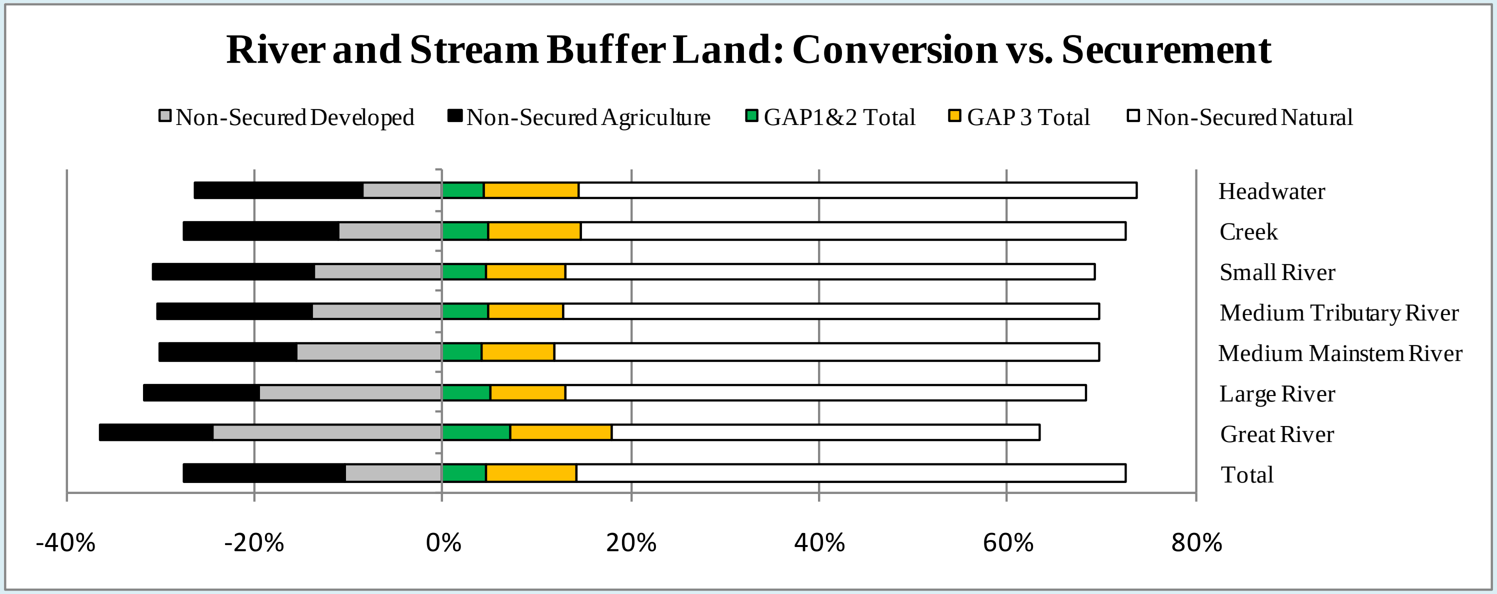
- •Riparian Secured Land
- •Riparian Land Cover Conversion
- •Impervious Surfaces
- •Dams: Type and Density
- •Dams: Connected Network Length
- •Flow Alteration
- •Brook Trout Status
- •Wadeable Stream IBI
- •Nonindigenous Species
- •Fish Fuanal Intactness

Funding: NEAFWA + TNC
Report:
http://conserveonline.org/workspaces/ecs/documents/northeast-conservation-status-report-april-2011/view.html

Rivers: Secured Riparian Land

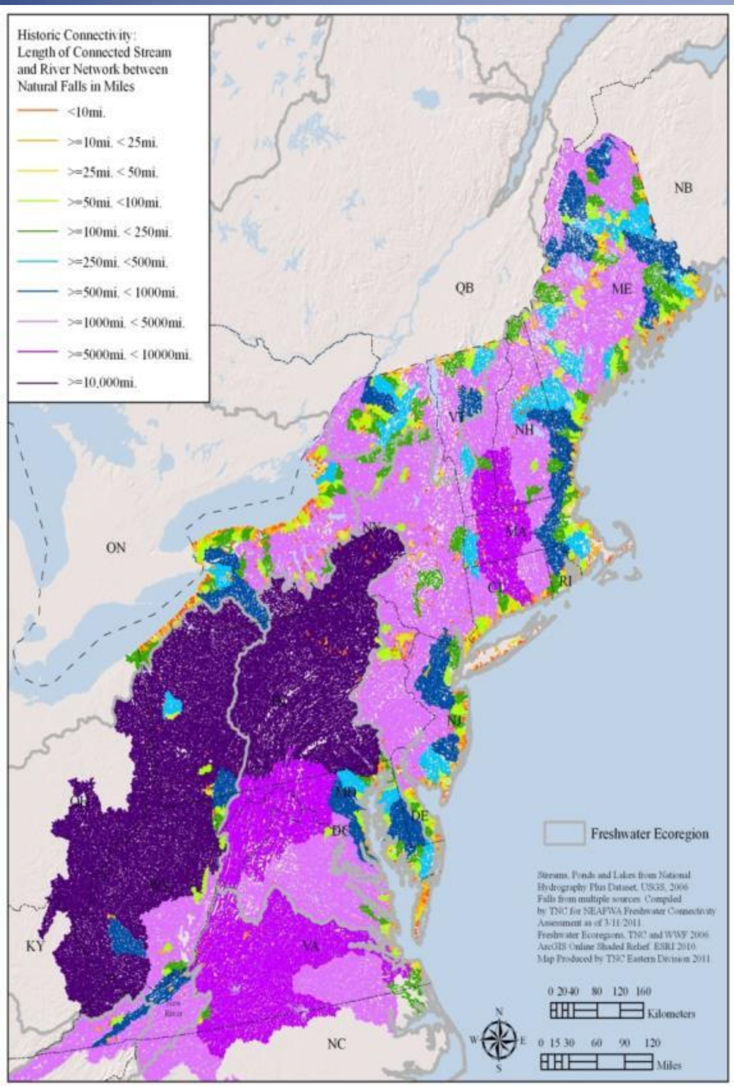
.

Conversion of riparian habitat exceeds securement 2:1, as 27 percent of stream riparian area is converted to development or agriculture and 14 percent is secured for biodiversity or multiple uses.

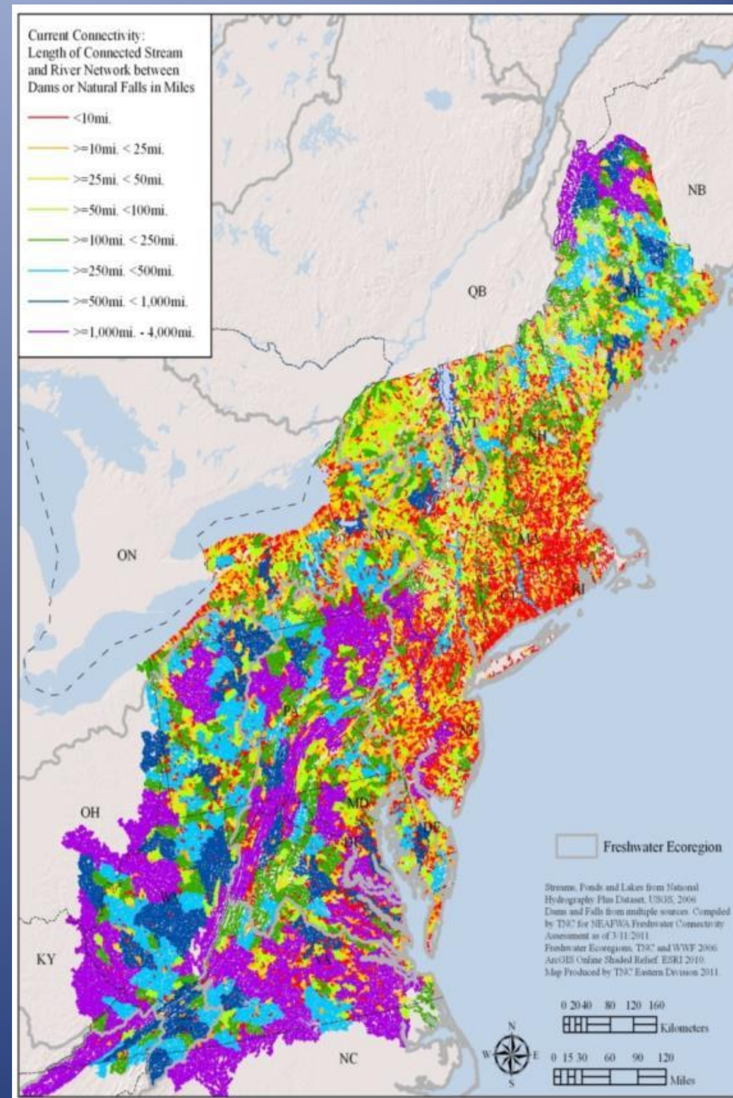


Connected Networks

Original State: falls only



Current State: falls and dams



Original = 41 % in networks over 5,000 miles long
Current = 0 %

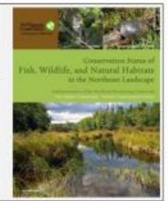
Original = 3 % in networks 1-25 miles long
Current = 23 %

Freshwater Measures for the Northeastern United States

Mark G. Anderson Ph.D. Director of Conservation Science, The Nature Conservancy, Eastern North America Division, manderson@tnc.org 99 Bedford Street, Boston, MA 02111.
Arlene Olivero Sheldon M.S., Aquatic Ecologist/GIS Manager, The Nature Conservancy, Eastern North America Division, arelene_olivero@tnc.org 99 Bedford Street, Boston, MA 02111.

Abstract

This research aims to measure the conservation status and condition of a freshwater systems in the northeast, using the metrics and datasets recommended by the Northeast Monitoring and Performance Reporting Framework (Tomajer et al. 2008). We report on three types of freshwater targets: riverine systems, lakes and ponds, and freshwater wetlands. For each target, we summarized the conservation management status of the target by overlaying target locations with information on conservation land ownership and management. Additional key indicators for each habitat were also assessed. Results reveal a mixed and complex picture on the condition of these systems and the success of conservation efforts. This work was funded by a "Regional Conservation Need" (RCN) grant from the United States Fish and Wildlife Service through The Northeast Association of Fish and Wildlife Agencies. The entire report "Conservation Status of Fish, Wildlife and Natural Habitats in the Northeast Landscape" is available at http://conserveonline.org/workspaces/ecs/documents/northeast-conservation-status-report-april-2011/view.html



River Summary Findings

Conversion and Securement in the Riparian Zone: Currently, conversion in the riparian zone (100m buffer) exceeds securement 2:1, with 27 percent of the stream riparian area converted to development or agriculture and 14 percent secured.

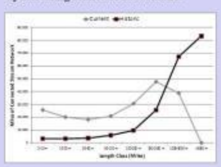
Dams and Connected Networks: Today no connected networks >5,000 miles remain, and even the smaller ones over 1,000 miles long have been reduced by half. There has been a corresponding increase in short networks, less than 25 miles long, that now account for 23 percent of all stream miles, up from 3 percent historically.

Water Flow: Flow is the essence of a stream ecosystem, but 61 percent of the region's streams have flow regimes that are altered enough to result in biotic impacts.

Stream Fragmentation: Size of connected stream network between barriers. Results highlight a large increase in small networks and the loss of large network in the current condition.

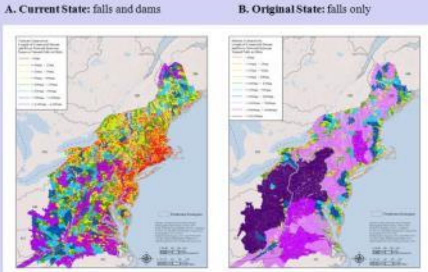
Example of connected stream networks. Each network is bounded by dams and/or the topmost extent of headwater streams. Showing a unique color for each connected network.

Change in Connectivity: The current and historical number of miles falling within each connected network size class is plotted by increasing connected network size.



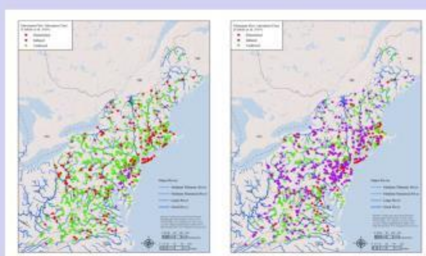
A. Current State: falls and dams

B. Original State: falls only



Gages by their minimum flow alteration class and maximum flow alteration class. Data summarized from Carlisle et al. 2010.

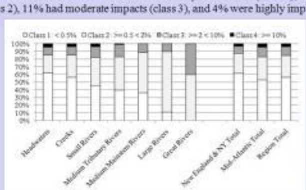
A. Minimum flow alteration class. **B. Maximum flow alteration class.**



Combinations of flow alteration most likely to results in impaired fish communities are starred (*). Data provided by Carlisle, D. M., Wolock, D.M., and Meador, M.R. 2010. Alteration of stream flow magnitudes and potential ecological consequences: a multiregional assessment. Frontiers in Ecology and the Environment. Doi: 10.1890/100053

	Minimum Flow Class	Maximum Flow Class	Region # of gages	Region % of gages	New England/New York # of gages	New England/New York % of gages	Mid-Atlantic # of gages	Mid-Atlantic % of gages
*	Diminished	Diminished	27	3%	19	6%	8	2%
*	Diminished	Inflated	12	1%	3	1%	9	2%
*	Diminished	Unaltered	52	6%	25	8%	27	5%
*	Inflated	Diminished	136	17%	65	22%	71	14%
	Inflated	Inflated	27	3%	2	1%	25	5%
*	Inflated	Unaltered	233	29%	73	24%	160	32%
*	Unaltered	Diminished	32	4%	16	5%	16	3%
	Unaltered	Inflated	10	1%	2	1%	8	2%
	Unaltered	Unaltered	278	34%	97	32%	181	36%
		Totals	807	100%	302	100%	505	100%

Percent of streams and rivers by impervious surface impacts: We summarized the amount of impervious cover for the upstream watershed of each stream. The results revealed that 58% of stream and river miles were essentially undisturbed (class 1), 28% had low impacts (class 2), 11% had moderate impacts (class 3), and 4% were highly impacted (class 4).



Percent conversion to agriculture or development compared with the current securement status of riparian buffer. Based on a 100 m buffer area around each stream or river, each bar represents 100 percent of area assessed. Area to the left of the "0" axis indicates acreage of non secured land converted to development or agriculture, to the right is remaining natural area and secured land.

Lake Summary Findings

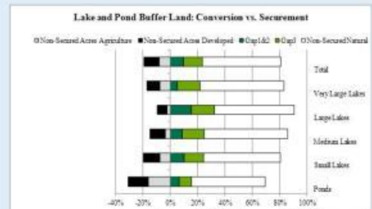
Distribution, Loss, and Protection: Of the regions 33,744 waterbodies, 13 percent are fully secured against conversion to development. Small lakes of 10 to 100 acres are the most secured (16 percent) and very large lakes over 10,000 acres the least (4 percent).

Shoreline Conversion: Forty percent of the regions waterbodies have severe disturbance impacts in their shoreline buffer zones.

Roads, Impervious Surfaces, and Dams: Lakes and ponds in this region are highly accessible, as only 7 percent are over 1 mile from a road and 69 percent are less than one tenth of a mile from a road.

Biological Integrity: Based on the National Lake Assessment, over half of our small to large waterbodies have lost 20 percent or more of their expected plankton and diatom taxa, and over a third have lost 40 percent or more.

Percent Conversion Compared with the Percent Securement for all Lakes and Ponds. Results are based on a 100 m buffer area around each waterbody.



	Ponds	Small Lakes	Medium Lakes	Large Lakes	Very Large Lakes	Total
Non-Secured Acres Agriculture	-67,351	-48,355	-15,102	-6,165	-12,132	-149,105
Non-Secured Acres Developed	-61,959	-80,163	-44,288	-19,732	-15,048	-221,191
Gap1&2	28,503	68,839	37,159	42,866	8,953	186,319
Gap3	38,509	91,839	65,566	46,727	25,833	268,474
Non-Secured Natural	228,210	369,781	250,575	162,103	98,227	1,108,896

Lakes by Secured Lands Status
19% of the regions lakes have buffers >50% secured, while 13% have buffers >90% secured.

Lakes by Land Cover Buffer Impacts
New England and New York have twice the proportion of lakes in the low disturbance class compared to the Mid-Atlantic.

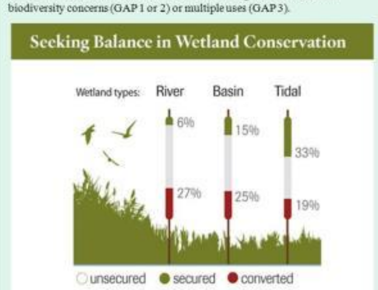
Wetland Summary Findings

Distribution, Loss, and Protection: Seven percent of the region was once covered by wetlands and at least one-quarter of that, 2.8 million acres, has been converted to agriculture or development. Conservation efforts have secured 25 percent of the remaining wetland acres. Alluvial wetlands are the least protected and most converted wetland type.

Ecological Condition: Of all wetlands in this region, 67 percent have paved roads so close to them, and in high enough densities, that they have likely experienced a loss of species.

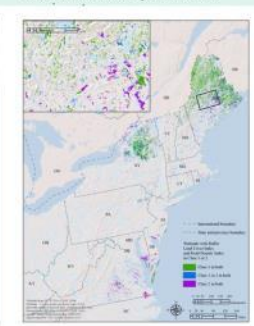
Trends in Wetland Birds: Species change is strongly correlated with the degree of conversion in the buffer zone and with the density of nearby roads. Alluvial wetlands have seen the most bird species declines and tidal marshes the least.

Estimates of Historic Wetland Conversion to Agriculture or Development Compared with the Current Status of Wetland Protection. Each cattail represents 100 percent of the historic wetland area. Securement is defined as wetlands secured against conversion for biodiversity concerns (GAP 1 or 2) or multiple uses (GAP 3).



Wetlands by Secured Lands Status. The map highlights areas where wetlands are secured from conversion.

Most Intact Wetlands. The map highlights wetlands that fell in the most intact class for both road density and buffer land



2. A Geospatial Condition Analysis of Northeast Habitats

Evaluates the condition of terrestrial and aquatic habitats in the Northeast and Mid-Atlantic.

Analyze the condition of each of the <u>revised northeast stream and river classification types.</u>

Will provide a report and database that can be queried to feed into State Wildlife Action Plans.

Funding: NEAFWA + TNC

Due: Sept. 2013

Possible Stream and River Metrics

Biotic and Geophysical Indicators
•Richness: XX rare species found within 100m of this habiat type
•TNC Portfolio: XXX miles of this type are identified in the portfolio
•SWAP Portfolio: XXX miles of this type are identified in the portfolio

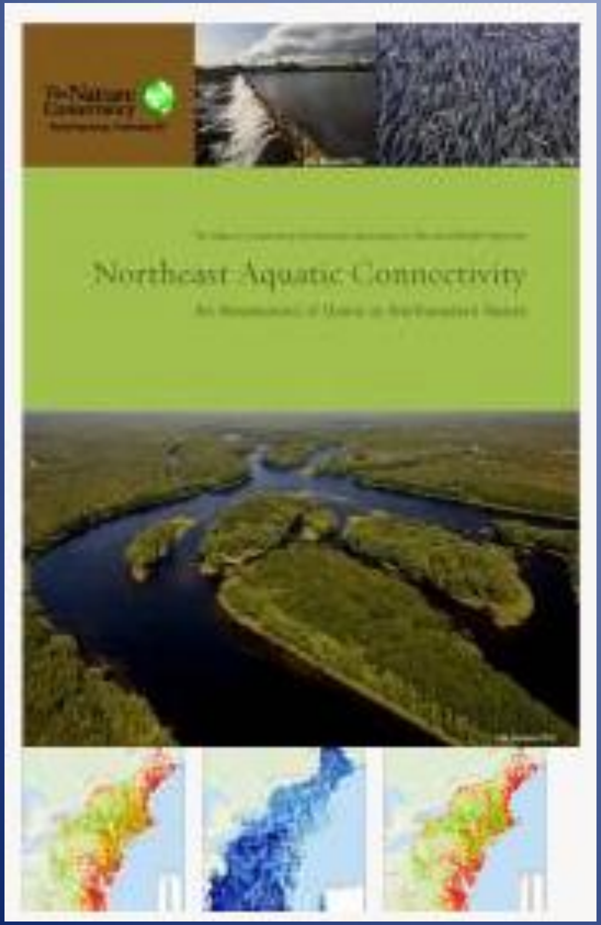
Ecological Setting
•Length of this habitat
•Mean size of Funcationally Connected Network containing this habitat type
•Largest Funcationally Connected Network containing this habitat type
•Mean # of Stream Types in a Functionally Connected Network of this habitat type

Human Modification
•Mean and SD of Housing Density Pressure on this Habitat
•% of this type's miles that intersects a core terrestrial area
•Intactness of ARA Score for this habitat type
•Length of miles of this habitat type in each of 4 dam storage impact categories
•# Dams and Density of Dams on this habitat type

Securement
•% of 100m buffer in securement
•% of Secured Land by GAP Status
•% of Secured Land by Ownership Classes
•Secured Land by % Interest Types

3. Aquatic Connectivity Assessments

Erik Martin (emartin@tnc.org)



Northeast Aquatic Connectivity Assessment

Funded by NEAFWA + TNC

Completed 2011

http://rcngrants.org/content/northeast-aquatic-connectivity

Southeast Aquatic Connectivity Assessment

Funded by South Atlantic LCC + TNC

Due Sept. 2014

http://www.southatlanticlcc.org/page/projects-1?projectid=1465119

Conceptual Approach

- Calculate a host of metrics for every dam & allow users to weight the relative importance of each metric for their purposes

On a size '3b' river

15 miles connected river upstream

2 rare mussel spp in watershed

40 total river miles upstream

Current habitat for 3 Anadromous species downstream of dam

2 other dams downstream

3 road crossings/acre in upstream watershed

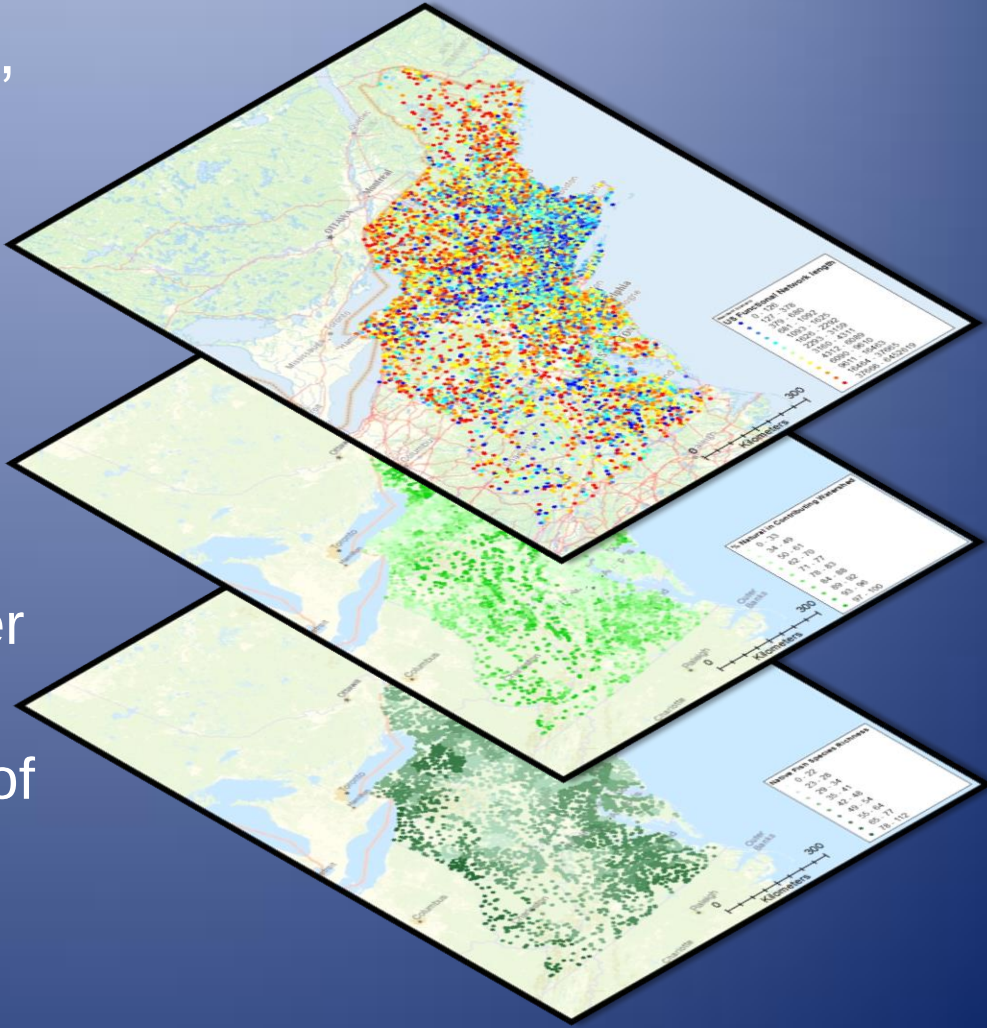
4% Impervious in upstream watershed

90% natural LC in upstream watershed

In a watershed with healthy brook trout populations

Metrics Combined

- The hypothetical 'best' dam would have….
  - The longest connected networks
  - 0% impervious surface in its watershed
  - 100% natural landcover
  - The most rare fish
  - The greatest diversity of native fish
  - Etc., etc., etc.,



Northeast Aquatic Connectivity Assessment

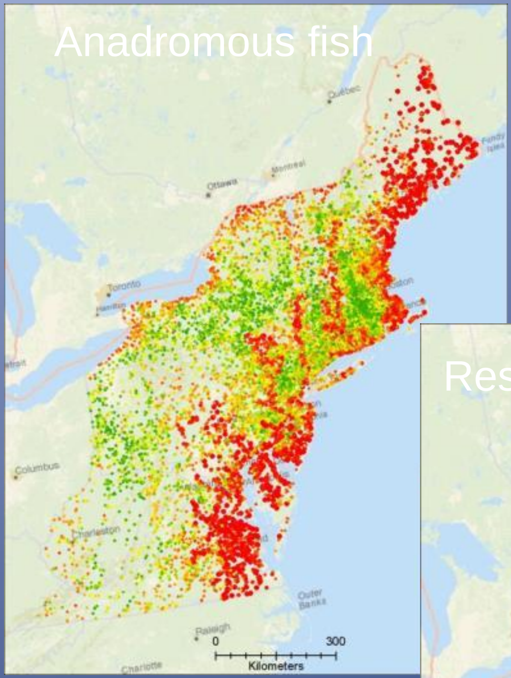
Results:

- **Compiled and qc'd 28,103 dams**
- **Workgroup consensus on ranking scenarios**

- Metric weights = quantify objectives/priorities for a given scenario

- Results depict which dams have the potential to provide the most benefit for a given scenario if mitigated

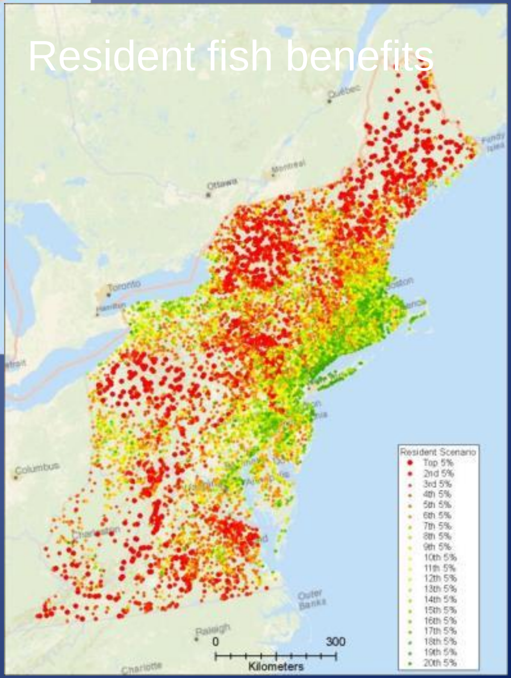
- Custom analysis tool – user defined scenarios: metric weights & extent



Relative benefit for **anadromous** fish if mitigated

more

less



Relative benefit for **resident** fish if mitigated

more

less

A Tool for Assessing Connectivity
Dams and Fish in the Northeastern US

Erik Martin and Colin Apse, The Nature Conservancy

Introduction

DAMS and other barriers to the free movement of fish and other aquatic organisms have had a negative impact on the health and viability of these populations for well over a century in the eastern United States. Removing or otherwise mitigating dams can improve the health of aquatic ecosystems and allow fish populations to recover. Given the cost of dam removal projects and the limited funds available to do the work, it is critical that managers focus their efforts and resources where they can have the greatest impact. The Nature Conservancy, in partnership with members of the Northeast Association of Fish and Wildlife Agencies (NEAFWA), has developed a dam assessment dataset and tool for the NEAFWA region (Maine-Virginia). The dataset and tool provide a screening-level assessment of the ecological benefits of dam mitigation. Managers can use the tool to compare the relative benefits of different restoration scenarios and narrow their focus and highlight valuable restoration opportunities that may not have been otherwise obvious.

Goals

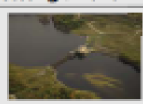
1. Develop a unified database of barrier information
2. Collect and standardize spatial information of target species presence
3. Produce relative ecological rankings for barriers at multiple scales "Potential Project Benefit Rank"
4. Produce a landscape scale management strategy document

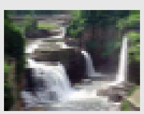
Methods

A straightforward sort-and-rank methodology was used to prioritize dams based on their potential to improve aquatic connectivity.

1. Data Preparation: Collection, Processing & Review

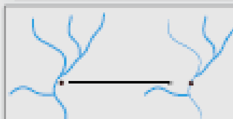
Dams – Dam locations and attributes were provided by participating state agencies, the USACE National Inventory of Dams, and the USGS Geographic Names Information System (GNIS)





Waterfalls – Waterfall locations were extracted from the GNIS

Anadromous Fish – Anadromous fish presence data was adapted from the 2008 ASMFC database and assigned to 1:100k NHDPlus hydrography.



Dams and falls were "snapped" to the stream network. Topological precision was necessary for the subsequent analysis.

Snapped dams & falls prioritized for review with QC checks:
1. River name match in dam dataset and stream dataset
2. Large dams snapped to small streams
3. All dams on large rivers
4. All large dams

Prioritized dams compared to USGS topo maps, aerial photos and other reference sources (e.g. Google earth).

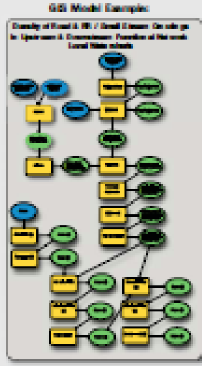
→ Reviewed dams, falls, and fish data sent to state contacts for additional review / QC

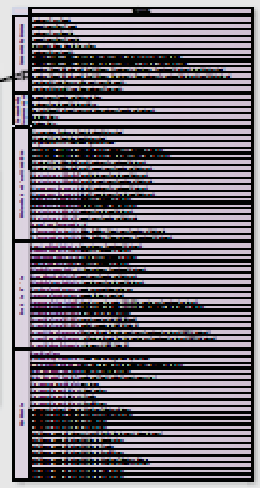
Methods

2. Metrics calculated for all dams

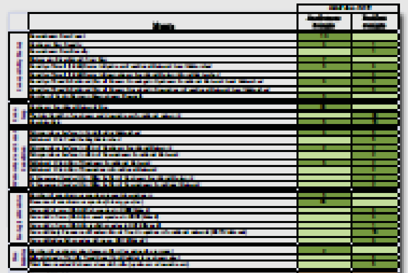
A total of 73 metrics from five categories were calculated in a GIS for all dams in the region. Different subsets of the metrics were used in scenarios for anadromous and resident fish species. Metrics were calculated using ArcGIS ModelBuilder for easy documentation and repeatability.

GIS Model Example:





The NEAFWA working group collaborated on developing metric weights:
- Not all metrics are of equal importance to aquatic connectivity
- Weights are indicative of the relative importance of a metric to the other metrics (Weight total = 100)
- A subjective aspect to the analysis. Although there is literature to support the importance of connected aquatic habitat to anadromous and resident fish species, there is no literature to support the relative importance of miles of connected network vs. the number of downstream dams to overall aquatic connectivity. Several iterations of weights were developed through conference calls and review of drafts.



Methods

3. Metrics and weights were combined in an Excel tool to calculate a tiered list of dams based on "Potential Project Benefit Rank"

A. Data filtered by area of geographic interest (State, HU, region or attribute (e.g. stream size)

B. All dams are sequentially ranked for all attributes[1].

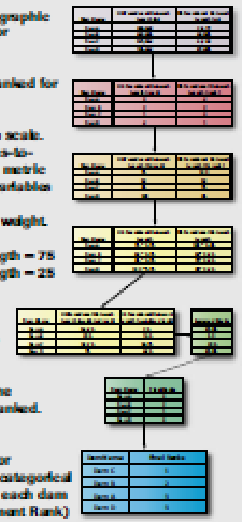
C. Ranks are converted to a % scale. This is necessary for "apples-to-apples" comparisons when metric values are not continuous variables

D. Multiply % ran by attribute weight. In this example if
US Functional Network Length = 75
DS Functional Network Length = 25

E. Sum weighted ranks. All metrics which are included (weight >0) are summed to result in a summed rank.

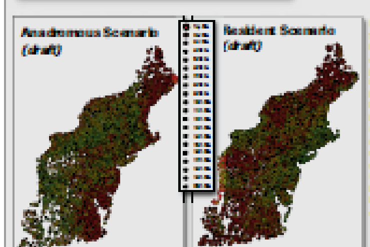
F. Re-rank summed ranks. The summed ranks are in turn ranked.

G. The final ranks are sorted for presentation. Additionally, categorical ranks can be calculated for each dam (e.g. Connectivity Improvement Rank)



[1] Metrics can be ranked in ascending or descending order, depending on whether larger values are "good" or "bad". In this example larger values are positive factors for anadromous fish – more network length = more habitat. Therefore for present upstream number to be maximized, for example, would be ranked in the opposite order.

Products



Ranked results were tiered in 5% increments to emphasize that the precise order of the ranked results is not as important as the broad tiers (i.e. is a dam with 10.2 miles of network upstream really different from a dam with 10.1 miles?) This also helps ameliorate imperfections in the data.

Outcomes & Challenges

Conservation Outcomes

Through this work, state agencies and conservation practitioners will be empowered to focus their efforts and limited resources on projects that have the greatest potential to result in the increased viability of anadromous fish and resident fish conservation targets. Without the focus on likely results, actors such as GMS are likely to limit federal investment in connectivity restoration. Additionally, by providing a consistent and unbiased regional prioritization, practitioners will be able to better leverage funds to achieve these conservation goals. Moving forward, this project provides a methodological platform which can be built upon and as data improves. In and of itself this project also serves as a catalyst for data improvements.

Caveats and Challenges

With any analysis, the quality of the results is highly dependent on the quality of the input data. This analysis, in which dams are part of a network and are evaluated based on their position within the network, is particularly sensitive to data errors.

Despite efforts to prioritize the dam review process, months were spent working to improve the data, and more can always be done. With data, perfection is sometimes the enemy of good.

Thus, it is important to note that the analysis results are a starting point for further investigation. They don't provide the definitive answers. They are our best screening-level approximations and need input and verification from people who know the sites and can provide more detailed data on a proposed project's ecology, economics, and feasibility.

Additionally, there can be valid concerns regarding how people might perceive a prioritized list. If too much faith is put in a given list, it can be to the detriment of other worthy projects. Clarity regarding appropriate use of the results is critical (e.g. as a screening tool to help, along with other applicable information, inform high level planning efforts)

Finally, engaging participants throughout the process is critical. Regular conference calls were held to review project status, solicit feedback from participants, and make key decisions.

Next Steps & Improvements

1. Dam review and metric weight revisions are on-going. Final product, tool, and report are scheduled for completion in early September 2011.
2. Future analyses or work at smaller extents can be performed using finer resolution data. In the Chesapeake Bay watershed, approximately 84% of dams in the NEAFWA database snap to the 1:100k hydrography while approximately 83% snap to the 1:24,000 scale hydrography. This provides a more accurate picture of fragmentation on smaller streams. Likewise, if data exists, treating culverts as barriers would improve the analysis beyond their current use in summary (non-ranking) metrics.
3. More sophisticated prioritization methods, such as the optimization models developed in recent years (e.g. O'Hanley and Tomberlin 2005, Zheng 2009), are available. While not all of the inputs required to run these analyses is available at a regional scale, and computational and programming requirements can be limiting, they have the potential to improve the prioritization process, particularly in the context of cost.

[illegible]

Acknowledgements

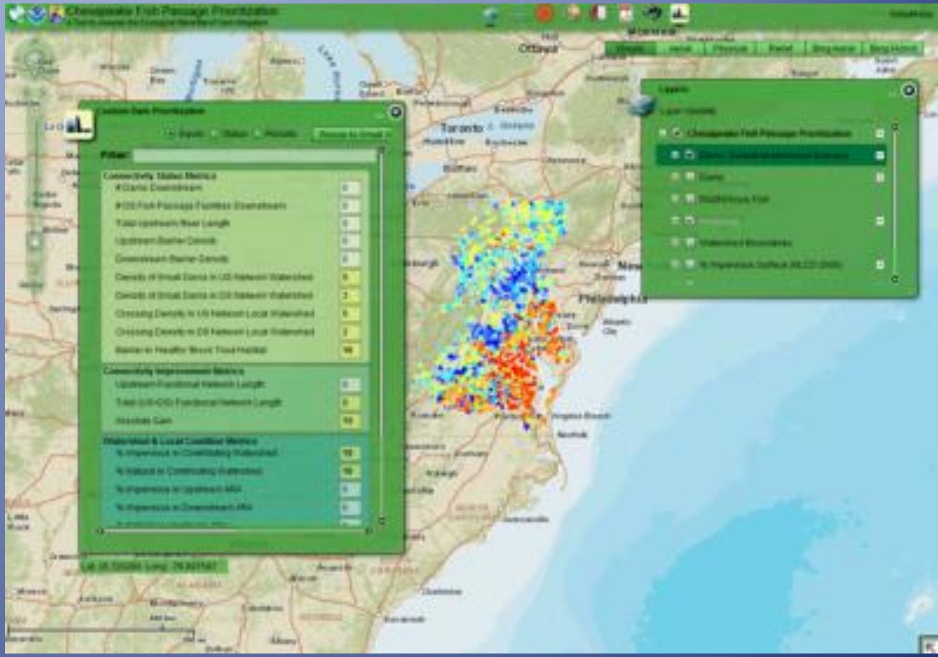
Funding for this work was provided by the Northeast Association of Fish and Wildlife Agencies. The authors would also like to thank the NEAFWA working group for being participants in this process [illegible]

Erik Martin, The Nature Conservancy
[illegible]

Colin Apse, The Nature Conservancy
[illegible]

Chesapeake Fish Passage Prioritization

- http://maps.tnc.org/EROF_ChesapeakeFPP
- Grew out of the NE Aquatic Connectivity project
- Funded by NOAA / USFWS
- Same conceptual framework as NE
- Incorporates additional regional data (water quality, biological)
- Higher resolution input hydrography (1:24,000)
- Project workgroup



- Custom analysis tool
  - user defined scenarios: metric weights & extent
  - Web-map based
    - easier to use
    - Faster
    - graphic results

Southeast Aquatic Connectivity Assessment

- TNC / SARP Co-Lead
- Project Kickoff Jan 2013
- Completion Dec 2014

- Follows same conceptual framework as NE project

- Web map – based custom analysis / decision support tool

Southeast Aquatic Connectivity Study Area

Freshwater Ecosystem Resilience for the Northeast

The Nature Conservancy
Protecting nature. Preserving life.

AUTHORS: *Mark G. Anderson Ph.D. Director of Conservation Science, The Nature Conservancy, Eastern North America Divisio, manderson@tnc.org 99 Bedford Street, Boston, MA 02111, 617-532-8300 phone.*
Arlene Olivero Sheldon M.S., Aquatic Ecologist/GIS Manager, The Nature Conservancy, Eastern North America Division, arlene_olivero@tnc.org 99 Bedford Street, Boston, MA 02111, 617-532-8300 phone.

Abstract

Ecological resilience is the capacity of a system to renew itself in a dynamic environment or the capacity of a system to adapt to change while retaining the same basic structure and ways of functioning. We are undertaking an analysis to identify the freshwater systems in the eastern U.S. that will be the most resilient in the face of climate change, and that collectively represent the diversity of geophysical settings. Our initial hypothesis is that more resilient freshwater systems have connected linear habitats, connected lateral habitats, natural instream flows, intact watershed and riparian areas, access to groundwater, and a diversity of geophysical gradients within a geographic and ecologic stratification. To assess the linear fragmentation of rivers in the Northeast and Mid Atlantic, we have completed a stream network analysis using nearly 14,000 compiled dams and waterfalls. For lateral habitat connectivity, we have modeled the floodplain areas around rivers and used satellite imagery to verify which areas are still receiving spring inundation. We use gage data and upstream dam water storage as a method to evaluate alteration to the hydrologic regime, and we have mapped impervious surfaces and natural cover to evaluate the terrestrial landscape within watersheds and riparian areas. We have also calculated a number of geophysical diversity metrics for each connected stream network and proposed further geographic and ecologic stratification of the networks. We show examples of how we are using emerging results to highlight freshwater networks that appear to have a large capacity to adapt to climate change. We expect to implement a full analysis of the Northeast and Mid-Atlantic by March 2013.

What Factors Influence a Streams Ability to Adapt?

Linear Connectivity

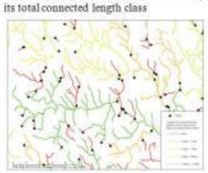
Connectivity within a network of streams is essential to freshwater organisms. It enables individuals to move throughout the network to find the best conditions for feeding and spawning, allows dispersal/recolinazation, and in times of stress it enables species to move to locations where the conditions are more suitable for survival. There has been considerable impact on the connectivity of river systems in the Northeast due to dams and impassible culverts. This has led to a substantial decrease in the length of connected stream networks throughout the region. These changes will have lasting impacts on the ability of these systems to respond to climate change and other stressors in the years to come. We hypothesize that areas with greater linear connectivity will be more resilient to climate change.

Our Unit of Analysis: Connected Stream Network

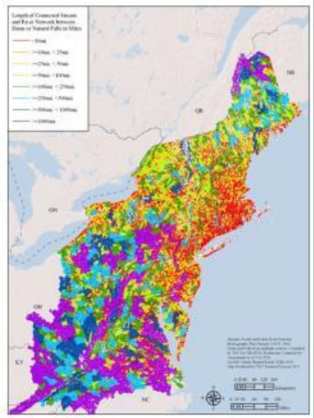
Each connected network is bounded by dams and/or the topmost extent of headwater streams.

A: Unique color for each connected network

B: Each connected network symbolized by its total connected length class



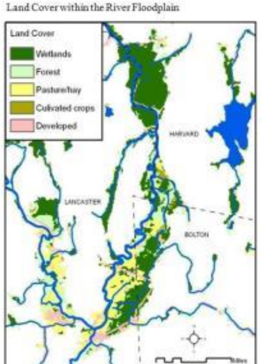
Partnering with the Northeast Connectivity Project (TNC & NEAFWA), we have developed a set of connected networks for the region. These networks were built using all streams with watersheds >1 sq.mi. and used the 14,000 dams and natural waterfalls that occur on these streams and rivers as barriers.



Lateral Connectivity

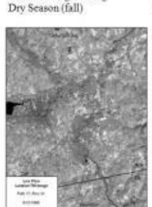
This metric refers to the two-way exchange of nutrients, sediments and organisms, that occurs between the stream and its floodplain given periodic innundation Periodic floods create additional habitat for aquatic organisms for feeding and/or spawning and serve to maintain the stream channel physical habitat and nearby terrestrial systems. Naturally vegetated floodplain areas can also store flood waters and sediment to reduce flooding and erosion damages downstream. These processes are all necessary to support a fully functional freshwater ecosystem and require good connectivity between the channel and floodplain, or "lateral connectivity". Due to land use change, channelization and altered flow regimes from dam operations, the historical extent of flooding has been much diminished in much of the northeast. We hypothesize that areas with higher lateral connectivity will be more resilient to climate change and other disturbances.

Land Cover within the River Floodplain

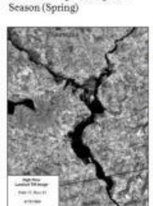


We have undertaken an analysis to map and evaluate the floodplain area adjacent to our streams and rivers. We have evaluated the current land cover within this area and used a satellite image analysis to verify which areas are still receiving floodwaters during a ~2-year flood event.

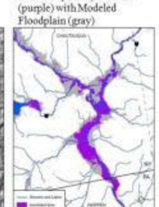
Satellite Image During Dry Season (fall)



Satellite Image During Wet Season (Spring)



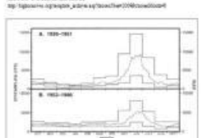
Area Temporarily Flooded (purple) with Modeled Floodplain (gray)



Natural Instream Flow

The instream flow regime, including the amount, frequency, duration and seasonality of flow though a stream, plays a critical role in shaping the communities that live in freshwater systems. Alterations in flow regime due to water withdrawals, land use and associated runoff, and dam operations are common throughout the Northeast. These alterations have had, and will in the future have, significant negative impacts on the species and communities that live in the region's waters. We hypothesize that streams with more natural flows (i.e. those with flows that are less altered) will be more resilient to environmental changes and to climate change.

Hydrographs comparing river flows prior to the creation of the dam, and releases after construction



Altered hydrograph in response to urbanization

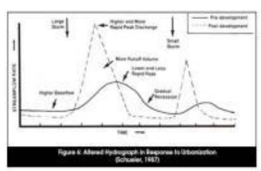
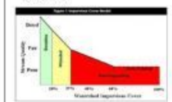


Figure 6: Altered Hydrograph in Response to Urbanization (Schueler, 1987)

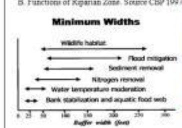
Intact Watershed and Riparian Areas

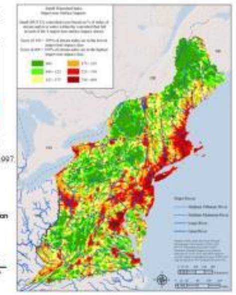
The ability of freshwater systems to adapt to disturbance relies on high water quality which in turn relies on the land uses surrounding the river system. Water quality declines with increasing watershed imperviousness and agriculture. Vegetated riparian zones provide bank stabilization, water temperature moderation, nitrogen and sediment removal, and are important sources of organic matter. We hypothesize that rivers with more intact watersheds and riparian areas will be more resilient to climate change and other disturbances.

A. Impacts of Upstream Impervious Surface (CWP, 2003)



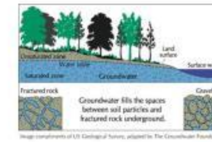
B. Functions of Riparian Zone. Source CBP 1997





Groundwater Access

Access to groundwater helps moderate flow regimes and leads to less flashy streams, reducing the likelihood that flows will fall below critical levels. The influx of groundwater also helps maintain cooler water temperatures which are important for some instream communities and which will become more critical as air and water temperatures rise due to climate change. We hypothesize that freshwater systems with greater access to groundwater will be more resilient.



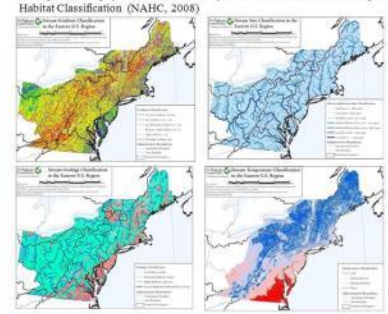
Baseflow is the component of streamflow that can be attributed to groundwater discharge into streams. The Baseflow Index is calculated as the ratio of baseflow to total flow expressed as a percentage.

Diversity Of Geophysical Settings and Stratification

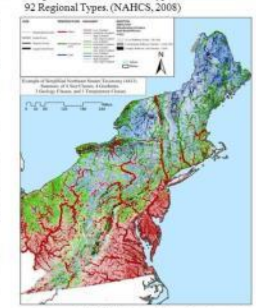
A highly resilient stream system would ideally include variation in elevation, gradient, geology and stream size. We propose to quantify the geophysical diversity of each connected network to highlight networks where the geophysical context is more diverse and hence more likely to be resilient when facing climate change and other disturbances. We propose to then cluster the connected networks into groups sharing similar geophysical characteristics, and next stratify our final selections by selecting the most intact examples of each cluster type within each Freshwater Ecoregion and subdivision. Incorporating information on geophysical diversity and stratification will allow us to: 1) take into account geophysical factors that have long been identified as important in shaping freshwater biodiversity, 2) capture the variety of available microclimates and gradients that species can take advantage of during rearrangement in response to climate change disturbance, and 3) better integrate redundancy and genetic and phenotypic diversity in our resilience planning.

Example of Biogeographic Stratification Units: Freshwater Ecoregions and Ecological Drainage Units

Example of Geophyscial Stream Diversity Metrics from the Northeast Aquatic Habitat Classification (NAHC, 2008)



Simplified Stream and River Type Classification 92 Regional Types. (NAHCS, 2008)



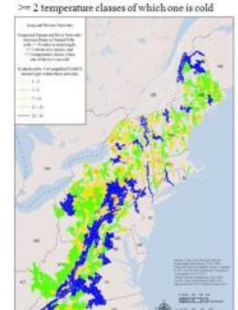
Resilient Stream Systems

Where are stream networks with the most…

1. Linear Connectivity
2. Lateral Connectivity
3. Natural Instream Flow
4. Intact Watershed and Riparian Areas
5. Groundwater Access
6. Diversity of geophysical settings within their geographic and ecologic stratification

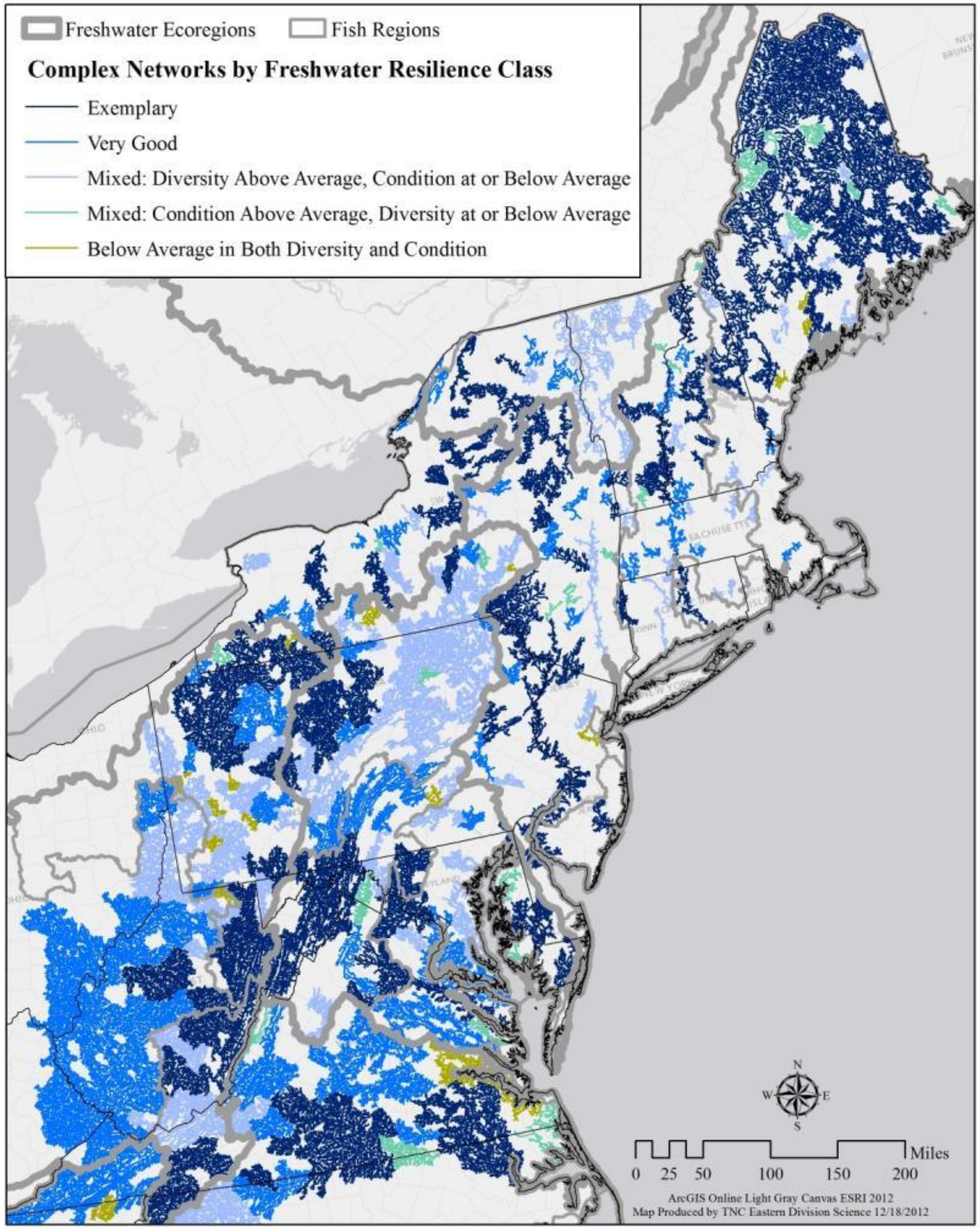
We are just beginning these types of queries. Shown at the right are two examples of querying connected networks on geophysical diversity attributes. We expect to implement a full analysis of the Northeast and Mid-Atlantic by January 2012.

Query of Long and Diverse Networks
>= 50 miles long
>= 3 stream or river size classes
>= 2 temperature classes of which one is cold



Query to Highlight Diverse Networks Containing Calcareous Stream Habitats
>= 50 miles long
>= 3 stream or river size classes
>= 2 temperature classes of which one is cold
>= 10 miles of calcareous streams

DRAFT RESULTS
3/2013



Regional Freshwater Resilience Class

Stratified by Fish Region and Freshwater Ecoregion

What are your primary data sources (model inputs) and how can data be shared across project teams?

- NHD: National Hydrography Dataset Plus (use the many value added attributes from NHD…)
- NLCD: National Land Cover Dataset, derived Impervious Surface
- NED: National Elevation Dataset and derived Active River Area Modeled Floodplain
- Bedrock Geology: state datasets crosswalked to ecological categories
- STATSGO/SSURGO Soils
- Conservation Land: Compiled by TNC from multiple state, federal, local, and NGO sources
- Roads
- Urban Growth Projections (Theobald, Purdue group)
- Wadeable Stream Assessment, USEPA
- National Lake Assessment, USEPA
- EBTJV: Brook Trout models
- Natural Heritage Program EO data for species and aquatic communities
- State Fish and Game fisheries datasets
- State dam databases
- Federal dam databases
- **All of these data are shareable except for the state fish and game fisheries datasets, natural heritage program data, and some state dam databases**.

What opportunities do you see for collaboration and model integration?

- These data support State Wildlife Action Plans and Federal LCC planning; goal is to make our data more seamless and easy to integrate into their plans (e.g. Geospatial Condition Analysis Project….)

- Other ecological researchers (Universities, NGOs, state agencies, etc.)

- Dam prioritizations and condition information can be inputs to other, finer-scale work (e.g. these can be the benefit in a cost/benefit optimization for a given watershed)

What are your primary science and data needs or most important technical challenges?

- **Data collection & normalization from many disparate sources**
- (state dam data, state and federal fish and macroinvertebrate data, water quality data, stream temperature data, state wildlife action plans, secured land…
- Lack of fine scale groundwater mapping
- Lack of regional compilation of water withdrawal and return data.
- Lack of ground truthing/QC of our verified flood satellite image analysis
- To date we have not been able to use the stream temperature continuous monitoring network data given volume/complexity of material. Also issues with data access and spotty coverage of the locations across stream types in the region.
-

Who are your target audiences (users) and how are you engaging them?

- NEAFWA and LCC and other state/federal groups looking for a regional perspective.
- State Fish and Game agencies who are looking for assistance in SWAP planning, particularly in providing a regional context for their target habitat types.
- People working on fish passage projects: state fish passage coordinators & other agency staff, federal agency staff (e.g. NOAA), non-profits (e.g. American Rivers), watershed groups
- Non-profit Conservation Organizations
- Greater ecology research community

- We have been engaging them by having them involved in the workgroup which helps guide and review the projects throughout their development.
- We have posted our reports online and are currently working to get our datasets online.
- We have produced a simplified State of Nature report with funding from Sweetwater Trust to take some of the results of the Conservation Status report and convert it to a publically digestible format.