Condition of the Northeast Terrestrial & Aquatic Habitats

The Nature Conservancy
Eastern Conservation Science

Condition of the Northeast Terrestrial and Aquatic Habitats: a geospatial analysis and tool set.

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North Atlantic LCC
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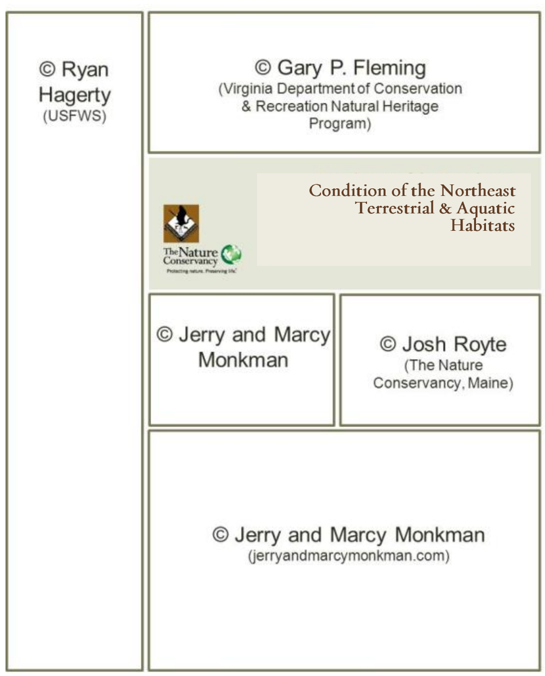

Acknowledgements

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Introduction to the Condition Analysis of the Northeast Terrestrial and Aquatic Habitats

The goal of this project was to assess the condition of 116 terrestrial and aquatic habitats in the Northeast and provide tools for state agencies and conservation organizations to evaluate the condition of specific habitats within their state. The project is based on the newly released Northeast Terrestrial Habitat Map (Ferree and Anderson 2011) and the Northeast Aquatic Habitat Classification (Olivero and Anderson 2008) and their accompanying datasets, which allow for each habitat to be evaluated across its entire range in the region. Additionally, the project used newly released region-wide spatial datasets that illustrate a facet of the region's ecological condition such as predicted loss to development, securement from development, forest stand age, and number of dams, as well as datasets developed specifically for this assessment such as habitat patch size and amount of core area.

The habitats were defined and mapped in the regional datasets. Additionally, for 109 of them, a description, photo, and distribution map of each habitat, along with information on its associated wildlife, rare species, relationship to state defined habitats, and information on its ecological condition may be found in the Northeast Habitat Guides (Anderson et al. 2013). These profiles of each habitat are essential for understanding the condition information presented in this report.

This report has two major sections:

- **Condition Metrics:** A description of 14 ecological condition metrics and comparative results of the metric as applied to the terrestrial and aquatic habitats.
- **Geospatial Units and Tools:** a database and tool to query the region for habitats that meet specific criteria, or to evaluate a particular area for its habitats and condition attributes.

Condition Metrics

The condition metrics were selected in consultation with Fish and Wildlife Agency staff to indicate an important aspect of the condition of the terrestrial and aquatic habitats. The final set of metrics was limited to those that could be measured at the regional scale using existing data. They include:

Shared Metrics	*Terrestrial*	*Freshwater*
Securement	Stand age	Impervious surface
Local connectedness	Patch size	Riparian landcover
Landscape context index	Landscape complexity	Dam types and density
Predicted loss to development	Core area	Risk of flow alteration
		Network size
		Road stream crossings

Geospatial Units and Tool Set.

The tool set provides the user with a comprehensive dataset of fine-scale units (blocks bounded by minor roads and stream segments) that can be queried with user-defined criteria for habitat types and condition characteristics. The units have been attributed with information on the types and patch size of each terrestrial habitat or wetland complex and the quality of the streams. Each unit also carries information on all the condition attributes described above, so that users may query the data for specific criteria combinations. For example: a patch of Laurentian-Acadian Northern Hardwood Forest in NH over 5,000 acres in size, with over 1000 acres of core area, and very high local connectedness over 75.

Citations and Links

Anderson, M.G., M. Clark, C.E. Ferree, A. Jospe, A. Olivero Sheldon and K.J. Weaver. 2013. Northeast Habitat Guides: A companion to the terrestrial and aquatic habitat maps. The Nature Conservancy, Eastern Conservation Science, Eastern Regional Office. Boston, MA. http://nature.ly/HabitatGuide.

Ferree C. and Anderson, M.G. 2011. A Terrestrial Habitat Map for the Northeastern United States. The Nature Conservancy, Eastern Conservation Science. https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/edc/reportsdata/terrestrial/habitatmap/Pages/default.aspx.

Olivero, A. and M.G. Anderson. 2008. The Northeast Aquatic Habitat Classification. The Nature Conservancy, Eastern Conservation Science. 90 pp. http://www.rcngrants.org/spatialData

CHAPTER

Habitat Types 1

Introduction to the Habitat Types

This report contains information about the condition and threats to 116 Eastern Habitats including 96 terrestrial upland and wetland habitats and 23 stream and river habitats. The habitats have been consistently mapped across all 13 states of New England and the Mid-Atlantic, and they have been described and characterized as to their distribution, vegetation, ecological setting, associated wildlife, and rare species. The information in this report builds heavily on the foundational classification work and we encourage users to explore the following documents and datasets:

- The Northeast Terrestrial Habitat Map (Ferree and Anderson 2012)
- The Northeast Aquatic Classification and Dataset (Olivero and Anderson 2010)
- The Northeast Habitat Guides (Anderson et al. 2013)
- The Northeast Terrestrial Habitat Classification (Gawler et al. 2008)

The Northeast Habitat Guides, available at http://nature.ly/HabitatGuide , give an overview of how the habitat types were developed and mapped, and for each individual habitat it provides a fact sheets about the habitat (Figure 1). The habitat fact sheets not only characterize each habitat but they also present basic information about the condition of each habitat using some of the metrics discussed in this report. Collectively, we hope these products provide a common language and spatial dataset for the conservation of our shared natural habitats in the region.

This geospatial condition report was conceived as a companion to the Northeast Habitat Guides to further explore the different levels of condition and human impact upon the habitats in the region. Information is presented by habitat type and macro group, which are broadly defined habitat types (Table 1):

Upland Macrogroups	*Wetland Macrogroups*
Alpine	Central Hardwood Swamp
Boreal Upland Forest	Coastal Plain Peatland
Central Oak-Pine	Coastal Plain Swamp
Central Oak-Pine/Longleaf Pine	Emergent Marsh
Cliff and Talus	Large River Floodplain
Coastal Grassland & Shrubland	Northern Peatland
Glade, Barren and Savanna	Northern Swamp
Northern Hardwood & Conifer	Southern Bottomland Forest
Outcrop & Summit Scrub	Tidal Marsh
Rocky Coast	Wet Meadow / Shrub Marsh
Southern Oak-Pine	

Stream and river habitats are divided into types within the major macrogroups (Table 2):

Large Rivers	Tidal Large Rivers
Medium Rivers	Tidal Small to Medium Rivers
Small Rivers	Tidal Headwaters and Creeks
Headwaters and Creeks	

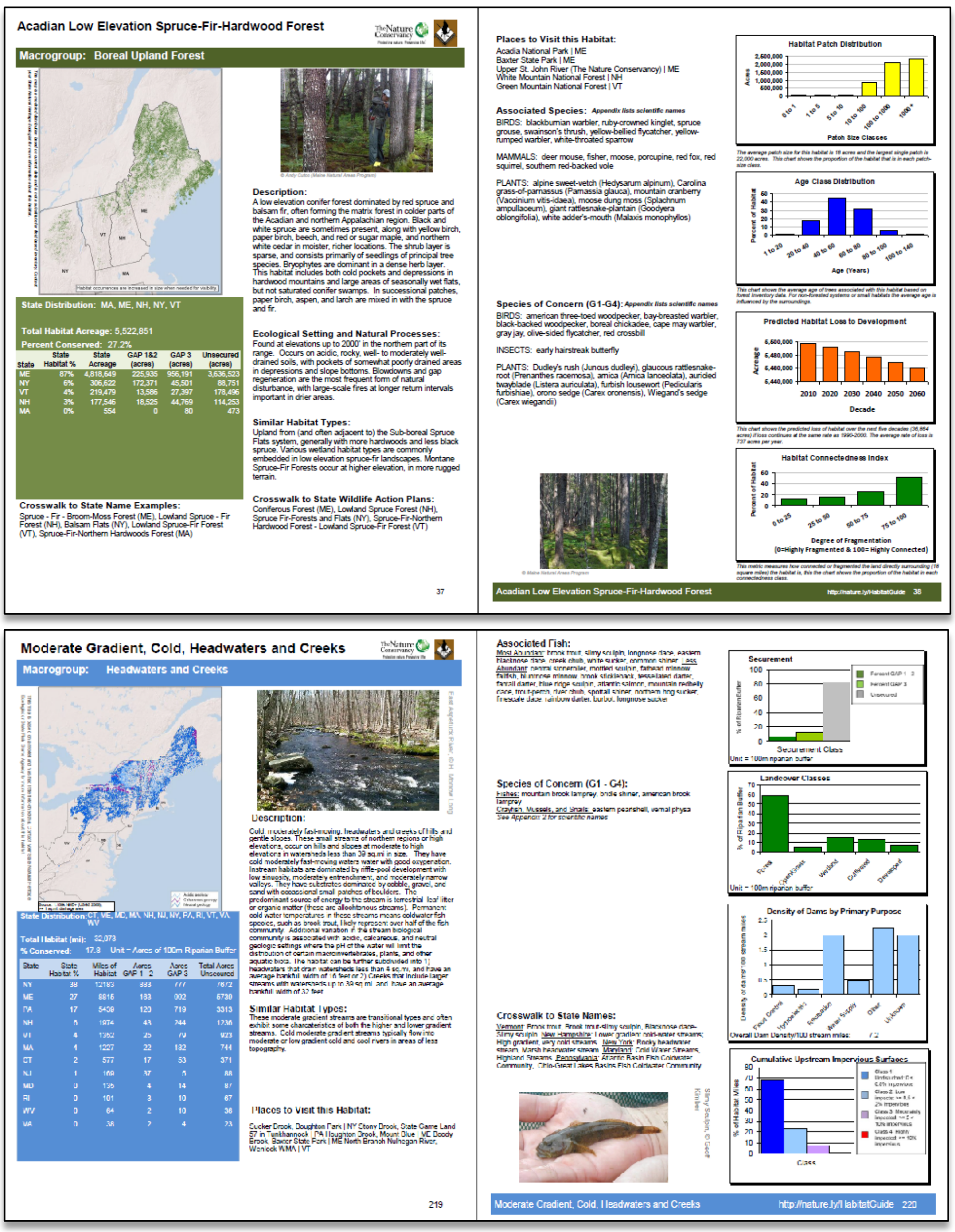


Figure 1. Example Pages from the Northeast Habitat Guides: A Companion to the Terrestrial and Aquatic Habitat Maps (Anderson et al. 2013). This figure shows terrestrial and aquatic sample pages.

Table 1. Terrestrial habitat types.

Patch types	Upland Macrogroup	Habitat Summary Group
Patch: edaphic	Alpine	Acadian-Appalachian Alpine Tundra
Matrix	Boreal Upland Forest	Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest
Matrix	Boreal Upland Forest	Acadian Low Elevation Spruce-Fir-Hardwood Forest
Patch: forest	Boreal Upland Forest	Central and Southern Appalachian Spruce-Fir Forest
Patch: forest	Boreal Upland Forest	Acadian Sub-boreal Spruce Flat
Matrix	Central Oak-Pine	North Atlantic Coastal Plain Pitch Pine Barrens
Matrix	Central Oak-Pine	Central Appalachian Dry Oak-Pine Forest
Matrix	Central Oak-Pine	Northeastern Interior Dry-Mesic Oak Forest
Matrix	Central Oak-Pine	North Atlantic Coastal Plain Hardwood Forest
Matrix	Central Oak-Pine	Southern Appalachian Oak Forest
Matrix	Central Oak-Pine	Allegheny-Cumberland Dry Oak Forest and Woodland
Matrix	Central Oak-Pine	Southern Piedmont Dry Oak-Pine Forest
Patch: forest	Central Oak-Pine	Southern Appalachian Montane Pine Forest and Woodland
Patch: forest	Central Oak-Pine	Central and Southern Appalachian Montane Oak Forest
Patch: forest	Central Oak-Pine	Central Appalachian Pine-Oak Rocky Woodland
Patch: forest	Central Oak-Pine	Northeastern Interior Pine Barrens
Patch: forest	Central Oak-Pine	North Atlantic Coastal Plain Maritime Forest
Patch: forest	Central Oak-Pine	Southern Ridge and Valley / Cumberland Dry Calcareous Forest
Patch: forest	Central Oak-Pine	Piedmont Hardpan Woodland and Forest
Patch: forest	Central Oak-Pine/Longleaf Pine	Southern Atlantic Coastal Plain Upland Longleaf Pine Woodland
Patch: edaphic	Cliff and Talus	Calcareous Cliff and Talus
Patch: edaphic	Cliff and Talus	Acidic Cliff and Talus
Patch: edaphic	Cliff and Talus	Circumneutral Cliff and Talus
Patch: edaphic	Coastal Grassland & Shrubland	Great Lakes Dune and Swale
Patch: edaphic	Coastal Grassland & Shrubland	Atlantic Coastal Plain Beach and Dune
Patch: edaphic	Coastal Grassland & Shrubland	North Atlantic Coastal Plain Heathland and Grassland
Patch: edaphic	Glade, Barren and Savanna	Appalachian Shale Barrens
Patch: edaphic	Glade, Barren and Savanna	Southern and Central Appalachian Mafic Glade and Barrens
Patch: edaphic	Glade, Barren and Savanna	Eastern Serpentine Woodland
Patch: edaphic	Glade, Barren and Savanna	Great Lakes Alvar
Patch: edaphic	Glade, Barren and Savanna	Central Appalachian Alkaline Glade and Woodland
Patch: edaphic	Glade, Barren and Savanna	Southern Ridge and Valley Calcareous Glade and Woodland
Patch: edaphic	Glade, Barren and Savanna	Southern Piedmont Glade and Barrens
Matrix	Northern Hardwood & Conifer	Laurentian-Acadian Northern Hardwood Forest
Matrix	Northern Hardwood & Conifer	Appalachian (Hemlock)-Northern Hardwood Forest
Matrix	Northern Hardwood & Conifer	Northeastern Coastal and Interior Pine-Oak Forest
Matrix	Northern Hardwood & Conifer	Laurentian-Acadian Pine-Hemlock-Hardwood Forest
Matrix	Northern Hardwood & Conifer	Southern Atlantic Coastal Plain Mesic Hardwood Forest
Matrix	Northern Hardwood & Conifer	Southern Piedmont Mesic Forest
Patch: forest	Northern Hardwood & Conifer	Southern Appalachian Northern Hardwood Forest
Patch: forest	Northern Hardwood & Conifer	Southern and Central Appalachian Cove Forest
Patch: forest	Northern Hardwood & Conifer	Laurentian-Acadian Red Oak-Northern Hardwood Forest
Patch: forest	Northern Hardwood & Conifer	Glacial Marine & Lake Mesic Clayplain Forest
Patch: forest	Northern Hardwood & Conifer	North-Central Interior Beech-Maple Forest
Patch: forest	Northern Hardwood & Conifer	South-Central Interior Mesophytic Forest
Patch: forest	Northern Hardwood & Conifer	Laurentian-Acadian Northern Pine-(Oak) Forest
Patch: edaphic	Outcrop & Summit Scrub	Southern Appalachian Grass and Shrub Bald
Patch: edaphic	Outcrop & Summit Scrub	Acidic Rocky Outcrop

Table 1, cont.

Patch type	Macrogroup	Habitat Summary Group
Patch: edaphic	Outcrop & Summit Scrub	Calcareous Rocky Outcrop
Patch: edaphic	Outcrop & Summit Scrub	Acidic Rocky Outcrop
Patch: edaphic	Rocky Coast	Acadian-North Atlantic Rocky Coast
Patch: forest	Southern Oak-Pine	Southern Appalachian Low Elevation Pine Forest
Patch: forest	Southern Oak-Pine	Central Atlantic Coastal Plain Maritime Forest
Wetland	Central Hardwood Swamp	Glacial Marine & Lake Wet Clayplain Forest
Wetland	Central Hardwood Swamp	Piedmont Upland Depression Swamp
Wetland	Central Hardwood Swamp	Central Interior Highlands and Appalachian Sinkhole and Depression Pond
Wetland	Central Hardwood Swamp	North-Central Interior Wet Flatwoods
Wetland	Coastal Plain Peatland	Atlantic Coastal Plain Peatland Pocosin and Canebrake
Wetland	Coastal Plain Peatland	Atlantic Coastal Plain Northern Bog
Wetland	Coastal Plain Swamp	North Atlantic Coastal Plain Basin Peat Swamp
Wetland	Coastal Plain Swamp	Southern Atlantic Coastal Plain Tidal Wooded Swamp
Wetland	Coastal Plain Swamp	Central Atlantic Coastal Plain Non-riverine Swamp and Wet Hardwood Forest
Wetland	Coastal Plain Swamp	North Atlantic Coastal Plain Pitch Pine Lowland
Wetland	Coastal Plain Swamp	North Atlantic Coastal Plain Tidal Swamp
Wetland	Coastal Plain Swamp	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest
Wetland	Coastal Plain Swamp	North Atlantic Coastal Plain Stream and River
Wetland	Emergent Marsh	Laurentian-Acadian Freshwater Marsh
Wetland	Emergent Marsh	Piedmont-Coastal Plain Freshwater Marsh
Wetland	Large River Floodplain	Laurentian-Acadian Large River Floodplain
Wetland	Large River Floodplain	Piedmont-Coastal Plain Large River Floodplain
Wetland	Large River Floodplain	North-Central Interior Large River Floodplain
Wetland	Large River Floodplain	North-Central Appalachian Large River Floodplain
Wetland	Large River Floodplain	North Atlantic Coastal Plain Large River Floodplain
Wetland	Northern Peatland	Boreal-Laurentian Bog
Wetland	Northern Peatland	Laurentian-Acadian Alkaline Fen
Wetland	Northern Peatland	Acadian Maritime Bog
Wetland	Northern Peatland	Boreal-Laurentian-Acadian Acidic Basin Fen
Wetland	Northern Peatland	North-Central Interior and Appalachian Acidic Peatland
Wetland	Northern Swamp	Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp
Wetland	Northern Swamp	High Allegheny Headwater Wetland
Wetland	Northern Swamp	Central Appalachian Stream and Riparian
Wetland	Northern Swamp	Laurentian-Acadian Alkaline Conifer-Hardwood Swamp
Wetland	Northern Swamp	North-Central Appalachian Acidic Swamp
Wetland	Northern Swamp	North-Central Interior and Appalachian Rich Swamp
Wetland	Southern Bottomland Forest	Southern Piedmont Small Floodplain and Riparian Forest
Wetland	Southern Bottomland Forest	Atlantic Coastal Plain Blackwater/Brownwater Stream Floodplain Forest
Wetland	Southern Bottomland Forest	Southern Piedmont Lake Floodplain Forest
Wetland	Tidal Marsh	Atlantic Coastal Plain Embayed Region Tidal Freshwater/Brackish Marsh
Wetland	Tidal Marsh	Acadian Coastal Salt and Estuary Marsh
Wetland	Tidal Marsh	North Atlantic Coastal Plain Tidal Salt Marsh
Wetland	Tidal Marsh	North Atlantic Coastal Plain Brackish/Fresh & Oligohaline Tidal Marsh
Wetland	Wet Meadow / Shrub Marsh	Piedmont-Coastal Plain Shrub Swamp
Wetland	Wet Meadow / Shrub Marsh	Laurentian-Acadian Wet Meadow-Shrub Swamp

Table 2. Stream and river habitat types.

Macrogroup	Habitat Type
Headwaters and Creeks	High Gradient, Cold, Headwaters and Creeks
Headwaters and Creeks	High Gradient, Cool, Headwaters and Creeks
Headwaters and Creeks	High Gradient, Warm, Headwaters and Creeks
Headwaters and Creeks	Moderate Gradient, Cold, Headwaters and Creeks
Headwaters and Creeks	Moderate Gradient, Cool, Headwaters and Creeks
Headwaters and Creeks	Moderate Gradient, Warm, Headwaters and Creeks
Headwaters and Creeks	Low Gradient, Cold, Headwaters and Creeks
Headwaters and Creeks	Low Gradient, Cool, Headwaters and Creeks
Headwaters and Creeks	Low Gradient, Warm, Headwaters and Creeks
Small River	Moderate Gradient, Cold, Small River
Small River	Moderate Gradient, Cool, Small River
Small River	Moderate Gradient, Warm, Small River
Small River	Low Gradient, Cold, Small River
Small River	Low Gradient, Cool, Small River
Small River	Low Gradient, Warm, Small River
Medium River	Cold, Medium River
Medium River	Cool, Medium River
Medium River	Warm, Medium River
Large River	Cool, Large River
Large River	Warm, Large River
Tidal Headwaters and Creeks	Tidal Headwaters and Creeks
Tidal Small and Medium River	Tidal Small and Medium River
Tidal Large River	Tidal Large River

Part 1: Condition Metrics

Condition Metrics

CHAPTER 2

Introduction to the Metrics

The metrics used in this report and accompanying toolset were selected to indicate the ecological condition of the terrestrial and aquatic habitats. They were selected in consultation with a group of Fish and Wildlife agency staff and represent the final set of prioritized metrics that emerged from a set of conference calls and meetings held in 2012. These metrics were limited to those that could be measured using existing datasets and that were consistently available at a regional scale covering all 13 states in the project area. A list of all metrics and their definitions is provided (Table 3).

The metric sections focus on displaying the resultant patterns in as clear and transparent a way as possible. Each section includes the following key components:

1. **Description**: A short text summary description of the metric.
2. **Why is this metric important?** A few paragraphs of background information on why this metric is ecologically important to northeast habitats.
3. **Methods**: A brief explanation of how the metric was calculated.
4. **Results**: Summary charts, figures, and text which highlight patterns across the region, across macrogroups, and across individual habitat types. A few major trends across individual types are discussed, however further interpretation of the detailed results is left to the users of this report.
5. **Detailed Methods:** A more detailed explanation of the methods for technical audiences.
6. **References**: Key references related to each metric.
7. **Tables by Habitat Type:** Detailed tables for each habitat type for the given metric.
8. **Map:** A regional map displaying the metric.

Caveats: Calculation of the metrics required detailed study of each source dataset and related literature to understand its strengths and limitations, its schema or field names, and the relevant reporting thresholds. Effort was made to use the most precise and accurate spatial data available; however, the source data for the metrics were at differing levels of spatial precision (e.g. 30m grid cell, 90m grid cell, 250m grid cell, 1:25,000, 1:100,000) and most datasets had limited or no formal accuracy assessments available. These differences in spatial precision and accuracy affect the results when the condition metric data were combined with the source terrestrial habitats (30m grid cell) and stream and river lines (1:100,000). The calculated acreages or lengths in each condition reporting class will not necessarily conform to true survey scale acreages; however, the calculated metrics were consistently applied across all habitats, allowing for a meaningful comparison across habitats. The resultant patterns and figures shown for each metric should be suggestive of the relative level of impact across system types and allow for a study of comparative trends across habitats in the region.

Table 3. List of metrics used in the condition analysis.

Category	Name	Definition
Shared	Secured lands	Amount of unit permanently maintained in a natural state
	Local connectivity	An estimate of the degree of permeability, or conversely the degree of resistance, surrounding each cell in the region. We summarized this metric into a habitat connectedness index.
	Landscape context	The degree of human conversion of natural landcover in the immediate neighborhood of that cell on the landscape.
	Predicted development	The acres of a habitat predicted to be developed over the next 50 years, calculated within each unit
Terrestrial	Forest stand age	The proportion of various age classes of a forest or habitat type within its geographic range.
	Patch size	The size of each contiguous patch of habitat, bounded by roads, development, agriculture or contrasting habitats.
	Core area	Core area is the amount of interior habitat in the central region of a habitat patch. This sheltered secluded habitat is preferred by many species for breeding.
	Landscape complexity	An estimate of the number of micro-climates in a 100 acre area surrounding each cell of habitat, based on the variety of landforms, the elevation range, and the density of wetlands.
Aquatic	Impervious surfaces	Impervious surfaces are hard substrates like paved roads, parking lots, and roves. The amount of impervious surface in the upstream watershed of each reach was summarized
	Riparian landcover	The riparian zone is the land area directly adjacent to a stream or river and subject to its influence. The different types of landcover (NLCD 2006) in the riparian zone within 100m on either side of mapped streams and rivers was summarized.
	Dam types and density	The number of dams, types of dams (hydroelectric, flood control, water supply, recreation, other), and density of dams per 100 miles of stream was calculated for each habitat type
	Risk of flow alteration from dam water storage	The risk of flow alteration from dam water storage is expressed as the ratio of the volume of water capable of being stored behind dams upstream to the mean annual flow volume expected in a reach expressed as a percent
	Network size	A connected network is defined as the set of stream and river segments bounded by fragmenting features (dams) and/or the topmost extent of headwater streams. The total linear length of all segments in each connected network was calculated
	Road-stream crossings	At each point when a road crosses a stream, manmade infrastructure allows the road to cross the stream. On small streams, these structures are often culverts, that frequently act as barriers to aquatic biota
Query tool	Species	The biodiversity of our region is composed of thousands of different species of animals, plants, fungi, microorganisms, and bacteria.
	Anadromous fish	Anadromous fish migrate between freshwater and saltwater habitats throughout the course of their lives. Dams and other manmade structures limit their ability to migrate as necessary
	Resilience	Resilience concerns the ability of a living system to adapt. Resilient stream systems are those that will support a full spectrum of biodiversity and maintain their functional integrity even as species compositions and hydrologic properties change in response to shifts in ambient conditions due to climate change.

CHAPTER

3

Terrestrial and Aquatic Metrics

Secured Land

Definition

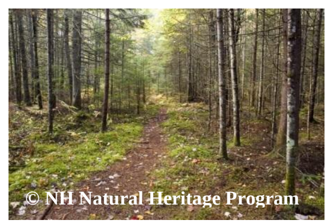
Land that is permanently secured against conversion to development. This includes both designated and undesignated conservation lands intended for permanent securement.

Why is Securement Important?

Land and water permanently maintained in a natural state remains the most effective, long lasting, and essential tool for conserving habitats. Securement, in essence, aims to maintain the quality of land and water by regulating its use in specific places. In this region, the 16 million acres of secured lands, held by both private and public agencies, represent a commitment to nature and to future generations, and an indication of what can be achieved through collective effort. These lands represent the core of efforts to protect the region's outstanding habitats and threatened species, and are increasingly understood as essential providers of ecosystem services and storehouses of terrestrial and aquatic biological resources. As the region's ecology adjusts in response to a changing climate, secured land play a critical role in maintaining arenas for evolution and to provide people with the opportunities and rewards of direct contact with the land.

Secured lands may not be developed, but beyond that they are far from uniform entities. They have a wide range of management intents and are governed by a variety of public and private stakeholders. In this section we refer to three categories of secured land (Christ et al. 1998) based largely on management intent (Anderson and Olivero 2011).

GAP 1: Permanently Secured from Development and **Intended Only for Nature and Natural Processes**



GAP 2: Permanently Secured from Development and **Intended for Nature with Some Management**

GAP 3: Permanently Secured from Development and **Intended for Multiple Natural Resource Uses** (e.g. forest management)

GAP Status 1-Intended for Nature and Natural Processes: An area having permanent protection from conversion of natural landcover and a mandated management plan in operation to maintain a natural state within which disturbance events (of natural type, frequency, intensity, and legacy) are allowed to proceed without interference or are mimicked through management.

GAP Status 2-Intended for Nature with Management: An area under permanent protection from conversion of natural landcover and a mandated management plan in operation to maintain a primarily natural state, but which may receive uses or management practices that degrade the quality of existing natural communities, including suppression of natural disturbance. Recreation such as hiking is generally allowed on GAP 1 and 2 land, but extensive use of motorized vehicles usually fits better under GAP 3 for multiple uses.

GAP Status 3-Intended for Multiple Uses: An area having permanent protection from conversion of natural landcover for the majority of the area, but subject to extractive uses of either a broad, low-intensity type (e.g., logging) or localized intense type (e.g., mining), or motorized recreation. GAP status 3 also confers protection to federally listed endangered and threatened species throughout the area.

Methods

The amount of each terrestrial habitat type secured from conversion was calculated using an overlay of the 2011 TNC secured lands on the Northeast Terrestrial Habitat map. For aquatic habitats, the amount of secured land within the 100 m riparian zone adjacent to streams and rivers was calculated and summarized by type. The 100 m buffer distance was chosen to encompass the types of critical riparian functions noted for eastern riparian areas such as shading, filtering nutrients and other pollutants, erosion control, flood mitigation, and providing wildlife habitat (Palone et al. 1997). Detail on data sources at end of section.

Results

Terrestrial Securement (map 1, 12, 13)

One-sixth (16%) of the region is secured against conversion to development, and five percent of that land is intended explicitly for nature (GAP 1 or 2). The secured land is held by over 6,000 fee owners and 2,000 easement holders. State government is the largest public conservation land owner, 12 million acres, followed by federal government, 6 million acres. Private lands held in easements account for 3 million acres and land owned by private non-profit land trusts account for another 1.4 million acres. Land conversion, however, outweighs land securement roughly 2:1 (28%:16%).

State Distribution: CT, DC, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VA, VT, WV

Total Habitat Acreage: 566,276

Percent Conserved: 38.4%

State	State Habitat %	State Acreage	GAP 1&2 (acres)	GAP 3 (acres)	Unsecured (acres)
PA	55%	310,493	14,587	101,740	194,166
VA	17%	93,666	25,531	25,815	42,321
WV	12%	70,182	3,064	17,481	49,637
MD	5%	28,081	1,416	6,178	20,488
NY	4%	24,145	2,574	6,526	15,045
MA	2%	8,545	463	2,840	5,241
NJ	1%	8,243	3,245	1,440	3,558
NH	1%	7,739	286	1,353	6,099
VT	1%	6,188	192	377	5,619
CT	1%	4,918	653	957	3,309
ME	1%	4,009	321	233	3,455
RI	0%	38	0	5	33
DE	0%	24	1	10	14
DC	0%	4	0	0	4

Figure 2. This is an example from the Northeast Habitat Guide for Central Appalachian Pine-Oak Rocky Woodland. Each factsheet details the state distribution of habitats and percent of each habitat secured in each state.

Results for each Terrestrial Habitat

Tables for each terrestrial and aquatic habitat are provided in the Northeast Habitat Guides (Anderson et al. 2013). Figure 2, for example, shows the securement status and acreage for the Central Appalachian Pine-Oak Rocky Woodland across the states. Fourteen states have at least one acre of the habitat and it is 38% secured overall. Pennsylvania had the largest proportion of the habitat (55%) and it was 37% secured including 14,587 acres in Gap 1&2. Virginia had a smaller proportion of the habitat (17%) but it was 55% secured. We caution that although the data were consistently collected and are accurate for comparisons across states, all numbers should be thought of as rough estimates.

Comparison across Habitats

Among all natural habitats the proportion of securement was 23%, including 7% secured primarily for nature and 15% secured for multiple uses. Mountain habitats collectively had over 63% securement. Acadian-Appalachian Alpine Tundra (98%), Southern Appalachian Northern Hardwood Forest (91%) and Central and Southern Appalachian Spruce-Fir forest (87%) were among the most secured of any habitat (Table 4, 5). A few low elevation coastal habitats like the Central Atlantic Coastal Plain Maritime Forest (89%) and Great Lakes Dune and Swale (69%) were also well secured. Piedmont habitats were the least secured habitats in the region, especially Southern Piedmont Mesic Forest (3%), Southern Piedmont Dry Oak-Pine Forest (3%), Piedmont Hardpan Woodland and Forest (2%) and Southern Piedmont Glade and Barrens (0%).

Several coastal plain peatland, marshes and swamps were well secured: Atlantic Coastal Plain Peatland Pocosin and Canebrake (99%), Atlantic Coastal Plain Northern Bog (72%), Atlantic Coastal Plain Embayed Region Tidal Freshwater/Brackish Marsh (69%), and North Atlantic Coastal Plain Basin Peat Swamp (54%). Large river floodplains ranged from 9% to 25%. The least secured wetlands were mostly Piedmont habitats including shrub swamp, lake floodplain forest, freshwater marsh, and small floodplain, which were all less than 6% secured.

Stream and River Securement

The results indicate that just over 22,572 acres of riparian buffer has been permanently secured against conversion to development; 15% of all the riparian area in the region (Figure 3). Five percent was secured primarily for nature (GAP1-2) and 10% was secured for multiple use. The vast majority of this secured acreage, 83%, was associated with small headwaters and creeks. This would be expected given that these small streams make up most of the miles of stream and river systems in the region.

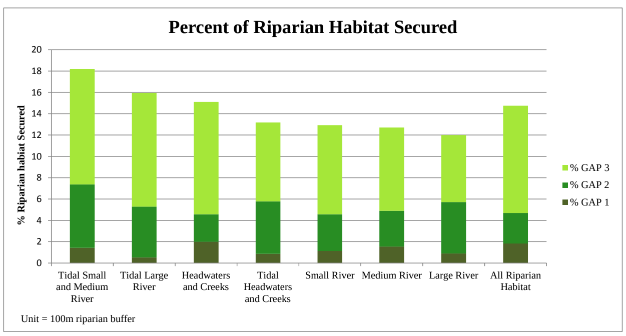
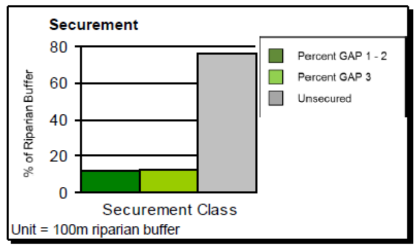


Figure 3. Stream and river macrogroups by percent of riparian habitat secured from development.

Considering the stream and river macrogroups, the amount of secured lands in the riparian buffer ranged from 12 to 18% (Figure 3). Tidal small and medium rivers had the highest percentages of secured lands in their riparian area followed by tidal large rivers which highlighted the focus of conservation efforts to protect the ecological rich tidal wetlands and marshes that are found in these settings. Headwaters and creeks also had higher levels of securement than the small to large freshwater rivers. Large freshwater rivers had the lowest amount of riparian secured lands. Many of these large river riparian settings are highly desirable as agricultural lands and as places for roads and other development.

The tables and charts in the Northeast Habitat Guide pages (Anderson et al. 2013) present the riparian secured land information for each stream and river type. For example the chart and table (Figure 4) for moderate gradient, cold, small rivers shows 11% of the riparian area in GAP 1-2, 13% in GAP 3, and 76% in unsecured land. The detailed table shows the acreage of the riparian area across the states. New York had the highest percentage of the riparian area for this river type secured with 40% secured, and Vermont the least with only 8% secured. We caution that although the data were consistently collected and are accurate for comparisons across states, all numbers should be thought of as rough estimates.



State Distribution: ME, NH, NY, VT

Total Habitat (mi): 2,352

% Conserved: 23.8 Unit = Acres of 100m Riparian Buffer

State	State Habitat %	Miles of Habitat	Acres GAP 1 - 2	Acres GAP 3	Total Acres Unsecured
ME	43	1032	37	90	526
NY	28	671	123	46	255
VT	19	460	3	18	271
NH	9	223	7	36	99

Figure 4.This is an example from the Northeast Habitat Guide for moderate gradient, cold, small rivers. Each fact sheet details the distribution of stream and river habitats and securement information by each state.

Comparing trends across stream and river habitat types, some interesting differences in securement can be seen between streams and rivers by their temperature and gradient class (Table 6). For example, all of the cold headwater through river types had securement levels above the regional average (15%), while none of the cool and warm streams or rivers had greater than 13.7% securement. This highlights the geographic distribution of secured lands (Map 1) where a larger amount of the high elevation and northern areas of the region are currently secured. Six of the seven types with less than 10% securement are warm headwater through river types, which highlights the need for more focused attention to ensure adequate levels of securement along these warm stream and river types.

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Detailed Methods and Sources:

The TNC secured land data set is compiled annually from over sixty sources (TNC 2011). For the most part, it is a combination of public land information maintained by each state, and private conservation land information compiled by the Nature Conservancy's state field offices. Nature Conservancy staff in each state office compile the dataset for their state, assign the securement status to each tract, and fill out the other standard fields. The completed state datasets are then compiled by the regional science office and quality checked for consistency and discrepancies.

Sources:

- Maine
  Maine Chapter of The Nature Conservancy The Maine Conservation Lands Geodatabase.
- New Hampshire
  New Hampshire Chapter of The Nature Conservancy with NH GRANIT Conservation/Public Lands Data.
- Vermont
  The Vermont Conservation Lands Database with the Spatial Analysis Laboratory (SAL) University of Vermont working in cooperation with the Vermont Agency of Natural Resources, the Vermont Housing and Conservation Board, the Vermont Land Trust , The Nature Conservancy, the Green Mountain National Forest, regional planning commissions, and community land trusts throughout the state.
- Massachusetts
  Executive Office of Energy and Environmental Affairs, Office of Geographic and Environmental Information (MassGIS).
- Rhode Island
  Local & NGO Conservation and Park Lands layer, The State of Rhode Island Department of Environmental Management-State Conservation and Park Lands layer.
- Connecticut
  Office of Policy and Management- Municipal and Private Open Space, Connecticut Department of Environmental Protection DEP Property.
- New York
  New York DEC, New York DEP, New York OPRHP, New York State Civil and Public Boundaries, The Nature Conservancy survey information, and local land trusts. NYS Parks and Historic Sites Boundaries, NYSDEC Division of Lands & Forests, NYC DEP Property - Division of Lands & Forests, Land Trust data : Open Space Institute, Albany County Land Conservancy, Agricultural Stewardship Association, Finger Lakes Land Trust, Lake George Land Conservancy, Hudson Highlands Land Trust, Rondout Esopus Land Conservancy, Wallkill Valley Land Trust, Inc., Shawangunk Conservancy, Genesee Land Trust, Scenic Hudson, Inc., Tug Hill Tomorrow Land Trust, Mohonk Preserve, Saratoga PLAN .
- Pennsylvania
  PA GAP Analysis Program's Managed Lands, Pennsylvania Game Commission Pennsylvania - State Game Lands, Pennsylvania Department of Conservation and Natural Resources, Bureau of Forestry Pennsylvania - State Forest Lands, Pennsylvania Department of

Conservation and Natural Resources, Bureau of State Parks Pennsylvania State Parks, County Government Pennsylvania - Country Parcel.
(the basis for TNC fee and eased lands polygons) Date Acquired: Chester County (2001), Clinton County (2003), Elk County (2005), Juniata County (2007), Lancaster County (2001), Monroe County (2006), Northampton County (2004), Pike County (2005), Venango County (2004), Wayne County (2003), Western Pennsylvania Conservancy, Natural Lands Trust Pennsylvania - Northeast Pennsylvania Protected Lands Inventory.
Organizations include: Countryside Conservancy, Delaware Highlands Conservancy, Lackawanna Valley Conservancy, North Branch Land Trust, Pocono Heritage Land Trust, Wildlands Conservancy.

- New Jersey
  New Jersey – PSEG Power Company properties that TNC manages, NJDEP and Office of Policy, Planning and Science (OPPS) New Jersey - Highlands Regulatory Area- as described by the Highlands Water Protection and Planning Act of 2004, New Jersey Pinelands Commission New Jersey - Pinelands Regulatory Areas, NJDEP, New Jersey - Green Acres Program, New Jersey Department of Agriculture (NJDA) and State Agriculture Development Committee (SADC)-New Jersey - Farmland Preservation.
- Delaware
  Delaware - Conservation Easements, DNREC Division of Parks and Recreation Delaware - Nature Preserves, DNREC Division of Parks and Recreation Delaware Outdoor Recreation Inventory, Delaware Forest Service Delaware Forestry Easement.
- Maryland
  Maryland Department of Agriculture Maryland - Agricultural Land Preservation Foundation Easements/Districts (MALPF), MD DNR Maryland - County Parks, MD DNR Maryland - DNR Lands, Maryland Environmental Trust Maryland - Environmental Trust Easements, MD DNR Maryland - Federal Lands, MD DNR Maryland - Forest Legacy Easements, MD DNR Maryland - Private Conservation Properties.
- West Virginia
  West Virginia Chapter of The Nature Conservancy Secured Lands 2007.
- Virginia
  Virginia Department of Conservation & Recreation Virginia - Conservation Lands Database.

Table 4. Securement of the upland habitats in the Northeast, sorted by securement within patch type.

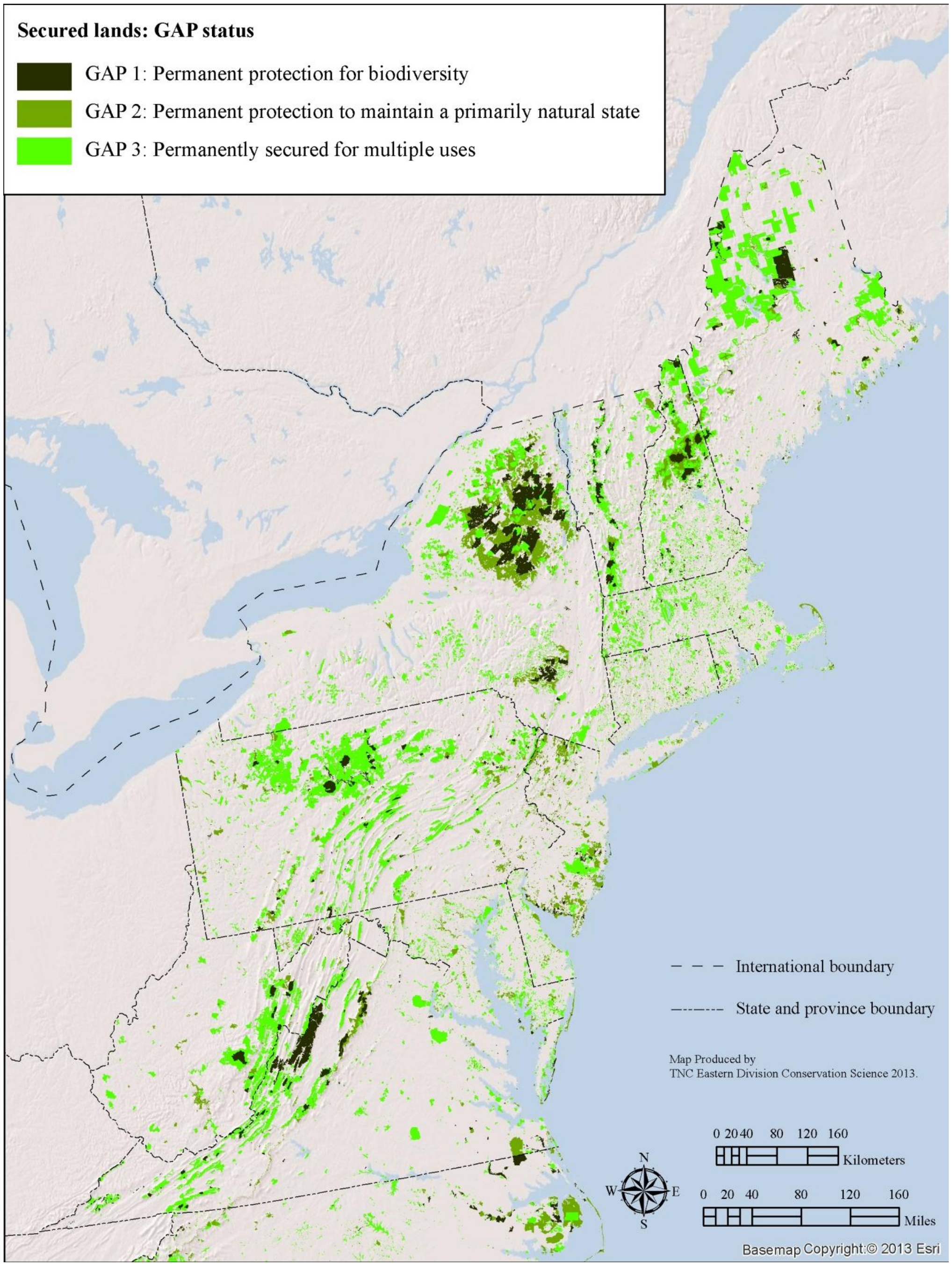
Patch types	Upland Macrogroup	Habitat Summary Group	% Conserved
Matrix	Boreal Upland Forest	Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest	68%
Matrix	Central Oak-Pine	North Atlantic Coastal Plain Pitch Pine Barrens	48%
Matrix	Northern Hardwood & Conifer	Laurentian-Acadian Northern Hardwood Forest	38%
Matrix	Central Oak-Pine	Central Appalachian Dry Oak-Pine Forest	34%
Matrix	Boreal Upland Forest	Acadian Low Elevation Spruce-Fir-Hardwood Forest	27%
Matrix	Northern Hardwood & Conifer	Appalachian (Hemlock)-Northern Hardwood Forest	20%
Matrix	Central Oak-Pine	Northeastern Interior Dry-Mesic Oak Forest	19%
Matrix	Central Oak-Pine	North Atlantic Coastal Plain Hardwood Forest	16%
Matrix	Northern Hardwood & Conifer	Northeastern Coastal and Interior Pine-Oak Forest	16%
Matrix	Northern Hardwood & Conifer	Laurentian-Acadian Pine-Hemlock-Hardwood Forest	15%
Matrix	Central Oak-Pine	Southern Appalachian Oak Forest	13%
Matrix	Northern Hardwood & Conifer	Southern Atlantic Coastal Plain Mesic Hardwood Forest	12%
Matrix	Central Oak-Pine	Allegheny-Cumberland Dry Oak Forest and Woodland	8%
Matrix	Northern Hardwood & Conifer	Southern Piedmont Mesic Forest	3%
Matrix	Central Oak-Pine	Southern Piedmont Dry Oak-Pine Forest	3%
Patch: forest	Northern Hardwood & Conifer	Southern Appalachian Northern Hardwood Forest	91%
Patch: forest	Southern Oak-Pine	Central Atlantic Coastal Plain Maritime Forest	89%
Patch: forest	Boreal Upland Forest	Central and Southern Appalachian Spruce-Fir Forest	87%
Patch: forest	Central Oak-Pine	Southern Appalachian Montane Pine Forest and Woodland	70%
Patch: forest	Central Oak-Pine	Central and Southern Appalachian Montane Oak Forest	63%
Patch: forest	Central Oak-Pine	Central Appalachian Pine-Oak Rocky Woodland	38%
Patch: forest	Northern Hardwood & Conifer	Southern and Central Appalachian Cove Forest	33%
Patch: forest	Boreal Upland Forest	Acadian Sub-boreal Spruce Flat	30%
Patch: forest	Central Oak-Pine	Northeastern Interior Pine Barrens	28%
Patch: forest	Central Oak-Pine/Longleaf Pine	Southern Atlantic Coastal Plain Upland Longleaf Pine Woodland	27%
Patch: forest	Central Oak-Pine	North Atlantic Coastal Plain Maritime Forest	21%
Patch: forest	Northern Hardwood & Conifer	Laurentian-Acadian Red Oak-Northern Hardwood Forest	19%
Patch: forest	Central Oak-Pine	Southern Ridge and Valley / Cumberland Dry Calcareous Forest	10%
Patch: forest	Northern Hardwood & Conifer	Glacial Marine & Lake Mesic Clayplain Forest	8%
Patch: forest	Southern Oak-Pine	Southern Appalachian Low Elevation Pine Forest	7%
Patch: forest	Northern Hardwood & Conifer	North-Central Interior Beech-Maple Forest	7%
Patch: forest	Northern Hardwood & Conifer	South-Central Interior Mesophytic Forest	4%
Patch: forest	Northern Hardwood & Conifer	Laurentian-Acadian Northern Pine-(Oak) Forest	4%
Patch: forest	Central Oak-Pine	Piedmont Hardpan Woodland and Forest	2%
Patch: edaphic	Alpine	Acadian-Appalachian Alpine Tundra	98%
Patch: edaphic	Outcrop & Summit Scrub	Southern Appalachian Grass and Shrub Bald	71%
Patch: edaphic	Coastal Grassland & Shrubland	Great Lakes Dune and Swale	65%
Patch: edaphic	Glade, Barren and Savanna	Appalachian Shale Barrens	62%
Patch: edaphic	Outcrop & Summit Scrub	Acidic Rocky Outcrop	56%
Patch: edaphic	Outcrop & Summit Scrub	Calcareous Rocky Outcrop	52%
Patch: edaphic	Cliff and Talus	Calcareous Cliff and Talus	48%
Patch: edaphic	Cliff and Talus	Acidic Cliff and Talus	48%
Patch: edaphic	Glade, Barren and Savanna	Southern and Central Appalachian Mafic Glade and Barrens	41%
Patch: edaphic	Coastal Grassland & Shrubland	Atlantic Coastal Plain Beach and Dune	39%
Patch: edaphic	Cliff and Talus	Circumneutral Cliff and Talus	36%
Patch: edaphic	Coastal Grassland & Shrubland	North Atlantic Coastal Plain Heathland and Grassland	30%
Patch: edaphic	Outcrop & Summit Scrub	Southern Piedmont Granite Flatrock and Outcrop	29%
Patch: edaphic	Glade, Barren and Savanna	Eastern Serpentine Woodland	20%
Patch: edaphic	Rocky Coast	Acadian-North Atlantic Rocky Coast	18%
Patch: edaphic	Glade, Barren and Savanna	Great Lakes Alvar	12%
Patch: edaphic	Glade, Barren and Savanna	Central Appalachian Alkaline Glade and Woodland	12%
Patch: edaphic	Glade, Barren and Savanna	Southern Ridge and Valley Calcareous Glade and Woodland	10%
Patch: edaphic	Glade, Barren and Savanna	Southern Piedmont Glade and Barrens	0%

Table 5. Securement of the wetland habitats sorted by securement and patch type.

Wetland Macrogroup	Habitat Summary Group	% Conserved
Coastal Plain Peatland	Atlantic Coastal Plain Peatland Pocosin and Canebrake	99%
Coastal Plain Peatland	Atlantic Coastal Plain Northern Bog	72%
Tidal Marsh	Atlantic Coastal Plain Embayed Region Tidal Freshwater/Brackish Ma	69%
Coastal Plain Swamp	North Atlantic Coastal Plain Basin Peat Swamp	54%
Northern Swamp	High Allegheny Headwater Wetland	52%
Coastal Plain Swamp	North Atlantic Coastal Plain Pitch Pine Lowland	52%
Coastal Plain Swamp	Central Atlantic Coastal Plain Non-riverine Swamp and Wet Hardwoo	48%
Tidal Marsh	North Atlantic Coastal Plain Tidal Salt Marsh	46%
Northern Peatland	Boreal-Laurentian Bog	41%
Northern Peatland	North-Central Interior and Appalachian Acidic Peatland	38%
Northern Swamp	Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp	38%
Northern Peatland	Boreal-Laurentian-Acadian Acidic Basin Fen	34%
Coastal Plain Swamp	Southern Atlantic Coastal Plain Tidal Wooded Swamp	34%
Coastal Plain Swamp	North Atlantic Coastal Plain Tidal Swamp	30%
Wet Meadow / Shrub Marsh	Laurentian-Acadian Wet Meadow-Shrub Swamp	26%
Large River Floodplain	Laurentian-Acadian Large River Floodplain	25%
Northern Peatland	Laurentian-Acadian Alkaline Fen	24%
Tidal Marsh	Acadian Coastal Salt and Estuary Marsh	24%
Northern Peatland	Acadian Maritime Bog	22%
Emergent Marsh	Laurentian-Acadian Freshwater Marsh	22%
Large River Floodplain	North Atlantic Coastal Plain Large River Floodplain	20%
Large River Floodplain	North-Central Appalachian Large River Floodplain	20%
Northern Swamp	Laurentian-Acadian Alkaline Conifer-Hardwood Swamp	20%
Northern Swamp	North-Central Appalachian Acidic Swamp	19%
Coastal Plain Swamp	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest	19%
Large River Floodplain	North-Central Interior Large River Floodplain	16%
Tidal Marsh	North Atlantic Coastal Plain Brackish/Fresh & Oligohaline Tidal Mars	15%
Northern Swamp	North-Central Interior and Appalachian Rich Swamp	12%
Central Hardwood Swamp	Glacial Marine & Lake Wet Clayplain Forest	9%
Large River Floodplain	Piedmont-Coastal Plain Large River Floodplain	9%
Central Hardwood Swamp	Central Interior Highlands and Appalachian Sinkhole and Depression F	8%
Central Hardwood Swamp	North-Central Interior Wet Flatwoods	8%
Wet Meadow / Shrub Marsh	Piedmont-Coastal Plain Shrub Swamp	7%
Southern Bottomland Forest	Southern Piedmont Lake Floodplain Forest	6%
Emergent Marsh	Piedmont-Coastal Plain Freshwater Marsh	6%
Southern Bottomland Forest	Atlantic Coastal Plain Blackwater/Brownwater Stream Floodplain For	6%
Southern Bottomland Forest	Southern Piedmont Small Floodplain and Riparian Forest	6%
Coastal Plain Swamp	North Atlantic Coastal Plain Stream and River	5%
Central Hardwood Swamp	Piedmont Upland Depression Swamp	5%
Northern Swamp	Central Appalachian Stream and Riparian	3%

Table 6. Securement of the stream and river habitats in the Northeast in a 100m riparian buffer.

Macrogroup	Habitat Type	% Conserved
Medium River	Cold, Medium River	36%
Headwaters and Creeks	Low Gradient, Cold, Headwaters and Creeks	29%
Headwaters and Creeks	High Gradient, Cold, Headwaters and Creeks	26%
Small River	Low Gradient, Cold, Small River	25%
Small River	Moderate Gradient, Cold, Small River	24%
Tidal Small and Medium River	Tidal Small and Medium River	18%
Headwaters and Creeks	Moderate Gradient, Cold, Headwaters and Creeks	18%
Tidal Large River	Tidal Large River	16%
Medium River	Cool, Medium River	14%
Small River	Low Gradient, Cool, Small River	13%
Tidal Headwaters and Creeks	Tidal Headwaters and Creeks	13%
Headwaters and Creeks	High Gradient, Cool, Headwaters and Creeks	13%
Large River	Cool, Large River	12%
Large River	Warm, Large River	12%
Headwaters and Creeks	Low Gradient, Cool, Headwaters and Creeks	11%
Small River	Moderate Gradient, Cool, Small River	11%
Small River	Low Gradient, Warm, Small River	9%
Headwaters and Creeks	Low Gradient, Warm, Headwaters and Creeks	9%
Medium River	Warm, Medium River	9%
Small River	Moderate Gradient, Warm, Small River	8%
Headwaters and Creeks	Moderate Gradient, Cool, Headwaters and Creeks	8%
Headwaters and Creeks	High Gradient, Warm, Headwaters and Creeks	6%
Headwaters and Creeks	Moderate Gradient, Warm, Headwaters and Creeks	4%



Map 1. Secured lands of the Northeast United States.

Local Connectedness

Definition.

An estimate of the degree of permeability, or conversely the degree of resistance, surrounding each cell in the region. We summarized this metric into a habitat connectedness index.

Why is Local Connectedness Important?

The natural world constantly rearranges, and climate change is expected to accelerate natural dynamics, shifting seasonal temperature and precipitation patterns and altering disturbance cycles of fire, wind, drought, and flood. To stay in synch with these changes wildlife and plant populations need to adjust their ranges, migrating and reestablishing in more favorable conditions. Most of this movement is expected to take place in local neighborhoods (e.g. shifting from a hot southern slope to a cool north facing cove) but over time some shifts will happen on a larger scale. During rapid periods of climate change in the Quaternary, when the landscape was highly connected by continuous natural cover, there were many shifts in species distributions, but few extinctions (Botkin et al. 2007). Now, however, pervasive landscape fragmentation disrupts ecological processes and impedes the ability of many species to respond, move, or adapt to changes. The concern is that broad-scale degradation will result from the impaired ability of nature to adjust to rapid change, creating a world dominated by depleted environments and weedy generalist species.

The Northeast and Mid-Atlantic region is crisscrossed by over 732,000 miles of roads, enough to circle the earth 29 times. Not surprisingly, fragmentation, combined with habitat loss, poses one of the greatest challenges to conserving biodiversity in a changing climate. The need to maintain connectivity has emerged as a point of agreement among scientists (Heller and Zavaleta 2009, Krosby et al. 2010).

We prefer the term 'permeability' instead of 'connectivity' because the metric is not based on individual species movements, but is a measure of landscape structure: the hardness of barriers, the connectedness of natural cover, and the arrangement of land uses. It is defined as the degree to which regional landscapes, encompassing a variety of natural, semi-natural and developed landcover types, will sustain ecological processes and be conducive to the movement of organisms (modified from Meiklejohn et al. 2010). Maintaining a permeable landscape, in conjunction with protecting and restoring sufficient areas of high quality habitat, should facilitate the persistence of species.

Methods

We used a resistant kernel algorithm designed to measure the connectedness of a focal cell to its ecological neighborhood when the cell is viewed as a source of movement radiating out in all directions. (Compton et al. 2007). It was built on the assumption that the permeability of two adjacent cells increases with their ecological similarity and decreases with their contrast. Contrasting elements were scored with resistance weights to reflect differences in structure, composition, degree of development, or use. The theoretical spread of a species or process outward from a focal cell is a function of the resistance values of the neighboring cells and their distance from the focal cell, out to a maximum distance of three kilometers (Figure 5).

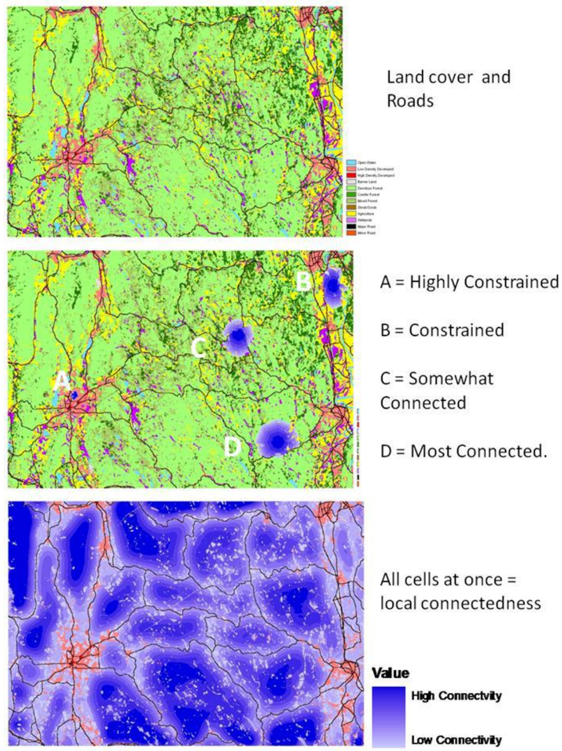


Figure 5. Graphical description of how the local connectedness was calculated.

Our resistance surface was based on a classified land use map with roads and railroads embedded into the grid (NLCD 2001, Tele Atlas North America 2012). We simplified the landcover into six basic elements and assigned resistance weights to each category based on a version of Compton's (2007) similarity index, where natural land was given the lowest resistance weight (10) and high intensity developed land was given the highest weight (100). Minor roads were overlaid on the grid and added 10 points of resistance to the cell containing them. We tested the sensitivity of the outcomes to the resistance weights by running the analysis for three test areas, and systematically changing the weights. The final weights were as follows (NLCD classes in parenthesis): 10 = natural lands and water (evergreen, deciduous, and mixed forest, shrub/scrub, grassland, woody and herbaceous wetland, water); 50 = non-natural barrens (barren); 80 = agricultural or modified lands (pasture, cultivated); 90 = low intensity development (developed open space, low intensity developed); 100 = high intensity development (medium intensity developed, high intensity developed, major roads). We aggregated the 30 m resistance surface to a grid of 90 meter cells to reduce the considerable processing time, before running the resistant kernel algorithm and computing the score for each cell. Cell scores ranged from 0 to 1 and were converted to a scale of 0 to 100 for comparability with low scores for highly fragmented and high scores for high local connectedness (see Figure 6 for two example areas).

Figure 6. **Local connectedness:** the image on the left has a mean score of 23 for the area under the circle and the one on the right has a mean score of 43 for the area under the circle. A pristine area would score "100".

Results

The region's habitats had a wide range of results with respect to connectedness, ranging the very intact mountain spruce-fir forests of the Laurentian Acadian region (LC=85) to the highly fragmented hardpan woodlands of the Piedmont (LC= 10). We generated individual charts for each habitat that can be found in the Northeast Habitat Guide (Anderson et al. 2013).

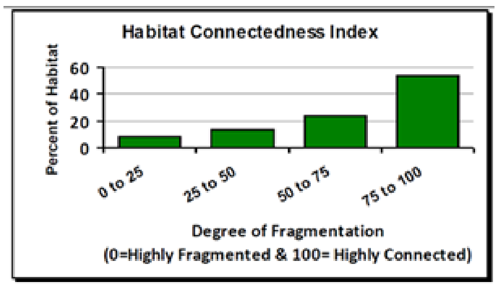


Figure 7. This is an example from the Northeast Habitat Guide for Acadian Sub-Boreal Spruce Flats showing the proportion of the habitat in each connectedness class.

To create the charts (Figure 7), we calculated the connectedness score for every cell of each habitat and classified each cell into a four class index (0-25, 25-50, 50-75, 75-100) where 0 = highly fragmented and 100 = highly connected.

The charts summarize the information as the percent of the habitat in each connectedness class. Figure 7 for Acadian Sub-Boreal Spruce Flat indicates that 50% of the habitat is in a highly connected, unfragmented state (class 75-100), and less that 10% is highly fragmented.

Results across all Terrestrial Habitats (map 2, 14)

Outcrops, summits, boreal forests and northern hardwood forest had the highest local connectedness of the upland habitat ranging from 67 to a high of 85 for Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest (Table 7). At the low end were coastal plain, Piedmont and maritime communities, with the lowest five ranging from 10 to 22. Piedmont Hardpan Woodland and Forest (10), and the very small-patch Serpentine Woodlands (11) emerge as the two habitats with the most fragmentation.

Wetland results were comparable to the uplands with northern peatlands and northern swamps having the highest connectedness along with the coastal plain pocosons and the northern large river floodplains (Table 8). Collectively the top five scores ranged from 52 to 74. The widespread Laurentian-Acadian Freshwater Marsh (30) and the Laurentian-Acadian Wet Meadow/Shrub Swamp (41.0) both scored average. At the fragmented end were the North-Central Interior Flatwoods and the very small patch sinkhole and depression ponds, both scoring between 10-11.

Streams and River Habitats

The local catchments of streams and rivers had an average local terrestrial connectedness score of 28. By macrogroup, the connectedness scores decreased from a high in headwaters and creeks (29) to a low for tidal small and medium rivers, tidal large rivers, and large freshwater rivers at 20 (Figure 8). Considering the more detailed stream types, all six cold stream and river types have the most connected local catchments with scores above 36, reflecting the more intact terrestrial conditions in northern and high elevation areas where cold streams and rivers are found (Table 9). At the lower end below a score of 20, were warm and cool streams and rivers. Moderate gradient cool headwaters and creeks scored the lowest followed by warm large rivers, low gradient warm headwaters and creeks, moderate gradient warm small rivers, moderate gradient cool small rivers, and warm medium rivers. These results highlight the development of housing, roads, and agriculture which limit terrestrial system connectivity near many of the cool and warm rivers and near many of the warm moderate and low gradient streams in the region.

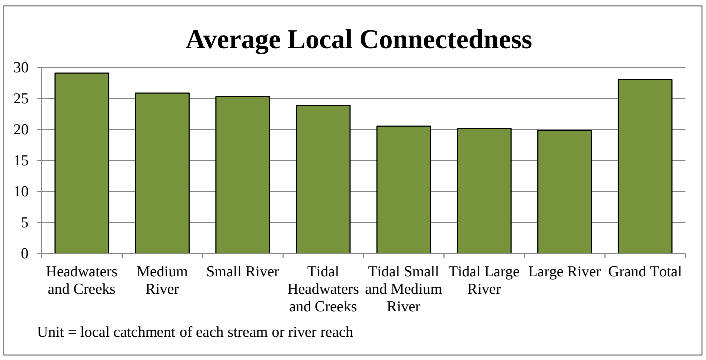


Figure 8. Local connectedness scores for the stream and river habitats macrogroups.

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Table 7. Local connectedness in the upland habitats.

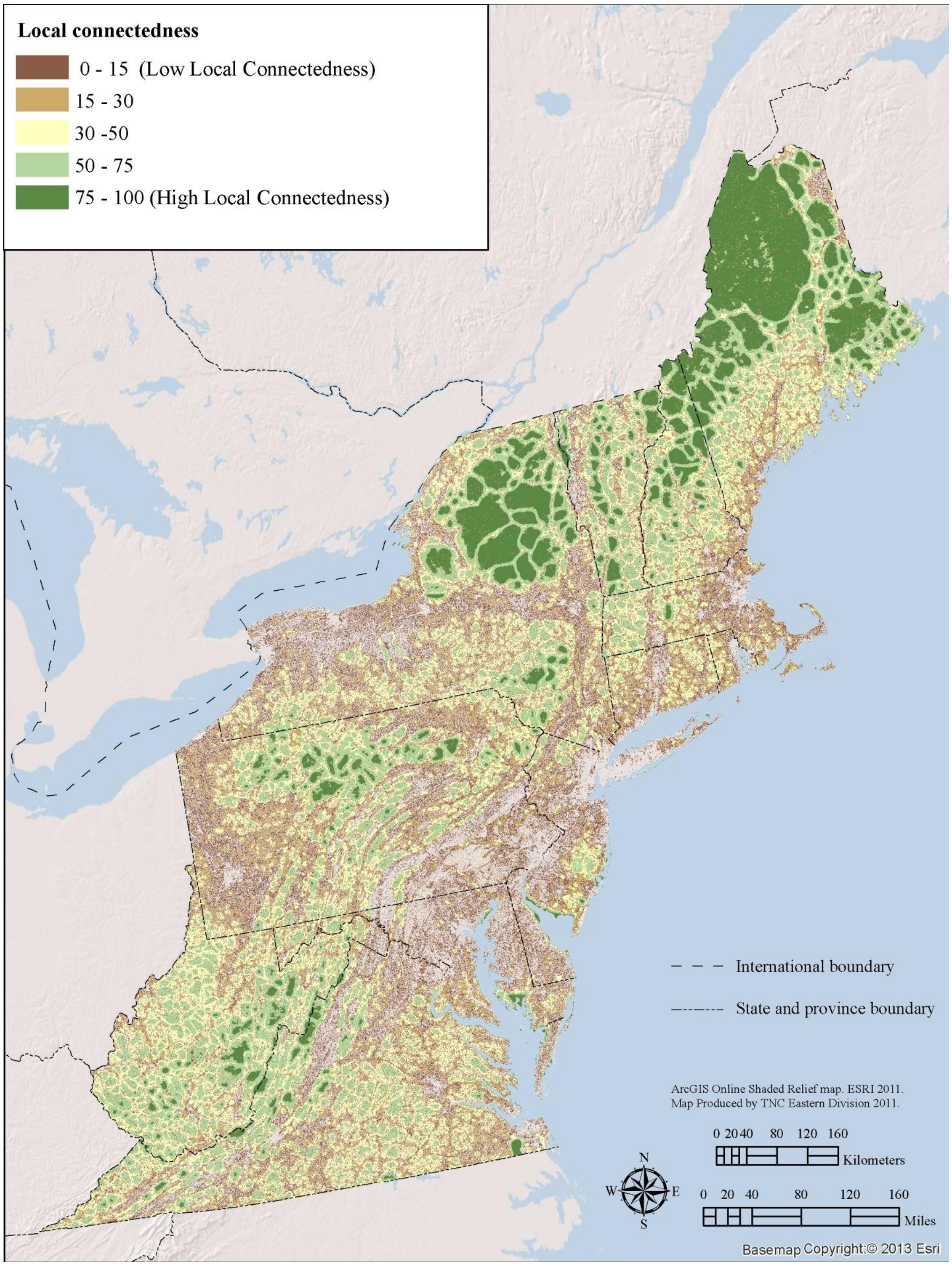
Patch Type	Upland Macrogroup	Habitat Summary Group	Average Local Connectedness
Matrix	Boreal Upland Forest	Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest	85.0
Matrix	Northern Hardwood & Conifer	Laurentian-Acadian Northern Hardwood Forest	68.3
Matrix	Boreal Upland Forest	Acadian Low Elevation Spruce-Fir-Hardwood Forest	67.1
Matrix	Central Oak-Pine	Allegheny-Cumberland Dry Oak Forest and Woodland	45.3
Matrix	Northern Hardwood & Conifer	Laurentian-Acadian Pine-Hemlock-Hardwood Forest	44.1
Matrix	Central Oak-Pine	Central Appalachian Dry Oak-Pine Forest	43.6
Matrix	Central Oak-Pine	Southern Appalachian Oak Forest	42.7
Matrix	Northern Hardwood & Conifer	Appalachian (Hemlock)-Northern Hardwood Forest	34.9
Matrix	Central Oak-Pine	Northeastern Interior Dry-Mesic Oak Forest	32.4
Matrix	Northern Hardwood & Conifer	Southern Piedmont Mesic Forest	30.1
Matrix	Central Oak-Pine	Southern Piedmont Dry Oak-Pine Forest	29.7
Matrix	Northern Hardwood & Conifer	Northeastern Coastal and Interior Pine-Oak Forest	25.4
Matrix	Central Oak-Pine	North Atlantic Coastal Plain Pitch Pine Barrens	24.6
Matrix	Northern Hardwood & Conifer	Southern Atlantic Coastal Plain Mesic Hardwood Forest	22.6
Matrix	Central Oak-Pine	North Atlantic Coastal Plain Hardwood Forest	19.6
Patch: forest	Boreal Upland Forest	Central and Southern Appalachian Spruce-Fir Forest	69.9
Patch: forest	Boreal Upland Forest	Acadian Sub-boreal Spruce Flat	69.6
Patch: forest	Northern Hardwood & Conifer	Southern Appalachian Northern Hardwood Forest	62.6
Patch: forest	Central Oak-Pine	Southern Appalachian Montane Pine Forest and Woodland	60.4
Patch: forest	Central Oak-Pine	Central and Southern Appalachian Montane Oak Forest	56.3
Patch: forest	Northern Hardwood & Conifer	Laurentian-Acadian Red Oak-Northern Hardwood Forest	51.4
Patch: forest	Northern Hardwood & Conifer	Southern and Central Appalachian Cove Forest	48.9
Patch: forest	Central Oak-Pine	Central Appalachian Pine-Oak Rocky Woodland	44.2
Patch: forest	Southern Oak-Pine	Southern Appalachian Low Elevation Pine Forest	39.3
Patch: forest	Northern Hardwood & Conifer	South-Central Interior Mesophytic Forest	37.9
Patch: forest	Central Oak-Pine	Northeastern Interior Pine Barrens	34.5
Patch: forest	Northern Hardwood & Conifer	Laurentian-Acadian Northern Pine-(Oak) Forest	32.7
Patch: forest	Central Oak-Pine	Southern Ridge and Valley / Cumberland Dry Calcareous Forest	31.0
Patch: forest	Central Oak-Pine	North Atlantic Coastal Plain Maritime Forest	25.8
Patch: forest	Northern Hardwood & Conifer	Glacial Marine & Lake Mesic Clayplain Forest	25.2
Patch: forest	Northern Hardwood & Conifer	North-Central Interior Beech-Maple Forest	25.1
Patch: forest	Southern Oak-Pine	Central Atlantic Coastal Plain Maritime Forest	24.4
Patch: forest	Central Oak-Pine/Longleaf Pine	Southern Atlantic Coastal Plain Upland Longleaf Pine Woodland	21.5
Patch: forest	Central Oak-Pine	Piedmont Hardpan Woodland and Forest	10.1
Patch: edaphic	Outcrop & Summit Scrub	Southern Appalachian Grass and Shrub Bald	76.6
Patch: edaphic	Outcrop & Summit Scrub	Acidic Rocky Outcrop	75.8
Patch: edaphic	Outcrop & Summit Scrub	Calcareous Rocky Outcrop	74.7
Patch: edaphic	Cliff and Talus	Calcareous Cliff and Talus	62.9
Patch: edaphic	Cliff and Talus	Acidic Cliff and Talus	56.0
Patch: edaphic	Glade, Barren and Savanna	Appalachian Shale Barrens	46.9
Patch: edaphic	Alpine	Acadian-Appalachian Alpine Tundra	45.8
Patch: edaphic	Cliff and Talus	Circumneutral Cliff and Talus	43.3
Patch: edaphic	Glade, Barren and Savanna	Southern and Central Appalachian Mafic Glade and Barrens	37.7
Patch: edaphic	Outcrop & Summit Scrub	Southern Piedmont Granite Flatrock and Outcrop	34.2
Patch: edaphic	Glade, Barren and Savanna	Southern Ridge and Valley Calcareous Glade and Woodland	33.9
Patch: edaphic	Glade, Barren and Savanna	Southern Piedmont Glade and Barrens	33.0
Patch: edaphic	Glade, Barren and Savanna	Central Appalachian Alkaline Glade and Woodland	31.1
Patch: edaphic	Coastal Grassland & Shrubland	Great Lakes Dune and Swale	29.7
Patch: edaphic	Glade, Barren and Savanna	Great Lakes Alvar	28.6
Patch: edaphic	Rocky Coast	Acadian-North Atlantic Rocky Coast	24.3
Patch: edaphic	Coastal Grassland & Shrubland	North Atlantic Coastal Plain Heathland and Grassland	22.3
Patch: edaphic	Coastal Grassland & Shrubland	Atlantic Coastal Plain Beach and Dune	11.0
Patch: edaphic	Glade, Barren and Savanna	Eastern Serpentine Woodland	10.9

Table 8. Local connectedness in the wetland habitats.

Wetland Macrogroup	Habitat Summary Group	Average Local Connectedness
Northern Peatland	Boreal-Laurentian Bog	74.1
Northern Peatland	Boreal-Laurentian-Acadian Acidic Basin Fen	70.6
Northern Swamp	Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp	67.2
Coastal Plain Peatland	Atlantic Coastal Plain Peatland Pocosin and Canebrake	66.8
Large River Floodplain	Laurentian-Acadian Large River Floodplain	52.1
Northern Peatland	Acadian Maritime Bog	50.7
Northern Swamp	High Allegheny Headwater Wetland	49.0
Northern Swamp	Laurentian-Acadian Alkaline Conifer-Hardwood Swamp	48.9
Coastal Plain Swamp	Central Atlantic Coastal Plain Non-riverine Swamp and Wet Hardwood Forest	45.9
Tidal Marsh	North Atlantic Coastal Plain Tidal Salt Marsh	45.0
Tidal Marsh	Atlantic Coastal Plain Embayed Region Tidal Freshwater/Brackish Marsh	44.8
Wet Meadow / Shrub Marsh	Laurentian-Acadian Wet Meadow-Shrub Swamp	41.0
Northern Peatland	Laurentian-Acadian Alkaline Fen	39.1
Coastal Plain Peatland	Atlantic Coastal Plain Northern Bog	35.2
Large River Floodplain	Piedmont-Coastal Plain Large River Floodplain	34.5
Coastal Plain Swamp	North Atlantic Coastal Plain Tidal Swamp	33.5
Northern Peatland	North-Central Interior and Appalachian Acidic Peatland	33.0
Southern Bottomland Forest	Southern Piedmont Small Floodplain and Riparian Forest	32.9
Emergent Marsh	Laurentian-Acadian Freshwater Marsh	30.9
Coastal Plain Swamp	North Atlantic Coastal Plain Basin Peat Swamp	30.3
Wet Meadow / Shrub Marsh	Piedmont-Coastal Plain Shrub Swamp	30.2
Coastal Plain Swamp	North Atlantic Coastal Plain Pitch Pine Lowland	29.5
Tidal Marsh	Acadian Coastal Salt and Estuary Marsh	28.8
Coastal Plain Swamp	Southern Atlantic Coastal Plain Tidal Wooded Swamp	28.3
Tidal Marsh	North Atlantic Coastal Plain Brackish/Fresh & Oligohaline Tidal Marsh	27.2
Southern Bottomland Forest	Southern Piedmont Lake Floodplain Forest	26.3
Northern Swamp	Central Appalachian Stream and Riparian	25.8
Large River Floodplain	North Atlantic Coastal Plain Large River Floodplain	25.6
Central Hardwood Swamp	Glacial Marine & Lake Wet Clayplain Forest	24.7
Northern Swamp	North-Central Appalachian Acidic Swamp	24.3
Southern Bottomland Forest	Atlantic Coastal Plain Blackwater/Brownwater Stream Floodplain Forest	23.9
Coastal Plain Swamp	North Atlantic Coastal Plain Stream and River	23.6
Emergent Marsh	Piedmont-Coastal Plain Freshwater Marsh	20.7
Large River Floodplain	North-Central Interior Large River Floodplain	20.0
Central Hardwood Swamp	Piedmont Upland Depression Swamp	19.6
Large River Floodplain	North-Central Appalachian Large River Floodplain	18.0
Coastal Plain Swamp	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest	18.0
Northern Swamp	North-Central Interior and Appalachian Rich Swamp	17.3
Central Hardwood Swamp	Central Interior Highlands and Appalachian Sinkhole and Depression Pond	11.4
Central Hardwood Swamp	North-Central Interior Wet Flatwoods	10.7

Table 9. Local connectedness in the stream and river habitats.

Macrogroup	Habitat Type	Average Local Connectedness
Headwaters and Creeks	Low Gradient, Cold, Headwaters and Creeks	68.4
Medium River	Cold, Medium River	60.9
Small River	Low Gradient, Cold, Small River	55.5
Small River	Moderate Gradient, Cold, Small River	51.4
Headwaters and Creeks	High Gradient, Cold, Headwaters and Creeks	39.3
Headwaters and Creeks	Moderate Gradient, Cold, Headwaters and Creeks	36.4
Large River	Cool, Large River	29.4
Headwaters and Creeks	High Gradient, Cool, Headwaters and Creeks	28.4
Headwaters and Creeks	High Gradient, Warm, Headwaters and Creeks	27.3
Headwaters and Creeks	Low Gradient, Cool, Headwaters and Creeks	26.6
Medium River	Cool, Medium River	26.2
Tidal Headwaters and Creeks	Tidal Headwaters and Creeks	23.9
Small River	Low Gradient, Warm, Small River	20.8
Headwaters and Creeks	Moderate Gradient, Warm, Headwaters and Creeks	20.7
Tidal Small and Medium River	Tidal Small and Medium River	20.6
Tidal Large River	Tidal Large River	20.2
Medium River	Warm, Medium River	19.9
Small River	Moderate Gradient, Cool, Small River	19.2
Small River	Moderate Gradient, Warm, Small River	19.1
Small River	Low Gradient, Cool, Small River	17.2
Headwaters and Creeks	Low Gradient, Warm, Headwaters and Creeks	17.2
Large River	Warm, Large River	17.1
Headwaters and Creeks	Moderate Gradient, Cool, Headwaters and Creeks	14.0



Map 2. Local connectedness in the Northeastern United States.

Landscape Context Index

Definition

The Landscape Context Index (LCI) quantifies the degree of human conversion of natural landcover in the immediate neighborhood of that cell on the landscape.

Why is Landscape Context Important?

The local context of a habitat patch has a large influence on the viability, reproductive success, and quality of the available food and shelter resources to the wildlife and plants within the patch, but the individual species dynamics are complex (Tewksbury et al. 2006). It often appears that the smaller the habitat patch, the more dependent it is on the surrounding landscape for species inputs and processes, but exactly how the interactions work between the quality of a patch of habitat and the character of the landscape surrounding it is not well understood (Forman 1995, Lindenmayor and Fischer 2006.)

The landscape processes that sustain a habitat patch vary in space and time. Consider, for example the degradation of a pine barren habitat when fire regimes are altered, or the changes in the quality and composition of dune habitats when coastal revetments alter long-shore sand flows. Additionally, habitats differ in their landscape dependence, and some, such as raised bogs, perched wetlands, and rocky summits may be more dependent on atmospheric inputs for water and nutrients than on the surrounding landscape (Mitsch and Gosselink 2000).

NatureServe and the Natural Heritage network use a measure of landscape context as a factor in estimating the viability of a rare species or community, along with measures of size and condition. Based on this, The Nature Conservancy used the LCI metric as criteria for portfolio site selection after it was found to correlate closely to field estimates for landscape context provided by the Natural Heritage inventory records. The metric is most useful to small-patch habitats (TNC 2011).

Methods

This measure quantifies the relative amount of development, agriculture, quarries, roads, or other fragmenting features within an area directly surrounding each 30m cell of land. It is similar to the local connectedness metric, but searches a much smaller (about 1 km) area to provide an estimate of the isolation of, and current encroachments on, the cell. Base data layers included roads, high intensity developed lands, low intensity developed lands, agriculture, quarries, and natural cover. A LCI below 20 indicates that the occurrence is surrounded primarily by natural cover. Higher LCIs indicate increasing amounts of roads, development, and agriculture. The metric values range from 0 to 400 (Figure 9).

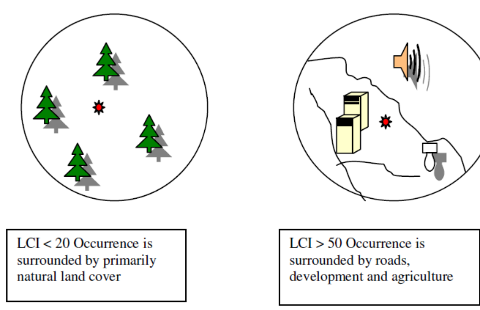


Figure 9. The context of the landscape around an occurrence will affect the health and survival of the occurrence.

We used the 2001 National Landcover Dataset (NLCD) for the region as the base data for this metric, a grid of 30 meter cells (Homer et al. 2007). We simplified the dataset by reclassifying landcover codes to 5 ranked values, integers from 0 to 400, indicating degree of landcover conversion (Table 10).

Table 10. Simplification of the NLCD 2006 to five landcover codes for use in the landscape context index.

Landcover codes	Landcover description	Reclassified to:
11	water	0 (natural)
21/22	low intensity developed	300 (low intensity devel'd)
23/24	med-high intensity residential/	400 (med to high intensity developed)
31	open bare	0 (natural)
41/42/43	decid/conif/mixed forest	0 (natural)
52/71	shrublands/grasslands	0 (natural)
81/82	Pasture/hay & cropland	200 (agricultural)
90	forested wetland	0 (natural)
95	emergent wetland	0 (natural)

We used a grid "focalmean" on the reclassified landcover data for a 1000 acre circular window. This procedure assigns to each cell in the output grid an average of the reclassified landcover values (which, again, range from 0/natural to 400/intensely developed) for all cells within a 1140m radius of that cell. For each minor road bounded block we calculated zonal statistics for the landscape context index grid to determine the average landscape context index value for the minor road bounded block.

Results

Terrestrial Habitats (map 3, 15)

The mean LCI score for the natural habitats in the region ranged from a best score of 1.1 to a worst score of 140 with an average of 41. The latter was somewhat lower than the score for all lands in the region with developed and agricultural lands included (LCI=68). Upland habitats (LCI=40) had a lower average score than the wetland habitats (LCI=55). High elevation forests and patch systems scored the best with alpine, outcrops and summits, and northern spruce fir habitats all had scores below 10. The Glade, Barren, and Savanna macrogroup scored the worse with an average LCI of 62. The Piedmont Hardpan Forest (111) and Eastern Serpentine Woodland (103) were the only terrestrial habitats to score over 100 (Table 11).

Peatlands scored the best among wetlands, with Atlantic Coastal Plain Peatland Pocosin and Canebrake (LCI=1), Boreal-Laurentian Bog (LCI=4), Boreal-Laurentian-Acadian Acidic Basin Fen (LCI=7), and Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp (LCI=12) all with scores below 15(Table 12). The habitats with the poorest scores included two of the limestone-related habitats: North-Central Interior and Appalachian Rich Swamp (LCI=92) and Central Interior Highlands and Appalachian Sinkhole and Depression Pond (LCI=140). Also scoring poorly were the North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest (LCI=92) and North-Central Interior Wet Flatwoods (LCI=122).

Streams and Rivers:

Stream and river local catchments have an overall LCI value of 72 out of the maximum 400 (very developed). By macrogroup, tidal headwaters and creeks, large rivers, and tidal small and medium rivers have the highest scores, indicating their local catchments are in settings more altered by roads, agriculture, and development (Figure 10). The lowest scoring, most intact, macrogroups are headwaters and creeks and tidal large rivers. Although smaller tidal river and creek systems are more highly impacted, the local catchments directly adjacent to large tidal rivers are more intact possibly because these catchments are often mostly made of up tidal wetlands where development is not possible. By detailed habitat type (Table 13), the six cold stream and river types have the lowest scores with low gradient cold headwaters and creeks (LCI=16) at the top and all six scoring under 51. These types are in the more northern and higher elevation areas, where there has been less development. High gradient warm and high gradient cool headwaters and creeks followed the cold types. These types also have highly intact local catchments which might be explained by physical limitations on local development given their steeper topography. Cool medium rivers, tidal large rivers, moderate gradient warm headwaters and creeks and cool large rivers also scored in the upper half of all types. These types are more impacted than the cold types and high gradient streams, but overall they are less impacted than many of the other warm and cool stream and river types. The most impacted type was moderate gradient cool headwaters and creeks (LCI=104) followed by low gradient cool small rivers, low gradient warm headwaters and creeks, warm large rivers, tidal headwaters and creeks, and warm medium rivers, and tidal small and medium rivers, which all had scores above 85. These types should be studied more intensively to determine how development in the local catchments adjacent to these streams and rivers is affecting aquatic organisms and stream health.

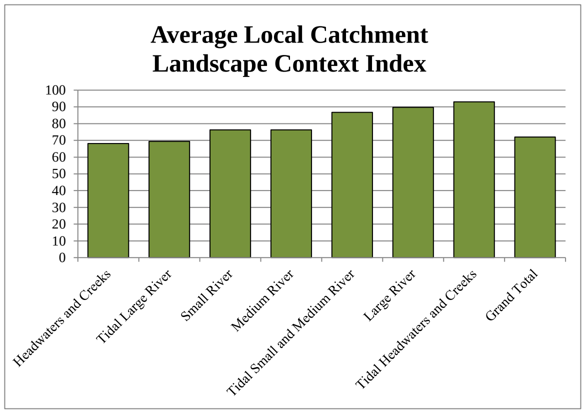


Figure 10.Average local catchment landscape condition index by macrogroup.

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Table 11. Landscape context index in the upland habitats.

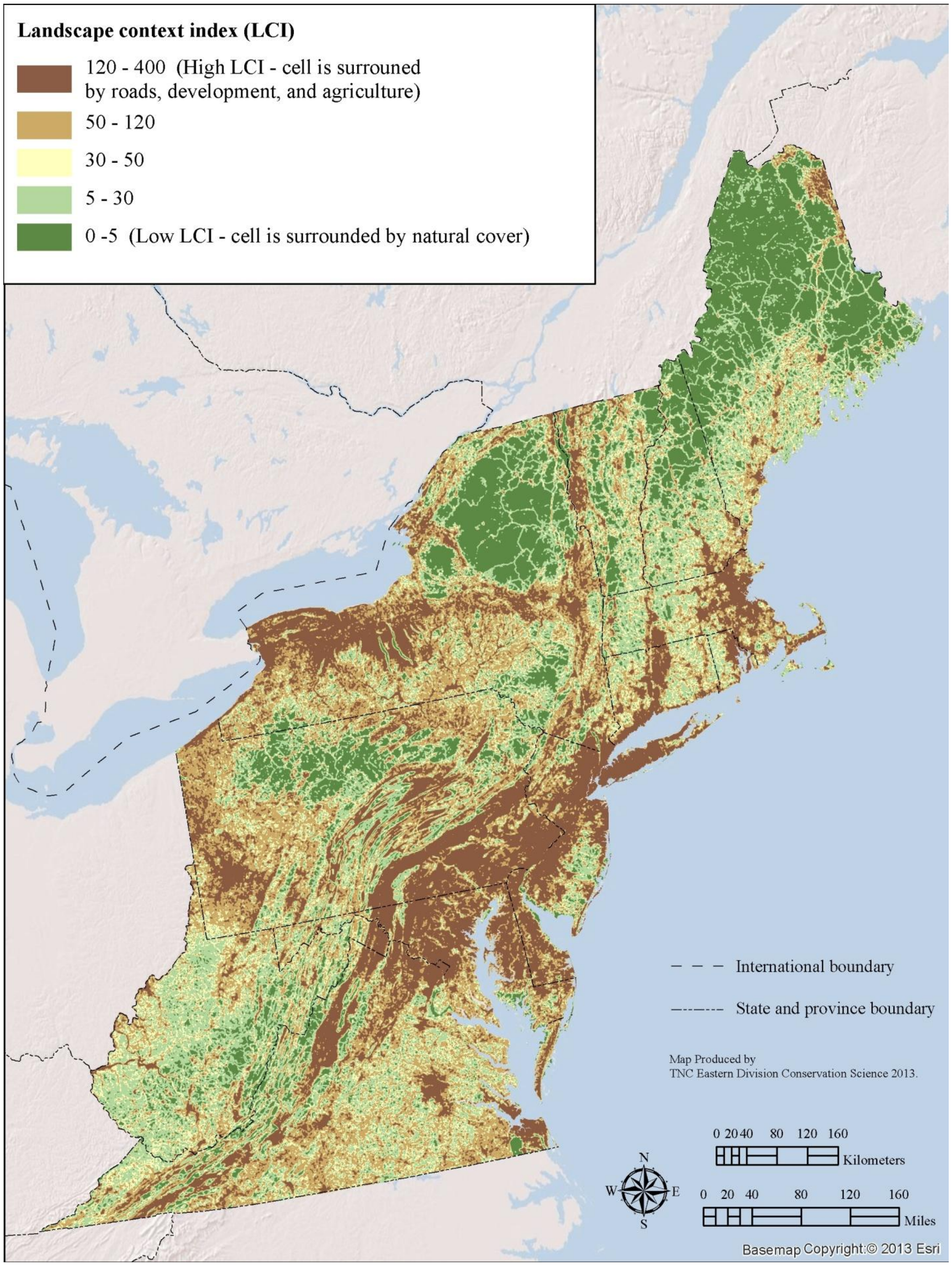
Patch Type	Macrogroup	Habitat Summary Group	Average Landscape Context Index
Matrix	Boreal Upland Forest	Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest	1.3
Matrix	Northern Hardwood & Conifer	Laurentian-Acadian Northern Hardwood Forest	10.0
Matrix	Boreal Upland Forest	Acadian Low Elevation Spruce-Fir-Hardwood Forest	11.3
Matrix	Central Oak-Pine	Allegheny-Cumberland Dry Oak Forest and Woodland	29.9
Matrix	Northern Hardwood & Conifer	Laurentian-Acadian Pine-Hemlock-Hardwood Forest	30.1
Matrix	Central Oak-Pine	Central Appalachian Dry Oak-Pine Forest	32.8
Matrix	Central Oak-Pine	Southern Appalachian Oak Forest	35.8
Matrix	Northern Hardwood & Conifer	Appalachian (Hemlock)-Northern Hardwood Forest	48.3
Matrix	Central Oak-Pine	Southern Piedmont Dry Oak-Pine Forest	52.7
Matrix	Central Oak-Pine	Northeastern Interior Dry-Mesic Oak Forest	55.0
Matrix	Northern Hardwood & Conifer	Southern Piedmont Mesic Forest	58.7
Matrix	Central Oak-Pine	North Atlantic Coastal Plain Pitch Pine Barrens	60.8
Matrix	Northern Hardwood & Conifer	Northeastern Coastal and Interior Pine-Oak Forest	61.5
Matrix	Northern Hardwood & Conifer	Southern Atlantic Coastal Plain Mesic Hardwood Forest	75.5
Matrix	Central Oak-Pine	North Atlantic Coastal Plain Hardwood Forest	83.8
Patch: forest	Boreal Upland Forest	Central and Southern Appalachian Spruce-Fir Forest	5.5
Patch: forest	Boreal Upland Forest	Acadian Sub-boreal Spruce Flat	9.4
Patch: forest	Central Oak-Pine	Central and Southern Appalachian Montane Oak Forest	13.2
Patch: forest	Central Oak-Pine	Southern Appalachian Montane Pine Forest and Woodland	14.0
Patch: forest	Northern Hardwood & Conifer	Southern Appalachian Northern Hardwood Forest	15.6
Patch: forest	Northern Hardwood & Conifer	Laurentian-Acadian Red Oak-Northern Hardwood Forest	19.9
Patch: forest	Northern Hardwood & Conifer	Southern and Central Appalachian Cove Forest	20.8
Patch: forest	Central Oak-Pine	Central Appalachian Pine-Oak Rocky Woodland	28.7
Patch: forest	Central Oak-Pine	Northeastern Interior Pine Barrens	36.8
Patch: forest	Northern Hardwood & Conifer	South-Central Interior Mesophytic Forest	41.1
Patch: forest	Southern Oak-Pine	Southern Appalachian Low Elevation Pine Forest	42.1
Patch: forest	Central Oak-Pine/Longleaf Pine	Southern Atlantic Coastal Plain Upland Longleaf Pine Woodland	43.2
Patch: forest	Northern Hardwood & Conifer	Laurentian-Acadian Northern Pine-(Oak) Forest	51.9
Patch: forest	Southern Oak-Pine	Central Atlantic Coastal Plain Maritime Forest	65.7
Patch: forest	Central Oak-Pine	Southern Ridge and Valley / Cumberland Dry Calcareous Forest	66.7
Patch: forest	Northern Hardwood & Conifer	North-Central Interior Beech-Maple Forest	68.8
Patch: forest	Central Oak-Pine	North Atlantic Coastal Plain Maritime Forest	68.9
Patch: forest	Northern Hardwood & Conifer	Glacial Marine & Lake Mesic Clayplain Forest	72.6
Patch: forest	Central Oak-Pine	Piedmont Hardpan Woodland and Forest	111.4
Patch: edaphic	Alpine	Acadian-Appalachian Alpine Tundra	3.6
Patch: edaphic	Outcrop & Summit Scrub	Acidic Rocky Outcrop	4.1
Patch: edaphic	Outcrop & Summit Scrub	Calcareous Rocky Outcrop	7.2
Patch: edaphic	Outcrop & Summit Scrub	Southern Appalachian Grass and Shrub Bald	10.3
Patch: edaphic	Cliff and Talus	Acidic Cliff and Talus	17.0
Patch: edaphic	Cliff and Talus	Calcareous Cliff and Talus	17.8
Patch: edaphic	Glade, Barren and Savanna	Appalachian Shale Barrens	30.6
Patch: edaphic	Glade, Barren and Savanna	Southern and Central Appalachian Mafic Glade and Barrens	33.1
Patch: edaphic	Cliff and Talus	Circumneutral Cliff and Talus	33.1
Patch: edaphic	Coastal Grassland & Shrubland	Great Lakes Dune and Swale	35.8
Patch: edaphic	Glade, Barren and Savanna	Southern Ridge and Valley Calcareous Glade and Woodland	40.0
Patch: edaphic	Rocky Coast	Acadian-North Atlantic Rocky Coast	42.9
Patch: edaphic	Coastal Grassland & Shrubland	Atlantic Coastal Plain Beach and Dune	48.3
Patch: edaphic	Outcrop & Summit Scrub	Southern Piedmont Granite Flatrock and Outcrop	48.7
Patch: edaphic	Glade, Barren and Savanna	Central Appalachian Alkaline Glade and Woodland	61.6
Patch: edaphic	Glade, Barren and Savanna	Southern Piedmont Glade and Barrens	64.8
Patch: edaphic	Glade, Barren and Savanna	Great Lakes Alvar	66.2
Patch: edaphic	Coastal Grassland & Shrubland	North Atlantic Coastal Plain Heathland and Grassland	74.3
Patch: edaphic	Glade, Barren and Savanna	Eastern Serpentine Woodland	102.5

Table 12. Landscape context index for the wetland habitats of the northeastern United States.

Patch type	Macrogroup	Habitat Summary Group	Average Landscape Context Index
Wetland	Coastal Plain Peatland	Atlantic Coastal Plain Peatland Pocosin and Canebrake	● 1.1
Wetland	Northern Peatland	Boreal-Laurentian Bog	● 4.0
Wetland	Northern Peatland	Boreal-Laurentian-Acadian Acidic Basin Fen	● 7.5
Wetland	Northern Swamp	Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp	● 11.2
Wetland	Northern Peatland	Acadian Maritime Bog	● 14.2
Wetland	Tidal Marsh	Atlantic Coastal Plain Embayed Region Tidal Freshwater/Brackish Marsh	● 25.5
Wetland	Large River Floodplain	Laurentian-Acadian Large River Floodplain	● 27.1
Wetland	Northern Swamp	Laurentian-Acadian Alkaline Conifer-Hardwood Swamp	◕ 31.0
Wetland	Coastal Plain Peatland	Atlantic Coastal Plain Northern Bog	◕ 40.5
Wetland	Northern Swamp	High Allegheny Headwater Wetland	◕ 41.0
Wetland	Tidal Marsh	Acadian Coastal Salt and Estuary Marsh	◕ 41.2
Wetland	Northern Peatland	Laurentian-Acadian Alkaline Fen	◕ 42.8
Wetland	Tidal Marsh	North Atlantic Coastal Plain Tidal Salt Marsh	◕ 45.1
Wetland	Coastal Plain Swamp	North Atlantic Coastal Plain Basin Peat Swamp	◕ 45.8
Wetland	Large River Floodplain	Piedmont-Coastal Plain Large River Floodplain	◕ 46.5
Wetland	Northern Peatland	North-Central Interior and Appalachian Acidic Peatland	◕ 47.3
Wetland	Coastal Plain Swamp	North Atlantic Coastal Plain Pitch Pine Lowland	◕ 47.8
Wetland	Wet Meadow / Shrub Marsh	Laurentian-Acadian Wet Meadow-Shrub Swamp	◕ 48.0
Wetland	Coastal Plain Swamp	Central Atlantic Coastal Plain Non-riverine Swamp and Wet Hardwood Forest	◕ 48.2
Wetland	Southern Bottomland Forest	Southern Piedmont Small Floodplain and Riparian Forest	◕ 56.1
Wetland	Coastal Plain Swamp	North Atlantic Coastal Plain Tidal Swamp	◑ 60.1
Wetland	Wet Meadow / Shrub Marsh	Piedmont-Coastal Plain Shrub Swamp	◑ 60.3
Wetland	Coastal Plain Swamp	Southern Atlantic Coastal Plain Tidal Wooded Swamp	◑ 63.3
Wetland	Large River Floodplain	North-Central Interior Large River Floodplain	◑ 69.7
Wetland	Emergent Marsh	Laurentian-Acadian Freshwater Marsh	◑ 69.8
Wetland	Central Hardwood Swamp	Glacial Marine & Lake Wet Clayplain Forest	◑ 70.7
Wetland	Northern Swamp	Central Appalachian Stream and Riparian	◑ 71.0
Wetland	Southern Bottomland Forest	Atlantic Coastal Plain Blackwater/Brownwater Stream Floodplain Forest	◑ 71.1
Wetland	Northern Swamp	North-Central Appalachian Acidic Swamp	◑ 74.2
Wetland	Southern Bottomland Forest	Southern Piedmont Lake Floodplain Forest	◑ 78.0
Wetland	Large River Floodplain	North Atlantic Coastal Plain Large River Floodplain	◑ 78.8
Wetland	Coastal Plain Swamp	North Atlantic Coastal Plain Stream and River	◑ 82.6
Wetland	Large River Floodplain	North-Central Appalachian Large River Floodplain	◔ 86.0
Wetland	Emergent Marsh	Piedmont-Coastal Plain Freshwater Marsh	◔ 86.6
Wetland	Central Hardwood Swamp	Piedmont Upland Depression Swamp	◔ 87.5
Wetland	Tidal Marsh	North Atlantic Coastal Plain Brackish/Fresh & Oligohaline Tidal Marsh	◔ 90.4
Wetland	Northern Swamp	North-Central Interior and Appalachian Rich Swamp	◔ 91.5
Wetland	Coastal Plain Swamp	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest	◔ 92.4
Wetland	Central Hardwood Swamp	North-Central Interior Wet Flatwoods	○ 122.4
Wetland	Central Hardwood Swamp	Central Interior Highlands and Appalachian Sinkhole and Depression Pond	○ 139.5

Table 13. Landscape context index for the stream and river habitats.

Macrogroup	Habitat Type	Average Landscape Context Index
Headwaters and Creeks	Low Gradient, Cold, Headwaters and Creeks	15.9
Medium River	Cold, Medium River	21.1
Small River	Low Gradient, Cold, Small River	25.3
Small River	Moderate Gradient, Cold, Small River	28.9
Headwaters and Creeks	High Gradient, Cold, Headwaters and Creeks	39.9
Headwaters and Creeks	Moderate Gradient, Cold, Headwaters and Creeks	50.7
Headwaters and Creeks	High Gradient, Warm, Headwaters and Creeks	55.1
Headwaters and Creeks	High Gradient, Cool, Headwaters and Creeks	56.4
Medium River	Cool, Medium River	66.4
Tidal Large River	Tidal Large River	69.4
Headwaters and Creeks	Moderate Gradient, Warm, Headwaters and Creeks	76.0
Large River	Cool, Large River	76.2
Small River	Low Gradient, Warm, Small River	79.7
Headwaters and Creeks	Low Gradient, Cool, Headwaters and Creeks	81.6
Small River	Moderate Gradient, Cool, Small River	83.3
Small River	Moderate Gradient, Warm, Small River	84.1
Tidal Small and Medium River	Tidal Small and Medium River	86.7
Medium River	Warm, Medium River	89.4
Tidal Headwaters and Creeks	Tidal Headwaters and Creeks	93.0
Large River	Warm, Large River	93.6
Headwaters and Creeks	Low Gradient, Warm, Headwaters and Creeks	93.8
Small River	Low Gradient, Cool, Small River	96.6
Headwaters and Creeks	Moderate Gradient, Cool, Headwaters and Creeks	103.7



Map 3. Map showing the landscape context index in the northeastern United States.

Predicted Development

Definition.

The acres of a habitat predicted to be developed over the next 50 years.

Why is Habitat Loss to Development Important?

Development is perhaps the largest and most permanent threat to natural systems. In the U.S., more than 34 million acres of open space were lost to development between 1982 and 2001, about 6,000 acres per day, 4 acres a minute. Of this loss, over 10 million acres were in forestland. Rapid development of forestland is expected to continue over the next couple of decades bringing not only direct destruction of habitat, but also people, roads, noise and pollution (http://www.fs.fed.us/projects/four-threats).

High density development of natural habitats can change local hydrology, increase recreation pressure, introduce invasive species either by design or by accident with the introduction of vehicles, and bring significant disturbance to the area, Moreover, urbanization, along with forest fragmentation, are inextricably linked to the effects of climate change, since the dispersal and movement of forest plants and animals are disrupted by development and roads (McDonnell and Pickett 1990).

Methods

We used future development predictions created by the Land Transformation Model (LTM) Version 3 developed by the Human-Environment Modeling and Analysis Laboratory at Purdue (Tayyebi et al 2013). In this model the quantity of urban growth at county and place (i.e. city) scales is simulated using population, urban density, and nearest neighbor dependent attributes. Future urban landcover is meant to serve as an example of one possible scenario of urban expansion. Future land use predictions were created in five year increments from 2010 to 2060 and used NLCD 2001 version 2 as the basis for projections.

For each decade (2010, 2020, 2030, 2040, 2050, and 2060), each grid was re-classified into three values: 1) developed or Agriculture in 2001, 2) natural in 2001 natural in 2060 3) natural in 2001 developed in 2060 (see table 14 below for exact values). For each habitat, the total amount of remaining habitat was calculated for each decade by overlaying the habitat with the habitat grid. For the minor road bounded blocks, we used 2060 as a benchmark, and measured the transition from natural habitat in the habitat map to developed in the 2060 predictions. Each minor block was attributed with information on the total acres developed in 2060 as well as the amount developed in 2060.

Original Grid Value	Original Value Description	Reclassed Value
11	Open Water	1
12	Ice/Snow	1
21	Developed, Open Space	0
22	Developed, Low Intensity	0
23	Developed, Medium Intensity	0
24	Developed, High Intensity	0
31	Barren Land	1
41	Deciduous Forest	1
42	Evergreen Forest	1
43	Mixed Forest	1
52	Scrub/Shrub	1
71	Grasslands	1
81	Pasture/Hay	0
82	Cultivated Crops	0
90	Woody Wetlands	1
90	Emergent Herbaceous Wetlands	1
131	Transitioned to urban from original category barren	2
141	Transitioned to urban from original category Deciduous Forest	2
142	Transitioned to urban from original category Evergreen Forest	2
143	Transitioned to urban from original category Mixed Forest	2
152	Transitioned to urban from original category Scrub/shrub	2
171	Transitioned to urban from original category Grasslands	2
181	Transitioned to urban from original category Pasture/hay	0
182	Transitioned to urban from original category Cultivated Crops	0
190	Transitioned to urban from original category Woody Wetlands	2
195	Transitioned to urban from original category Emergent Herbacous Wetlands	2

Table 14 shows the starting NLCD landcover code and its reclassified value into developed or agricultural, natural, or in transition. Pixel values below 99 represent NLCD 2001 V2 classes. Values above 100 are those that transitioned to urban that year. For example of 143 would represent mixed forest (2001 value = 43) that transitioned to urban. These areas are simply "urban" and no distinction is made between low, medium, and high density urban like there was in the 2001 NLCD data.

Results

The average estimated amount of conversion to development for all natural habitats was just under 5% for the period between 2010 and 2060. Uplands (5% loss) face less predicted development than wetlands (10% loss). The types of habitat affected reflect the general pattern of future development in the region, which is concentrated in the coastal plain, valley bottoms, and low elevations.

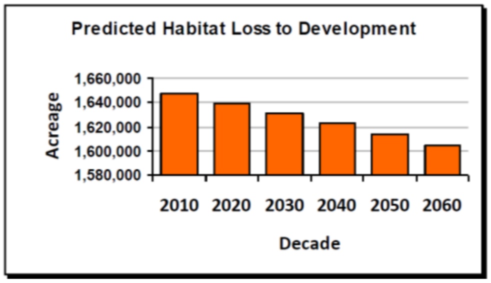


Figure 11. This is an example from the Northeast Habitat Guide for Piedmont Dry Oak showing the total amount of habitat remaining in each decade.

The charts in the northeast habitat guides (Anderson et al. 2013) present the information by actual acreage for each habitat. For example, a chart of predicted development in the Southern Piedmont Dry Oak-Pine Forest (Figure 11) suggests that we are losing 848 acres a year to development, which could amount to 42,000 acres over the next 50 years.

We calculated this metric for all habitats, but we caution users that some interpretation is needed. The predicted development data is modeled regional data and may not be as fine scaled as habitat data. Thus, for small habitats the analysis largely reflects the surrounding landscape.

Terrestrial Habitats (map 4, 16)

The five most threatened upland habitats are all in the coastal plain. The North Atlantic Coastal Plain Heathland and Grassland (22% loss), Maritime Forest (23% loss), and Hardwood Forest (14% loss) are estimated to lose substantial acreage (Table 15). Of these, the latter is one of the dominant matrix-forming forest types and the estimated actual acreage loss is huge: 296,000 acres. Central Atlantic Coastal Plain Maritime Forest (20% loss) and the small-patch Serpentine Woodlands (17% loss) are also in the five most threatened. At the reverse end, most of the montane forest habitats and the small patch outcrop, summit, cliff and flatrock habitats are estimated to have little loss to development in the next 50 years. The ten most threatened wetland habitats include a variety of habitats, but tidal habitats, flatwoods, floodplains and swamps figure prominantly. The greatest absolute loss (109,524 ac) is estimated for the North-Central Appalachian Acidic Swamp (8% loss) (Table 16). The tidal wetland on the south shore of the James rivers (North Atlantic Coastal Plain Brackish/Fresh and Oligohaline) is predicted to lose almost one-fifth (17% loss) of its current extent. Peatlands, it would seem, are mostly free from development pressure with four types of Northern Peatland (0.2% – 0.4% loss) and one Coastal Plain Peatland, Atlantic Coastal Plain Peatland Pocoson and canebreak (0.01% loss) having the least estimated development.

Stream and River Habitats

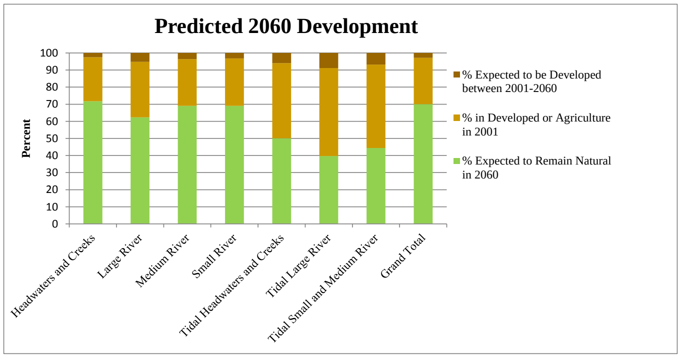


Figure 12. Percent local catchment predicted to be developed by 2060 by macrogroups.

Results highlight a progression across stream and river macrogroups of increasing future development as streams grow in size, highlighting that devevlopment in areas near larger rivers will continue to be highly desired (Figure 12). Comparing freshwater vs. tidal habitat types, tidal types currently have the most development in their local catchments and are expected to continue to have high losses to development.
The six habitats predicted to remain the most intact are all cold water systems (5% to 21% loss), suggesting that development pressure in the northern and high elevation areas of our region will continue to be lower than in the lower elevation, coastal, and more southern portion (Table 17). The habitats where development in the local catchments is predicted to climb above 40% include the tidal habitat types, warm medium rivers, moderate gradient warm small rivers, warm large rivers, low gradient warm headwaters and creeks and moderate gradient cool headwaters and creeks. Many of these warm habitat types have current low levels of secured lands and they are again highlighted as areas where strategies related to mitigation of furture development, impervious surfaces, agricultural runoff, and procurement of secured lands may be particularly warranted in the future.

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Table 15. Predicted development in the upland habitats.

Patch type	Upland Macrogroup	Habitat Summary Group	Perdicted 2060 New Development (acres)	% of Habitat Predicted to Convert to Development by 2060
Matrix	Boreal Upland Forest	Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest	721	0.1%
Matrix	Northern Hardwood & Conifer	Laurentian-Acadian Northern Hardwood Forest	61,144	0.5%
Matrix	Boreal Upland Forest	Acadian Low Elevation Spruce-Fir-Hardwood Forest	39,751	0.7%
Matrix	Northern Hardwood & Conifer	Laurentian-Acadian Pine-Hemlock-Hardwood Forest	128,280	2.2%
Matrix	Central Oak-Pine	Central Appalachian Dry Oak-Pine Forest	84,793	2.2%
Matrix	Central Oak-Pine	Allegheny-Cumberland Dry Oak Forest and Woodland	53,276	2.4%
Matrix	Central Oak-Pine	Southern Appalachian Oak Forest	71,441	2.5%
Matrix	Central Oak-Pine	Southern Piedmont Dry Oak-Pine Forest	46,212	2.7%
Matrix	Northern Hardwood & Conifer	Southern Piedmont Mesic Forest	66,168	2.8%
Matrix	Northern Hardwood & Conifer	Appalachian (Hemlock)-Northern Hardwood Forest	720,710	3.5%
Matrix	Central Oak-Pine	Northeastern Interior Dry-Mesic Oak Forest	850,088	5.2%
Matrix	Northern Hardwood & Conifer	Southern Atlantic Coastal Plain Mesic Hardwood Forest	132,040	7.1%
Matrix	Northern Hardwood & Conifer	Northeastern Coastal and Interior Pine-Oak Forest	152,776	10.4%
Matrix	Central Oak-Pine	North Atlantic Coastal Plain Pitch Pine Barrens	55,868	12.1%
Matrix	Central Oak-Pine	North Atlantic Coastal Plain Hardwood Forest	296,037	14.6%
Patch: edaphic	Alpine	Acadian-Appalachian Alpine Tundra	0	0.0%
Patch: edaphic	Outcrop & Summit Scrub	Southern Piedmont Granite Flatrock and Outcrop	0	0.0%
Patch: edaphic	Outcrop & Summit Scrub	Southern Appalachian Grass and Shrub Bald	6	0.2%
Patch: edaphic	Outcrop & Summit Scrub	Calcareous Rocky Outcrop	122	0.2%
Patch: edaphic	Outcrop & Summit Scrub	Acidic Rocky Outcrop	693	0.4%
Patch: edaphic	Glade, Barren and Savanna	Southern Ridge and Valley Calcareous Glade and Woodland	121	1.3%
Patch: edaphic	Glade, Barren and Savanna	Great Lakes Alvar	521	1.9%
Patch: edaphic	Cliff and Talus	Calcareous Cliff and Talus	1,137	2.0%
Patch: edaphic	Cliff and Talus	Acidic Cliff and Talus	13,561	2.4%
Patch: edaphic	Glade, Barren and Savanna	Southern and Central Appalachian Mafic Glade and Barrens	36	2.5%
Patch: edaphic	Glade, Barren and Savanna	Southern Piedmont Glade and Barrens	3	3.2%
Patch: edaphic	Glade, Barren and Savanna	Appalachian Shale Barrens	159	3.2%
Patch: edaphic	Glade, Barren and Savanna	Central Appalachian Alkaline Glade and Woodland	13,661	3.4%
Patch: edaphic	Cliff and Talus	Circumneutral Cliff and Talus	3,295	5.9%
Patch: edaphic	Coastal Grassland & Shrubland	Great Lakes Dune and Swale	110	6.7%
Patch: edaphic	Coastal Grassland & Shrubland	Atlantic Coastal Plain Beach and Dune	10,692	12.3%
Patch: edaphic	Rocky Coast	Acadian-North Atlantic Rocky Coast	895	13.6%
Patch: edaphic	Glade, Barren and Savanna	Eastern Serpentine Woodland	1,896	17.0%
Patch: edaphic	Coastal Grassland & Shrubland	North Atlantic Coastal Plain Heathland and Grassland	6,775	23.1%
Patch: forest	Northern Hardwood & Conifer	Southern Appalachian Northern Hardwood Forest	0	0.0%
Patch: forest	Boreal Upland Forest	Central and Southern Appalachian Spruce-Fir Forest	63	0.1%
Patch: forest	Central Oak-Pine	Central and Southern Appalachian Montane Oak Forest	308	0.2%
Patch: forest	Central Oak-Pine	Southern Appalachian Montane Pine Forest and Woodland	123	0.4%
Patch: forest	Boreal Upland Forest	Acadian Sub-boreal Spruce Flat	5,715	0.4%
Patch: forest	Central Oak-Pine/Longleaf Pine	Southern Atlantic Coastal Plain Upland Longleaf Pine Woodland	3	0.5%
Patch: forest	Northern Hardwood & Conifer	Southern and Central Appalachian Cove Forest	9,058	0.9%
Patch: forest	Northern Hardwood & Conifer	Laurentian-Acadian Red Oak-Northern Hardwood Forest	15,203	1.3%
Patch: forest	Central Oak-Pine	Central Appalachian Pine-Oak Rocky Woodland	11,244	2.0%
Patch: forest	Northern Hardwood & Conifer	North-Central Interior Beech-Maple Forest	1,670	2.3%
Patch: forest	Northern Hardwood & Conifer	Laurentian-Acadian Northern Pine-(Oak) Forest	325	2.3%
Patch: forest	Northern Hardwood & Conifer	Glacial Marine & Lake Mesic Clayplain Forest	5,727	2.5%
Patch: forest	Central Oak-Pine	Northeastern Interior Pine Barrens	1,332	3.2%
Patch: forest	Southern Oak-Pine	Southern Appalachian Low Elevation Pine Forest	810	3.7%
Patch: forest	Central Oak-Pine	Southern Ridge and Valley / Cumberland Dry Calcareous Forest	35,860	4.0%
Patch: forest	Northern Hardwood & Conifer	South-Central Interior Mesophytic Forest	163,308	4.7%
Patch: forest	Central Oak-Pine	Piedmont Hardpan Woodland and Forest	4,393	9.1%
Patch: forest	Southern Oak-Pine	Central Atlantic Coastal Plain Maritime Forest	1,199	19.7%
Patch: forest	Central Oak-Pine	North Atlantic Coastal Plain Maritime Forest	25,328	22.1%

Table 16. Predicted development in the wetland habitats.

Wetland Macrogroup	Habitat Summary Group	Perdicted 2060 New Development (acres)	% of Habitat Predicted to Convert to Development by 2060
Coastal Plain Peatland	Atlantic Coastal Plain Peatland Pocosin and Canebrake	0	0.0%
Northern Peatland	Boreal-Laurentian Bog	71	0.2%
Northern Peatland	Laurentian-Acadian Alkaline Fen	1	0.3%
Northern Peatland	Acadian Maritime Bog	19	0.4%
Northern Peatland	Boreal-Laurentian-Acadian Acidic Basin Fen	1,566	0.4%
Northern Swamp	Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp	5,312	0.4%
Northern Swamp	High Allegheny Headwater Wetland	226	0.8%
Large River Floodplain	Laurentian-Acadian Large River Floodplain	4,134	1.0%
Northern Swamp	Central Appalachian Stream and Riparian	287	1.1%
Northern Swamp	Laurentian-Acadian Alkaline Conifer-Hardwood Swamp	11,012	1.2%
Tidal Marsh	Atlantic Coastal Plain Embayed Region Tidal Freshwater/Brackish Marsh	192	1.4%
Large River Floodplain	Piedmont-Coastal Plain Large River Floodplain	2,619	2.0%
Southern Bottomland Forest	Southern Piedmont Small Floodplain and Riparian Forest	4,062	2.2%
Northern Peatland	North-Central Interior and Appalachian Acidic Peatland	1,850	2.2%
Large River Floodplain	North-Central Interior Large River Floodplain	1,629	2.4%
Central Hardwood Swamp	Glacial Marine & Lake Wet Clayplain Forest	2,107	2.4%
Wet Meadow / Shrub Marsh	Piedmont-Coastal Plain Shrub Swamp	1,285	2.8%
Wet Meadow / Shrub Marsh	Laurentian-Acadian Wet Meadow-Shrub Swamp	28,050	2.9%
Tidal Marsh	Acadian Coastal Salt and Estuary Marsh	939	3.2%
Coastal Plain Swamp	North Atlantic Coastal Plain Basin Peat Swamp	2,111	3.7%
Coastal Plain Peatland	Atlantic Coastal Plain Northern Bog	208	4.0%
Coastal Plain Swamp	Southern Atlantic Coastal Plain Tidal Wooded Swamp	566	4.4%
Southern Bottomland Forest	Atlantic Coastal Plain Blackwater/Brownwater Stream Floodplain Forest	7,523	4.7%
Emergent Marsh	Laurentian-Acadian Freshwater Marsh	42,218	4.8%
Coastal Plain Swamp	Central Atlantic Coastal Plain Non-riverine Swamp and Wet Hardwood Forest	9,885	5.2%
Coastal Plain Swamp	North Atlantic Coastal Plain Pitch Pine Lowland	8,968	5.2%
Emergent Marsh	Piedmont-Coastal Plain Freshwater Marsh	2,596	5.8%
Central Hardwood Swamp	Piedmont Upland Depression Swamp	1,313	6.2%
Large River Floodplain	North-Central Appalachian Large River Floodplain	15,639	6.3%
Tidal Marsh	North Atlantic Coastal Plain Tidal Salt Marsh	61,075	6.7%
Coastal Plain Swamp	North Atlantic Coastal Plain Tidal Swamp	14,100	7.3%
Northern Swamp	North-Central Appalachian Acidic Swamp	109,514	7.5%
Coastal Plain Swamp	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest	71,938	7.6%
Northern Swamp	North-Central Interior and Appalachian Rich Swamp	62,124	7.7%
Coastal Plain Swamp	North Atlantic Coastal Plain Stream and River	2,289	8.1%
Large River Floodplain	North Atlantic Coastal Plain Large River Floodplain	3,679	10.9%
Southern Bottomland Forest	Southern Piedmont Lake Floodplain Forest	1,028	12.3%
Central Hardwood Swamp	Central Interior Highlands and Appalachian Sinkhole and Depression Pond	196	13.9%
Central Hardwood Swamp	North-Central Interior Wet Flatwoods	11,686	14.6%
Tidal Marsh	North Atlantic Coastal Plain Brackish/Fresh & Oligohaline Tidal Marsh	2,938	17.4%

Table 17. Predicted development for the stream and river habitats.

Macrogroup	Habitat	% of Habitat Predicted to Convert to Development by 2060	% of Local Catchment Habitat Expected to Remain Natural in 2060	% of Local Catchment Habitat Expected to be Developed between 2001-2060	% of Local Catchment Habitat in Developed or Agriculture in 2001
Headwaters and Creeks	Low Gradient, Cold, Headwaters and Creeks	4.6	95.4	0.4	4.2
Medium River	Cold, Medium River	6.1	93.9	1.0	5.1
Small River	Low Gradient, Cold, Small River	6.4	93.6	0.6	5.8
Small River	Moderate Gradient, Cold, Small River	11.7	88.3	1.2	10.6
Headwaters and Creeks	High Gradient, Cold, Headwaters and Creeks	16.2	83.8	1.2	15.0
Headwaters and Creeks	Moderate Gradient, Cold, Headwaters and Creeks	21.5	78.5	1.6	19.9
Headwaters and Creeks	High Gradient, Warm, Headwaters and Creeks	25.1	74.9	2.4	22.7
Headwaters and Creeks	High Gradient, Cool, Headwaters and Creeks	25.3	74.7	2.3	23.1
Large River	Cool, Large River	27.2	72.8	3.8	23.4
Medium River	Cool, Medium River	28.0	72.0	3.3	24.6
Headwaters and Creeks	Low Gradient, Cool, Headwaters and Creeks	32.2	67.8	3.4	28.8
Headwaters and Creeks	Moderate Gradient, Warm, Headwaters and Creeks	36.4	63.6	3.8	32.6
Small River	Moderate Gradient, Cool, Small River	36.5	63.5	4.0	32.6
Small River	Low Gradient, Cool, Small River	37.3	62.7	4.0	33.3
Small River	Low Gradient, Warm, Small River	38.5	61.5	4.1	34.4
Medium River	Warm, Medium River	40.6	59.4	4.5	36.1
Small River	Moderate Gradient, Warm, Small River	41.4	58.6	3.7	37.7
Large River	Warm, Large River	41.6	58.4	5.7	35.9
Headwaters and Creeks	Low Gradient, Warm, Headwaters and Creeks	45.7	54.3	4.2	41.5
Headwaters and Creeks	Moderate Gradient, Cool, Headwaters and Creeks	48.8	51.2	3.8	45.0
Tidal Headwaters and Creeks	Tidal Headwaters and Creeks	49.9	50.1	6.0	43.9
Tidal Small and Medium River	Tidal Small and Medium River	55.6	44.4	6.8	48.8
Tidal Large River	Tidal Large River	60.3	39.7	8.8	51.5

Map 4. Predicted development. The grey area in the map is land currently developed or in agriculture in 2001.

CHAPTER

4

Terrestrial Metrics

Patch Size

Definition

The size of each contiguous patch of habitat, bounded by roads, development, agriculture, or contrasting habitats.

Why is Patch Size Important?

Habitats naturally occur at a variety of scales because they are driven by environmental and disturbance factors that occur at different scales (Poiani et al. 2000). In the Northeast Terrestrial Habitat Classification (Anderson et al. 2013), each ecological habitat was assigned to one of three patterns:

- ***Matrix*** systems are large dominant forest types which define the landscape character of an area, occupy large contiguous areas, and typically have wide ecological amplitudes. Examples include Laurentian-Acadian Northern Hardwood Forest and Central Appalachian Dry Oak-Pine Forest.
- ***Patch*** systems occupy particular landscape settings and have narrow ecological amplitudes. To highlight patterns we further split these into *patch-forming forests* that generally have a wooded canopy (e.g. Northeast Interior Pine Barren), and *non-forested, edaphic habitats* that tend to occur under very localized environmental conditions distinctly different from the surrounding landscape (cliffs, summits, glades, dunes, pavement, alvars, steep slopes etc.) The separation between the two groups is not hard and fast. For example: cove forests occur in a very particular landform setting (concave toe slopes), while non-forested alpine summits may have a lot of stunted trees under certain conditions.
- ***Wetland*** systems are all patch systems, and many are hydrologically connected into a patch network. They can be *basin* types (e.g. Northern Appalachian –Acadian Swamp) or *linear* systems, which occur as long narrow strips, often at the ecotone between terrestrial and aquatic systems (e.g. North-Central Appalachian Large River Floodplain).

The size of an individual habitat patch partially determines the quality and quantity of wildlife habitat it provides and the degree to which it can sustain its internal ecological processes. Individual species maintain a flexible home range area in which they find basic food, shelter, and mating resources, and many defend a smaller breeding territory. The latter can range, in birds, from the area directly around the nest to several hundred acres. Mammal territories can be even larger (Degraaf and Yamasaki 2001). For physical reasons, a small patch of habitat cannot provide enough breeding habitat to support the full range of species associated with the habitat. In a dominant forest type it may take a patch size of several thousand acres to provide enough area for multiple breeding territories of all the associated species (Anderson 1999). Further, large patches of high quality habitat naturally serve as source areas: places where a species population is thriving and exporting offspring to the surrounding landscape. Researchers have found that in small habitat patches the offspring of its wildlife inhabitants are often not surviving to reproduce. These are known as “sink areas” because the continued presence of the species in the patch is accounted for by continued subsidies from a nearby source area.

Larger patches of habitat have other benefits as well. They tend to offer more water quality protection, connectivity, microhabitats, and microclimates, all of which buffer the patch from degradation and its inhabitants from local extinction during times of environmental change. (Forman 1995) Additionally, many species avoid breeding in small patches of habitat because they are more vulnerable to predation by edge related predators (Wilcove 1985), or they are loosely colonial and prefer to inhabit patches that contain other members of their species.

Methods

To create the individual habitat patches, we burned the major and minor roads into the grid of habitat types. We used major and minor roads from the U.S. and Canada Streets Cartographic (Tele Atlas North America, Inc., 2005) and the following classes:

- Major Roads: A10 – A28, primary Roads with limited access, primary highways without limited Access and A63 access ramps
- Minor Roads: A30 – A48, secondary state and county highways, local, neighborhood, rural road, city streets, and A60 At grade ramp, A62 traffic circle, A 64 service roads.

For Maine, we added the Tiger road coverage feature class SF1400 (local neighborhood road, rural road, city street, Census Tiger Geodatabase 2013) because it contained many minor roads that were missing from the ESRI roads.

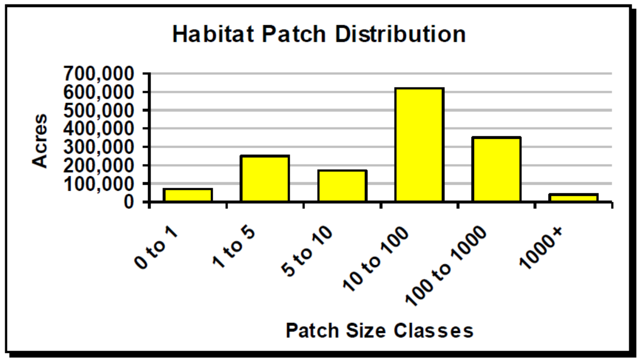
The road line files were converted to a 30 m grid and these areas were removed from the habitat grid using raster calculator. Next we removed the developed and agriculture landcover classes from the grid by reclassifying them to "no data". We converted the remaining grid of natural land into a polygon using the raster to polygon tool in ArcToolbox, which creates single part polygons each with its own unique identifier. The result was a polygon dataset of habitat patches for every terrestrial habitat.

Results

The 15 Matrix forest habitats collectively covered 79% of the region followed in total acreage by wetlands (11%), patch-forming forests (9%) and the edaphic, non-forest patch habitats (1%). Maximum patch size ranged from a low of 18 acres in Southern Piedmont Glade and Barren to a high of 176,448 acres in Laurentian-Acadian Northern Hardwod Forest. Only three habitats had more than half of their area in patches of 1000 acres or larger. On average, only 13% of each habitat's area was in patches larger than 1000 acres.

Results within each Habitat

We calculated the distribution of each habitat's area across six patch size classes (0-1, 1-5, 5-10, 10-100, 100-1000, 1000+ acres). We used 1000 acres as the largest class because for patch-forming habitats this size is often adequate size to provide space for most of the associated species. Matrix types typically need larger areas on the scale of 10000 – 25000 acres to contain multiple breeding areas of all the associated species and to be buffered from disturbances (Anderson 2008). We also report on the size of the largest patch and on the average patch size, although the latter is typically very small even for matrix types.



The average patch size for this habitat is 4 acres and the largest single patch is

Figure 13. This is an example from the Northeast Habitat Guide for North-Central Appalachian Acidic Swamp showing the total acres in each patch-size class.

The chart (from The Northeast Habitat Guides, Anderson et al. 2013) shows the patch size distribution of North-Central Appalachian Acidic Swamp (Figure 13). This wetland type has over 600,000 acres (41%) of its area in small patches of 10-100 acres in size, 350,000 acres (23%) in medium patches 100-1000 acres and 39,000 acres (3%) in large patches over 1000 acres. The single largest patch is 2,811 acres. These large patches might be particularly important areas for conservation action.

Comparisons across all Terrestrial Habitats

Three matrix-forming forest types: Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest (81%), Laurentian-Acadian Northern Hardwood Forest (79%), and Appalachian (Hemlock)-Northern Hardwood Forest (50%), had the majority of their acreage in large patches over 1000 acres in size (Table 18). Among these habitats there were some exceptionally huge contiguous patches left (176,448 acres, 61,167 acres, and 39,064 acres respectively). At the other end of the scale, seven matrix habitats have 10% or less of their acreage in large patches, and a maximum patch size of less than 5,000 acres. One type, the Southern Piedmont Dry Oak-Pine Forest, no longer has a single patch over 1,000 acres in this study area. Once the dominant matrix-forming forest of the Piedmont, this habitat is now composed of small patches of post-clearing successional forests, the largest of which is 484 acres.

The patch-forming habitats occur naturally as discrete elements on the landscape, so patch size information for this group should be regarded as a characterization of the type as opposed to a condition factor. However, several of the patch-forming forests (high elevation, maritime, and pine barren) have 25% or more of their occurrence in large patches over 1000 acres, and six habitats, including Long Leaf Pine and the common North-Central Interior Beech-Maple Forest, have no patches over 1000 acres in size in this study area. Among the non-forested edaphic communities all have relatively small patch sizes, although a few, such as Acadian-Appalachian Alpine Tundra (43%) and Atlantic Coastal Plain Beach and Dune (30%), have a substantial amount of their acreage in large patches.

To determine if the small patch size of one of these habitats is being exacerbated by fragmentation, the measures in this section should be combined with the metrics of *landscape context* and *local* *connectedness*. For example, one of the most diverse forest habitats in the region, Southern and Central Appalachian Cove Forest, has less than 1% of its acres in large patches over 1000 acres, although there are over a million acres of the habitat. However, because this patch-forming forest always occurs as small patches, and because its landscape context score (LCI = 20) is close to natural, and its local connectedness score (LC = 43) is relatively good, the small size of the habitat patches simply reflects its natural pattern. In contrast, the Eastern Serpentine Woodland, a small patch edaphic habitat, has a largest measured patch size of 209 acres and it had the worst landscape context score (LCI=109) of all terrestrial habitats, and the second worst local connectedness score (LC=11). The combination of a small patch size and a highly fragmented landscape context makes this habitat susceptible to degradation.

Several of the coastal plain tidal marshes, floodplains, wet-hardwoods, and bottom land forests have a substantial portion of their acreage in larger blocks over 1000 acres (Table 19). Bogs and swamps tend to have less than 20% of their acreage in large patches and moderate patch sizes with their largest habitat patches in the a 2000 to 3000 acre range. Fifteen wetland habitats have less than 1% of their acreage in large patches over 1000 acres and this includes the regionally ubiquitous Laurentian-Acadian freshwater marsh, and Laurentian-Acadian shrub swamp

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Table 18. Percent of upland habitats in large patches over1000 acres, arranged by patch size groups.

Patchtypes	Upland Macrogroup	Habitat Summary Group	Percent of Habitat in patches > 1000 acres	Maximum Patch Size (acres)	Total Acres
Matrix	Boreal Upland Forest	Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest	81%	61,167	1,145,622
Matrix	Northern Hardwood & Conifer	Laurentian-Acadian Northern Hardwood Forest	79%	176,448	12,916,995
Matrix	Northern Hardwood & Conifer	Appalachian (Hemlock)-Northern Hardwood Forest	50%	39,064	21,046,521
Matrix	Northern Hardwood & Conifer	Laurentian-Acadian Pine-Hemlock-Hardwood Forest	43%	28,879	6,134,592
Matrix	Boreal Upland Forest	Acadian Low Elevation Spruce-Fir-Hardwood Forest	42%	22,000	5,545,059
Matrix	Central Oak-Pine	North Atlantic Coastal Plain Pitch Pine Barrens	31%	6,876	498,438
Matrix	Central Oak-Pine	Northeastern Interior Dry-Mesic Oak Forest	30%	20,946	17,060,881
Matrix	Central Oak-Pine	Southern Appalachian Oak Forest	27%	9,777	2,897,432
Matrix	Northern Hardwood & Conifer	Northeastern Coastal and Interior Pine-Oak Forest	10%	2,638	1,540,752
Matrix	Northern Hardwood & Conifer	Southern Piedmont Mesic Forest	5%	2,780	2,441,825
Matrix	Central Oak-Pine	Central Appalachian Dry Oak-Pine Forest	4%	4,519	3,850,012
Matrix	Central Oak-Pine	North Atlantic Coastal Plain Hardwood Forest	4%	3,742	2,149,415
Matrix	Northern Hardwood & Conifer	Southern Atlantic Coastal Plain Mesic Hardwood Forest	3%	1,277	1,936,306
Matrix	Central Oak-Pine	Allegheny-Cumberland Dry Oak Forest and Woodland	1%	2,688	2,275,958
Matrix	Central Oak-Pine	Southern Piedmont Dry Oak-Pine Forest	0%	493	1,797,508
Patch: forest	Northern Hardwood & Conifer	Southern Appalachian Northern Hardwood Forest	54%	4,441	17,276
Patch: forest	Southern Oak-Pine	Central Atlantic Coastal Plain Maritime Forest	52%	2,447	8,806
Patch: forest	Boreal Upland Forest	Central and Southern Appalachian Spruce-Fir Forest	36%	6,790	71,746
Patch: forest	Central Oak-Pine	Northeastern Interior Pine Barrens	29%	1,247	43,989
Patch: forest	Northern Hardwood & Conifer	Laurentian-Acadian Red Oak-Northern Hardwood Forest	25%	5,050	1,173,877
Patch: forest	Central Oak-Pine	Southern Ridge and Valley / Cumberland Dry Calcareous Forest	20%	4,828	922,460
Patch: forest	Northern Hardwood & Conifer	Glacial Marine & Lake Mesic Clayplain Forest	17%	4,192	241,049
Patch: forest	Northern Hardwood & Conifer	South-Central Interior Mesophytic Forest	5%	5,040	3,561,170
Patch: forest	Central Oak-Pine	Piedmont Hardpan Woodland and Forest	5%	1,239	50,669
Patch: forest	Northern Hardwood & Conifer	Southern and Central Appalachian Cove Forest	1%	1,905	1,020,345
Patch: forest	Central Oak-Pine	North Atlantic Coastal Plain Maritime Forest	1%	385	127,510
Patch: forest	Boreal Upland Forest	Acadian Sub-boreal Spruce Flat	1%	1,193	1,514,345
Patch: forest	Central Oak-Pine	Central Appalachian Pine-Oak Rocky Woodland	0%	1,202	567,926
Patch: forest	Central Oak-Pine	Central and Southern Appalachian Montane Oak Forest	0%	902	149,615
Patch: forest	Central Oak-Pine	Southern Appalachian Montane Pine Forest and Woodland	0%	228	33,763
Patch: forest	Central Oak-Pine/Longleaf Pine	Southern Atlantic Coastal Plain Upland Longleaf Pine Woodland	0%	153	731
Patch: forest	Northern Hardwood & Conifer	Laurentian-Acadian Northern Pine-(Oak) Forest	0%	362	14,691
Patch: forest	Northern Hardwood & Conifer	North-Central Interior Beech-Maple Forest	0%	484	73,618
Patch: forest	Southern Oak-Pine	Southern Appalachian Low Elevation Pine Forest	0%	110	22,464
Patch: edaphic	Alpine	Acadian-Appalachian Alpine Tundra	42%	3,949	12,136
Patch: edaphic	Coastal Grassland & Shrubland	Atlantic Coastal Plain Beach and Dune	30%	5,945	102,668
Patch: edaphic	Glade, Barren and Savanna	Great Lakes Alvar	15%	2,141	29,797
Patch: edaphic	Cliff and Talus	Acidic Cliff and Talus	4%	2,038	565,683
Patch: edaphic	Coastal Grassland & Shrubland	North Atlantic Coastal Plain Heathland and Grassland	4%	993	33,832
Patch: edaphic	Outcrop & Summit Scrub	Acidic Rocky Outcrop	2%	4,555	201,964
Patch: edaphic	Glade, Barren and Savanna	Central Appalachian Alkaline Glade and Woodland	1%	1,190	414,701
Patch: edaphic	Cliff and Talus	Calcareous Cliff and Talus	0%	612	56,998
Patch: edaphic	Cliff and Talus	Circumneutral Cliff and Talus	0%	408	56,864
Patch: edaphic	Coastal Grassland & Shrubland	Great Lakes Dune and Swale	0%	224	2,029
Patch: edaphic	Glade, Barren and Savanna	Appalachian Shale Barrens	0%	296	5,466
Patch: edaphic	Glade, Barren and Savanna	Eastern Serpentine Woodland	0%	209	12,163
Patch: edaphic	Glade, Barren and Savanna	Southern and Central Appalachian Mafic Glade and Barrens	0%	85	1,542
Patch: edaphic	Glade, Barren and Savanna	Southern Piedmont Glade and Barrens	0%	18	125
Patch: edaphic	Glade, Barren and Savanna	Southern Ridge and Valley Calcareous Glade and Woodland	0%	183	9,976
Patch: edaphic	Outcrop & Summit Scrub	Calcareous Rocky Outcrop	0%	136	50,908
Patch: edaphic	Outcrop & Summit Scrub	Southern Appalachian Grass and Shrub Bald	0%	641	3,840
Patch: edaphic	Outcrop & Summit Scrub	Southern Piedmont Granite Flatrock and Outcrop	0%	20	103
Patch: edaphic	Rocky Coast	Acadian-North Atlantic Rocky Coast	0%	81	7,788

Table 19. Percent of wetland habitats in large patches over 1000 acres

Wetland Macrogroup	Habitat Summary Group	% of Habitat in patches > 1000 acres	Maximum Patch Size (acres)
Tidal Marsh	North Atlantic Coastal Plain Tidal Salt Marsh	49%	19,464
Large River Floodplain	Piedmont-Coastal Plain Large River Floodplain	47%	12,142
Coastal Plain Swamp	Central Atlantic Coastal Plain Non-riverine Swamp and Wet Hardwood For	41%	78,723
Tidal Marsh	Atlantic Coastal Plain Embayed Region Tidal Freshwater/Brackish Marsh	39%	1,916
Large River Floodplain	North-Central Interior Large River Floodplain	35%	2,249
Southern Bottomland Forest	Atlantic Coastal Plain Blackwater/Brownwater Stream Floodplain Forest	31%	3,841
Northern Swamp	High Allegheny Headwater Wetland	28%	6,345
Coastal Plain Swamp	Southern Atlantic Coastal Plain Tidal Wooded Swamp	28%	1,140
Large River Floodplain	Laurentian-Acadian Large River Floodplain	25%	4,151
Coastal Plain Peatland	Atlantic Coastal Plain Northern Bog	24%	1,349
Northern Peatland	Boreal-Laurentian Bog	18%	3,173
Large River Floodplain	North-Central Appalachian Large River Floodplain	16%	3,512
Coastal Plain Swamp	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest	14%	3,190
Coastal Plain Swamp	North Atlantic Coastal Plain Tidal Swamp	12%	3,555
Northern Peatland	North-Central Interior and Appalachian Acidic Peatland	11%	2,839
Coastal Plain Swamp	North Atlantic Coastal Plain Basin Peat Swamp	8%	1,791
Tidal Marsh	North Atlantic Coastal Plain Brackish/Fresh & Oligohaline Tidal Marsh	7%	1,237
Coastal Plain Swamp	North Atlantic Coastal Plain Pitch Pine Lowland	6%	1,694
Northern Peatland	Boreal-Laurentian-Acadian Acidic Basin Fen	6%	3,118
Northern Swamp	North-Central Interior and Appalachian Rich Swamp	5%	3,380
Northern Swamp	Laurentian-Acadian Alkaline Conifer-Hardwood Swamp	4%	2,091
Coastal Plain Swamp	North Atlantic Coastal Plain Stream and River	4%	574
Northern Swamp	North-Central Appalachian Acidic Swamp	3%	2,811
Northern Swamp	Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp	2%	1,976
Southern Bottomland Forest	Southern Piedmont Small Floodplain and Riparian Forest	1%	785
Emergent Marsh	Laurentian-Acadian Freshwater Marsh	0%	1,258
Wet Meadow / Shrub Marsh	Laurentian-Acadian Wet Meadow-Shrub Swamp	0%	1,460
Tidal Marsh	Acadian Coastal Salt and Estuary Marsh	0%	832
Northern Peatland	Acadian Maritime Bog	0%	206
Coastal Plain Peatland	Atlantic Coastal Plain Peatland Pocosin and Canebrake	0%	895
Northern Swamp	Central Appalachian Stream and Riparian	0%	405
Central Hardwood Swamp	Central Interior Highlands and Appalachian Sinkhole and Depression Pond	0%	15
Central Hardwood Swamp	Glacial Marine & Lake Wet Clayplain Forest	0%	617
Northern Peatland	Laurentian-Acadian Alkaline Fen	0%	48
Large River Floodplain	North Atlantic Coastal Plain Large River Floodplain	0%	776
Central Hardwood Swamp	North-Central Interior Wet Flatwoods	0%	219
Central Hardwood Swamp	Piedmont Upland Depression Swamp	0%	154
Emergent Marsh	Piedmont-Coastal Plain Freshwater Marsh	0%	735
Wet Meadow / Shrub Marsh	Piedmont-Coastal Plain Shrub Swamp	0%	980
Southern Bottomland Forest	Southern Piedmont Lake Floodplain Forest	0%	233

Core Area

Definition

Core area is the amount of interior habitat in the central region of a minor road bounded block. This sheltered secluded habitat is preferred by many species for breeding.

Why is Core Area Important?

A patch of natural lands contains a central region (the core) bounded by an outer border (the edge), and these two regions are ecologically different. Typically, the edge is subject to more light, more disturbance, warmer temperatures, and stronger winds than the central region, and it may be dominated by species found only near the border (Forman 1995). If the boundary is a heavily-used road, the edge will also be noisy and dangerous. The core area, in contrast, offers a more sheltered and secluded habitat buffered from the extremes of the edge, and offers favorable habitat for breeding and resting. Forest interior species are those that show a preference for the quiet core region, although these preferences are variable and may not surface until after the vegetation differentiates (Villard et al. 2007, Villard 1998).

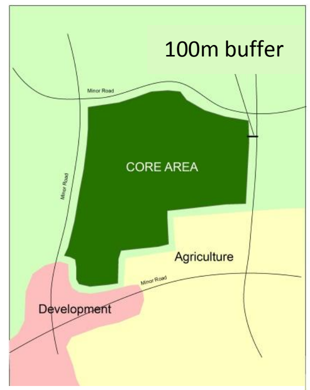

Figure 14. Diagram of core area.

Edge effects may extend far into a habitat patch depending on the shape and context of the patch, but typically they lessen at 100 - 300m inward (Harper et al. 2005, Lindenmayer and Fischer 2006). A small ten acre patch of northern hardwood forest in a matrix of agriculture is virtually all edge, but the same ten acre patch in a matrix of spruce-fir-hardwood forest is virtually all core, because the surrounding forest serves as buffer. As the illustration shows, we measured core area by combining adjacent natural habitats into a single patch and buffering the perimeter inward for 100 m (Figure 14). The remaining habitat patch is a measure of core area, and we assigned the acreages of core area proportionally to the variety of habitats that comprised the patch.

This metric is closely related to patch size and shape. In large contiguous blocks of habitat the edge has little influence, but small patches, long linear patches, or other oddly shaped patches might have not have any core area at all. For each minor road bounded block, we calculated the total amount of core area (in acres) and the percentage of the block that was core area.

Methods

To create the individual habitat patches, we burned the major and minor roads into the grid of habitat types. We used major and minor roads from the U.S. and Canada Streets Cartographic (Tele Atlas North America, Inc., 2005) and the following classes

- Major Roads: A10 – A28, primary Roads with limited access, primary highways without limited Access and A63 access ramps
- Minor Roads: A30 – A48, secondary state and county highways, local, neighborhood, rural road, city streets, and A60 At grade ramp, A62 traffic circle, A 64 service roads.

For Maine, we added the Tiger road coverage feature class SF1400 (local neighborhood road, rural road, city street, Census Tiger Geodatabase 2013) because it contained the forest logging roads that were missing from the ESRI roads.

The road line files were converted to a 30m grid and these areas were removed from the habitat grid using raster calculator. Next we removed the developed and agriculture landcover classes from the grid by reclassifying them to “no data”. We converted the remaining grid of natural land into a polygon using the raster to polygon tool in ArcToolbox, which creates single part polygons each with its own unique identifier. The result was a polygon dataset of habitat patches for every terrestrial habitat.

To create the core area, we used the grid of natural land and reclassified it from habitat types to one value for natural groups. We then used the shrink function in ArcToolbox to shrink inward 100m (3 grid cells) around the border of the patch. This removed the edge region from the natural habitat patch, leaving the remaining core.

Results (map 17, 18)

Percent core area within a habitat ranged from a maximum of 100% to a minimum of 17% and was correlated with the total acreage of habitat. Matrix forest types varied greatly in the percent and amount of core area (Table 20). Three Acadian forest habitats had 78% to 96% of their acreage in core area. In contrast, all the coastal plain matrix habitats had few acres in core area (35% to 44%). Piedmont habitats were also low in core area (44% to 49%). The remaining matrix habitats had moderate amounts (52% to 64%), including the widespread and common Appalachian (Hemlock)-Northern Hardwood Forest which had about half (56%) of its 20 million acres in core area.

Patch-forming forest types ranged from highs of 90-97% core area among the montane habitats to lows of 26%-39% in the coastal plain maritime and Piedmont hardpan habitats. Patterns were similar for the edaphic types with alpine and acidic summits having over 98% of their acreage in core, while coastal dunes, grasslands, rocky coast, serpentine woodlands and Piedmont flatrock all had less then 50% of their acreage in core. Thus our coastal habitats are never far from roads and development.

Wetland habitats differed from the terrestrial habitats in that some coastal plain habitats, namely the coastal plain pocosan and canebreak (100%), and Virginia’s embayed region freshwater tidal marsh (88%), both had substantial core area, as did the Boreal-Laurentian bog (97%), maritime bog (92%) and basin fen (90%) (Table 21). The wetland habitats varied greatly within their types and geographies with no consistent pattern.

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Table 20. Core area for upland habitats.

Patch Type	Macrogroup	Habitat Summary Group	Habitat Acreage	Core Area (acres)	% Core Area (100 meter buffer)
Matrix	Boreal Upland Forest	Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest	1,079,375	944,396	96%
Matrix	Northern Hardwood & Conifer	Laurentian-Acadian Northern Hardwood Forest	12,552,915	7,393,430	84%
Matrix	Boreal Upland Forest	Acadian Low Elevation Spruce-Fir-Hardwood Forest	5,403,770	2,617,827	78%
Matrix	Central Oak-Pine	Allegheny-Cumberland Dry Oak Forest and Woodland	2,246,628	599,504	74%
Matrix	Central Oak-Pine	Central Appalachian Dry Oak-Pine Forest	3,781,098	1,369,394	73%
Matrix	Northern Hardwood & Conifer	Laurentian-Acadian Pine-Hemlock-Hardwood Forest	5,938,075	1,527,034	64%
Matrix	Central Oak-Pine	Southern Appalachian Oak Forest	2,823,456	672,606	62%
Matrix	Northern Hardwood & Conifer	Appalachian (Hemlock)-Northern Hardwood Forest	20,362,820	4,100,501	56%
Matrix	Central Oak-Pine	Northeastern Interior Dry-Mesic Oak Forest	16,487,542	3,096,657	52%
Matrix	Northern Hardwood & Conifer	Southern Piedmont Mesic Forest	2,383,958	254,407	49%
Matrix	Northern Hardwood & Conifer	Northeastern Coastal and Interior Pine-Oak Forest	1,463,561	136,231	44%
Matrix	Central Oak-Pine	North Atlantic Coastal Plain Pitch Pine Barrens	462,977	44,307	44%
Matrix	Central Oak-Pine	Southern Piedmont Dry Oak-Pine Forest	1,728,293	170,107	44%
Matrix	Northern Hardwood & Conifer	Southern Atlantic Coastal Plain Mesic Hardwood Forest	1,854,411	82,223	35%
Matrix	Central Oak-Pine	North Atlantic Coastal Plain Hardwood Forest	2,026,734	106,136	33%
Patch: forest	Central Oak-Pine	Central and Southern Appalachian Montane Oak Forest	145,836	80,662	97%
Patch: forest	Boreal Upland Forest	Central and Southern Appalachian Spruce-Fir Forest	64,750	47,866	97%
Patch: forest	Central Oak-Pine	Southern Appalachian Montane Pine Forest and Woodland	33,322	20,312	90%
Patch: forest	Boreal Upland Forest	Acadian Sub-boreal Spruce Flat	1,486,320	772,269	83%
Patch: forest	Northern Hardwood & Conifer	Southern Appalachian Northern Hardwood Forest	12,637	5,797	78%
Patch: forest	Northern Hardwood & Conifer	Laurentian-Acadian Red Oak-Northern Hardwood Forest	1,148,393	463,523	75%
Patch: forest	Central Oak-Pine	Central Appalachian Pine-Oak Rocky Woodland	558,089	210,276	73%
Patch: forest	Southern Oak-Pine	Central Atlantic Coastal Plain Maritime Forest	6,102	2,561	72%
Patch: forest	Northern Hardwood & Conifer	North-Central Interior Beech-Maple Forest	72,708	8,431	68%
Patch: forest	Northern Hardwood & Conifer	Laurentian-Acadian Northern Pine-(Oak) Forest	14,102	1,959	63%
Patch: forest	Central Oak-Pine/Longleaf Pine	Southern Atlantic Coastal Plain Upland Longleaf Pine Woodland	535	1	59%
Patch: forest	Southern Oak-Pine	Southern Appalachian Low Elevation Pine Forest	22,032	2,907	54%
Patch: forest	Northern Hardwood & Conifer	Southern and Central Appalachian Cove Forest	978,640	375,968	54%
Patch: forest	Northern Hardwood & Conifer	South-Central Interior Mesophytic Forest	3,438,270	627,879	54%
Patch: forest	Central Oak-Pine	Northeastern Interior Pine Barrens	41,147	8,184	52%
Patch: forest	Central Oak-Pine	Southern Ridge and Valley / Cumberland Dry Calcareous Forest	902,472	128,616	50%
Patch: forest	Northern Hardwood & Conifer	Glacial Marine & Lake Mesic Clayplain Forest	231,686	24,118	44%
Patch: forest	Central Oak-Pine	Piedmont Hardpan Woodland and Forest	48,087	2,451	39%
Patch: forest	Central Oak-Pine	North Atlantic Coastal Plain Maritime Forest	114,479	2,355	26%
Patch: edaphic	Outcrop & Summit Scrub	Acidic Rocky Outcrop	197,045	166,506	98%
Patch: edaphic	Outcrop & Summit Scrub	Calcareous Rocky Outcrop	50,685	39,476	97%
Patch: edaphic	Alpine	Acadian-Appalachian Alpine Tundra	8,177	7,062	95%
Patch: edaphic	Cliff and Talus	Calcareous Cliff and Talus	55,977	34,149	84%
Patch: edaphic	Cliff and Talus	Acidic Cliff and Talus	556,624	264,444	80%
Patch: edaphic	Cliff and Talus	Circumneutral Cliff and Talus	55,570	16,614	71%
Patch: edaphic	Glade, Barren and Savanna	Appalachian Shale Barrens	5,013	1,006	67%
Patch: edaphic	Glade, Barren and Savanna	Southern Piedmont Glade and Barrens	106	14	66%
Patch: edaphic	Glade, Barren and Savanna	Central Appalachian Alkaline Glade and Woodland	407,362	81,060	59%
Patch: edaphic	Outcrop & Summit Scrub	Southern Appalachian Grass and Shrub Bald	3,187	1,240	54%
Patch: edaphic	Glade, Barren and Savanna	Southern and Central Appalachian Mafic Glade and Barrens	1,418	578	54%
Patch: edaphic	Coastal Grassland & Shrubland	Great Lakes Dune and Swale	1,642	102	51%
Patch: edaphic	Coastal Grassland & Shrubland	Atlantic Coastal Plain Beach and Dune	86,980	1,780	50%
Patch: edaphic	Outcrop & Summit Scrub	Southern Piedmont Granite Flatrock and Outcrop	80	1	47%
Patch: edaphic	Glade, Barren and Savanna	Great Lakes Alvar	26,990	4,222	47%
Patch: edaphic	Rocky Coast	Acadian-North Atlantic Rocky Coast	6,574	0	42%
Patch: edaphic	Glade, Barren and Savanna	Southern Ridge and Valley Calcareous Glade and Woodland	9,193	578	34%
Patch: edaphic	Coastal Grassland & Shrubland	North Atlantic Coastal Plain Heathland and Grassland	29,330	804	24%
Patch: edaphic	Glade, Barren and Savanna	Eastern Serpentine Woodland	11,147	130	17%

Table 21. Core area for wetland habitats.

Wetland Macrogroup	Habitat Summary Group	Habitat Acreage	Core Area (acres)	% Core Area
Coastal Plain Peatland	Atlantic Coastal Plain Peatland Pocosin and Canebrake	2,408	2,364	100%
Northern Peatland	Boreal-Laurentian Bog	45,290	39,642	97%
Northern Peatland	Acadian Maritime Bog	5,212	3,111	92%
Northern Peatland	Boreal-Laurentian-Acadian Acidic Basin Fen	397,710	261,854	90%
Tidal Marsh	Atlantic Coastal Plain Embayed Region Tidal Freshwater/Brackish Marsh	14,174	9,394	88%
Northern Swamp	Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp	1,290,295	701,678	83%
Coastal Plain Swamp	North Atlantic Coastal Plain Basin Peat Swamp	57,537	17,324	75%
Northern Swamp	Laurentian-Acadian Alkaline Conifer-Hardwood Swamp	905,298	348,868	73%
Coastal Plain Swamp	Central Atlantic Coastal Plain Non-riverine Swamp and Wet Hardwood Forest	189,100	91,728	72%
Tidal Marsh	North Atlantic Coastal Plain Tidal Salt Marsh	906,519	174,803	70%
Large River Floodplain	Piedmont-Coastal Plain Large River Floodplain	131,531	29,661	68%
Northern Peatland	Laurentian-Acadian Alkaline Fen	205	26	66%
Wet Meadow / Shrub Marsh	Piedmont-Coastal Plain Shrub Swamp	46,012	10,049	64%
Southern Bottomland Forest	Southern Piedmont Small Floodplain and Riparian Forest	184,110	35,872	64%
Northern Swamp	High Allegheny Headwater Wetland	27,338	7,839	64%
Coastal Plain Peatland	Atlantic Coastal Plain Northern Bog	5,135	1,320	62%
Coastal Plain Swamp	North Atlantic Coastal Plain Pitch Pine Lowland	171,024	32,125	61%
Wet Meadow / Shrub Marsh	Laurentian-Acadian Wet Meadow-Shrub Swamp	970,859	277,150	60%
Tidal Marsh	Acadian Coastal Salt and Estuary Marsh	29,102	1,472	60%
Coastal Plain Swamp	Southern Atlantic Coastal Plain Tidal Wooded Swamp	12,785	3,226	59%
Southern Bottomland Forest	Atlantic Coastal Plain Blackwater/Brownwater Stream Floodplain Forest	161,633	26,249	58%
Tidal Marsh	North Atlantic Coastal Plain Brackish/Fresh & Oligohaline Tidal Marsh	16,905	550	57%
Coastal Plain Swamp	North Atlantic Coastal Plain Tidal Swamp	191,857	26,309	56%
Central Hardwood Swamp	Glacial Marine & Lake Wet Clayplain Forest	86,743	12,644	56%
Coastal Plain Swamp	North Atlantic Coastal Plain Stream and River	28,207	3,276	56%
Northern Swamp	Central Appalachian Stream and Riparian	26,594	3,754	50%
Northern Swamp	North-Central Appalachian Acidic Swamp	1,464,256	175,357	48%
Large River Floodplain	Laurentian-Acadian Large River Floodplain	424,368	177,913	47%
Emergent Marsh	Laurentian-Acadian Freshwater Marsh	883,547	177,247	47%
Emergent Marsh	Piedmont-Coastal Plain Freshwater Marsh	44,945	5,992	45%
Coastal Plain Swamp	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest	946,104	82,438	44%
Southern Bottomland Forest	Southern Piedmont Lake Floodplain Forest	8,387	673	43%
Large River Floodplain	North-Central Interior Large River Floodplain	68,877	11,062	43%
Central Hardwood Swamp	North-Central Interior Wet Flatwoods	79,781	1,015	43%
Large River Floodplain	North Atlantic Coastal Plain Large River Floodplain	33,788	2,739	42%
Northern Swamp	North-Central Interior and Appalachian Rich Swamp	807,365	55,972	41%
Northern Peatland	North-Central Interior and Appalachian Acidic Peatland	82,637	22,923	41%
Large River Floodplain	North-Central Appalachian Large River Floodplain	246,528	23,918	41%
Central Hardwood Swamp	Piedmont Upland Depression Swamp	21,024	1,476	38%
Central Hardwood Swamp	Central Interior Highlands and Appalachian Sinkhole and Depression Pond	1,405	112	20%

Forest Stand Age

Definition.

The proportion of various age classes of a forest or habitat type within its geographic range.

Why is Stand Age Important?

The return of forest to the Northeast is one of the great examples of ecological resilience, but it is a story of recovery laced with repeated setbacks. Cleared for pasture and agriculture at the turn of the century, the region now supports a large forest products industry and thousands of Northeasters manage small woodlots for timber and firewood. Harvesting on the third or fourth cycle is pervasive and periodic, and as a result data individual forest stands (naturally living for several centuries) rarely make it past 60 years of age. The result is a perpetually young forest of thin trees (Anderson and Olivero 2012).

In addition to losing large-diameter trees, the structural characteristics typical of older forests such as large standing snags with numerous cavities, big fallen logs, and dense shrubby understory layers are missing from younger forests. These features greatly increase a forest's value to wildlife, providing nesting, foraging, and denning sites for many species. For instance, an estimated 39 species utilize dead and down woody materials for foraging or shelter sites (Degraaf et al 1989). Lichens and fungi are often more diverse in older forests (Figure 15).

The age and size structure of a forest also provides a picture of ecosystem development. Over centuries, a wild forest will develop a complex structural heterogeneity characteristic of uneven-aged stands that contrasts markedly with the even age structure of a young or heavily managed forest. Swamps also accumulate snags and dead wood over time, to be taken advantage of by wildlife.

Structure of Old Forests
Tip-up mounds, rotting logs, and understory, create stability and diversity.

Old logs create wildlife habitat and seedbeds for new trees.

Figure 15. Structure of old forests.

Methods

The stand age dataset was created by B. Tyler Wilson of the USDA Forest Service, Northern Research Station. The stand age grid provides a cost-effective means for conducting regional to continental-scale mapping of tree species abundance and distribution. The method integrates vegetation phenology derived from MODIS imagery and raster data describing relevant environmental parameters with extensive field plot data of tree species stand age, to create maps of tree species abundance and distribution at a 250-m pixel size for the entire eastern contiguous United States. They used recent field plot data (circa 2009 evaluations). The dataset used for this report was created using methods similar to those described in Wilson et al. (2012) but for this analysis a condition-level variable (stand age) was used during imputation rather than a tree-level variable (live basal area). To attribute the minor road bounded blocks we calculated zonal stats for the stand age grid to determine the average stand age for the minor road bounded block.

This data is not yet published or distributable in grid format. For more information please contact B. Tyler Wilson, USDA Forest Service, Northern Research Station (barrywilson@fs.fed.us).

Results

The average stand age for the forest types in the region was 51.4 years (based on a weighted average of each forested habitat type), and the maximum estimated age recorded in the dataset was 136 years.

Results within each Habitat

These age class distribution charts were created by estimating the age of all forest stands or patches of each habitat, dividing the age range into intervals (e.g., 0–20 years, 20–40 years, 40-60 years, 60-80 years, 80-100 years ,100+ years), and calculating the distribution of the stands or patches across the age classes.

The charts in the northeast habitat guides (Anderson et al. 2013) present the information by actual acreage for each habitat. In Figure 16, the chart or Acadian Low Elevation Spruce-Fir-Hardwood forest shows that the majority of the forest stands are estimated to be 40-50 years old with another 31% estimated to be 60-80 years old, and a few stands are even older.

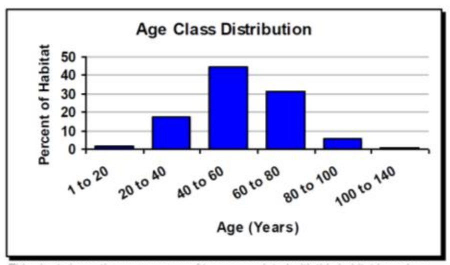

Figure 16. This is an example from the Northeast Habitat Guide for Acadian Low Elevation Spruce-Fir Harwood forest showing the percent of habitat in each age class.

We calculated this metric for all habitats, but we caution users that some interpretation is needed. For large non-forested habitats, for example, Atlantic Coast Beach and Dune, the chart shows 90% of the habitat in the 1-10 year age class, and this may not be very useful information. However, for small non-forested habitats like Acidic Cliff and Talus, the analysis picks up on the surrounding forest and shows 45% of the stands in the 60-80 year classification suggesting that the acidic cliffs are mostly embedded in older forests. This is interesting and potentially useful information.

Comparisons across all Terrestrial Habitats (map 5, 19)

Boral Upland Forest has the highest stand age of the forest macrogroups (57 years) followed by Northern Hardwood (52 years) then Central Oak Pine (49 years) (Table 22). Montane habitats and the forests surrounding cliffs and outcrop were the oldest types in the region (59 to 71 years). Piedmont and coastal plain forests were considerably younger (<45 years). Wetland habitats had younger average stand ages than the upland habitats (Table 23). Among the treed wetlands (swamps), three northern swamps and two coastal plain swamps were among the five oldest types (avg. 49-58 years). Four central hardwood swamps and the two tidal coastal plain swamps were among the lowest (avg. 26-30 years). For comparison, the range of the large non-forested North Atlantic tidal marshes ranged from 7-10.

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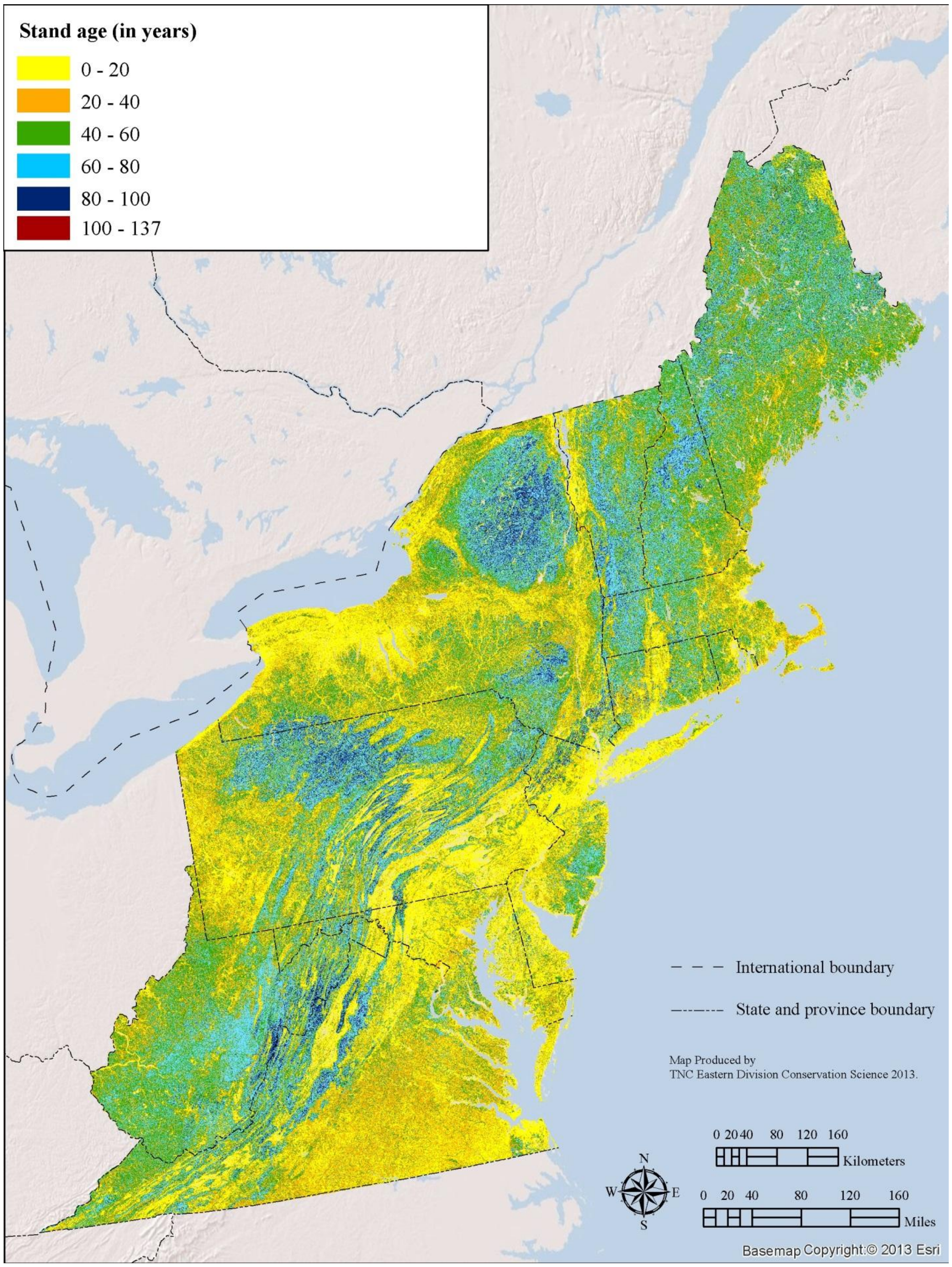
Table 22. Forest stand age in the upland habitats.

Patch type	Upland Macrogroup	Habitat Summary Group	Average Stand Age
Matrix	Boreal Upland Forest	Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest	70.4
Matrix	Northern Hardwood & Conifer	Laurentian-Acadian Northern Hardwood Forest	61.8
Matrix	Central Oak-Pine	Central Appalachian Dry Oak-Pine Forest	61.5
Matrix	Boreal Upland Forest	Acadian Low Elevation Spruce-Fir-Hardwood Forest	54.5
Matrix	Northern Hardwood & Conifer	Laurentian-Acadian Pine-Hemlock-Hardwood Forest	53.3
Matrix	Central Oak-Pine	Allegheny-Cumberland Dry Oak Forest and Woodland	52.6
Matrix	Central Oak-Pine	Southern Appalachian Oak Forest	50.9
Matrix	Northern Hardwood & Conifer	Appalachian (Hemlock)-Northern Hardwood Forest	49.6
Matrix	Central Oak-Pine	Northeastern Interior Dry-Mesic Oak Forest	49.3
Matrix	Central Oak-Pine	North Atlantic Coastal Plain Pitch Pine Barrens	44.4
Matrix	Northern Hardwood & Conifer	Northeastern Coastal and Interior Pine-Oak Forest	43.9
Matrix	Central Oak-Pine	North Atlantic Coastal Plain Hardwood Forest	36.4
Matrix	Northern Hardwood & Conifer	Southern Atlantic Coastal Plain Mesic Hardwood Forest	33.4
Matrix	Northern Hardwood & Conifer	Southern Piedmont Mesic Forest	31.6
Matrix	Central Oak-Pine	Southern Piedmont Dry Oak-Pine Forest	30.3
Patch: edaphic	Outcrop & Summit Scrub	Calcareous Rocky Outcrop	71.2
Patch: edaphic	Outcrop & Summit Scrub	Acidic Rocky Outcrop	69.8
Patch: edaphic	Alpine	Acadian-Appalachian Alpine Tundra	69.4
Patch: edaphic	Cliff and Talus	Calcareous Cliff and Talus	65.9
Patch: edaphic	Outcrop & Summit Scrub	Southern Appalachian Grass and Shrub Bald	65.4
Patch: edaphic	Cliff and Talus	Acidic Cliff and Talus	64.2
Patch: edaphic	Glade, Barren and Savanna	Southern and Central Appalachian Mafic Glade and Barrens	63.1
Patch: edaphic	Cliff and Talus	Circumneutral Cliff and Talus	59.5
Patch: edaphic	Glade, Barren and Savanna	Appalachian Shale Barrens	59.5
Patch: edaphic	Glade, Barren and Savanna	Central Appalachian Alkaline Glade and Woodland	54.4
Patch: edaphic	Glade, Barren and Savanna	Southern Piedmont Glade and Barrens	43.4
Patch: edaphic	Glade, Barren and Savanna	Southern Ridge and Valley Calcareous Glade and Woodland	36.4
Patch: edaphic	Glade, Barren and Savanna	Eastern Serpentine Woodland	30.0
Patch: edaphic	Outcrop & Summit Scrub	Southern Piedmont Granite Flatrock and Outcrop	29.2
Patch: edaphic	Glade, Barren and Savanna	Great Lakes Alvar	23.4
Patch: edaphic	Coastal Grassland & Shrubland	North Atlantic Coastal Plain Heathland and Grassland	18.7
Patch: edaphic	Coastal Grassland & Shrubland	Great Lakes Dune and Swale	15.1
Patch: edaphic	Rocky Coast	Acadian-North Atlantic Rocky Coast	10.1
Patch: edaphic	Coastal Grassland & Shrubland	Atlantic Coastal Plain Beach and Dune	5.1
Patch: forest	Central Oak-Pine	Central and Southern Appalachian Montane Oak Forest	69.1
Patch: forest	Northern Hardwood & Conifer	Southern Appalachian Northern Hardwood Forest	67.8
Patch: forest	Central Oak-Pine	Southern Appalachian Montane Pine Forest and Woodland	67.8
Patch: forest	Boreal Upland Forest	Central and Southern Appalachian Spruce-Fir Forest	65.2
Patch: forest	Central Oak-Pine	Central Appalachian Pine-Oak Rocky Woodland	62.6
Patch: forest	Northern Hardwood & Conifer	Southern and Central Appalachian Cove Forest	61.8
Patch: forest	Northern Hardwood & Conifer	Laurentian-Acadian Red Oak-Northern Hardwood Forest	59.9
Patch: forest	Boreal Upland Forest	Acadian Sub-boreal Spruce Flat	55.9
Patch: forest	Northern Hardwood & Conifer	South-Central Interior Mesophytic Forest	47.2
Patch: forest	Central Oak-Pine	Southern Ridge and Valley / Cumberland Dry Calcareous Forest	46.2
Patch: forest	Southern Oak-Pine	Southern Appalachian Low Elevation Pine Forest	45.6
Patch: forest	Central Oak-Pine	Northeastern Interior Pine Barrens	44.9
Patch: forest	Northern Hardwood & Conifer	North-Central Interior Beech-Maple Forest	43.3
Patch: forest	Northern Hardwood & Conifer	Laurentian-Acadian Northern Pine-(Oak) Forest	33.3
Patch: forest	Central Oak-Pine	Piedmont Hardpan Woodland and Forest	31.6
Patch: forest	Northern Hardwood & Conifer	Glacial Marine & Lake Mesic Clayplain Forest	30.5
Patch: forest	Central Oak-Pine	North Atlantic Coastal Plain Maritime Forest	26.1
Patch: forest	Southern Oak-Pine	Central Atlantic Coastal Plain Maritime Forest	21.2
Patch: forest	Central Oak-Pine/Longleaf Pine	Southern Atlantic Coastal Plain Upland Longleaf Pine Woodland	16.7

Table 23. Forest stand age in the wetland habitats.

Wetland Macrogroup	Habitat Summary Group	Average Stand Age
Northern Swamp	Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp	57.9
Northern Peatland	Boreal-Laurentian-Acadian Acidic Basin Fen	53.9
Coastal Plain Swamp	North Atlantic Coastal Plain Pitch Pine Lowland	52.8
Northern Peatland	Boreal-Laurentian Bog	52.4
Northern Swamp	High Allegheny Headwater Wetland	49.8
Northern Swamp	Laurentian-Acadian Alkaline Conifer-Hardwood Swamp	49.7
Coastal Plain Swamp	North Atlantic Coastal Plain Basin Peat Swamp	49.3
Northern Peatland	Acadian Maritime Bog	48.3
Large River Floodplain	Laurentian-Acadian Large River Floodplain	47.2
Coastal Plain Peatland	Atlantic Coastal Plain Northern Bog	46.9
Northern Peatland	Laurentian-Acadian Alkaline Fen	45.7
Wet Meadow / Shrub Marsh	Laurentian-Acadian Wet Meadow-Shrub Swamp	44.2
Northern Peatland	North-Central Interior and Appalachian Acidic Peatland	41.0
Northern Swamp	North-Central Appalachian Acidic Swamp	39.8
Coastal Plain Swamp	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest	37.2
Northern Swamp	North-Central Interior and Appalachian Rich Swamp	34.7
Coastal Plain Swamp	North Atlantic Coastal Plain Stream and River	34.5
Coastal Plain Swamp	Central Atlantic Coastal Plain Non-riverine Swamp and Wet Hardwood Forest	34.1
Emergent Marsh	Laurentian-Acadian Freshwater Marsh	33.6
Large River Floodplain	North Atlantic Coastal Plain Large River Floodplain	32.7
Northern Swamp	Central Appalachian Stream and Riparian	32.4
Southern Bottomland Forest	Southern Piedmont Small Floodplain and Riparian Forest	31.6
Large River Floodplain	Piedmont-Coastal Plain Large River Floodplain	31.5
Large River Floodplain	North-Central Appalachian Large River Floodplain	30.6
Coastal Plain Peatland	Atlantic Coastal Plain Peatland Pocosin and Canebrake	30.5
Large River Floodplain	North-Central Interior Large River Floodplain	30.4
Central Hardwood Swamp	Glacial Marine & Lake Wet Clayplain Forest	30.1
Central Hardwood Swamp	North-Central Interior Wet Flatwoods	29.2
Coastal Plain Swamp	North Atlantic Coastal Plain Tidal Swamp	28.8
Wet Meadow / Shrub Marsh	Piedmont-Coastal Plain Shrub Swamp	28.4
Southern Bottomland Forest	Atlantic Coastal Plain Blackwater/Brownwater Stream Floodplain Forest	28.0
Central Hardwood Swamp	Central Interior Highlands and Appalachian Sinkhole and Depression Pond	27.6
Central Hardwood Swamp	Piedmont Upland Depression Swamp	26.1
Coastal Plain Swamp	Southern Atlantic Coastal Plain Tidal Wooded Swamp	26.0
Tidal Marsh	Acadian Coastal Salt and Estuary Marsh	23.4
Emergent Marsh	Piedmont-Coastal Plain Freshwater Marsh	22.7
Southern Bottomland Forest	Southern Piedmont Lake Floodplain Forest	19.6
Tidal Marsh	North Atlantic Coastal Plain Brackish/Fresh & Oligohaline Tidal Marsh	10.4
Tidal Marsh	Atlantic Coastal Plain Embayed Region Tidal Freshwater/Brackish Marsh	8.0
Tidal Marsh	North Atlantic Coastal Plain Tidal Salt Marsh	7.6



Map 5. Stand age in years in the Northeastern United States.

Landscape Complexity

Definition

An estimate of the number of micro-climates in a 100 acre area surrounding each cell of habitat, based on the variety of landforms, the elevation range, and the density of wetlands.

Why is Landscape Complexity Important?

Landscape complexity, also known as landscape diversity, refers to the variety of landforms created by an area's topography, the range of its elevation gradients, and the density of its wetlands. These factors increase a site's resilience by offering micro-topographic thermal climate options to resident species, buffering them from changes in the regional climate, and slowing down the velocity of change (Ackerly et al. 2010, Dobrowski 2010, Loarie et al. 2009, Willis & Bhagwat 2009). Under variable climatic conditions, areas of high landscape diversity are important for the long-term population persistence of plants, invertebrates, and other species (Randin et al. 2008, Weiss et al. 1988). Because species shift their locations to take advantage of micro-climate variation, extinction rates predicted from coarse-scale climate models that fail to account for topographic and elevation diversity have been disputed (Wiens & Bachelet 2010, Luato & Heikkinen 2008).

Methods

This metric summarized the variety of landforms, the elevation range, and the density of wetlands, in a 100 acre search area around each 30 meter cell of habitat. The landform variety component was based on a spatially comprehensive landform model delineating 11 surface features (Figure 17):

- cliff and steep slope
- summit and ridge-top
- northeast facing side-slope
- southwest facing side-slope
- cove and slope bottom
- low hill
- low hilltop flat
- valley and toe-slope
- dry flat
- wet flat
- water

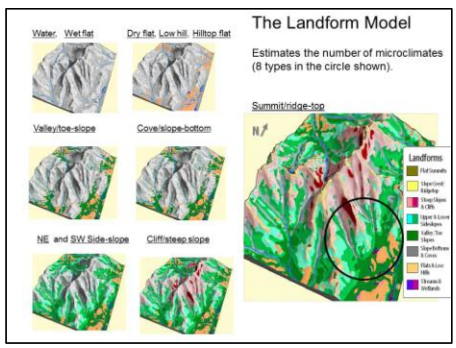


Figure 17. The landform model, from which estimates the number of microclimates in a given area were estimated.

The model delimits recognizable landforms as combinations of slope, land position, aspect, and moisture accumulation that correspond to local topographic environments with distinct combinations of moisture, radiant energy, and deposition. We used a focal variety analysis to tabulate the number of landforms within a 100 acre circular area around every 30 m cell. The size of the search area was derived by systematically testing many possible sizes to find the one with the maximum discrimination between sites (i.e. too large and all sites had all landforms, too small and all sites had only one landform). To assess the local elevation range, we used a focal range analysis on the DEM to tabulate the range in elevation within a 100 acre circular search area around each 30 m cell.

In extremely flat areas (less than 0.5% slope), the landforms and elevation range did not provide enough information to discriminate between many equivalent cells. For these areas, we added wetland density as a finer-scale indicator of subtle micro topographic features not captured by the "wet flat" element in the landform model. With a regional wetland dataset, we used a focal function to calculate the density of surrounding wetlands for every 30 m cell in the region. Because these areas had such flat topography, we used a combination of two circular search areas: a smaller 100 acre area and a larger 1000 acre area and to create a weighted index giving twice the weight to the 100 acre search area.

Before combining landform variety, elevation range and wetland density were summarized into a single index after transforming all the metrics to standardized normal distributions so each had equal influence unless we weighted it. The final index was:

For most areas: ***Landscape Complexity = (2*Landform variety + 1* Elevation range)/3.***

For flats: ***Landscape Complexity = (2*Landform variety + 1* Elevation range + 1*Wetland density)/4.***

In the combined index landform variety was weighted twice as much as the other factors because the landform model delineates contrasting micro-climates more precisely than elevation or wetland density. Cells with higher scores had more complexity in their local neighborhoods. Our assumption was that most plants and vertebrate populations could access this small area to locate suitable microclimates.

The results presented here are relative and are given in standard deviations above or below the mean value for the region. For instance a score of .5 indicates that the habitat is one-half standard deviation above the mean of all habitats. The metric grid multiplies the standard deviations by 100 for ease of display. Technical methods for mapping landforms were based on Fels and Matson (1996) and more detail in the landscape complexity model can be found in Anderson et al. (2012).

Results (map 20)

The matrix forests of the Southern and Central Appalachians have the highest degree of landscape diversity and thus offer the highest level of micro-climatic diversity to species (Table 24). Four oak-dominated forests were among the highest scoring: Southern Appalachian Oak Forest (0.57 SD), Allegheny-Cumberland Dry Oak Forest and Woodland (0.49 SD), Central Appalachian Dry Oak-Pine Forest (0.46 SD), and Northeastern Interior Dry-Mesic Oak Forest (0.43 SD). The low scoring forests were all in the coastal plain: North Atlantic Coastal Plain Hardwood Forest (-0.09 SD), Southern Atlantic Coastal Plain Mesic Hardwood Forest (-0.18 SD), and North Atlantic Coastal Plain Pitch Pine Barrens (-0.51 SD).

The patch-forming forests showed a similar pattern with the highest scoring types all being from the Central and Southern Appalachians: Southern Appalachian Low Elevation Pine Forest (0.77 SD), Southern Ridge and Valley / Cumberland Dry Calcareous Forest (0.61 SD), and South-Central Interior Mesophytic Forest (0.53 SD). Laurentian –Acadian habitats scored average. The lowest scoring types were again in the coastal plain and Piedmont : Piedmont Hardpan Woodland and Forest (-0.26), Central Atlantic Coastal Plain Maritime Forest (-0.43), and Upland Longleaf Pine Woodland (-.63 SD).

Appalachian Shale Barren (0.96 SD) scored the highest of any habitat type. Cliff and talus habitats and the southern glade and barren habitats all scored high, ranging from 0.86 SD for Southern Piedmont Glade and Barrens to 0.22 SD for Southern and Central Appalachian Mafic Glade and Barrens. At the low end were the dune, alvar, and maritime grassland communities North Atlantic Coastal Plain Heathland and Grassland (-0.14 SD), Atlantic Coastal Plain Beach and Dune (-0.41 SD), and Great Lakes Alvar (-0.43 SD). Somewhat surprisingly, the Acadian-Appalachian Alpine Tundra (-0.15 SD) also scored low reflecting the small and uniform nature of these habitats.

Stream-related wetlands scored the highest among the wetland types, along with the very small northern fens: Laurentian-Acadian Alkaline Fen (0.45 SD), High Allegheny Headwater Wetland (0.39 SD), Central Appalachian Stream and Riparian (0.26 SD), Southern Piedmont Small Floodplain and Riparian Forest (0.24 SD), and North-Central Appalachian Large River Floodplain (0.24) (Table 25). As with the terrestrial type the low scoring wetlands were almost uniformly from the coastal plain, with 12 of the coastal plain tidal marshes, floodplains, swamps, and pocoson scoring the lowest in the region (-0.40 to -1.47 SD) along with the Boreal-Laurentian Bog (-0.93 SD).

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Table 24. Average landscape complexity for terrestrial upland habitats.

Patch Type	Upland Macrogroup	Habitat Summary Group	Landscape Complexity
Matrix	Central Oak-Pine	Southern Appalachian Oak Forest	0.57
Matrix	Central Oak-Pine	Allegheny-Cumberland Dry Oak Forest and Woodland	0.49
Matrix	Central Oak-Pine	Central Appalachian Dry Oak-Pine Forest	0.46
Matrix	Central Oak-Pine	Northeastern Interior Dry-Mesic Oak Forest	0.43
Matrix	Northern Hardwood & Conifer	Appalachian (Hemlock)-Northern Hardwood Forest	0.42
Matrix	Northern Hardwood & Conifer	Laurentian-Acadian Pine-Hemlock-Hardwood Forest	0.34
Matrix	Northern Hardwood & Conifer	Laurentian-Acadian Northern Hardwood Forest	0.28
Matrix	Northern Hardwood & Conifer	Northeastern Coastal and Interior Pine-Oak Forest	0.14
Matrix	Northern Hardwood & Conifer	Southern Piedmont Mesic Forest	0.13
Matrix	Boreal Upland Forest	Acadian Low Elevation Spruce-Fir-Hardwood Forest	0.06
Matrix	Boreal Upland Forest	Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest	0.03
Matrix	Central Oak-Pine	Southern Piedmont Dry Oak-Pine Forest	0.03
Matrix	Central Oak-Pine	North Atlantic Coastal Plain Hardwood Forest	-0.09
Matrix	Northern Hardwood & Conifer	Southern Atlantic Coastal Plain Mesic Hardwood Forest	-0.18
Matrix	Central Oak-Pine	North Atlantic Coastal Plain Pitch Pine Barrens	-0.51
Patch: forest	Southern Oak-Pine	Southern Appalachian Low Elevation Pine Forest	0.77
Patch: forest	Central Oak-Pine	Southern Ridge and Valley / Cumberland Dry Calcareous Forest	0.61
Patch: forest	Northern Hardwood & Conifer	South-Central Interior Mesophytic Forest	0.53
Patch: forest	Northern Hardwood & Conifer	Laurentian-Acadian Red Oak-Northern Hardwood Forest	0.44
Patch: forest	Northern Hardwood & Conifer	Southern and Central Appalachian Cove Forest	0.39
Patch: forest	Central Oak-Pine	Central Appalachian Pine-Oak Rocky Woodland	0.36
Patch: forest	Central Oak-Pine	Southern Appalachian Montane Pine Forest and Woodland	0.34
Patch: forest	Boreal Upland Forest	Central and Southern Appalachian Spruce-Fir Forest	0.23
Patch: forest	Central Oak-Pine	Central and Southern Appalachian Montane Oak Forest	0.20
Patch: forest	Northern Hardwood & Conifer	Glacial Marine & Lake Mesic Clayplain Forest	0.17
Patch: forest	Northern Hardwood & Conifer	North-Central Interior Beech-Maple Forest	0.07
Patch: forest	Central Oak-Pine	North Atlantic Coastal Plain Maritime Forest	0.07
Patch: forest	Boreal Upland Forest	Acadian Sub-boreal Spruce Flat	0.01
Patch: forest	Central Oak-Pine	Northeastern Interior Pine Barrens	-0.03
Patch: forest	Northern Hardwood & Conifer	Southern Appalachian Northern Hardwood Forest	-0.12
Patch: forest	Northern Hardwood & Conifer	Laurentian-Acadian Northern Pine-(Oak) Forest	-0.13
Patch: forest	Central Oak-Pine	Piedmont Hardpan Woodland and Forest	-0.26
Patch: forest	Southern Oak-Pine	Central Atlantic Coastal Plain Maritime Forest	-0.43
Patch: forest	Central Oak-Pine/Longleaf Pine	Southern Atlantic Coastal Plain Upland Longleaf Pine Woodland	-0.63
Patch: edaphic	Glade, Barren and Savanna	Appalachian Shale Barrens	0.96
Patch: edaphic	Glade, Barren and Savanna	Southern Piedmont Glade and Barrens	0.86
Patch: edaphic	Cliff and Talus	Circumneutral Cliff and Talus	0.84
Patch: edaphic	Cliff and Talus	Acidic Cliff and Talus	0.56
Patch: edaphic	Glade, Barren and Savanna	Central Appalachian Alkaline Glade and Woodland	0.50
Patch: edaphic	Cliff and Talus	Calcareous Cliff and Talus	0.49
Patch: edaphic	Glade, Barren and Savanna	Southern Ridge and Valley Calcareous Glade and Woodland	0.42
Patch: edaphic	Outcrop & Summit Scrub	Calcareous Rocky Outcrop	0.30
Patch: edaphic	Outcrop & Summit Scrub	Southern Appalachian Grass and Shrub Bald	0.28
Patch: edaphic	Glade, Barren and Savanna	Southern and Central Appalachian Mafic Glade and Barrens	0.22
Patch: edaphic	Outcrop & Summit Scrub	Southern Piedmont Granite Flatrock and Outcrop	0.20
Patch: edaphic	Outcrop & Summit Scrub	Acidic Rocky Outcrop	0.16
Patch: edaphic	Rocky Coast	Acadian-North Atlantic Rocky Coast	0.16
Patch: edaphic	Glade, Barren and Savanna	Eastern Serpentine Woodland	0.14
Patch: edaphic	Coastal Grassland & Shrubland	Great Lakes Dune and Swale	0.02
Patch: edaphic	Coastal Grassland & Shrubland	North Atlantic Coastal Plain Heathland and Grassland	-0.14
Patch: edaphic	Alpine	Acadian-Appalachian Alpine Tundra	-0.15
Patch: edaphic	Coastal Grassland & Shrubland	Atlantic Coastal Plain Beach and Dune	-0.41
Patch: edaphic	Glade, Barren and Savanna	Great Lakes Alvar	-0.43

Table 25. Average landscape complexity for terrestrial wetland habitats.

Upland Macrogroup	Habitat Summary Group	Landscape Complexity
Northern Peatland	Laurentian-Acadian Alkaline Fen	0.45
Northern Swamp	High Allegheny Headwater Wetland	0.39
Northern Swamp	Central Appalachian Stream and Riparian	0.26
Southern Bottomland Forest	Southern Piedmont Small Floodplain and Riparian Forest	0.24
Large River Floodplain	North-Central Appalachian Large River Floodplain	0.24
Northern Swamp	North-Central Appalachian Acidic Swamp	0.22
Northern Swamp	Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp	0.21
Coastal Plain Swamp	North Atlantic Coastal Plain Stream and River	0.21
Tidal Marsh	Acadian Coastal Salt and Estuary Marsh	0.18
Northern Peatland	North-Central Interior and Appalachian Acidic Peatland	0.14
Northern Swamp	North-Central Interior and Appalachian Rich Swamp	0.13
Central Hardwood Swamp	Central Interior Highlands and Appalachian Sinkhole and Depression Pond	0.12
Wet Meadow / Shrub Marsh	Laurentian-Acadian Wet Meadow-Shrub Swamp	0.10
Northern Swamp	Laurentian-Acadian Alkaline Conifer-Hardwood Swamp	0.07
Emergent Marsh	Laurentian-Acadian Freshwater Marsh	0.05
Central Hardwood Swamp	North-Central Interior Wet Flatwoods	0.04
Southern Bottomland Forest	Southern Piedmont Lake Floodplain Forest	0.04
Large River Floodplain	Laurentian-Acadian Large River Floodplain	0.02
Central Hardwood Swamp	Glacial Marine & Lake Wet Clayplain Forest	-0.05
Northern Peatland	Boreal-Laurentian-Acadian Acidic Basin Fen	-0.07
Emergent Marsh	Piedmont-Coastal Plain Freshwater Marsh	-0.09
Northern Peatland	Acadian Maritime Bog	-0.12
Tidal Marsh	North Atlantic Coastal Plain Brackish/Fresh & Oligohaline Tidal Marsh	-0.14
Large River Floodplain	Piedmont-Coastal Plain Large River Floodplain	-0.19
Large River Floodplain	North-Central Interior Large River Floodplain	-0.21
Central Hardwood Swamp	Piedmont Upland Depression Swamp	-0.21
Wet Meadow / Shrub Marsh	Piedmont-Coastal Plain Shrub Swamp	-0.24
Southern Bottomland Forest	Atlantic Coastal Plain Blackwater/Brownwater Stream Floodplain Forest	-0.40
Coastal Plain Peatland	Atlantic Coastal Plain Northern Bog	-0.60
Coastal Plain Swamp	North Atlantic Coastal Plain Basin Peat Swamp	-0.62
Coastal Plain Swamp	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest	-0.64
Coastal Plain Swamp	North Atlantic Coastal Plain Pitch Pine Lowland	-0.68
Coastal Plain Swamp	North Atlantic Coastal Plain Tidal Swamp	-0.77
Tidal Marsh	North Atlantic Coastal Plain Tidal Salt Marsh	-0.93
Northern Peatland	Boreal-Laurentian Bog	-0.93
Large River Floodplain	North Atlantic Coastal Plain Large River Floodplain	-0.98
Coastal Plain Swamp	Central Atlantic Coastal Plain Non-riverine Swamp and Wet Hardwood Forest	-1.08
Coastal Plain Swamp	Southern Atlantic Coastal Plain Tidal Wooded Swamp	-1.08
Tidal Marsh	Atlantic Coastal Plain Embayed Region Tidal Freshwater/Brackish Marsh	-1.13
Coastal Plain Peatland	Atlantic Coastal Plain Peatland Pocosin and Canebrake	-1.47

CHAPTER 5

Aquatic Metrics

Impervious Surfaces

Definition

Impervious surfaces are hard substrates like paved roads, parking lots, and roof tiles. The amount of impervious surface in the upstream watershed of each reach was summarized.

Why do Impervious Surfaces Matter?

Impervious surfaces prevent the natural pattern of rainwater soaking into the ground and slowly seeping into streams. Instead, the rain water accumulates and flows rapidly overland into storm drains. This harms streams in four important ways (MD DNR 2012):

- **Water Quantity:** Storm drains deliver large volumes of water to streams much faster than would occur naturally, resulting in flooding and bank erosion. Flows peak more rapidly during storms, and peak flows are higher and more frequent. Lack of groundwater recharge during rain events leads to lower daily base flows.
- **Channel Habitat:** Stream channels become wider, less stable, and less complex. Stream inhabitants are stressed, displaced, or killed by fast moving water and the debris, sediment, and disturbed channel habitat it brings.
- **Water Quality:** Pollutants (gasoline, oil, fertilizers, etc.) accumulate on impervious surfaces and are washed into the streams.
- **Water Temperature:** During warm weather, rain that falls on impervious surfaces becomes superheated and can stress or kill stream inhabitants.

All indicators of stream quality relative to biotic condition, hydrologic integrity, and water quality, decline with increasing watershed imperviousness. The stream biological community changes as bacteria become more abundant, species diversity decreases, and tolerant species become more prevalent. Current research suggests that aquatic systems become strongly impacted when watershed impervious cover exceeds 10% (CWP 2003) and show significant declines in many stream taxa at much lower levels of impervious surfaces. Brook trout, for example, are not found in watersheds with more than 4%

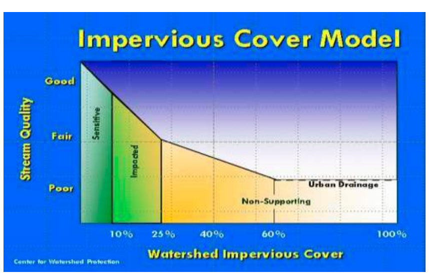

Figure 18. Impervious Cover Model (Center for Watershed Protection 2003).

Figure 19. Impervious surface example of a major road (Robert Jack 2009).

impervious surface (MD DNR 2012) and numerous declining species have been documented between 0.5 and 2% imperviousness. Recent research shows 40-45% declines in regional stream biodiversity (invertebrates, fish, amphibians) at imperviousness greater than 2-3% (King and Baker 2010), derived from the National Landcover Impervious Surface measurements.

Methods

To examine impervious surfaces in the region, we summarized the amount of impervious cover for the total upstream watershed of each stream reach using the 2006 National Landcover Impervious Surface Dataset (Fry et al. 2011). We grouped each stream and river reach in the region into one of four impact categories guided by the thresholds highlighted by the research of King and Baker (2010).

Watershed Percent Imperviousness Impact Categories

- Class 1: Undisturbed: 0 < 0.5%
- Class 2: Low impacts: 0.5-2%
- Class 3: Moderate Impacts: >=2-10 %
- Class 4: High Impacts: >=10%

The percent imperviousness of each NHDPlus local and network catchment was calculated using the National Landcover Dataset (NLCD) 2006 Percent Developed Imperviousness data and the NHDPlus CA3T tool. Key processing steps includ:
Download the NLCD 2006 Percent Developed Imperviousness grid from http://www.mrlc.gov/nlcd2006_downloads.php . The NLCD 2006 Percent Developed Imperviousness values were converted to impervious area (sq meters). For example, a grid cell with a value of 1 was converted to impervious area as follows: grid area = 30-m * 30-m cell = 900 sq meters * .01 = 9 sq meters of impervious surface in the grid cell. The NLCD 2006 impervious grid was clipped and snapped to the NHDPlus catchments. For each NHDPlus region, the NHDPlus CA3T tool was used to allocate the impervious surface area grid by summing the area of impervious surface within each catchment. For each NHDPlus region, the CA3T tool was used to accumulate the summed impervious surface allocation. The allocated output tables for each NHDPlus region were merged into a single file and joined to the NHDPlus catchment data by COMID. The allocated impervious surface area (sq meters) was converted to square kilometers. The % impervious for each local catchment was calculated as follows: (allocated impervious area [sq km] /catchment area [sq km]) * 100. As the cumulative drainage area is not always the same as that of the full network catchment area (accumulated area), the NHDPlus CA3T tool was used to accumulate the drainage area (AREASQKM attribute) of each catchment. The accumulated impervious surface area (sq meters) was converted to square kilometers. The percent impervious for the network (total upstream) catchment was calculated as follows: (accumulated impervious area [sq km] / network drainage area [sq km]) * 100.

Results

Across all streams and rivers, 53% were undisturbed by impervious surface impacts and 30% were in the low impact class. Conversely, twelve percent were in the moderately impacted class, and five percent were in the highly impacted class (Figure 20). Mapping the results highlights concentrations of highly impacted streams and rivers near the coast and within the urban and suburban fringe of existing cities (Map 6).

By the major macrogroup, we see a decreasing proportion of undisturbed miles as freshwater systems grow in size from headwaters to small rivers to medium rivers to large rivers indicating a larger proportion of miles of smaller streams and systems are in this most intact category (Figure 20). Tidal systems have much lower overall percent of undisturbed miles than the freshwater systems. Considering the most highly impacted class, smaller streams and rivers have a larger proportion of miles in the highly impacted class than the larger medium and large systems. This is probably due to the fact that medium and large river watersheds areas are so huge that the effects of very high impervious surfaces in one area may be offset by the presence of natural cover in another part of their large drainage areas making it more difficult for medium and large river reaches to end up in the most highly impacted class. These results highlight that strategies to mitigate the highest levels of impervious surface should be focused on the higher percentages of these miles that are found primarily within the headwater and creek and small river types, particularly the tidal headwaters-small rivers, where nearly 20% of all miles are in this most highly impacted class.

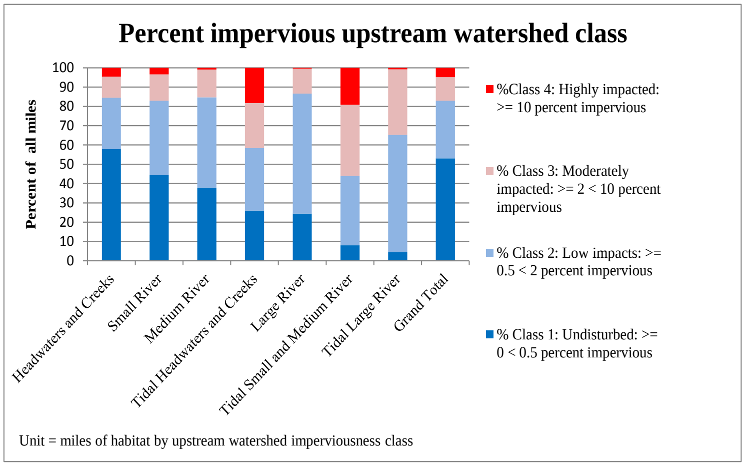

Figure 20. Upstream watershed percent impervious class by macrogroup.

The charts in the Northeast Habitat Guides (Anderson et al. 2013, Figure 21) present the detailed impervious surface information for each headwater and creek type. For example, the chart from low gradient, cool, headwaters and creeks shows 40% of stream miles in the undisturbed class, 37% of stream miles in the low impact class, 17% of stream miles in the moderately impacted class, and 7% of stream miles in the highly impacted class. Note: impervious surface charts were only produced for headwaters, creek, small streams and mid-sized streams.

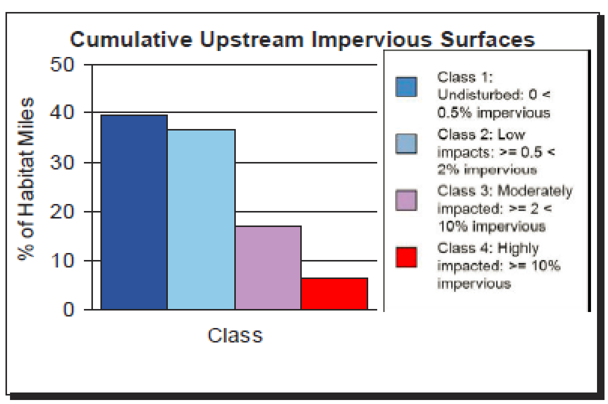

Figure 21. Example of one habitat upstream watershed percent impervious class

Considering patterns across the detailed 23 stream and river types (Table 26), differences can be seen between streams and rivers by their temperature and gradient class. All types with >70% undisturbed miles were cold types, again highlighting the intact settings in the more northern and higher elevation areas of our region. Considering only the headwater and creek types where the impacts of impervious cover have been most studied, we find low, high, and moderate gradient cold streams were the least impacted followed by high gradient cool, and high gradient warm streams. The lowest proportion of undisturbed habitats are found in the tidal streams followed by moderate gradient cool, low gradient warm, low gradient cool streams, and moderate gradient warm streams. Considering the most highly impacted class, tidal headwaters and creeks and low gradient warm headwaters and creeks also both have >10% of their miles in the most highly impacted class, followed by moderate gradient warm headwaters and creeks with 9% in the most highly impacted class.

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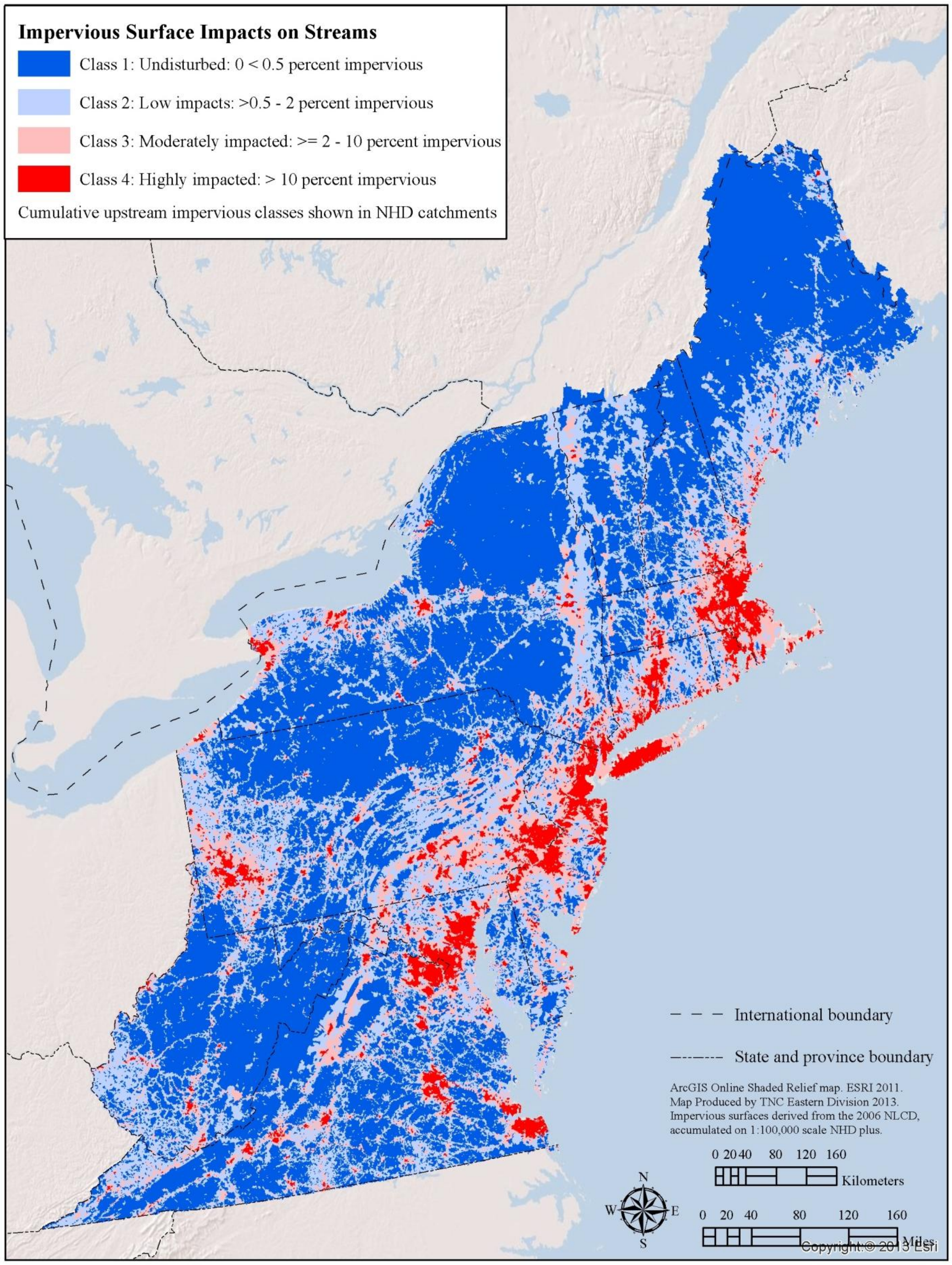
Table 26. Impervious surfaces by habitat type for stream and river habitats.

Macrogroup	Habitat Type	% Class 1: Undisturbed: >= 0 < 0.5 percent impervious	% Class 2: Low impacts: >= 0.5 < 2 percent impervious	% Class 3: Moderately impacted: >= 2 < 10 percent impervious	% Class 4: Highly impacted: >= 10 percent impervious	Index
Medium River	Cold, Medium River	95.0	5.0	0.0	0.0	105.0
Headwaters and Creeks	Low Gradient, Cold, Headwaters and Creeks	85.3	13.8	1.0	0.0	115.7
Small River	Moderate Gradient, Cold, Small River	79.7	19.8	0.5	0.0	120.8
Headwaters and Creeks	High Gradient, Cold, Headwaters and Creeks	79.0	16.5	4.0	0.5	126.0
Small River	Low Gradient, Cold, Small River	77.6	22.4	0.0	0.0	122.4
Large River	Cool, Large River	69.8	29.2	1.0	0.0	131.2
Headwaters and Creeks	Moderate Gradient, Cold, Headwaters and Creeks	68.2	23.5	6.9	1.3	141.3
Headwaters and Creeks	High Gradient, Cool, Headwaters and Creeks	66.3	22.8	8.9	2.0	146.5
Headwaters and Creeks	High Gradient, Warm, Headwaters and Creeks	55.9	31.9	10.0	2.2	158.5
Headwaters and Creeks	Moderate Gradient, Warm, Headwaters and Creeks	48.0	29.7	13.0	9.3	183.7
Medium River	Cool, Medium River	44.8	51.0	4.3	0.0	159.5
Small River	Moderate Gradient, Cool, Small River	44.4	40.2	13.8	1.6	172.7
Headwaters and Creeks	Low Gradient, Cool, Headwaters and Creeks	39.8	36.7	16.9	6.6	190.4
Headwaters and Creeks	Low Gradient, Warm, Headwaters and Creeks	37.0	33.9	18.2	11.0	203.2
Headwaters and Creeks	Moderate Gradient, Cool, Headwaters and Creeks	35.8	36.3	20.0	7.9	200.1
Small River	Low Gradient, Warm, Small River	34.8	41.1	18.7	5.4	194.7
Small River	Moderate Gradient, Warm, Small River	31.9	43.0	19.5	5.6	198.7
Medium River	Warm, Medium River	26.2	50.5	21.8	1.5	198.5
Small River	Low Gradient, Cool, Small River	26.2	49.1	17.3	7.3	205.7
Tidal Headwaters and Creeks	Tidal Headwaters and Creeks	26.0	32.4	23.3	18.3	233.8
Large River	Warm, Large River	10.6	72.3	16.6	0.6	207.1
Tidal Small and Medium River	Tidal Small and Medium River	8.0	35.9	36.9	19.2	267.2
Tidal Large River	Tidal Large River	4.4	60.9	33.9	0.8	231.1



Map 6. Impervious surfaces regional map

Riparian Landcover

Definition

The riparian zone is the land area directly adjacent to a stream or river and subject to its influence. The different types of landcover (NLCD 2006) in the riparian zone within 100m on either side of mapped streams and rivers was summarized.

Why does Riparian Landcover Matter?

The riparian zone is a dynamic and ecologically rich environment supporting many rare and common species and natural communities. As a transitional area between freshwater and terrestrial system, this zone facilitates the exchange of nutrients, sediments, and organisms necessary for the long-term health of terrestrial riparian, floodplain, and freshwater ecosystems. Riparian forests and bottomlands are also fertile and valued farmland and rangeland, as well as prime water-front property desired by developers. Many riparian areas have been cleared and converted for use as pastures, cultivated fields, and housing developments. Both agricultural and developed landcover patterns in the riparian area are associated with lower levels of aquatic biological integrity and water quality (Allan 2004, Figure 22a, Figure 22b).

Forested riparian zones are very important to the health of streams and rivers for a variety of reasons:

- Filter nutrients, sediment, and other pollutants from entering the stream
- Protect the stream banks from erosion
- Slow the flow of water during storm events
- Shade the stream and prevent it from getting too warm for sensitive species
- Dead leaves and branches provide essential input to streams which serve as food and habitat for many stream inhabitants.

When the natural riparian system is converted, heavy runoff into river channels is particularly damaging as it accelerates erosion and bank destabilization. Fine sediments eventually fill up stream pools, altering the shape of the stream channels and covering rocky stream bottoms, thereby impairing important food-producing, shelter, and spawning areas. Runoff can bring seeds of nonnative and nonriparian plant species, excess nutrients from fertilizers and manure in adjacent farmlands, increased turbidity and sediment load, and sediment particles carrying pesticides, pathogens, and heavy metals. Removal of

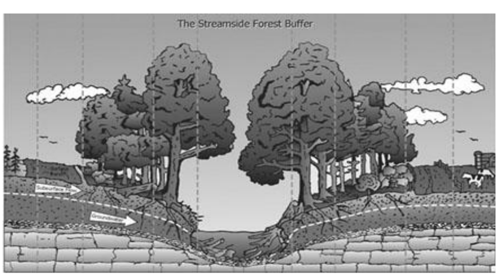


Figure 22a. Riparian zone conceptual model (Welsch 1997).

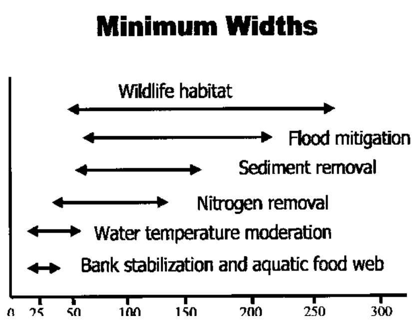


Figure 22b. Functions provided by riparian buffer zone (Palone et al. 1997).

streamside vegetation also reduces shading and increases sunlight entering the channel, resulting in increased water temperatures that decreases a stream's oxygen-carrying capacity. These effects can lead to less diverse and more tolerant macroinvertebrate communities, increased plant and algae growth, and overall homogenization of the fish fauna. In addition the direct loss of riparian terrestrial vegetation reduces habitat critical for breeding, feeding, shelter, and migratory stop over for many birds, mammals, amphibians, and reptiles (NRCS 2007).

Methods

To assess the amount of conversion in riparian lands around streams and rivers, we calculated the amount of agriculture and developed land within each riparian buffer zone by overlaying the 2006 National Landcover dataset on the 100m riparian buffers of NHD Plus 1:100,000 hydrography. We also transformed the landcover information into a summary impact index by summing the percent of development and agriculture in the buffer zone, and weighting the effect of medium to high intensity development twice as much as of agriculture:

*Impact = 0.5 * % agriculture + 0.75* % low intensity development+ 1.0* % medium to high intensity development.*

The impact index ranged from 100 for a watershed with its buffer zone totally developed to 0 where the buffer zone was completely within natural cover. National Landcover Dataset 2006 classes were lumped as follows: Low Intensity Developed = 21, 22, 31 (revised non-natural barren class), Medium to High Intensity Developed = 23, 24, Agriculture = 81, 82, Forest = 41, 42, 43, Wetland = 90, 95, Open / Grassland/ Shrubland = 32, 52, 71.

To create the stream buffers in GIS, we used two methods depending on the size of the habitat. For rivers size 2 and larger, we used input water 30m cell data from the Active River Area (Olivero, 2008) that had been previously assigned to NHD Plus reach COMID. From this dataset we erased lakes from the input water class. We then expanded the remaining input water by three 30m cells to give a ~90-127 meter buffer (sometimes a "3 cell buffer" in practice yields 4 cell expanded area depending on sinuosity and orientation the input reaches). We then erased any buffer cells which had expanded into lakes and erased the input water cells.

For size 1 stream (headwaters and creeks), we created a 30m raster grid from the size 1 streams. We erased lakes, expanded the input cells by three cells to yield a 90-127m buffer on each side, and then erased any buffer cells which had expanded into lakes. We did not erase the input water cells for headwaters and creeks because many of these streams are less than 30m wide, the minimum width of the input water cell, and most of these pixels were not mapped as "open water" in the NLCD 2006.

Results

Seventy three percent of the riparian land in the region is in a natural condition, with the majority (56%) in forested cover. Of the converted riparian land, 16% is in agricultural use, 10% in low intensity development and 2% in high intensity development. By major macrogroup, the highest amounts of development were found in the tidal and freshwater large rivers (Figure 23). Agriculture proportions were low in tidal systems and were highest in the medium and small freshwater rivers. Wetlands account for 14% of the riparian area, with very large proportions of riparian wetlands present in the tidal riparian systems.

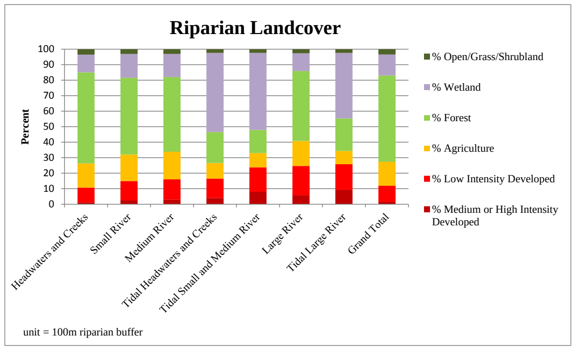


Figure 23. Percent of riparian area by landcover class by macrogroup

The charts in the Northeast Habitat Guides (Anderson et al. 2013, Figure 24) present the riparian landcover information for each stream and river type. For example, the chart from Low Gradient, Warm, Small Rivers shows low gradient, warm rivers have a riparian zone composed of 47% forest, 3% open/grass, 20% wetland, 17% cultivated agriculture, and 14% developed.

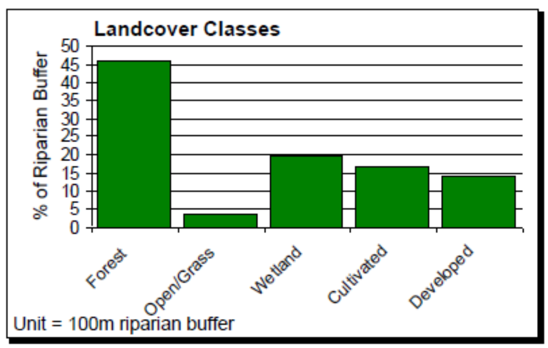


Figure 24. Example for one habitat of the distribution among landcover classes.

Considering patterns across the detailed 23 stream and river types (Table 27 Map 7), we find the six cold temperature headwaters through river types have the most intact riparian areas. High gradient cool and high gradient warm types also have high levels of intact riparian areas. Very low scoring types include the warm large rivers, tidal large rivers, tidal small and medium rivers, again highlighting the development and agricultural pressure on the riparian areas of these large and coastal rivers. Other low scoring types included moderate gradient cool headwaters and creeks, warm medium rivers, moderate gradient cool small rivers, and moderate gradient warm small rivers.

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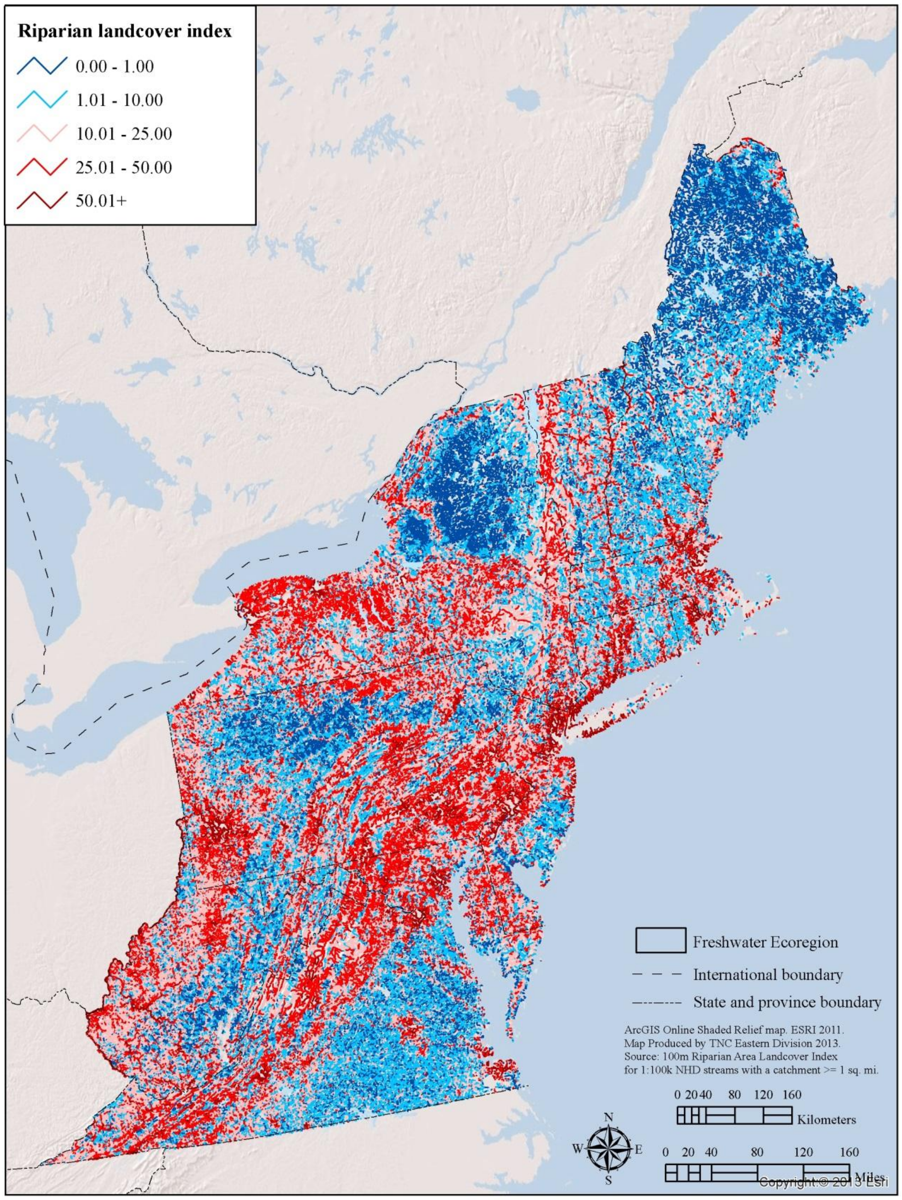
Table 27. Amount of each aquatic habitat in various landcover classes in the riparian buffer.

Macrogroup	Habitat Type	Index	% Low Developed	% Med/High Developed	% Agriculture	% Forest	% Wetland	% Open/Grass / Shrubland
Headwaters and Creeks	Low Gradient, Cold, Headwaters and Creeks	3.0	2.2	0.2	2.3	48.3	42.7	4.2
Small River	Low Gradient, Cold, Small River	6.9	4.3	0.5	6.4	39.1	46.9	2.7
Medium River	Cold, Medium River	8.0	5.3	1.0	6.0	53.8	28.9	5.0
Headwaters and Creeks	High Gradient, Cold, Headwaters and Creeks	10.4	6.4	0.4	10.5	75.0	4.6	3.2
Small River	Moderate Gradient, Cold, Small River	11.9	9.0	1.4	7.5	57.4	20.3	4.4
Headwaters and Creeks	Moderate Gradient, Cold, Headwaters and Creeks	12.4	6.6	0.8	13.4	58.7	15.5	5.0
Headwaters and Creeks	High Gradient, Cool, Headwaters and Creeks	14.9	10.5	0.7	12.7	74.1	0.5	1.5
Headwaters and Creeks	High Gradient, Warm, Headwaters and Creeks	16.4	12.1	0.7	13.3	68.6	0.4	4.9
Tidal Headwaters and Creeks	Tidal Headwaters and Creeks	18.4	12.5	4.1	10.0	20.0	51.1	2.3
Headwaters and Creeks	Moderate Gradient, Warm, Headwaters and Creeks	19.0	13.1	1.6	15.1	60.6	5.5	4.0
Headwaters and Creeks	Low Gradient, Cool, Headwaters and Creeks	19.6	9.7	2.0	20.6	39.6	24.6	3.5
Small River	Low Gradient, Warm, Small River	19.6	12.5	1.9	16.6	46.3	19.7	3.0
Headwaters and Creeks	Low Gradient, Warm, Headwaters and Creeks	19.7	11.4	1.9	18.6	40.7	23.8	3.6
Medium River	Cool, Medium River	21.3	12.2	2.2	19.9	43.1	18.9	3.7
Large River	Cool, Large River	21.6	14.0	3.4	15.6	47.3	15.9	3.9
Small River	Low Gradient, Cool, Small River	22.2	11.7	2.6	21.7	35.9	24.8	3.3
Small River	Moderate Gradient, Warm, Small River	22.9	14.1	2.7	19.1	55.1	6.3	2.6
Small River	Moderate Gradient, Cool, Small River	23.8	14.2	3.2	19.8	51.1	9.0	2.7
Medium River	Warm, Medium River	23.8	14.7	3.6	18.3	50.3	10.7	2.5
Tidal Small and Medium River	Tidal Small and Medium River	24.5	15.7	8.0	9.3	14.9	49.7	2.3
Tidal Large River	Tidal Large River	25.9	16.5	9.3	8.5	21.0	42.3	2.3
Headwaters and Creeks	Moderate Gradient, Cool, Headwaters and Creeks	26.9	15.4	2.0	26.6	49.8	4.1	2.0
Large River	Warm, Large River	29.9	20.5	6.5	16.2	44.6	10.1	2.3



Map 7. Riparian landcover index for streams and rivers in the Northeastern United States, calculated within a 100m riparian buffer.

Dam Type and Density

Description

The number of dams, types of dams (hydroelectric, flood control, water supply, recreation, other), and density of dams per 100 miles of stream was calculated for each habitat type.

Figure 25. Picture of a dam.

Why does Dam Type and Density Matter?

Dams significantly alter the biological, chemical and physical properties of rivers. In addition to blocking the movement of stream biota, altering flow and sediment transport has great sustained impacts. Life in and around a river is conditioned to the timing and quantities of flow, and even subtle changes can result in disruption to critical life cycle and ecological processes. Reduction in sediment transport as particles are trapped behind dams negatively affects the maintenance of downstream channel beds, floodplains, deltas, and coastal wetlands. Upstream of a dam, in the artificial slack-water reservoir habitat, changes in the water temperature, chemical composition, dissolved oxygen levels, and physical habitat creates conditions unsuitable to riverine biota (Allan 1995).

The size, purpose, and operation of dams affects their relative impact on river systems. For example, larger dams can hold more water volume and are greater impediments to riverine species movement. Lower "run-of-the-river" dams are thought to have smaller adverse effects because they create a smaller slack water upstream area and release water at the rate it enters the reservoir.

Impacts associated with major types of dams are summarized below (from Richter and Thomas 2007).

Hydropower dams: Hydroelectric dams store water and replace a stream's natural hydrology with artificial flow regimes designed to meet daily and seasonal energy demands. Although many small hydropower dams are operated as "run-of-the-river" facilities, larger hydropower dams can store large volumes of water and are associated with significant negative riverine impacts. Episodes of power generation and high flow releases are generally followed by periods in which dam water releases may be largely or completely curtailed to allow the reservoir to refill. The rapid fluctuations in water levels associated with hydropower daily and seasonal operations can cause considerable ecological damage, as it can leave slow-moving aquatic animals such as mussels stranded when levels drop, or sweep them away when levels rise too quickly. In addition to the elimination of small floods and creating an altered flow regime, the hydroelectric generators turbine blades directly kill fish that get swept into them as they move downstream.

Water supply dams: Water supply dams are designed to capture a significant proportion of high flow events and release water according to water demands. These dams can completely rearrange seasonal patterns of water flow, such as when wet-season flows are stored for release in the dry season to support irrigated agriculture. In addition to reduced downstream flows during periods of storage, depending on diversion and release methods, river flows may become unnaturally high during periods when stored water is being released for downstream uses. These high flows can cause channel scouring, downcutting, erosion, and severe disruption to life cycles of aquatic and riparian organisms.

Flood control dams: Flood control dams collect and store water during floods and gradually release it at a later date at a lower discharge level. The general effect of a flood control dam is to reduce the peak flow, eliminate small floods and eliminate all but the most extreme large floods. This regulation of flow has severe negative impacts on floodplain and ripairan ecosystems which require both small and large flood inundation for their maintenance. Riverine ecosystems are also negatively impacted by loss of peak flood flows and artificially long moderate-high flow pulses as flood control dams gradually discharge water stored during flood peaks.

Recreation dams: Recreational dams create impoundments within a river or maintain a constant high water level within a existing natural lake. These reservoirs serve as swimming, boating, and fishing places for people. In New England and New York, many of these dams are located on existing natural lakes, while in the mid-Atlantic most create new reservoirs which replace riverine habitat. Many recreation dams also have a secondary purpose such as flood control or water supply.

Methods

The types of dams on streams and rivers in the northeast were summarized using a dam dataset including National Inventory of Dams and state dams located on NHD Plus 1:100,000 streams with > 1 sq.mi. drainage area (Martin and Apse 2011).

Dam data for the Northeastern United States compiled from multiple state and federal sources by The Nature Conservancy and edited for use in the Northeast Aquatic Connectivity project (Martin and Apse 2011). This dataset was the result of a project to compile a dataset of dam barriers in the northeast states (ME, NH, VT, MA, CT, RI, NY, PA, NJ, DE, MD, VA, WV, DC) and spatially link the dams to the correct stream flowline in the USGS National Hydrography Plus (NHD-Plus) 1:100,000 stream dataset. A standardized, repeatable, and accurate dam snapping method was developed and implemented to create this dataset. The method is fully described in the Appendix I of Marin and Apse 2011. Primary steps included 1) snapping each state's dams to the 1:100,000 NHD flowlines, using a 100m snapping tolerance, 2) coding the dams for prioritization for manual review, 3) manual error checking of the prioritized dams, 4) returning the data to the states for expert review, and 5) re-incorporated the state edits into the final snapped dataset.

Original data for each state as follows (from Martin and Apse 2011):
CT: Connecticut DEP, Inland Water Resources Division; DE: Delaware Dams: DNREC; MA: Massachusetts Department of Fish and Game, Division of Ecological Restoration (DER) based on modified and updated datasets from the Massachusetts Department of Conservation and Recreation, Office of Dam Safety. ; MD: MD DNR; ME: Army Corp of Engineers (USACE), Maine Emergency Management Agency (MEMA), Maine Department of Environmental Protection (MEDEP)(comp., ed.), Maine Office of Geographic Information Systems (comp., ed.); NH: NH DES; NJ: NJDEP - Bureau of Dam Safety and Flood Control; NY: NYS Department of Environmental Conservation; USGS Great Lakes Science Center; PA: Division of Dam Safety, Department of Environmental Protection; PA Fish and Boat Commission; RI: RI Department of Environmental Management; VA: VA Dept. of Game & Inland Fisheries ; VT: Vermont Agency of Natural Resources, Department of Environmental Conservation; WV: WV DNR: Wildlife Diversity and Technical Support Units; WV Non-coal dams, DMR Dams, NID dams: WV State GIS Data Clearinghouse: http://wvgis.wvu.edu/data/data.php; US Army Corps' National Inventory of Dams; USGS Geographic Names Information System (GNIS).

Results

We focused our analysis on the 13,824 dams on streams and rivers with drainage areas over 1 sq. mi. because dams on smaller streams could not be comprehensively assessed at this regional scale. Three quarters of all dams were located on headwaters and creeks, but this is not unexpected given the high number of miles of headwaters and creeks in the region (Figure 26a.) The focal dams had a variety of primary purposes. The most common type was recreational followed by water supply, hydroelectric, and flood control dams. Some dams also had a variety of other purposes (industrial debris control, fire/farm pond, navigation) and many also did not report a given purpose (Figure 26b.) The highest dams in the region were flood control dams, followed by water supply, hydroelectric, and recreational. Hydroelectric dams had the highest normal and maximum storage capacity, and recreational dams the lowest, while flood control dams have a large difference between normal and maximum storage, with their maximum storage being almost three times their normal storage (Figure 27).

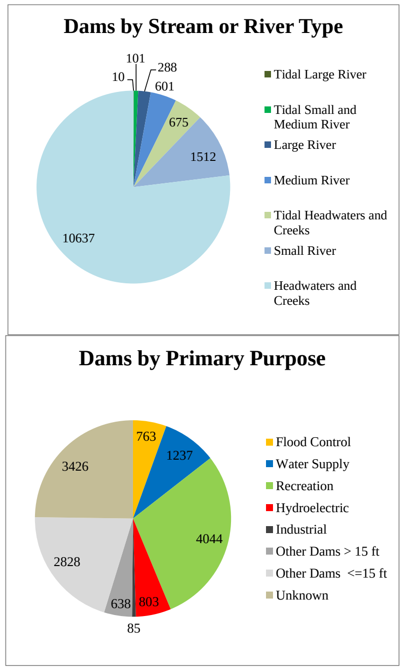


Figure 26. a) Number of dams by river macrogroup and b) Number of dams by primary purpose

Summarizing patterns across all streams and rivers, on average there were 7 dams for every 100 miles of streams and rivers in the region. By major macrogroup, small and medium rivers had the highest dam density along with tidal headwaters and creeks (Figure 28). Tidal headwaters and creeks had very high dam densities because dams were built at nearly every head of tide throughout New England and much of the mid-Atlantic. The coastal northern states such as Massachusetts, Connecticut, Rhode Island, and New Jersey also had a higher densities of dams than other states (Map 8), which likely reflects the patterns of population

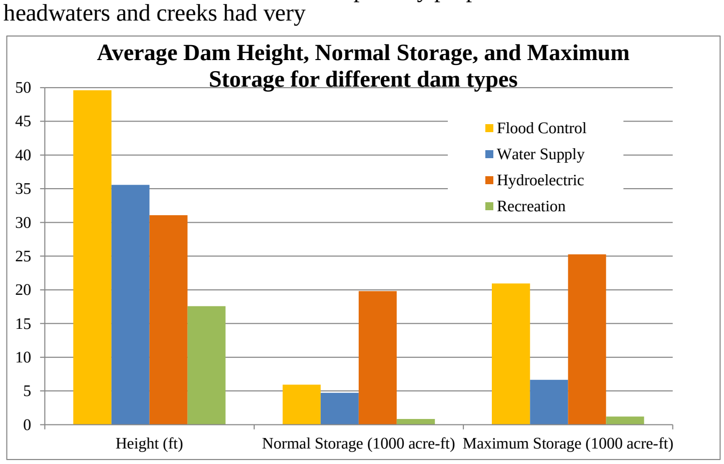


Figure 27: Average Height, Normal Storage, and Maximum Storage of Dams by Type

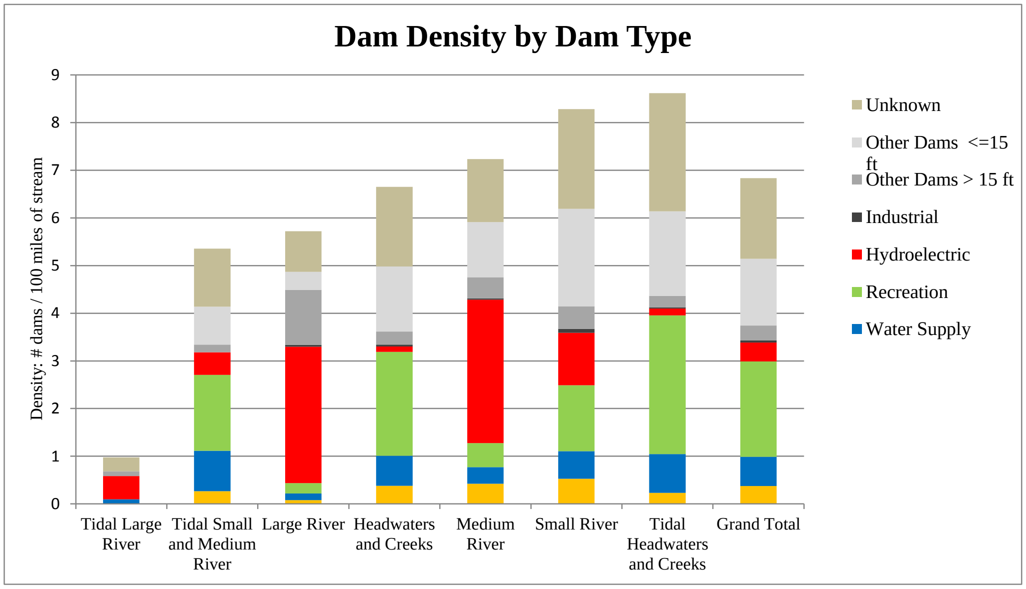


Figure 28. Dam density and dam type by macrogroup.

density in the early dam-building era of the late 1880s – early 1900s when dams supplied power to many local farms and grist mills. New England and New York also have higher densities of hydroelectric dams, which likely reflects their steeper topography and potential for hydropower generation (Map 8).

The charts in the Northeast Habitat Guides (Anderson et al. 2013) present the dam type and density information for each stream and river type. For example the facing chart (Figure 29) shows that warm medium rivers have an overall dam density of 5 dams per 100 stream miles. This density is composed of a density of 0.5 flood control dams/100 miles, 1.2 hydroelectric dams/100 miles, .7 recreation dams/100 miles, 0 .4 water supply dams/100 miles, 1.2 other dams/100 miles, and 1 unknown type dam/100 miles.

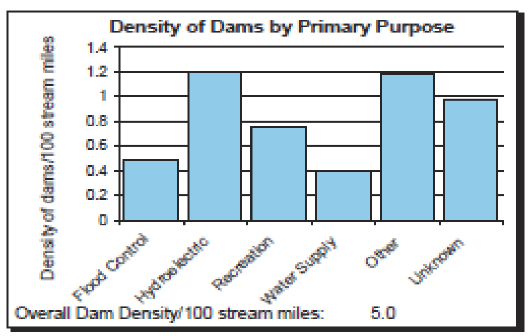


Figure 29. Example of one habitat dam density.by primary purpose.

Across stream and river type (Table 28), hydroelectric dams had their highest density on medium and large rivers, particularly on cool large rivers, and cool and cold medium rivers (Figure 29). Hydroelectric dams also had densities above one for moderate gradient cold and cool small rivers and on warm large and medium rivers. The density of recreational dams was highest in the tidal and freshwater headwaters and creeks, particularly low gradient cool, low gradient warm, and moderate gradient cool headwaters and creeks. Flood control dams were widely distributed across types as were water supply dams.

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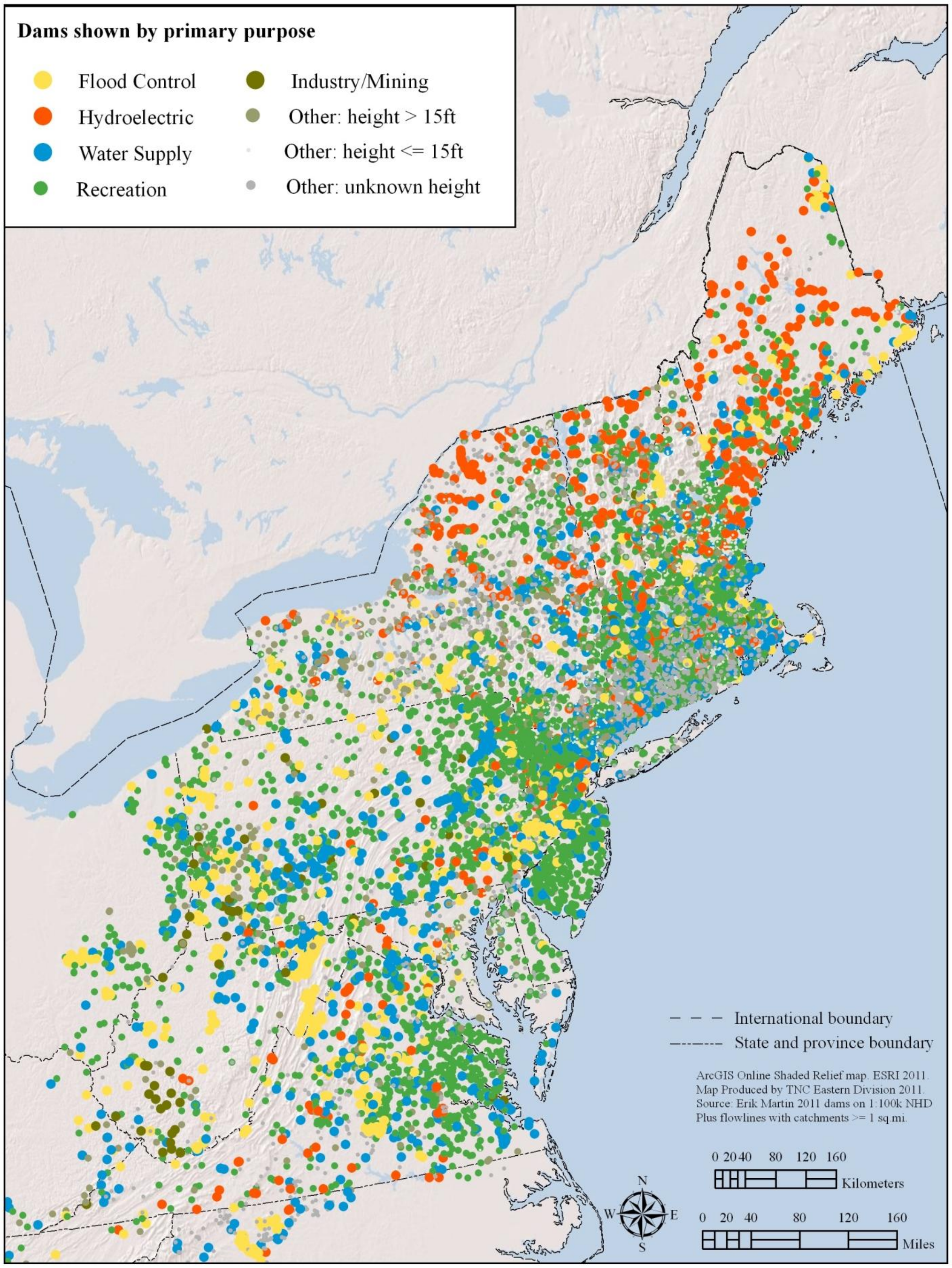
Table 28. Number and type of dam by aquatic habitat

Habitat Type	Total Dams	Miles of Habitat	Total Dam Density: # / 100 miles	Flood Control Dam Density: # / 100 miles	Water Supply Dam Density: # / 100 miles	Recreation Dam Density: # / 100 miles	Hydroelectric Dam Density: # / 100 miles	Industrial Dam Density: #/ 100 miles	Other Dams > 15 ft Density: # / 100 miles	Other Dams <=15 ft Density: # / 100 miles	Unknown Type Dam Density: # / 100 miles
Tidal Large River	10	1,026	1.0	0.0	0.1	0.0	0.5	0.0	0.1	0.0	0.3
High Gradient, Cool, Headwaters and Creeks	258	12,390	2.1	0.2	0.3	0.7	0.0	0.1	0.2	0.3	0.3
High Gradient, Warm, Headwaters and Creeks	64	2,681	2.4	0.2	0.3	0.8	0.0	0.2	0.1	0.4	0.3
Low Gradient, Cold, Small River	28	989	2.8	0.5	0.1	0.4	0.6	0.0	0.1	0.3	0.8
Low Gradient, Cold, Headwaters and Creeks	140	4,114	3.4	0.3	0.1	1.3	0.3	0.0	0.2	0.7	0.5
Low Gradient, Warm, Small River	87	2,488	3.5	0.3	0.3	1.0	0.2	0.2	0.2	0.7	0.7
Moderate Gradient, Warm, Headwaters and Creeks	605	16,894	3.6	0.5	0.3	1.5	0.0	0.1	0.1	0.6	0.5
Moderate Gradient, Warm, Small River	146	3,664	4.0	0.3	0.4	1.2	0.2	0.1	0.1	1.0	0.7
Warm, Large River	168	3,853	4.4	0.1	0.2	0.3	1.5	0.1	1.1	0.3	0.9
Warm, Medium River	248	4,953	5.0	0.5	0.4	0.7	1.2	0.0	0.2	1.0	1.0
Tidal Small and Medium River	101	1,885	5.4	0.3	0.8	1.6	0.5	0.0	0.2	0.8	1.2
Cold, Medium River	40	693	5.8	0.0	0.1	0.3	3.8	0.0	0.4	0.7	0.4
High Gradient, Cold, Headwaters and Creeks	2,339	36,183	6.5	0.2	0.8	1.6	0.1	0.0	0.4	1.7	1.5
Moderate Gradient, Cold, Headwaters and Creeks	2,301	32,073	7.2	0.3	0.5	2.0	0.2	0.0	0.4	1.9	2.0
Low Gradient, Warm, Headwaters and Creeks	1,291	17,704	7.3	0.5	0.7	3.6	0.1	0.0	0.1	0.9	1.4
Moderate Gradient, Cool, Headwaters and Creeks	1,654	21,323	7.8	0.6	0.6	2.2	0.1	0.1	0.3	1.2	2.8
Low Gradient, Cool, Small River	201	2,416	8.3	1.0	0.5	1.8	0.6	0.0	0.4	2.2	1.8
Moderate Gradient, Cold, Small River	202	2,352	8.6	0.3	0.3	0.9	2.7	0.0	0.6	1.0	2.8
Tidal Headwaters and Creeks	675	7,835	8.6	0.2	0.8	2.9	0.1	0.0	0.2	1.8	2.5
Cool, Large River	120	1,180	10.2	0.0	0.0	0.0	7.5	0.0	1.3	0.8	0.7
Cool, Medium River	313	2,661	11.8	0.4	0.3	0.1	6.2	0.0	0.9	1.6	2.2
Low Gradient, Cool, Headwaters and Creeks	1,985	16,579	12.0	0.5	1.3	4.5	0.3	0.0	0.2	2.2	2.9
Moderate Gradient, Cool, Small River	848	6,343	13.4	0.6	1.0	1.8	1.6	0.1	0.9	3.8	3.5
Grand Total	13,824	202,280	6.8	0.4	0.6	2.0	0.4	0.0	0.3	1.4	1.7



Map 8. Dams by Type Regional Map

Risk of Flow Alteration from Dam Water Storage

Definition

The risk of flow alteration from dam water storage is expressed as the ratio of the volume of water capable of being stored behind dams upstream to the mean annual flow volume expected in a reach expressed as a percent

Why does Flow Alteration Matter?

Flow alteration is among the most serious threats to freshwater ecosystems. Natural, seasonal patterns of rising and falling water levels shape aquatic and riparian habitats, provide cues for migration and spawning, distribute seeds and foster their growth, and enable rivers, lakes, wetlands, and estuaries to function properly (Bunn and Arthington 2002, Poff et al. 1997, Figure 30, 31). The need to allocate a portion of water to meet society's needs for water supply, crop production, energy generation, and flood management requires careful evaluation and integration of competing uses to ensure rivers and streams have hydrologic regimes adequate to support native fish and wildlife.

Although flows can be altered a variety of irrigation, interbasin transfer, and other management practices, dams are often responsible for a disproportionately large portion of all flow alteration in a basin. In particular, the storage capacity of dams has been found to be highly correlated with measures of overall hydrologic alteration (Graf 1999, Zimmerman 2006 a, b, c; Fitzhugh and Vogel 2010). Dams that can retain larger amounts of water are noted as agents of greater hydrologic alteration in the system. The ratio of dam water storage upstream of a reach to the mean annual flow volume expected in a reach has been used as a standardized metric to compare and classify rivers into categories of risk of hydrologic alteration in the absence of more detailed available site-specific flow measurements (Zimmerman 2006 a, b, c; Fitzhugh and Vogel 2010). Because different rivers can vary in the exact form of the relationship between dam storage and ecological condition (Figure 30), and because the inter- and intra-year timing of alteration in flows has an effect on ecological condition (Figure 31) the most appropriate use of this

Figure 30**.** Conceptual flow-ecology curves showing possible forms of the relationship. A: linear, B: threshold, C: curvilinear (Davies and Jackson 2006).

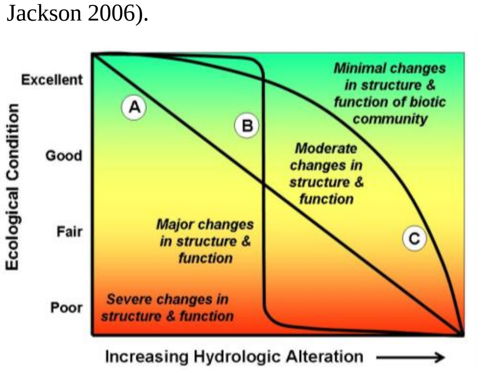
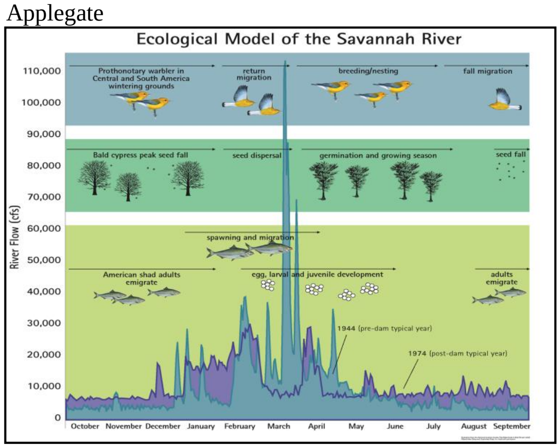


Figure 31. Ecological functions and hydrograph before (blue) and after (purple) damming. TNC GAFO, Kelly Applegate



upstream dam water volume storage metric is as an indicator of the maximum potential level of alteration of flood flows, and by inference ecological condition, and also the range of possible levels of alteration (Fitzhugh and Vogel 2010).

Methods

The maximum volume of water capable of being stored behind all dams upstream of a given reach was accumulated using the National Inventory of Dams (ACE 2010) and compared to the mean annual flow from the NHD Plus (USGS 2006).

The categories of maximum "Potential Risk of Flow Alteration from Upstream Dam Water Storage" used in this report are as follows (Zimmerman 2006) based on upstream storage volume of dams as a percent of mean annual flow volume:

- Class 1: <2% Very low risk
- Class 2: >= 2 < 10% Low risk
- Class 3: >= 10 < 30% Moderate risk
- Class 4: >= 30 < 50% High risk
- Class 5: >= 50% Severe risk

Dam data for the Northeastern United States compiled from multiple state and federal sources by The Nature Conservancy and edited for use in the Northeast Aquatic Connectivity project (Martin and Apse 2011). This dataset was the result of a project to compile a dataset of dam barriers in the northeast states (ME, NH, VT, MA, CT, RI, NY, PA, NJ, DE, MD, VA, WV, DC) and spatially link the dams to the correct stream flowline in the USGS National Hydrography Plus (NHD-Plus) 1:100,000 stream dataset. A standardized method of dam snapping was used to updgrade the data (Marin and Apse 2011). Thirteen dams that were slated to be removed within the next 3 years were removed from the regional dam dataset to incorporate these upcoming changes. The Barrier Assessment Tool (TNC 2010) was used in ArcGIS 9.3 on the dams and 1:100,000 NHD Plus centerline dataset to facilitate creation of networks and several network metric calculations. One of the metric calculations was an accumulation of the dam storage attribute from the National Inventory of Dams (NID) dams that were in the regional dam database. Only National Inventory of Dams were used in the dam storage accumulation because of inconsistencies in how other smaller dams from state or other sources did or did not track the storage volume. The NID maximum dam storage attributes was chosen for accumulation, rather than the normal storage attribute, to better reflect the maximum potential for water storage in the system (Fitzhugh per comm.). For example, many flood control dams had a normal storage of zero but a very large maximum potential storage which would be used to hold back water during floods and we wanted to account for this potential to alter flow in the system. When a maximum dam storage value was not listed in the NID database, the normal storage or NID storage was substituted (whichever was larger). This accumulation of the dam storage upstream of every NHD Plus 1:100,000 reach was then divided by the mean annual flow volume for that reach (NHD Plus 2006) and this ratio converted to a percent. The mean annual flow was converted from cfs to acre-feet per with the conversion factor 723.97 before the division and percent calculations to ensure the same units were being compared.

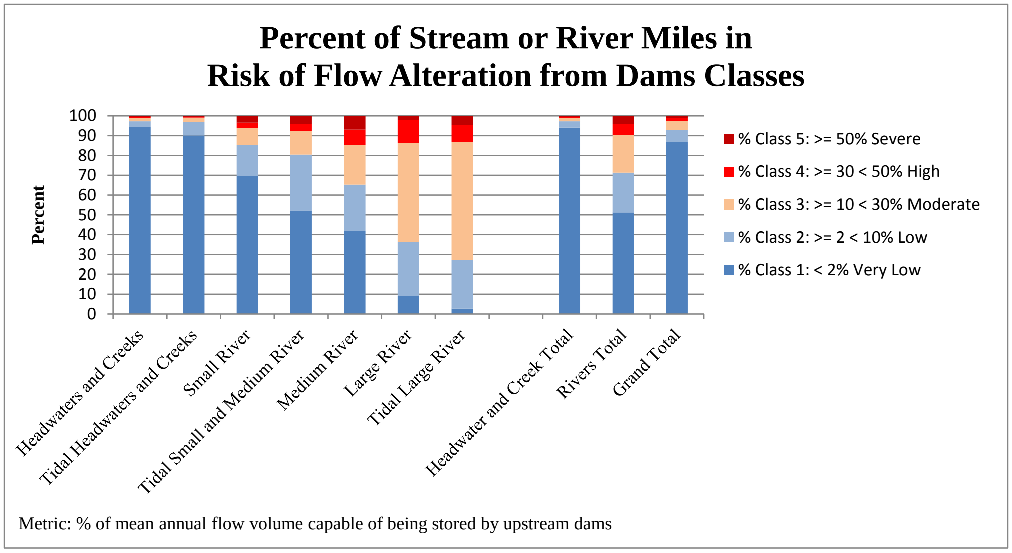


Figure 32. Percent of stream or river miles in risk of flow alteration from dams classes.

Results

The proportion of miles in the moderate to severe risk category increased as the size of the freshwater system increased (Figure 32). As a whole, rivers were also much more impacted than headwaters-creeks by upstream dam storage. For example, 94% of all headwater and creek miles were in the very low risk category while only 51% of river miles were in this very low risk category. This reflects the increasing occurrence of large storage dams as rivers grow in size and also the increasing effect of the accumulated upstream water storage behind all upstream dams from the many streams and rivers that flow into a given medium or large river. Considering just the severe risk category, the largest proportion of miles in this category occur in medium sized rivers followed by large tidal rivers, tidal medium and small rivers, and small freshwater rivers.

The charts in the Northeast Habitat Guides (Anderson et al. 2013) present the risk of flow alteration from dam water storage information for each river type. For example, the chart for Cool Medium Rivers show that 34% of miles are in the very low impact class, 29% of miles are in the low impact class, 21% of miles are in the moderate class, 8% of miles are in the high impact class, and 7% of miles are in the severe risk impact class (Figure 33). Please note the charts in the guide are only rivers.

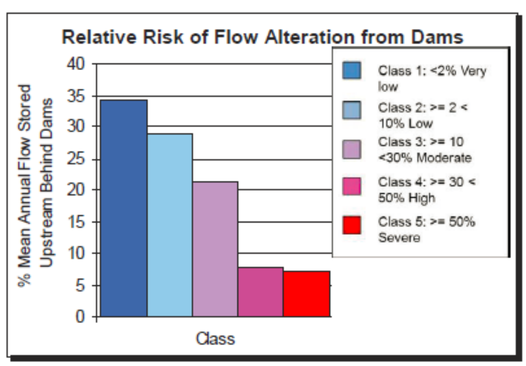


Figure 33.. Example of one habitat risk of flow alteration from dam water storage.

Considering patterns across all 23 detailed stream and river types using the overall index score (Table 29, Map 9), we find most impacted rivers are tidal large rivers, followed by warm large rivers, cool large rivers, cool medium rivers, warm medium rivers, cold medium rivers. These types are followed by the small rivers of which the low gradient cool, moderate gradient cool and low gradient warm rivers appear more highly impacted. Considering the percent of miles in the most highly impacted class, we find the highest percents in the warm medium river and cool medium rivers followed by moderate gradient cool small rivers. Additional site specific studies should be done to further address the range of effects and potential strategies to ameliorate the potential severe negative effects of dam storage in these reaches ecological health.

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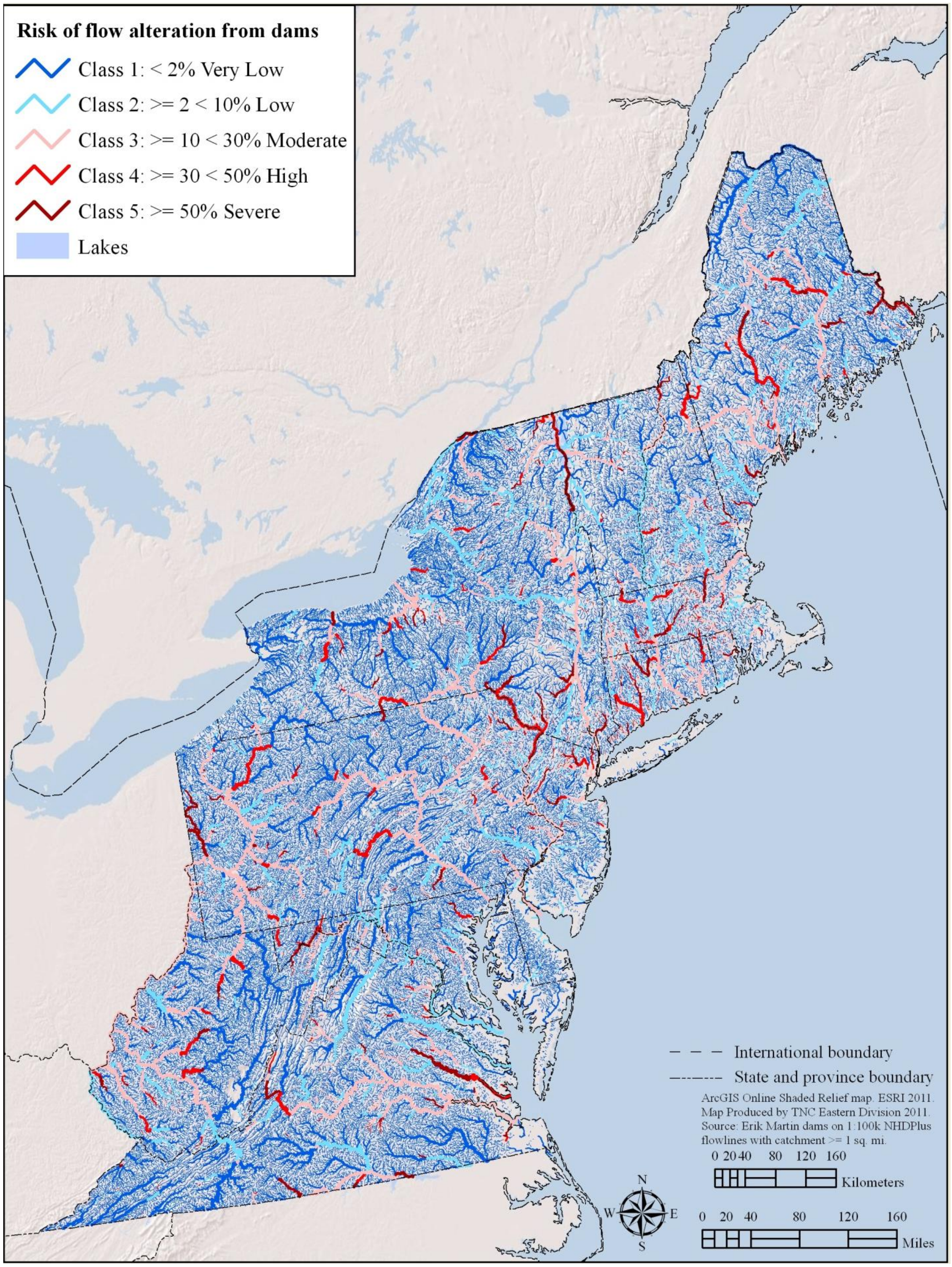
Table 29. Risk of flow alteration from dams for each stream and river habitat, grouped by macrogroup.

Macrogroup	Habitat Type	Summary Index	% Class 1: < 2% Very Low	% Class 2: >= 2 < 10% Low	% Class 3: >= 10 < 30% Moderate	% Class 4: >= 30 < 50% High	% Class 5: >= 50% Severe
Headwaters and Creeks	High Gradient, Warm, Headwaters and Creeks	103.0	98.8	0.2	0.4	0.1	0.4
Headwaters and Creeks	High Gradient, Cool, Headwaters and Creeks	103.5	98.3	0.8	0.5	0.2	0.3
Headwaters and Creeks	Moderate Gradient, Warm, Headwaters and Creeks	106.7	96.7	1.4	1.0	0.4	0.5
Headwaters and Creeks	High Gradient, Cold, Headwaters and Creeks	107.3	96.0	2.0	1.2	0.4	0.5
Headwaters and Creeks	Low Gradient, Cold, Headwaters and Creeks	108.0	95.6	2.2	1.6	0.2	0.5
Headwaters and Creeks	Moderate Gradient, Cool, Headwaters and Creeks	110.4	94.4	2.6	1.8	0.7	0.6
Headwaters and Creeks	Moderate Gradient, Cold, Headwaters and Creeks	112.8	92.5	4.0	2.3	0.5	0.6
Headwaters and Creeks	Low Gradient, Warm, Headwaters and Creeks	113.4	92.3	4.2	2.1	0.7	0.7
Tidal Headwaters and Creeks	Tidal Headwaters and Creeks	114.5	90.1	6.8	2.1	0.4	0.5
Headwaters and Creeks	Low Gradient, Cool, Headwaters and Creeks	119.0	88.9	6.0	3.2	0.9	0.9
Small River	Low Gradient, Cold, Small River	138.1	73.9	17.3	6.7	0.7	1.3
Small River	Moderate Gradient, Cold, Small River	141.0	73.7	16.3	6.8	1.9	1.3
Small River	Moderate Gradient, Warm, Small River	144.3	76.2	11.4	7.4	2.1	3.0
Small River	Low Gradient, Warm, Small River	152.0	72.9	11.9	9.0	2.9	3.3
Small River	Moderate Gradient, Cool, Small River	164.3	66.0	16.8	9.0	3.3	4.9
Small River	Low Gradient, Cool, Small River	168.3	60.6	21.4	10.8	3.3	3.9
Tidal Small and Medium River	Tidal Small and Medium River	179.2	52.2	28.3	11.8	3.7	4.1
Medium River	Cold, Medium River	196.4	47.8	17.4	27.2	5.4	2.1
Medium River	Warm, Medium River	211.7	44.9	21.4	18.4	7.8	7.5
Medium River	Cool, Medium River	224.7	34.4	28.9	21.4	7.9	7.3
Large River	Cool, Large River	253.9	12.7	39.0	32.4	13.3	2.6
Large River	Warm, Large River	275.3	8.0	23.5	55.5	11.1	1.9
Tidal Large River	Tidal Large River	288.1	2.7	24.5	59.5	8.5	4.8



Map 9. Risk of flow alteration from dams in the northeastern United States.

Network Size

Description

A connected network is defined as the set of stream and river segments bounded by fragmenting features (dams) and/or the topmost extent of headwater streams. The total linear length of all segments in each connected network was calculated.

Why does Network Size Matter?

Connectivity within a network of streams and rivers is essential to healthy freshwater ecosystems. Key benefits include:

- Permits individuals to move throughout the network to find the best feeding and spawning conditions
- Enables individuals to colonize, recolonize, and migrate to locations where conditions are more suitable for survival during times of stress
- Facilitates maintenance of metapopulations and accompanying genetic diversity
- Enables water flow, sediment and large woody debris transport, and nutrient regimes to function naturally

Isolation and reduced access to habitat due to damming has been linked to the precipitous decline over the last 50 year of many North American fish and mussels (Fausch et al. 2002, Pringel et al 2000, Busch et al. 1998). Some key freshwater biota benefiting from more connected stream networks include

Diadromous Fish: Diadromous fish exploit both freshwater and saltwater habitats. The distance traveled in order to do this varies widely among the species, from the rainbow smelt that lives its entire life within about a mile of the coast, to the Atlantic salmon that spawns in headwater streams hundreds of miles inland. Diadromous fish species of the northeast include alewife, American eel, American shad, Atlantic salmon, Atlantic sturgeon, Atlantic tomcod, blueback herring, hickory shad, rainbow smelt, searun trout, and shortnose sturgeon. Dams have caused the loss of access to 91% of stream habitat within the historic unrestricted range of diadromous fishes in New England from Maine to Connecticut (Busch et al. 1998).

Resident Freshwater Fish: Many resident freshwater fish species exhibit freshwater migrations and move significant distances within the stream network for feeding, seasonal refuge, and life stage segregation. This includes native eastern freshwater fish species such as: suckers, redhorses, brook trout, fallfish, yellow perch, bullhead, and pickerel (Nedeau 2006).

Freshwater Mussels: Many freshwater mussels are dependent upon migratory fishes as hosts for their parasitic larvae (Neves et al. 1997, Vaughn and Taylor 1999). Dams and the loss of migratory fish have been linked to mussel population declines and local mussel population extirpations (Watters 1996). By blocking fish movements, dams have eliminated host fish availability in reaches otherwise supportive to mussel populations.

Figure 34. Northern Riffleshell from French Creek, PA (D. Crabtree, TNC PAFO

Plants and Floodplain Ecosystems: Floodplain ecosystems depend on stream connectivity for natural flows to remove vegetative encroachment on floodplains, maintain sediment and nutrient regimes, and disperse seeds. In addition, dams disrupt the dispersal of other emergent and submerged floras whose spores or seeds are waterborne (Jansson et al. 2000).

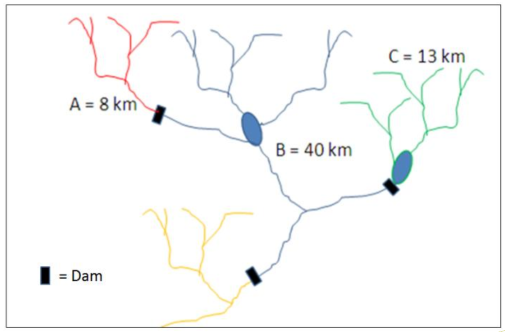


Figure 35. Length of a connected network. Calculated for streams between fragmenting dams or upper headwaters (Anderson and Olivero Sheldon 2011)

Methods

To assess current connectivity, we measured the length of **connected stream networks**, defined as the set of stream and river segments bounded by fragmenting features (dams) and/or the topmost extent of headwater streams. We used only dams and topmost headwaters as barriers (Figure 35). Dams were from a dam dataset including the National Inventory of Dams supplemented by each state's dataset of dam locations (Martin and Apse 2011), while river reaches were from the 1:100,000 National Hydrography Dataset Plus (U.S.G.S. 2006) and included all streams with >1 sq.mi. drainage area to focus results on a consistent set of perennial features. Road-stream crossings and waterfalls were not used due to uncertainty as to whether these features were true barriers to movement for most species, and because of inconsistencies in mapping these features across the region.

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Dam data for the Northeastern United States compiled from multiple state and federal sources by The Nature Conservancy and edited for use in the Northeast Aquatic Connectivity project (Martin and Apse 2011). This dataset was the result of a project to compile a dataset of dam barriers in the northeast states (ME, NH, VT, MA, CT, RI, NY, PA, NJ, DE, MD, VA, WV, DC) and spatially link the dams to the correct stream flowline in the USGS National Hydrography Plus (NHD-Plus) 1:100,000 stream dataset. A standardized, repeatable, and accurate dam snapping method was developed and implemented to create this dataset. The method is fully described in the Appendix I of Marin and Apse 2011. Primary steps included 1) snapping each state's dams to the 1:100,000 NHD flowlines, using a 100m snapping tolerance, 2) coding the dams for prioritization for manual review, 3) manual error checking of the prioritized dams, 4) returning the data to the states for expert review, and 5) re-incorporated the state edits into the final snapped dataset. In 2012, a team of TNC scientists used the dams to create "functionally connected networks" as part of a long term climate change resilience analysis. Thirteen dams slated to be removed within the next 3 years were removed from the regional dam dataset prior to creation of functionally connected networks so that network lengths would incorporate these upcoming changes to connected network length. The Barrier Assessment Tool (TNC 2010) was used in ArcGIS 9.3 on the dams and 1:100,000 NHD Plus centerline dataset to create the functionally connected networks. The functionally connected stream networks were defined as the set of streams, river, and lake centerline segments bounded by fragmenting features (dams) and/or the topmost extent of headwater streams (Figure 35). The Barrier Analysis Tool (BAT) is an ArcGIS 9.3 plug-in that facilitates creation of these networks and several network metric calculations.

Results

The map of network length show longer networks in the Mid-Atlantic region and shorter networks throughout much of New England, New York, and New Jersey (Map 10). Similarly, the Mid-Atlantic has a larger mean network size and higher proportion of its networks in the larger size classes (Table 30). These strong geographic patterns are reflected in the detailed stream and river habitats and less so in the macrogroups which lump together the entire geography. Stream and river types with over half of their miles in networks over 500 miles long include high gradient warm headwaters and creeks, warm large rivers, tidal large rivers, moderate gradient warm headwaters and creeks, warm medium rivers, high gradient cool headwaters and creeks, cold medium rivers, and low gradient warm small rivers (Table 30). Most of these types are warm or cool systems occurring primarily in the Mid-Atlantic portion of the region. Alternatively, most of the northerly and cold/cool stream habitats had less than a quarter of their miles in large networks over 500 miles: low gradient cool headwaters and csreeks, cool medium rivers, low gradient cool small rivers, moderate gradient cold headwaters and creeks, moderate gradient cold small rivers, and low gradient cold small rivers.

Some stream habitats had a very high percentage of their network lengths in small networks less than 25 miles long. For example, low gradient warm headwaters and creeks, moderate gradient cool headwaters and creeks, high gradient cold headwaters and creeks and tidal headwaters and creeks all have more than a quarter of their stream miles in these small networks. Although tidal headwaters and creeks are expected to have small network sizes naturally, many of these other types would be expected to have much larger natural network sizes. Efforts to reconnect miles of these types could be particularly beneficial to the overall health of these habitat types.

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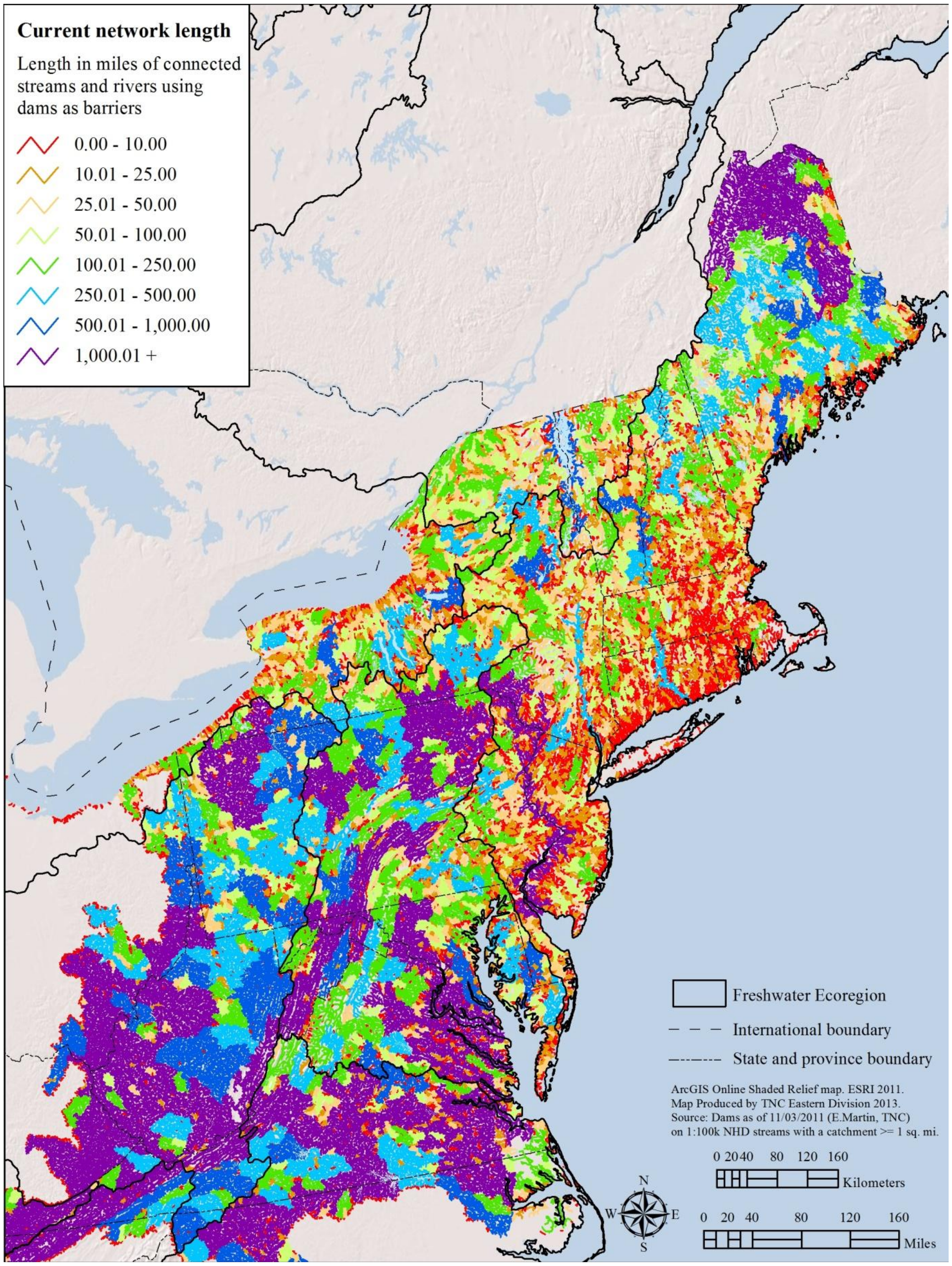
Table 30. Average network length for each habitat type.

Macrogroup	Habitat Type	Avg. Network Length (mi.)	Max Network Length (mi)	% Miles in Network <= 25 miles	% Miles in Network 25<100 miles	% Miles in Network 100<500 miles long	% Miles in Network> = 500 miles long
Headwaters and Creeks	High Gradient, Warm, Headwaters and Creeks	1,550	3,981	7.9	5.4	17.6	69.0
Large River	Warm, Large River	1,437	4,029	4.0	8.7	21.4	65.9
Tidal Large River	Tidal Large River	1,229	2,983	2.5	8.2	25.1	64.2
Headwaters and Creeks	Moderate Gradient, Warm, Headwaters and Creeks	1,123	3,981	15.1	8.6	19.8	56.5
Medium River	Warm, Medium River	1,109	4,029	7.2	8.5	30.8	53.5
Headwaters and Creeks	High Gradient, Cool, Headwaters and Creeks	1,098	4,029	9.1	7.9	28.3	54.7
Medium River	Cold, Medium River	1,054	3,069	3.9	3.6	45.2	47.4
Small River	Low Gradient, Warm, Small River	1,022	3,981	5.3	14.4	29.2	51.1
Small River	Moderate Gradient, Warm, Small River	1,008	3,981	5.6	10.4	34.9	49.1
Headwaters and Creeks	Low Gradient, Warm, Headwaters and Creeks	875	4,029	26.7	15.1	18.0	40.1
Large River	Cool, Large River	817	3,069	13.4	13.4	40.1	33.1
Small River	Moderate Gradient, Cool, Small River	710	4,029	18.7	24.4	27.9	29.0
Tidal Small and Medium River	Tidal Small and Medium River	702	2,983	11.1	25.9	26.8	36.2
Headwaters and Creeks	Moderate Gradient, Cool, Headwaters and Creeks	669	4,029	25.9	13.8	32.7	27.7
Headwaters and Creeks	High Gradient, Cold, Headwaters and Creeks	610	4,029	26.5	19.1	29.9	24.5
Headwaters and Creeks	Low Gradient, Cold, Headwaters and Creeks	597	3,069	11.5	22.9	36.1	29.6
Tidal Headwaters and Creeks	Tidal Headwaters and Creeks	588	2,983	35.3	18.3	13.2	33.2
Small River	Low Gradient, Cold, Small River	479	3,069	3.1	26.1	47.0	23.8
Small River	Moderate Gradient, Cold, Small River	475	3,069	9.6	30.8	38.7	20.8
Headwaters and Creeks	Moderate Gradient, Cold, Headwaters and Creeks	475	4,029	30.5	22.4	26.7	20.5
Small River	Low Gradient, Cool, Small River	464	4,029	17.4	34.6	30.0	18.0
Medium River	Cool, Medium River	412	4,029	12.9	28.1	40.3	18.7
Headwaters and Creeks	Low Gradient, Cool, Headwaters and Creeks	332	4,029	37.9	26.1	22.2	13.8



Map 10. Average network length in the Northeastern United States.

Road-Stream Crossings

Description

At each point when a road crosses a stream, manmade infrastructure allows the road to cross the stream. On small streams, these structures are often culverts, which frequently act as barriers to aquatic biota.

Why do Road/Stream Crossings Matter?

Road-stream crossings are ubiquitous and inevitable in any human-impacted landscape, and when improperly designed or maintained, can significantly impede organism passage and undermine the ecological integrity of river and stream systems (Beechie et al. 1994). Improperly designed road-stream crossings can fragment stream networks by restricting or preventing aquatic organism passage, and also disrupt ecosystem processes such as hydrology, sediment transport, and large woody debris transport (Jackson 2003).

Habitat fragmentation negatively affects habitat diversity, metapopulation persistence, genetic resilience, and ecosystem dynamics (Warren and Pardew 1998, Slatkin 1985). Headwater streams, which provide aquatic organism habitat for spawning, feeding, and predator avoidance, are disproportionately affected by road-stream crossings, as crossing structures on small streams are frequently culverts due to their cost-effectiveness (Gibson et al. 2005). Moreover, small streams cumulatively account for much more aquatic habitat than larger streams (Jackson 2003).

Culverts are more likely to be barriers than bridges, fords, or other crossing types (Cafferata et al. 2004). Culverts are extremely common because they are more cost-effective than bridges, but they become barriers because of large outlet drops, insufficient water depth, and excessive velocity (Blank et al. 2005, Warren and Pardew 1998, Votapka 1991, Figure 36). Passage rate decreases with increasing water velocity (Haro et al. 2004), but the magnitude of this passage rate varies among species. Poplar-Jeffers et al. (2009) found that overall fish movement was an order of magnitude lower through culverts than through other crossing types or natural reaches. The ability of fish to move linearly along the stream has significant metapopulation implications, and Letcher et al. (2007) found that isolated populations of brook trout (*Salvelinus fontinalis*) could be rescued from extinction by restoring connectivity, a process that can be done effectively by culvert retrofitting or removal (Kemp and O'Hanley 2010).

Figure 36. Example of a culvert that is a barrier to aquatic organism passage (© Wikipedia), and a culvert that can pass aquatic organisms (© USFS).

Methods

Because bridges are much less likely to pose a threat to stream connectivity, this analysis focused on road crossings of headwaters and creeks. Input data for streams were the 1:100,000 National Hydrography Dataset plus (2006), that had been modified for the 2008 Northeastern Aquatic Habitat Connectivity project by TNC, on headwaters and creeks only. Input data for roads were the North American Tele Atlas roads (2005). The Nature Conservancy then used Geospatial Modeling Environment to create points at all intersections of roads and streams.

Results

There are an average of 114 road crossings for every 100 miles of headwater and creek habitat in the region. The number of crossings per 100 miles varied across habitats. The least impacted habitats were low gradient cold headwaters and creeks (30), tidal headwaters and creeks (86), and moderate gradient cold headwaters and creeks (92). The most highly impacted types were moderate gradient cool headwaters (167) and high gradient warm headwaters (159) (Table 31, Map11).

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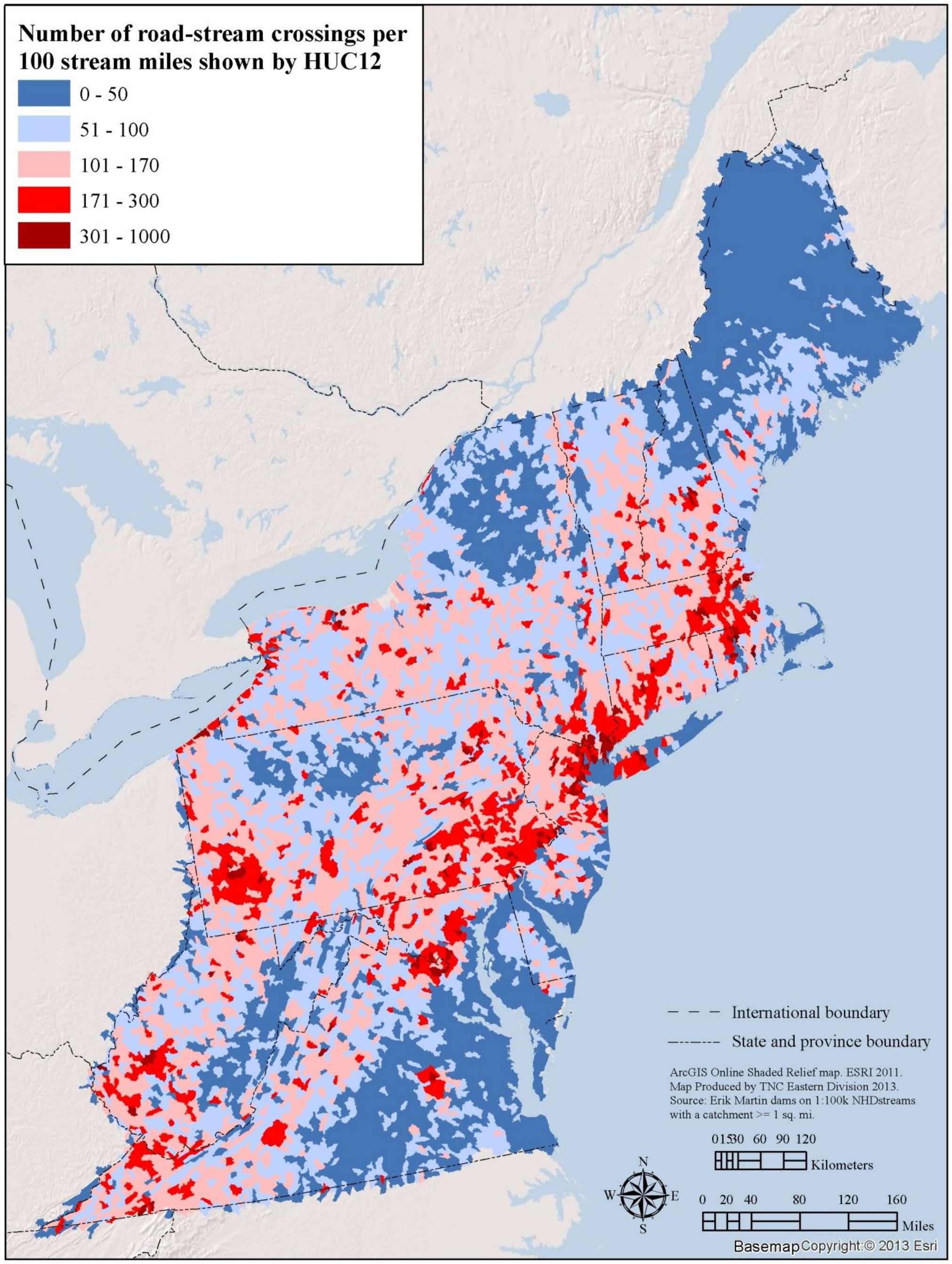
Table 31. Road stream crossing density by macrogroup.

Macrogroup	Habitat Type	Crossing Density Per 100 stream miles
Headwaters and Creeks	Low Gradient, Cold, Headwaters and Creeks	● 30
Tidal Headwaters and Creeks	Tidal Headwaters and Creeks	◑ 86
Headwaters and Creeks	Moderate Gradient, Cold, Headwaters and Creeks	◑ 92
Headwaters and Creeks	High Gradient, Cold, Headwaters and Creeks	◑ 103
Headwaters and Creeks	Low Gradient, Cool, Headwaters and Creeks	◔ 113
Headwaters and Creeks	Low Gradient, Warm, Headwaters and Creeks	◔ 115
Headwaters and Creeks	High Gradient, Cool, Headwaters and Creeks	◔ 127
Headwaters and Creeks	Moderate Gradient, Warm, Headwaters and Creeks	◔ 133
Headwaters and Creeks	High Gradient, Warm, Headwaters and Creeks	○ 159
Headwaters and Creeks	Moderate Gradient, Cool, Headwaters and Creeks	○ 167



Map 11. Road stream crossing density, displayed by HUC12s, in the northeastern United States.

Part 2: Geospatial Units and Tools

CHAPTER

Units of Analysis 6

Terrestrial Units:

Habitats do not occur in isolation, they interact and interplay with each other. More information is gained about individual habitat occurrences when we look at how the co-occur with other habitats and how they fit into larger natural systems as a whole. Land conservation also tends to happen on whole systems or on land that contains patches of multiple habitats, because organizations often work to protect and manage tracts or multiple tracts of land. For these reasons we used patches of natural habitat bounded by roads as the basic unit for terrestrial analysis. The unit could consist of a single habitat type but more commonly it was a mosaic of several types. The units are attributed to indicate how much of each habitat type occurs within the unit.

Minor and Major Roads

The region in this analysis has over 732,000 miles of permanent major and minor roads, enough to loop the equator 29 times. Of this amount there are 63,880 miles of major roads which form serious barriers for some habitat and species, tessellating our environment into patches and causing major fragmentation. These roads have caused shifts in the type and abundance of wildlife; including a decrease in forest interior species, a spike in the abundance of open habitat species, and an increase in forest generalists and game species (Forman et al 2003). Roads affect forest systems primarily by providing access into forest interior regions, thus decreasing the amount of sheltered secluded habitat preferred by many species for breeding. Additionally, heavily-used paved roads create noisy edge habitat that many species avoid, and the roads themselves may form movement barriers to small mammals, reptiles, and amphibians.

In this project, our goal was to define continuous small scale habitat blocks, and we used blocks of land bounded by major or minor roads as the unit of analysis. These road bounded blocks provide relatively discrete patches of natural habitat that are easy to locate on the ground. We refer to these units as the *minor road bounded blocks*, although they may have a major road bounding one part of the block.

Depending on the type of road, the road bounded blocks could represent a truly isolated patch cut off by wide paved surfaces and heavy traffic, or simply a distinct patch of habitat surrounded by small semi-permeable minor roads with little traffic. To account for this, the minor road bounded blocks nest within larger road bounded blocks so we could assess both contexts. The major road bounded blocks are bounded by the major highways in the region and are more significant barriers for species. The minor roads, however, may have damaging effects on natural habitats such as traffic casualties due to collisions, and providing a conduit for the spread of non-native species (Jaarsma and Geert 2002)

The relationships between the minor road bounded blocks and the habitats they contain can be complex. A typical block might contain several terrestrial upland and wetland habitats, a stream system and some developed land (Figures 37 & 38).

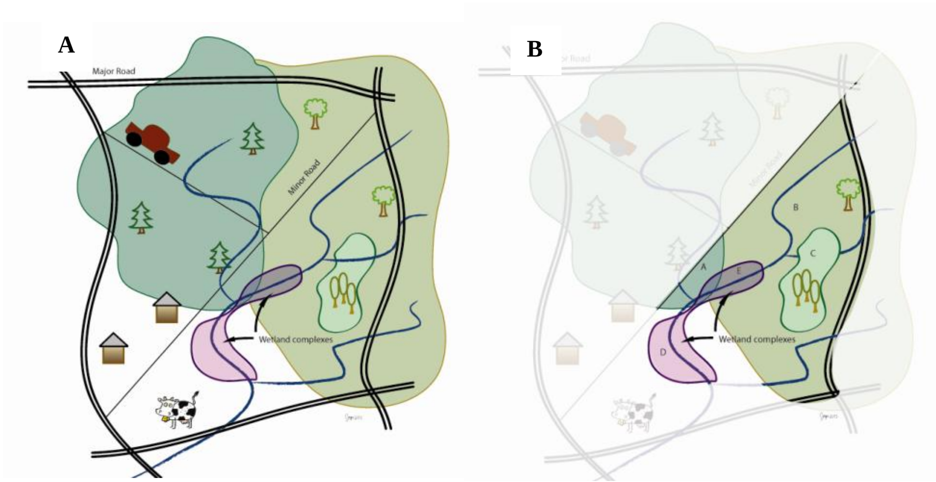


Figure 37. This set of images demonstrates the units of analysis. The image in the top left (A) is an example area. This area is bounded by major roads, has several minor roads that divide the area. There is one matrix habitat in the top left (in blue/green), another matrix habitat in the top right (in grey/green), a patch habitat in the middle of that (in true green), wetlands in the middle bottom (in purple) along a stream corridor, the bottom left is largely developed with houses and agriculture). The double line denotes major roads and the major road bounded block. The top right figure (B) shows a minor road bounded block with major roads defining part of the boundary.

Methods for Units

To build the road bounded blocks for the region, major and minor roads were used from the U.S. and Canada Streets Cartographic (Tele Atlas North America, Inc., 2005). The major road blocks used only the major roads. The minor roads blocks used all of the classes listed below:

- Major Roads (A10 – A28 Primary Roads with limited access, Primary Highways without Limited Access and A 63 Access ramps)
- Minor Roads (A30 – A48 Secondary state and county highways, Local, neighborhood, rural road, city streets, and A60 At grade ramp, A62 traffic circle, A 64 service roads
- For Maine, many of the forest logging roads are missing from the ESRI roads. These roads are better represented in the tiger road coverage feature class SF1400 (Local Neighborhood Road, Rural Road, City Street) in the 2013 Census Tiger Geodatabase (Census Tiger Geodatabase 2013). These were added into the block analysis.

To create closure features for the major road blocks along the ocean and great lakes edge of the region, the coastline was extracted from the NE terrestrial Habitat map. The major roads features had many places where the roads had gaps or breaks at rotaries or interchanges. These were manually fixed. For the major road bounded blocks, the major roads and coastline linework was built into polygon "block" topology using the feature to polygon tool in Arctoolbox 10.1.

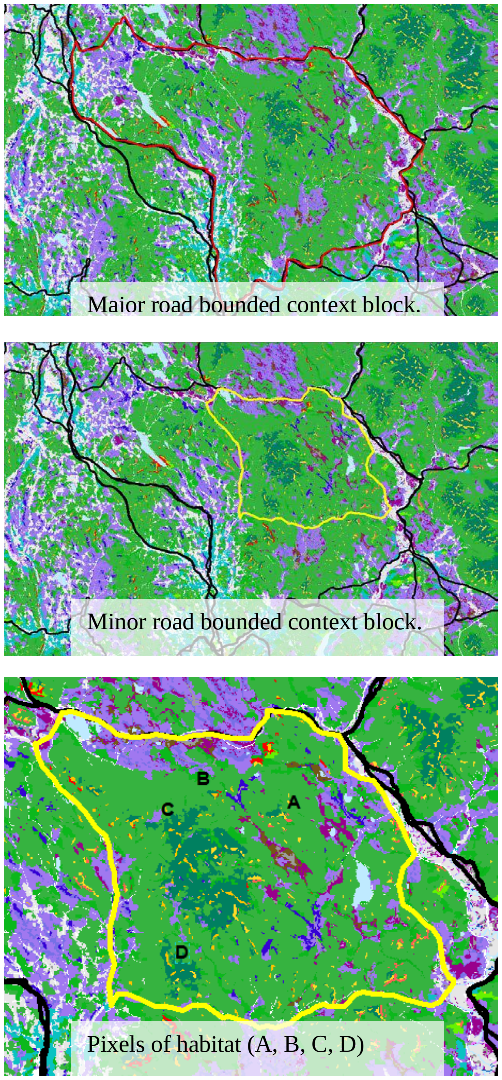


Figure 38. Illustration of different units used for the terrestrial geospatial analysis.

To create closure features for the minor road blocks along the ocean and great lakes edge of the region, the coastline was extracted from the NE Terrestrial Habitat map. For the minor road bounded blocks, the major roads, the minor roads, and coastline linework was built into polygon "block" topology using the feature to polygon tool in Arctoolbox 10.1.

A total of 86,591 major road bounded blocks and 1,294,404 minor road bounded blocks were created but not all of these were included in the analysis. We removed small blocks of low conservation values because they add much complexity to the dataset and slow down the processing time.

The following blocks were excluded:

- Blocks less than 1 acre (409,270 blocks)
- Blocks more than 90% developed (511,556 blocks)
- Blocks with less than 1 acre of natural habitat (673,739 blocks)

Removing the above blocks brought the final block count to 244,953. (note: the same block could be counted for all three factors)

Major Road Bounded Blocks

Many of these blocks built were either highway medians or the green space in the middle of highway on/off ramps. To remove the medians, we calculated the length to area ratio. A high length to area ratio signals a long skinny polygon, which we can assume is a highway median. To remove the on/off ramp areas, we removed major road bounded blocks less than 5 acres. The following major road bounded blocks were excluded:

- Blocks with length to area ratios >0.01. (84,159 blocks)
- Blocks less than 5 acres (73,153 major blocks)

Removing the above blocks brought the final block count to 2,432 major blocks for analysis (note: not straight math – some blocks were small and had high length to area ratios).

Habitat Patches

Habitat patches are continuous patches (uninterrupted by development or roads) of a single habitat type in the habitat map. These were created by removing road and development from the habitat map. Then we converted the raster to a polygon on the habitat name field. This created 13,756,405 habitat patches.

Although the number of patches was too large to analyze individually, we created aggregate statistics at the block level. For each minor road bounded block we calculated the number of patches, maximum patch size, and average patch size stats for each habitat. This information was included in the geodatabase along with the habitat patch polygon file is for people who would like to do their own analysis.

Wetland Complexes

Just as individual habitats do not occur in isolation, wetlands habitat types are integrated systems. Adjacent wetlands can share the same hydrology, species, and experience the same condition metrics. We created wetland complexes to analyze groups of adjacent wetland habitat types. Wetland complexes are groups of adjacent wetlands that are five acres or more, which are split at small connections to reduce really long wetlands (Figures 39 & 40).

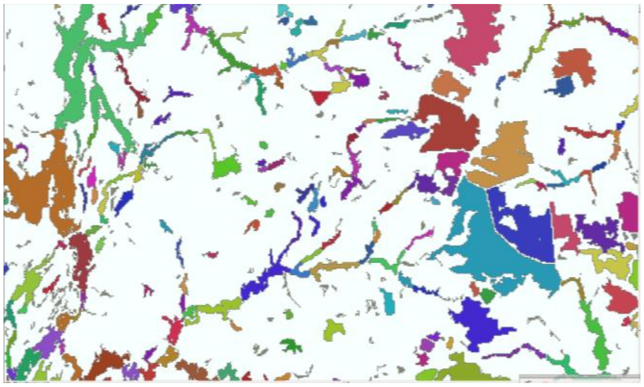


Figure 39: Wetland complex example. This image shows the wetland complexes in unique colors. You can see the long riparian wetlands are split into discrete complex units.

In the region there are 359,352 wetland complexes. Wetland complexes are attributed with their size and the total amount of each individual habitat type in the complex. The minor road bounded blocks are attributed with the number of wetlands complexes, the maximum size of the wetland complex and the average size of the wetland complex. The metrics for wetland complexes are attributed to the block.

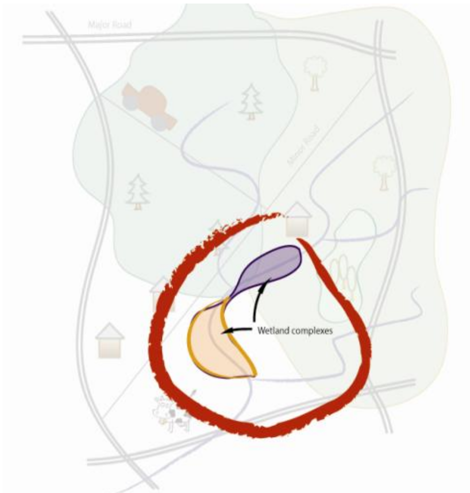


Figure 40: Wetland complexes are groups of adjacent wetlands that are five acres or more, which are split at small connections to reduce the number of really long wetlands.

Stream and River Units

Stream and river units are from the medium resolution (1:100,000) National Hydrography Plus (NHDPlus) Version 1 dataset (USGS 2006). The NHDPlus was developed through a partnership between the USGS and the U.S. Environmental Protection Agency (EPA). It combines the medium-resolution NHD with a 30m digital elevation model to produce several derivative datasets that enable the definition of the land surface areas that contribute flow to each stream reach (catchment) and that define numerous stream reach attributes such as reach slope and total upstream watershed area. Detailed information on the NHDPlus and access to available data can be found on the NHDPlus Web site. All final condition metrics were linked to the source NHD Plus reaches; however, the different spatial units sampled as these metrics were calculated are described below.

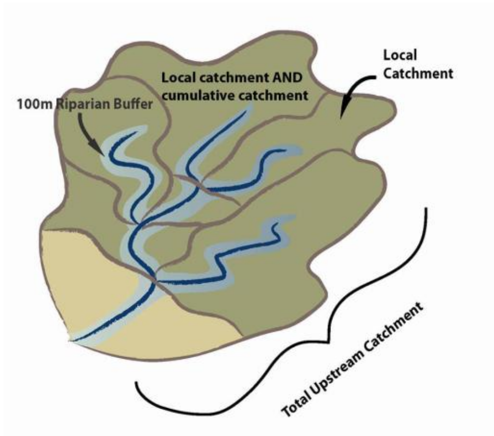


Figure 41. Stream units: reaches shown with their local catchments and total upstream cumulative catchment. Each river segment is referred to as a reach, and each of those reaches has a given catchment, as well as a cumulative upstream catchment (Jospe 2013).

Reaches

Reaches are commonly defined by a length of stream between two confluences or a lake or pond. Each reach is assigned a unique reach identification number and a flow direction. The length of the reach, the habitat type of the reach, and other condition information are assigned as attributes to each reach. Only reaches with upstream drainage areas >= 1 sq.mi were included in the regional summary statistics to focus the analysis on perennial streams and rivers that were consistently mapped across the region.

Riparian Zone

The riparian zone is the land area directly adjacent to a stream or river reach (see light blue area around streams in Figure 41). This dynamic zone is an ecologically rich environment supporting many rare and common species and natural communities. This zone also facilitates the exchange of nutrients, sediments, and organisms between the terrestrial and aquatic system. A 100m buffer distance was chosen to define a riparian zone that would encompass the types of critical riparian functions noted for eastern riparian areas such as shading, filtering nutrients and other pollutants, erosion control, flood mitigation, and providing wildlife habitat (Palone et al. 1997). We report securement status and land use for each reach based on this key riparian buffer habitat zone (Figure 41).

Local Catchment

A local catchment is the land area that drains directly to a given reach without going through another reach (Figure 41). This area is larger than the riparian buffer, and it represents the conditions within a local land area adjacent to a given reach. The local catchment area is smaller than the total upstream watershed for all reaches except for the very most upper reaches of a network where there is no other upstream reach. Many local catchments make up the total upstream watershed of larger streams and rivers that have many reaches upstream. We report terrestrial local connectivity, terrestrial landcover index, and predicted land development within each reach local catchment to consider these land based attributes within a local land area that drains directly to and has high influence on the reach.

Cumulative Upstream Watershed

The cumulative upstream watershed or catchment is the total land area upstream that drains to a given reach (Figure 41). It is made up of all the local catchments of all reaches upstream of a given reach in the network. For large rivers this total upstream watershed can be a very large area of land. We used NHDPlus network navigation tools (Ca3T) to accumulate conditions in the total upstream watershed of each reach. We report for each reach the impervious surfaces and upstream total volume of water stored behind dams using the total cumulative upstream watershed unit of the reach. Both impervious surface and upstream water storage have been shown to have significant cumulative effects and are best analyzed at total upstream watershed unit scales (CWP 2003, Bunn and Arthington2002).

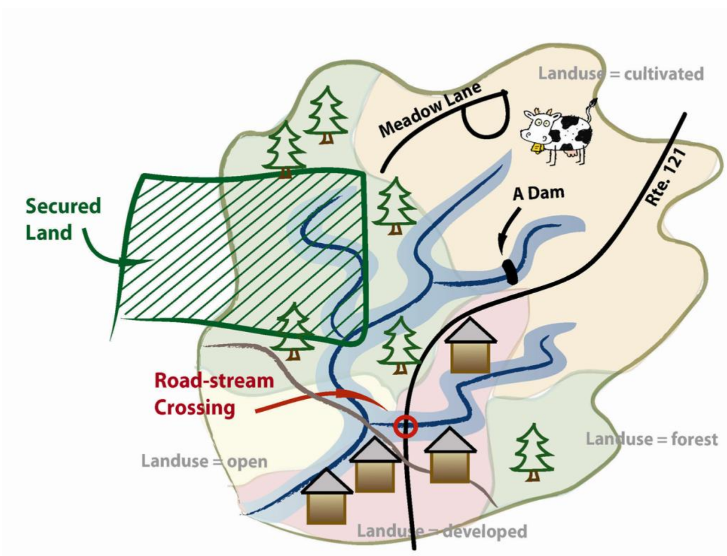


Figure 42. Various metrics calculated for catchment, reach, and 100m riparian buffer of the reaches. This diagram is not a comprehensive look at all of the metrics, but rather an example of how the metrics were calculated for these units (image by A. Jospe).

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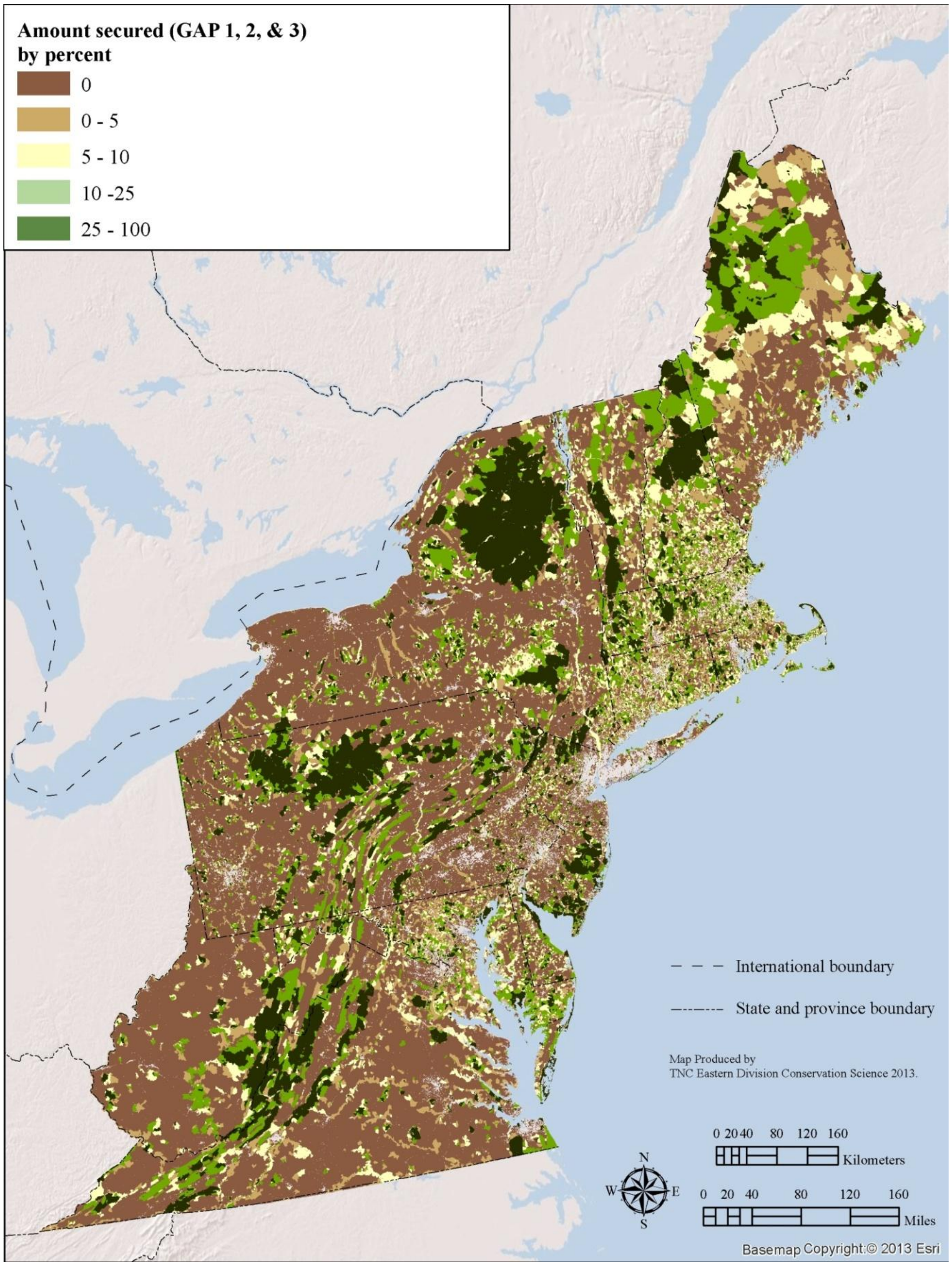
Maps of Terrestrial Condition Metrics by Minor Blocks

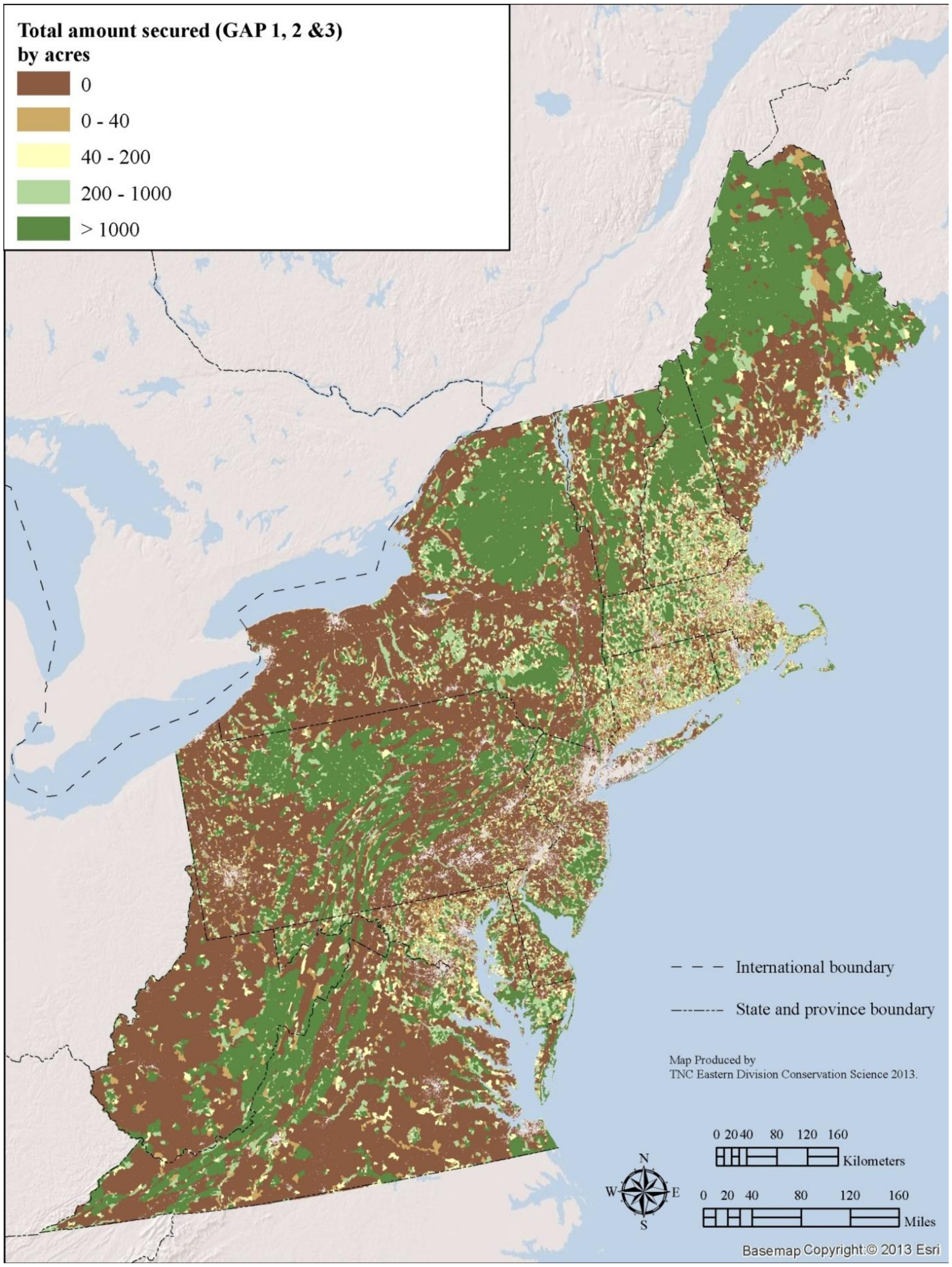
Much of the information contain in the condition section of this report can be displayed by the minor road-bounded block (e.g. percent of secured lands in the block). This information could help users of the geospatial tool gain a perspective on how the results for their area of interest compare with the region. Additionally they provide and interesting picture of how the various condition elements are distributed across the region. When querying the database these maps can help aid the user in picking appropriate ranges for the metric values.

The following maps are included in the next section of the report:

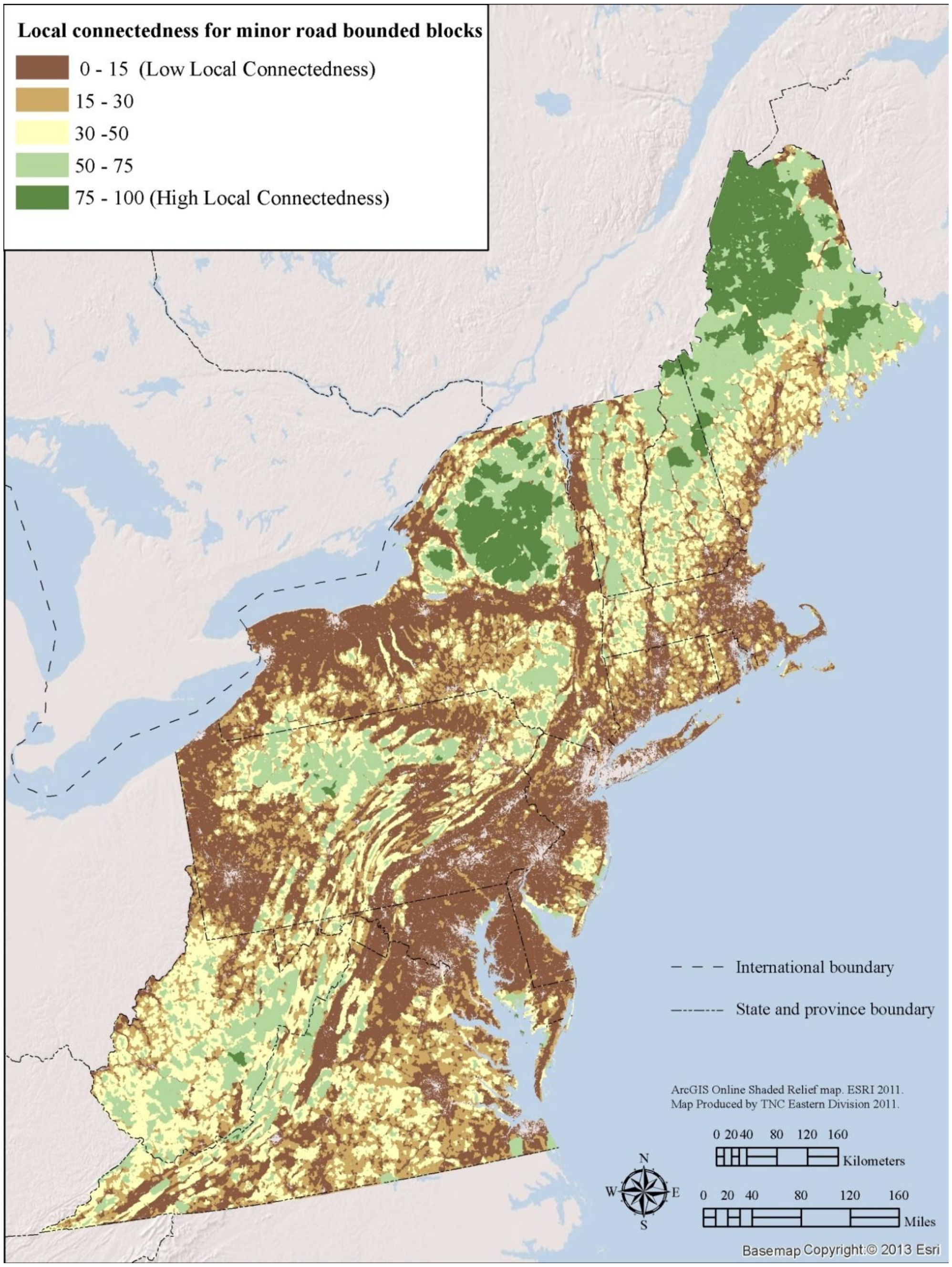
- Map 12. Percent of land secured by minor block
- Map 13. Acres of land secured by minor block.
- Map 14. Local connectedness for minor road bounded blocks.
- Map 15. Average landscape context index for minor road bounded blocks.
- Map 16. Percent of predicted development in 2060 by minor road bounded block.
- Map 17. Acres of predicted development in 2060 by minor road bounded block.
- Map 18. Acres of natural core area in minor road bounded block.
- Map 19. Percent of natural core area in minor road bounded block.
- Map 20. Stand age (in years) for minor road-bounded block.
- Map 21. Landscape complexity for minor road bounded blocks.



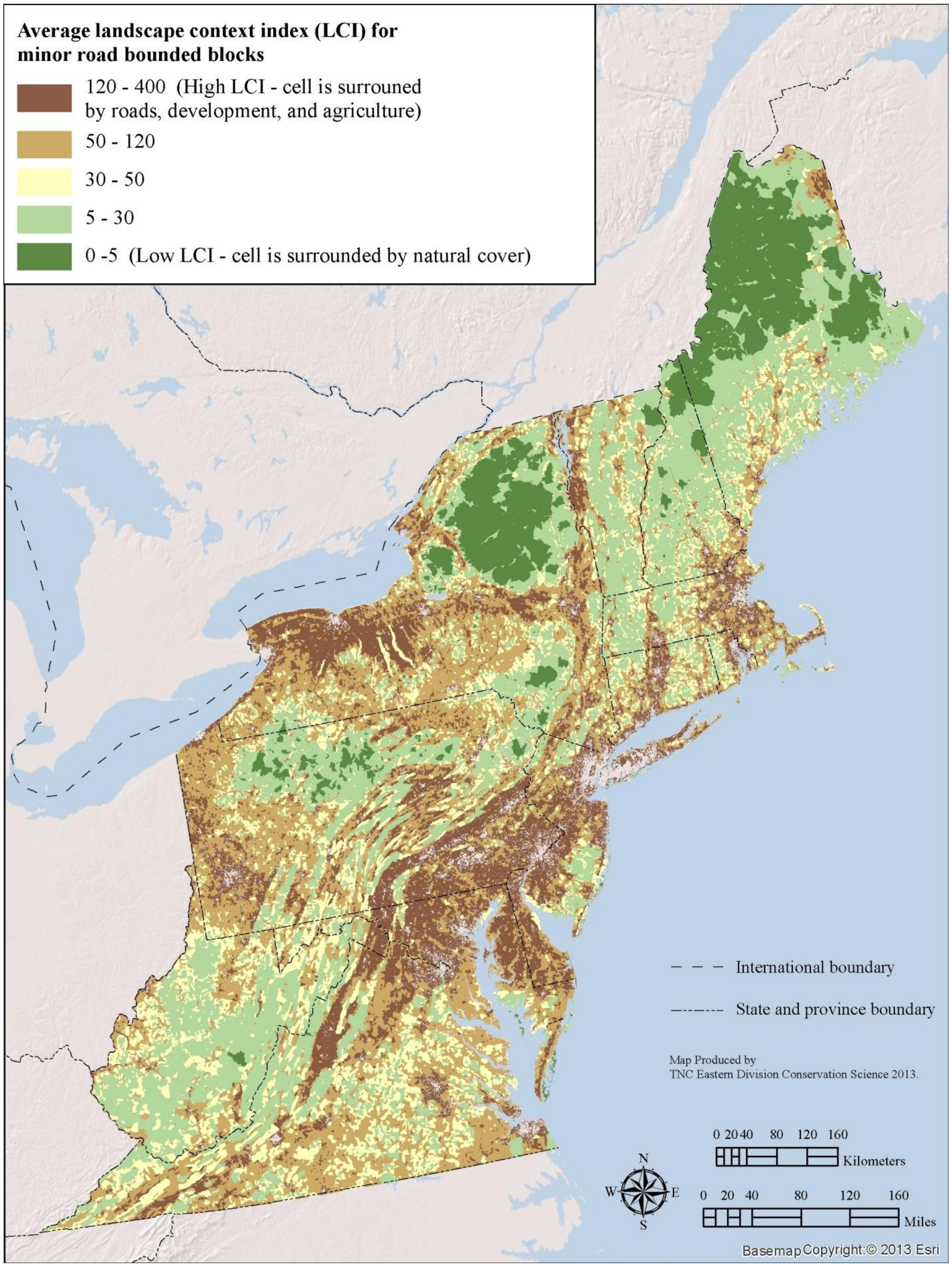
Map 12. Percent of land secured by minor block.



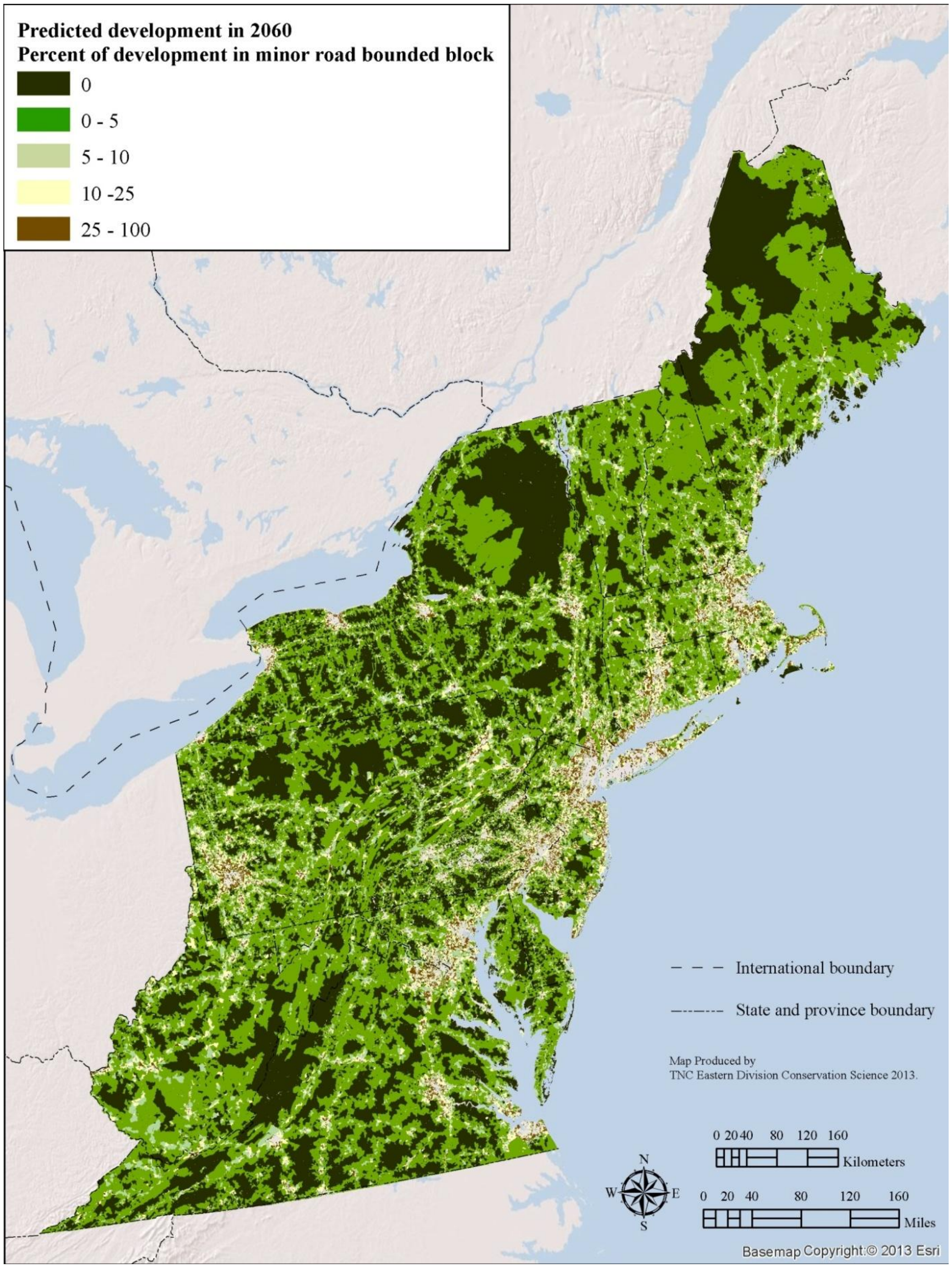
Map 13. Acres of land secured by minor block.



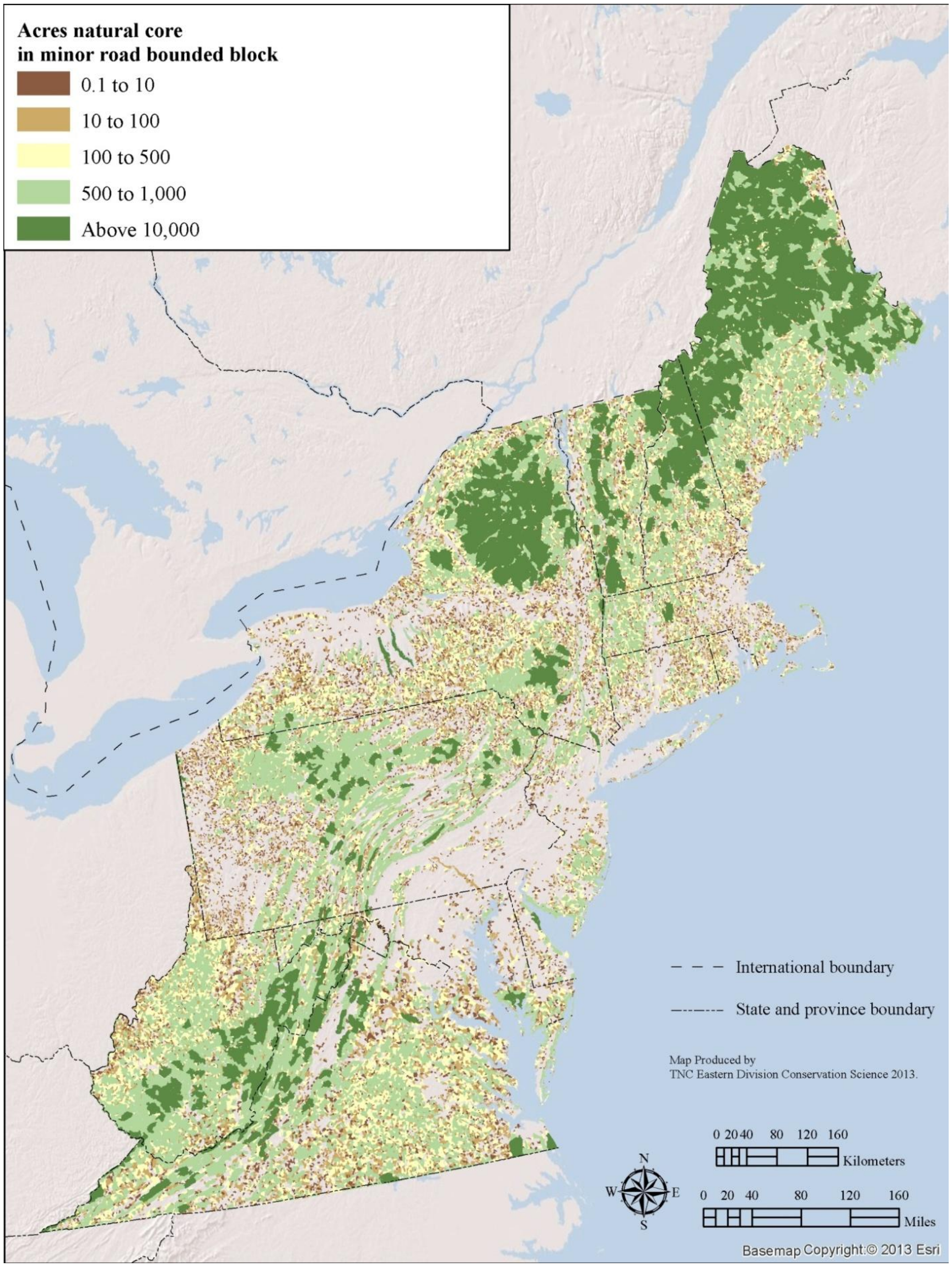
Map 14. Local connectedness for minor road bounded blocks.



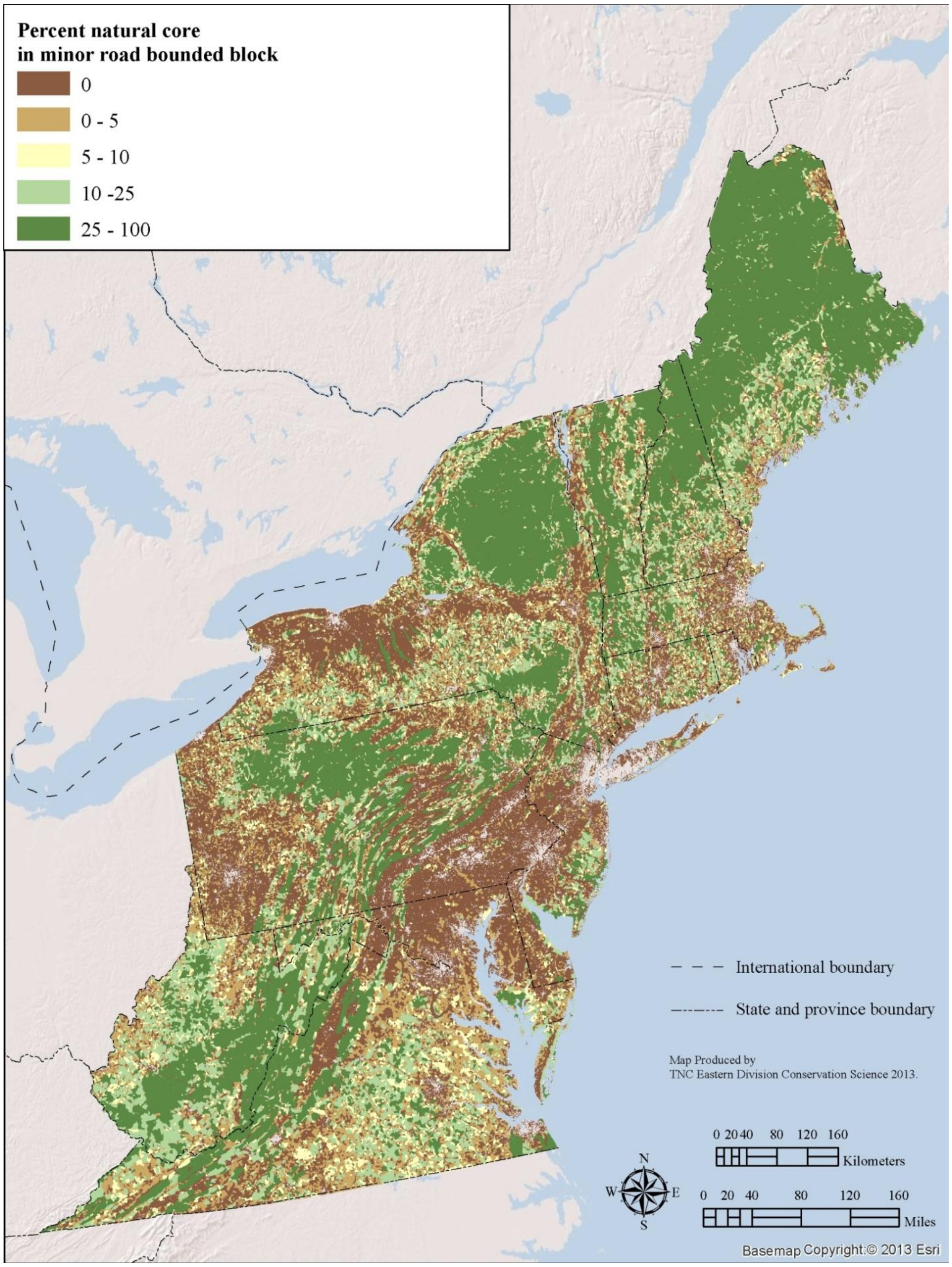
Map 15. Average landscape context index for minor road bounded blocks.



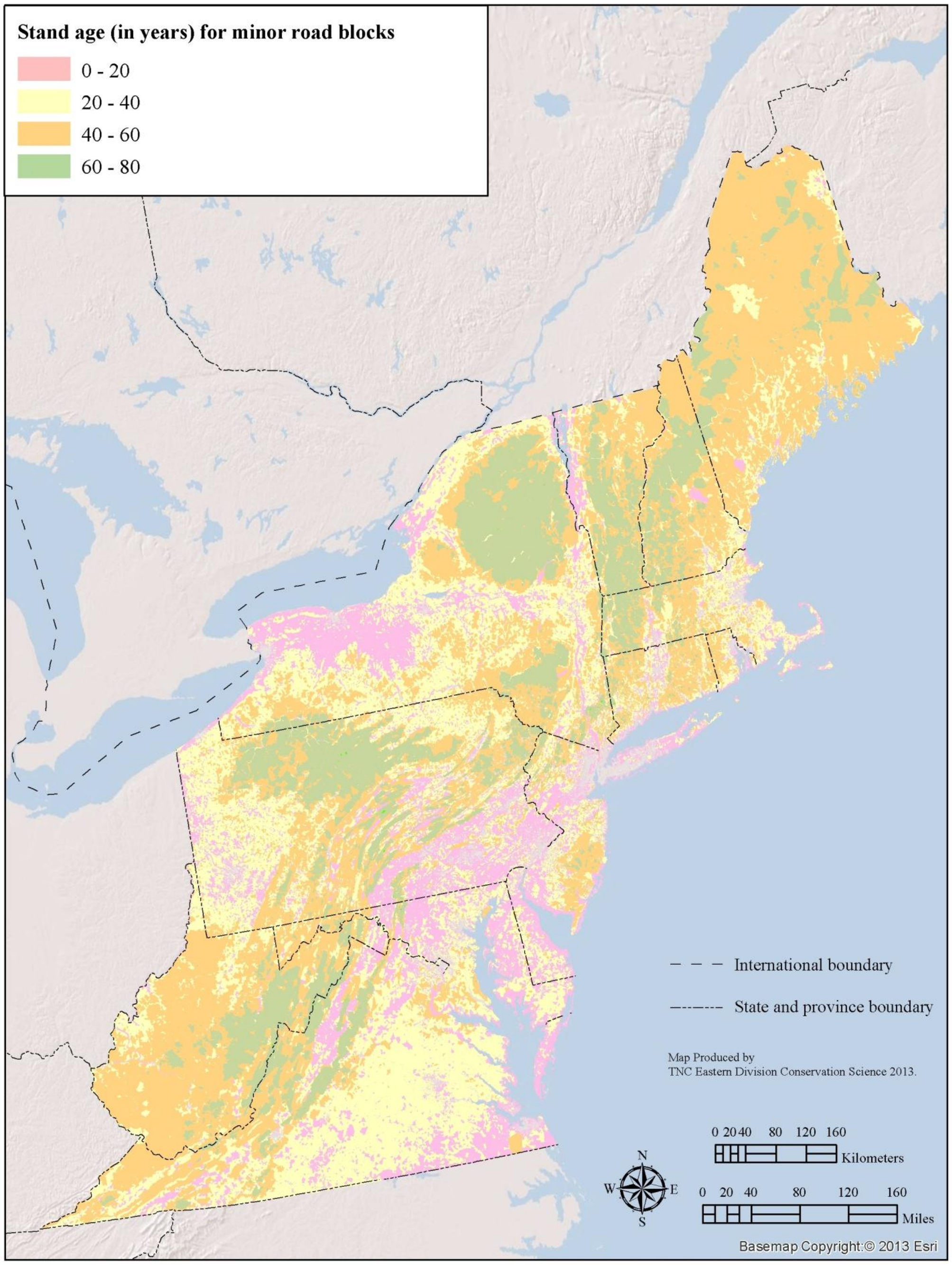
Map 16. Percent of predicted development in 2060 by minor road bounded block.



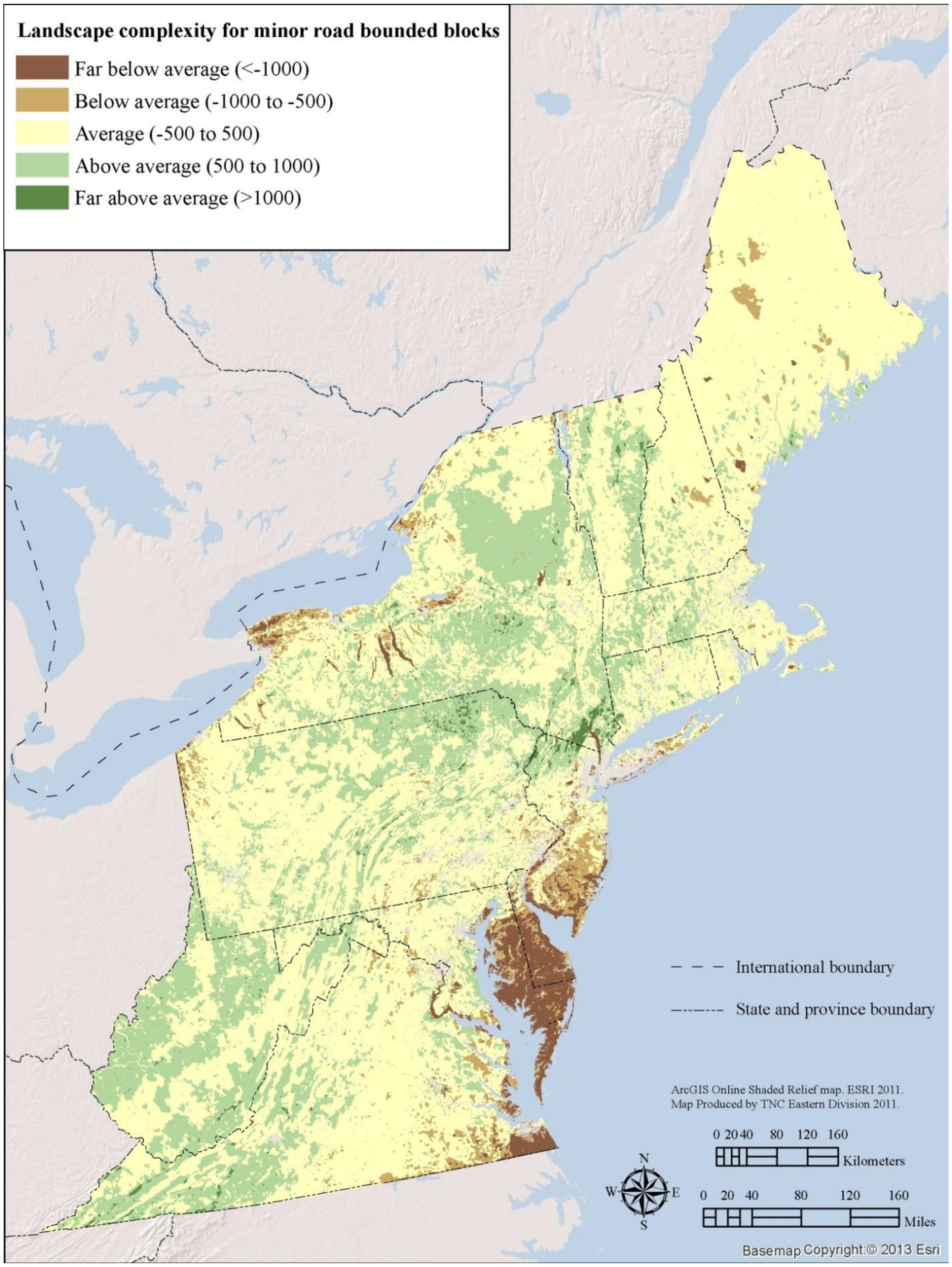
Map 17. Acres of natural core area in minor road bounded block.



Map 18. Percent of natural core area in minor road bounded block.



Map 19. Stand age (in years) for minor road-bounded block.



Map 20. Landscape complexity for minor road bounded blocks.

CHAPTER

7

Introduction to the Geodatabase

One goal of this project was to create a database and toolset to allow users to locate terrestrial and aquatic habitats that meet certain condition metrics. Creating and compiling the information for this report was a monumental task. There are over 2 million habitat patches and over 200,000 miles of streams and rivers. We simplified this dataset to reportable units of road bounded blocks and stream reaches, each with many metrics. In order to make this dataset as usable as possible, we have attempted to make a clear, well organized, and well documented database. We have also created an example query tool to show several possible way users to easily access and query the data. This could be developed further, in future projects. The database has been organized in such a way as to allow users flexibility in the units and metrics that they query.

The database has been organized in two parts: 1) Results Geodatabase 2) Inputs Geodatabase. This is both for organizational clarity and size/download ease. The first geodatabase contains the results of the condition metrics. Although this database is large, it is much smaller than the inputs download. The inputs geodatabase contains four feature classes; these are the units on which we reported all of the metrics in the report, summarized below. Metadata on each attribute is included for each geodatabase feature class, with table metadata included as an appendix to this report, and as a part of each database download as .pdf files. Feature classes of the Results Geodatabase (Figure 43) are:

1) Minor Road Bounded Blocks: This feature class is the main unit of analysis for this project. The resultant calculations for the metrics link to the minor road bounded block table from separate join tables.
2) Major Road Bounded Blocks: This feature class has the units that tie to the minor road bounded blocks. The primary use of this dataset is to provide context for the minor road bounded blocks. The major road bounded blocks link to the minor blocks through a join field in the minor road bounded blocks attribute table. The minor road bounded blocks are attributed with the total size of the major road bounded block.
3) Wetland Complexes: The attribute table of this feature class is primarily the area in meters of each wetland habitat in the wetland complex. This dataset has a join table with information about maximum size of wetland complex, average size of wetland complex, total area of wetland complex, number of wetland complexes, and total acres of wetlands (both within and without wetland complexes).
4) Stream Reaches. For the aquatic analysis, all results are in the stream reach unit attribute table. The stream reaches are tied to the block attributes through a join table.

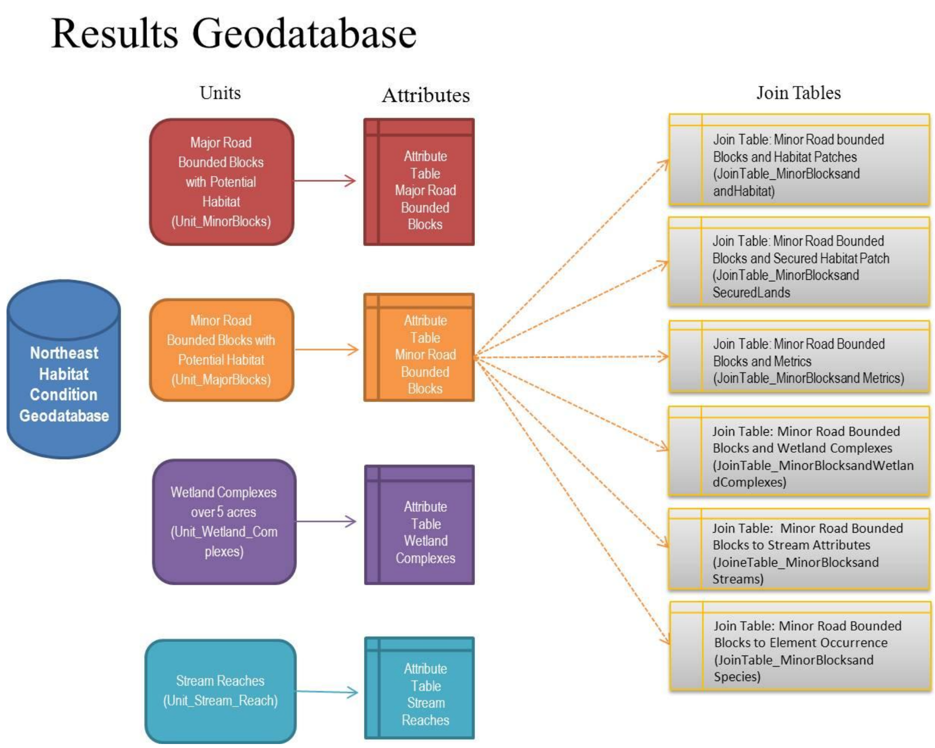


Figure 43. Schematic of the results geodatabase that accompanies this document.

The Inputs Geodatabase is huge and has a large download size. This geodatabase provides all of the input data (those without data sharing limitations) used in the condition calculations (Figure 44). This includes boundary/mapping files, all of the input units, and the base metrics. These data are for the advanced user who wants to do their own mapping or advanced analysis.

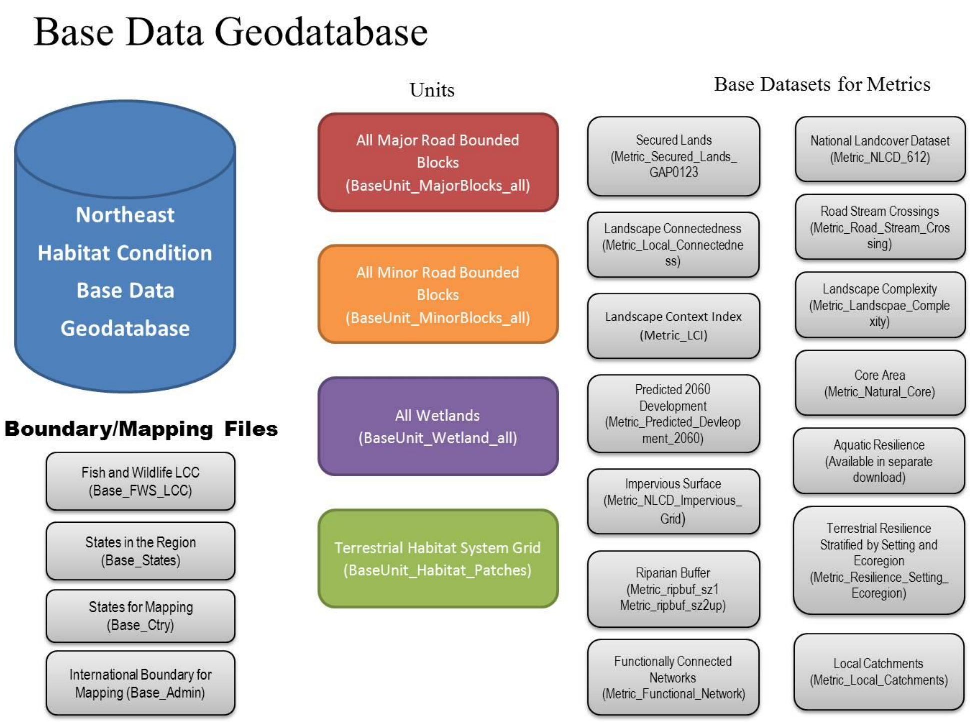


Figure 44. Schematic of the base inputs data in the geodatabase that accompanies this document.

Introduction to the Query Tool

Even with a well-organized geodatabase, querying and analyzing information for hundreds of thousands of unit records across hundreds of fields can prove to be an overwhelming task. One solution is to create custom Arctoolbox queries to guide users through analysis of the database, without needing to know a lot about the field names, database structure, or data ranges. We have created a few example queries to demonstrate this solution. Further refinement and customization are outside the scope of this project. The query toolbox is distributed with the results geodatabase. The toolbox is called Querytool and is distributed within the results geodatabase. To use the tool, simply double click on the name of the script in the toolbox. All queries were built using Python coding language and have comments built into the code for further modification.

The queries allow you to search a specific geography and several metrics. The number of records selected in each step of the query is returned in the results window (Note: if your selection is invalid, i.e. you search for the stream major drainage unit Delaware in the state of Maine, the results of the search will return zero records). Upon final selection, the search units will be added to your ArcMap project with the results of the query selected and the extent will zoom to that selection.

We have designed 3 example queries:

1. Terrestrial Forest Query (Figure 45 & 46)
2. Stream and River Query (Figure 47)
3. Wetland Query Example Tool

The "Query Tool" toolbox is in the results geodatabase. You may have to relink the python scripts. To do this double click on the "Query Tool" to open the toolbox and then left click on your desired toolbox tool. Select "properties" from the menu and go to the "source" tab. From here navigate to the location of the python script in the "python_scripts" folder of the results_geodatabase There is also the toolbox exported to a 10.0 toolbox for users that have not yet upgraded to ArcGIS 10.1.

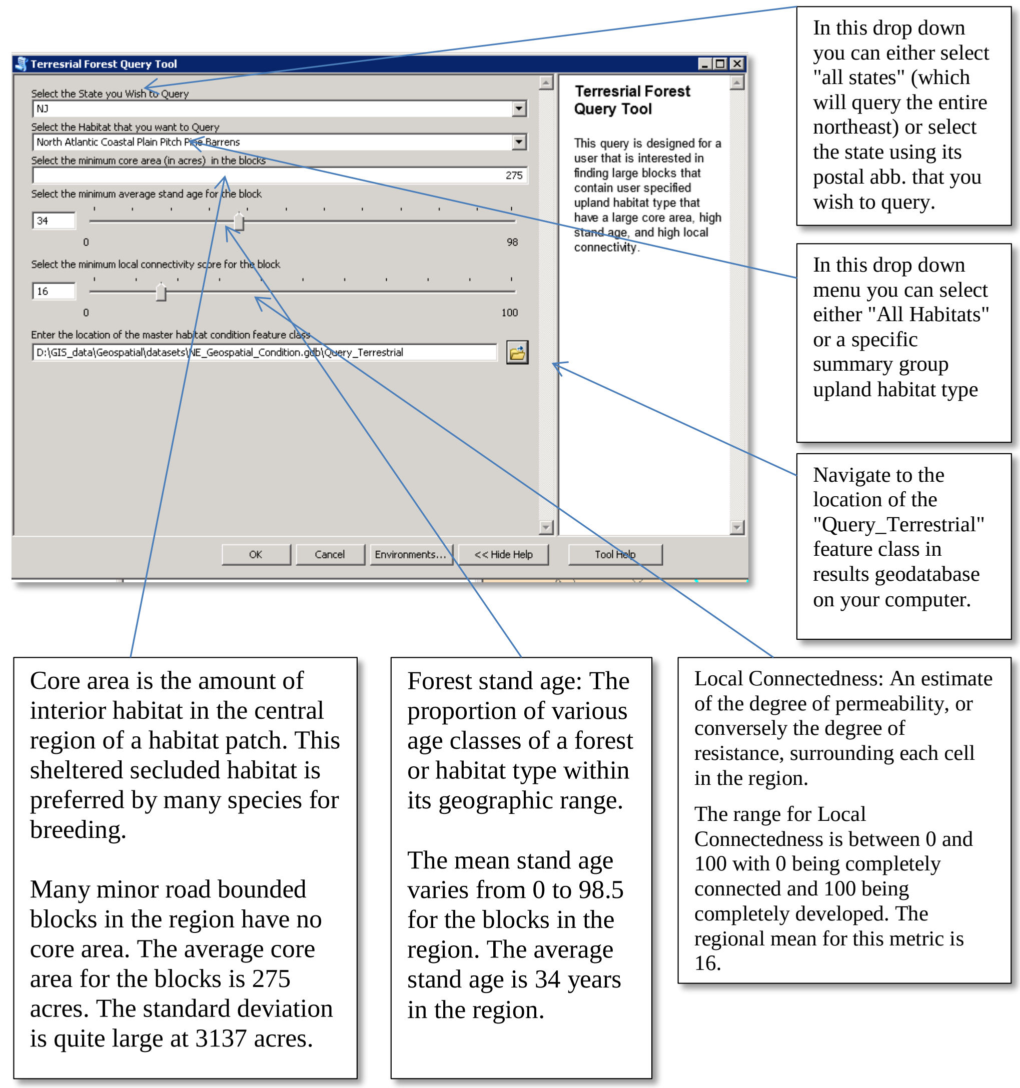


Figure 45. This query is designed for a user that is interested in finding large blocks that contain user specified upland habitat type that have a large core area, high stand age, and high local connectivity.

The number of minor road bounded blocks selected for each metric is displayed in the results window of the toolbox and the results are selected in the feature class that is added to the map document. The map document also zooms to the selected features (Figure 46). These screenshots were created for this example as a demonstration of the results of this tool.

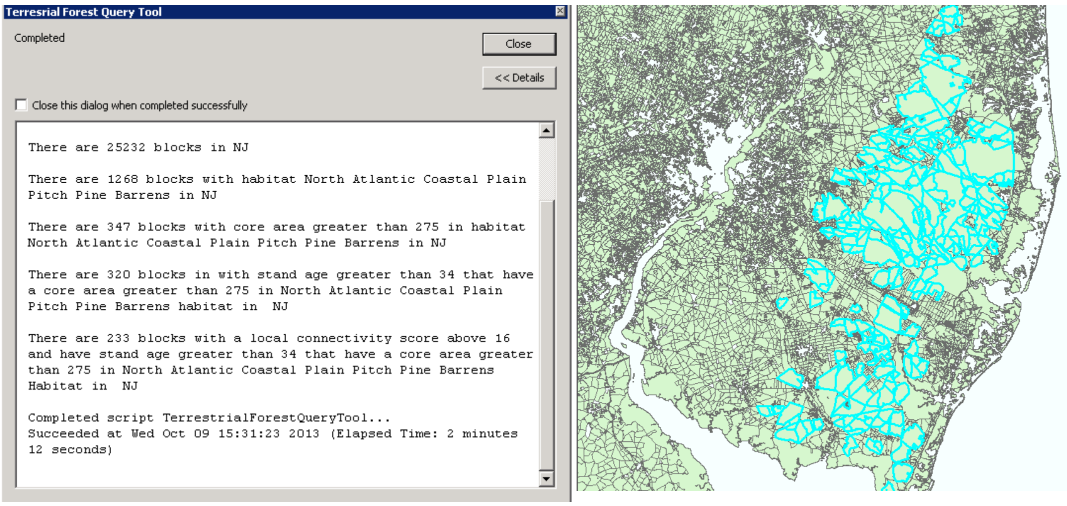
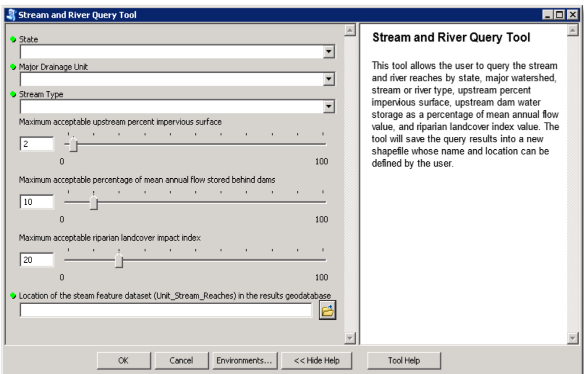


Figure 46. The image on the left is a screenshot of the results window displayed after running the terrestrial forest query tool. On the right is a screenshot of the results as displayed in the map document.

Primary state the reach is located within

HUC4 Major Watershed Names

Stream or River Major Habitat Type as defined in the Northeast Habitat Guides: A companion to the terrestrial and aquatic habitat maps. (Anderson et al 2013), http://nature.ly/HabitatGuide



Riparian Landcover Impact
The riparian zone is the land area directly adjacent to a stream or river and subject to its influence. The different types of landcover (NLCD 2006) in the riparian zone within 100m on either side of mapped streams and rivers was summarized. We then transformed the landcover information into a summary impact index by summing the percent of development and agriculture in the buffer zone, weighting the effect of medium to high intensity development twice as much as of agriculture as follows: Impact = 0.5 * % agriculture + 0.75* % low intensity development+ 1.0* % medium to high intensity development. The final riparian landcover impact index ranged from 100 for a watershed with its buffer zone totally in highly developed to 0 where the buffer zone was completely within natural cover.

Impervious Surface
Impervious surfaces are hard substrates like paved roads, buildings and parking lots. All indicators of stream quality relative to biotic condition, hydrologic integrity, and water quality decline with increasing watershed imperviousness. We summarized the amount of impervious cover for the total upstream watershed of each stream reach using the 2006 National Landcover Impervious Surface Dataset. Any level of impervious surface can be chosen as a maximum acceptable level in this query tool; however, the following general categories of impact may be useful references (King and Baker 2010).

Class 1: Undisturbed: 0 < 0.5%
Class 2: Low impacts: 0.5-2%
Class 3: Moderate Impacts: >=2-10 %
Class 4: High Impacts: >=10%

Risk of Flow Alteration from Dam Water Storage
The risk of flow alteration from dam water storage is expressed as the ratio of the volume of water capable of being stored behind dams upstream to the mean annual flow volume expected in a reach expressed as a percent. Any level can be chosen as a maximum acceptable level in this query tool; however, the following general categories of Potential Risk of Flow Alteration from Upstream Dam Water Storage may be useful references (Zimmerman 2006).
• Class 1: <2% Very low risk
• Class 2: >= 2 < 10% Low risk
• Class 3: >= 10 < 30% Moderate risk
• Class 4: >= 30 < 50% High risk
• Class 5: >= 50% Severe risk

Figure 47. This is the stream and river query tool, which allows the user to query the stream and river reaches by state, major watershed, stream or river type, upstream impervious surface, upstream dam storage as a percentage of mean annual flow value, and riparian landcover index value.

CHAPTER

Additional Characteristics 7

This sections contains additional information, beyond habitat types and condition metrics, that we tabulated for the road-bounded blocks or stream reaches using other sources of data. These characteristics include rare species information, anadromous fish habitat, and terrestrial and freshwater areas resilient to climate change. To fully understand this data we suggest users go to the original sources for information on how it was created.

Species

The biodiversity of our region is composed of thousands of different species of animals, plants, fungi, microorganisms, and bacteria. No one knows the total number of species, but there are tens of thousands of species of plants and animals alone. The most imperiled and rare species have been the focus of intensive field inventory and monitoring. These species are tracked and their occurrences mapped by the network of State Natural Heritage Programs and NatureServe. These tracked species include primarily globally rare species with fewer than 100 known populations (G1-G3), species endemic to an ecoregion or state, species currently in demonstrable decline, and those designated as threatened or endangered by federal or state authorities. Many of these species have also are "Species of Greatest Concern" in State Wildlife Action Plans and Regional Fish and Wildlife lists of "Regional Species of Greatest Conservation Need".

Occurrences of tracked species were compiled from the State Natural Heritage Program and NatureServe and placed into eight major taxa groups for reporting as follows:

1. Amphibians
2. Birds
3. Fish
4. Mammals
5. Reptiles
6. Invertebrates, Insects & Other (Arthropod, Insect, Porifera, Vermiform, Bryozoan)
7. Invertebrates, Mollusks & Crustaceans
8. Plants (Bryophyte, Dicot, Gymnosperm, Monocot, Pteridophyte)

The occurrences were coded with whether they met a minimum spatial precision threshold of being precise locations or locations accurate to less than 125 acres. The occurrences meeting the minimum spatial precision threshold (117,310 occurrences) were then overlaid with the minor road bounded blocks. We summarized the total number of species found in each block. We also summarized the number of occurrences of these species in each block and summarized these occurrence numbers within each taxa group in each minor road bounded block.

The species data is used with permission from the Natural Heritage Programs but due to sensitivity we only provide the species information for blocks over 1,000 acres and only by taxonomic group. We do not report exactly which species were in each block. We encourage users to contact their State Natural Heritage Program if they would like to obtain more detailed information, and we are grateful to those programs for collecting and sharing this irreplaceable data. Although we used the best available precise locational information for rare and imperiled species across the region, users should also realize the complete distributions of most species are still unknown and additional occurrences of tracked species may be discovered as field inventory in state Natural Heritage Programs continue. The summarized information by block thus provides only a "snapshot in time" summary of tracked species information; however, we hope the block summaries will be informative and useful to the user.

Source Data: Tracked species information consisted of 117,310 precise locations, or locations accurate to less than 125 acres. These locations were contributed by the Natural Heritage programs and NatureServe and were used with permission.

Detailed Sources:

- **A.** Natural Heritage Element Occurrence Database for Northeast U.S. 2008. Compiled from State Natural Heritage Programs for use by TNC Eastern Conservation Science for regional conservation planning 1998-2008.
- **B.** NatureServe 2011 NatureServe Central Databases. Arlington, Virginia. U.S.A. Precise locational (Element Occurrence) data polygons for all species in the following states: Connecticut, Delaware, District of Columbia, Maryland, Maine, New Hampshire, New Jersey, New York, Rhode Island, Virginia, Vermont, and West Virginia. Data Source: NatureServe (www.natureserve.org) and its Natural Heritage member programs. The data was exported from NatureServe 2/2011.
- **C.** Pennsylvania Natural Heritage Program, Pittsburg, PA. 2011. The Pennsylvania Natural Heritage Program and partnership provided The Nature Conservancy (TNC) with GIS shapefiles and tabular data for element occurrences for non-federally listed tracked birds, mammals, terrestrial invertebrates, plants, and natural communities contained in the database for the entire state of Pennsylvania. The data was exported from the Pennsylvania Natural Heritage Program 2/2011.
- **D.** Massachusetts Natural Heritage & Endangered Species Program. Westborough, Massachusetts. 2011. The Massachusetts Natural Heritage and Endangered Species Program provided The Nature Conservancy with GIS shapefiles and tabular data for all Element Occurrences contained in the database for species and natural communities within the state. The data was exported from the Massachusetts Natural Heritage & Endangered Species Program 1/2011.

Anadromous Fish

Anadromous fish spawn in freshwater, but spend a portion of their adult life in salt water. The stress associated with the physiological changes required to transition between fresh and salt water render these species extremely vulnerable to habitat impacts within freshwater and marine migratory corridors. Much of their historic freshwater spawning habitat is no longer accessible due to dams and other aquatic barriers or has been significantly degraded. The combination of habitat impacts and fishing pressure has caused significant declines in populations of these species. It is critical for conservation of these species that resource managers know what stream reaches contain documented current freshwater habitat (spawning, overwintering) for anadromous fish species.

Figure 43. Alewife swimming upstream (Pizer, TNC).

A newly available dataset linking seven anadromous fish species' current habitat to the 1:100,000 scale NHDPlus hydrography for the northeast (Martin and Apse 2011) was linked to each stream reach. The seven species include the following which are briefly described below (Greene et al. 2010):

Alewife spawn in rivers from northeastern Newfoundland to South Carolina, but are most abundant in the mid-Atlantic and northeastern United states. Alewife utilize a wide range of habitats and substrates, including large rivers, small streams, and ponds and lakes with substrates of gravel, sand, detritus, or submerged vegetation. At sea, alewife congregate in schools of thousands of fish, sometimes mixing with other herring species (Figure 43).

Blueback herring spawn from Nova Scotia to northern Florida, but are most numerous in warmer waters from the Chesapeake Bay south. Blueback herring prefer to spawn in swift-flowing sections of freshwater tributaries, channel sections of fresh and brackish tidal rivers, and Atlantic coastal ponds over gravel and clean sand substrates. In northeastern rivers alewife and blueback herring often co-exist and are collectively known as river herring.

American shad have a spawning range from Florida to the St. Lawrence River. Shad ascend tributaries in the spring and spawn in shallow water over gravel or rubble substrates. Larvae and juveniles use natal rivers during summer and begin downstream migration to the sea in the fall. Shad undertake extensive oceanic migrations.

Hickory shad occur along the Atlantic coast from the Bay of Fundy in Canada to Saint John's River in Florida, but spawning is reported in rivers from Maryland to Florida. Adult hickory shad appear to spawn in a diversity of physical habitats. In the Chesapeake Bay, hickory shad spawning runs usually precede American shad runs.

Atlantic salmon are found in coastal waters on both sides of the North Atlantic, from Spain to the Arctic circle and Long Island Sound to Labrador, and a few rivers in western Greenland. Atlantic salmon spend their first few years in small freshwater streams and rivers, often hundreds of miles from the sea, feeding primarily on aquatic insects. They then migrate down to the ocean where they will spend one or two years. They journey back to their natal rivers for fall spawning and typically do not die after spawning.

Atlantic sturgeon are currently present in 35 rivers from Maine to Florida, and spawning occurs in at least 20 of these rivers. Sturgeons are members of the ancient family *Acipenseridae*, large, slow-growing and late-maturing anadromous fish that migrate from the ocean into coastal estuaries and rivers to spawn. Historically abundant and widely distributed, the combination of slow rates of population growth and high economic demand for flesh and roe have made Atlantic sturgeon especially vulnerable to over-harvesting.

Shortnose sturgeon are found in rivers and estuaries from the Saint John River in New Brunswick to the Saint Johns River in Florida. There are currently 19 spawning populations that are considered to be viable; the largest known population is in the Hudson River, the second largest in the Saint John River. Fish move upriver to spawning grounds in the spring, then return to lower freshwater or brackish reaches. Spawning occurs in deep, fast currents over rocky substrate at or above the fall line.

Terrestrial Resilience

A climate-resilient conservation portfolio includes sites representative of all geophysical settings selected for their landscape diversity and local connectedness. The Nature Conservancy's study *"Resilient Sites for Terrestrial Conservation*" (Anderson et al 2012) develops a method to identify such a portfolio. First, 29 geophysical settings were mapped across the entire study area. The settings included characteristics Eastern landscapes like low elevation limestone valleys, mid elevation shale slopes and high elevation granite mountains. Second, within each geophysical setting areas were located that have diverse topography and are highly connected by natural cover. These areas were estimated to be the most resilient areas with respect to their geophysical setting.

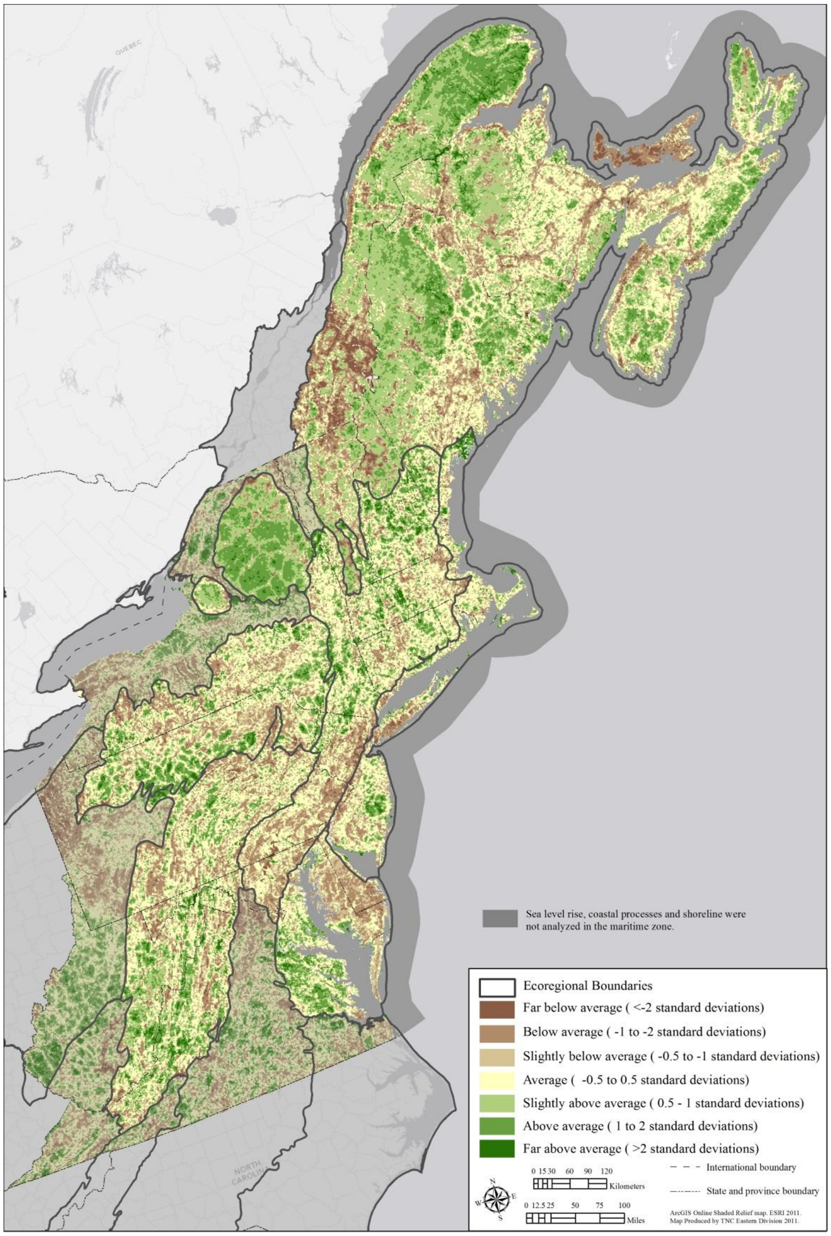
The final results were stratified by geophysical setting and ecoregion and are a relative measure. The map shows the area for each setting that has above average landscape complexity and connectedness, but individual settings are only compared to others areas of the same setting. For example, a high scoring area for low elevation surficial sand, might have much less complexity than a low scoring area of granite mountains. This was intentional because the goal was to locate the most resilient area for each setting.

Site resilience was measured as the sum of two quantitative metrics calculated using a geographic information system (GIS) for every 30 meter grid cell in the Northeast and Mid-Atlantic region of the US and Canada: (1) Landscape complexity: the variety of landforms, range of elevation, and density of wetlands in the surrounding landscape, and (2) Local connectedness: the permeability of the surrounding land cover. These metrics were based on growing evidence that resilience increases with these factors.

Landscape complexity (or Landscape diversity) is the variety of landforms created by an area's topography, together with the range of its elevation gradients. This factor increases a site's resilience by offering micro-topographic thermal climate options to resident species, buffering them from changes in the regional climate and slowing down the velocity of change. Under variable climatic conditions, areas of high landscape diversity are important for the long-term population persistence of plants, invertebrates (Weiss et al. 1988), and presumably for the more mobile species that depend on them. Because species locations shift to take advantage of micro-climate variation and stay within their preferred temperature and moisture regimes, extinction rates predicted from coarse-scale climate models that fail to account for topographic and elevation diversity have been disputed.

Local connectedness is a measure of landscape permeability: the degree to which a given landscape will be conducive to the movement of organisms and the natural flow of ecological processes such as water or fire. A highly permeable landscape promotes resilience by facilitating local movements, range shifts, and the reorganization of communities (Krosby et al. 2010). Maintaining a connected landscape is the most widely cited strategy in the scientific literature for building climate change resilience and has been suggested as an explanation for why there were few extinctions during the last period of comparably rapid climate change.

This text is extracted and simplified from Anderson et al. (2012)



Regional Terrestrial Resilience Score

Stratified by Setting and Ecoregion with Regional Override

Map 21. Resilience score for the eastern United States and Canada, stratified by setting and ecoregion.

Freshwater Resilience

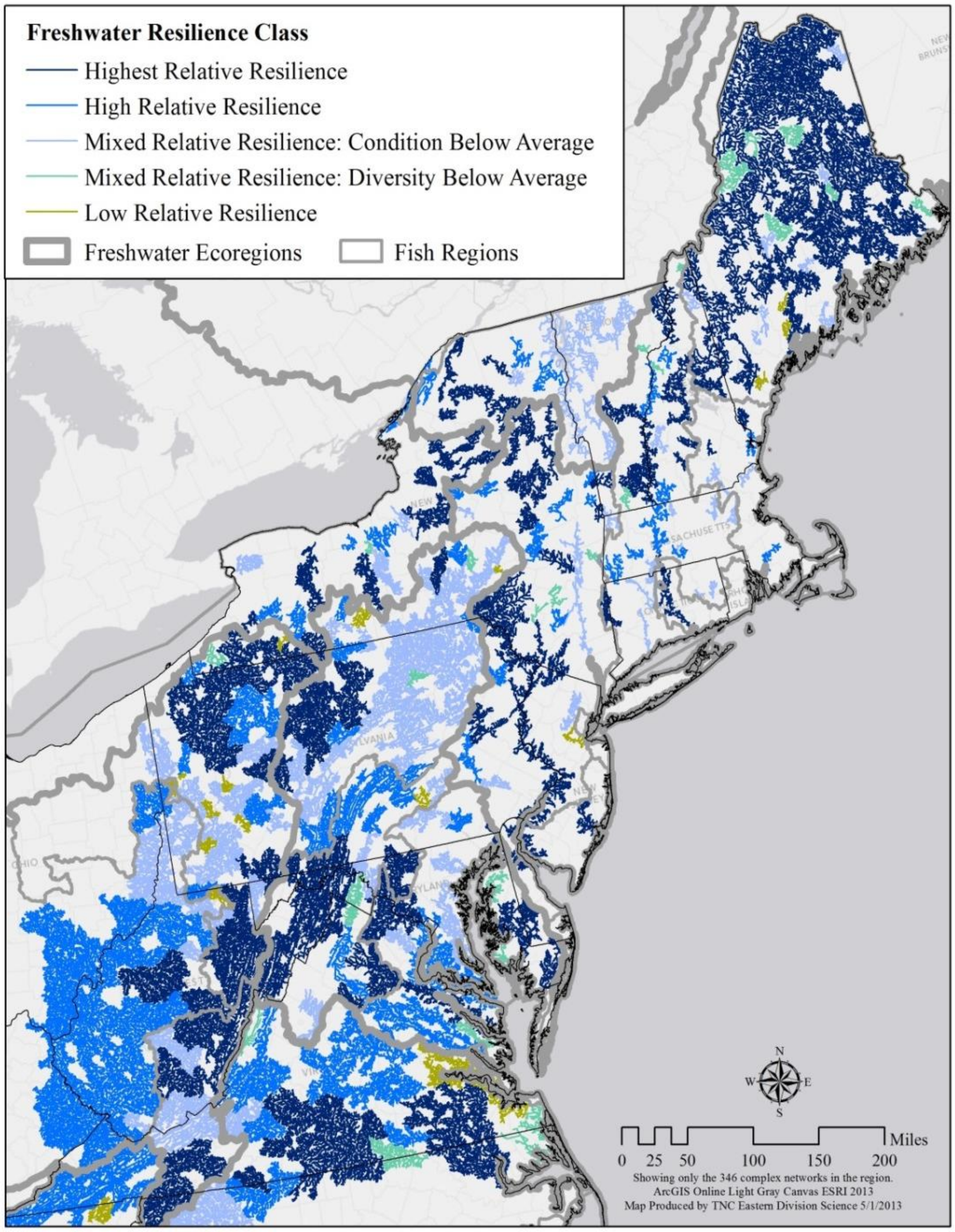
Resilient stream systems are those that will support a full spectrum of biodiversity and maintain their functional integrity even as species compositions and hydrologic properties change in response to shifts in ambient conditions due to climate change. As growing human populations increase the pace of climate and land use changes, estimating the resilience of freshwater systems will be increasingly important for delivering effective long-term conservation.

Recent research suggests that the resilience of freshwater systems can largely be characterized by a set of measurable elements such as: linear and lateral connectivity, water quality as shaped by surrounding land use, alterations to instream flow regime, access to groundwater, and the diversity of geophysical settings in the area (Rieman and Isaak 2010, Palmer et al. 2009). In this analysis, we aimed to quantify each of these factors for 1,438 stream networks occurring across 14 states of the Northeast and Mid-Atlantic region to identify the networks with the highest relative resilience (not taking into account possible restoration strategies). For each factor, we experimented with direct and indirect measures that could be applied consistently at a regional scale using regional datasets. Not all the elements of resilience were equally suited to measurements at the regional scale, and one element, access to groundwater, was excluded due to data limitations at this scale.

A network was defined as a continuous system of connected streams bounded by dams or upper headwaters. We scored all 1438 networks that contained at least 2 miles of river based on seven key characteristics (Box) within each freshwater ecoregion and within smaller fish regions (basins with similar fish fauna). We integrated three metrics into a physical properties score and three metrics into a condition score and then integrated the physical properties and condition indices to yield an overall resilience score. Because stream size is a variable of such fundamental importance to stream diversity and function, we used the network complexity metric as a threshold variable to identify a subset of "complex" stream networks that contained five or more size classes of streams, rivers, or lakes (max = 9). Networks with four or less sizes were felt to be more vulnerable to environmental changes due to major habitat diversity limitations. The focal complex networks were mapped by resilience score to study regional patterns. For more information, please see the full report and dataset at https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/edc/reportsdata/freshwater/fwresilience/Pages/default.aspx

Key metrics for scoring the networks:

- **Network Complexity:** The number of stream and lake size classes in a network.
- **Physical properties:** Factors that create habitat heterogeneity within a network and options for species to move and rearrange to find suitable habitat.
  1. Length of connected network
  2. Number of gradient classes in the network
  3. Number of temperature classes in the network
- **Condition characteristics:** Factors that maintain important functions and processes.
  4. The degree of natural cover in the floodplain
  5. The degree of unimpeded hydrologic flow
  6. The cumulative impervious surfaces in the watershed



Map 22. Complex networks by freshwater resilience class.

Appendices

All Metrics for all habitats

Appendix I. All condition metrics shown for habitat types in the upland macrogroups, of the matrix and edaphic patch type.

Upland Macrogroup	Habitat Summary Group	% Conserved	Habitat Acreage	GAP 1 (acres)	GAP 2 (acres)	GAP 3 (acres)	Average Local Connectedness	Average Landscape Condition Index	% of Habitat Predicted to Convert to Development by 2060	Percent of Habitat in patches > 1000 acres	Maximum Patch Size (acres)	% Core Area (100 meter buffer)	Average Stand Age	Average Landscape Complexity
Boreal Upland Forest	Acadian Low Elevation Spruce-Fir-Hardwood Forest	27%	5,403,770	205,726	219,215	1,050,942	67.1	11.3	0.7%	42%	22,000	78%	54.5	0.06
Boreal Upland Forest	Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest	68%	1,079,375	322,489	199,591	206,766	85.0	1.3	0.1%	81%	61,167	96%	70.4	0.03
Central Oak-Pine	Allegheny-Cumberland Dry Oak Forest and Woodland	8%	2,246,628	11,387	20,527	155,275	45.3	29.9	2.4%	1%	2,688	74%	52.6	0.49
Central Oak-Pine	Central Appalachian Dry Oak-Pine Forest	34%	3,781,098	207,866	123,669	962,668	43.6	32.8	2.2%	4%	4,519	73%	61.5	0.46
Central Oak-Pine	North Atlantic Coastal Plain Hardwood Forest	16%	2,026,734	11,242	76,981	244,271	19.6	83.8	14.6%	4%	3,742	33%	36.4	-0.09
Central Oak-Pine	North Atlantic Coastal Plain Pitch Pine Barrens	48%	462,977	17,629	78,542	123,845	24.6	60.8	12.1%	31%	6,876	44%	44.4	-0.51
Central Oak-Pine	Northeastern Interior Dry-Mesic Oak Forest	19%	16,487,542	355,522	440,618	2,385,249	32.4	55.0	5.2%	30%	20,946	52%	49.3	0.43
Central Oak-Pine	Southern Appalachian Oak Forest	13%	2,823,456	22,703	37,440	317,040	42.7	35.8	2.5%	27%	9,777	62%	50.9	0.57
Central Oak-Pine	Southern Piedmont Dry Oak-Pine Forest	3%	1,728,293	280	111	50,425	29.7	52.7	2.7%	0%	493	44%	30.3	0.03
Northern Hardwood & Conifer	Appalachian (Hemlock)-Northern Hardwood Forest	20%	20,362,820	298,226	415,111	3,407,840	34.9	48.3	3.5%	50%	39,064	56%	49.6	0.42
Northern Hardwood & Conifer	Laurentian-Acadian Northern Hardwood Forest	38%	12,552,915	1,037,465	1,122,112	2,612,043	68.3	10.0	0.5%	79%	176,448	84%	61.8	0.28
Northern Hardwood & Conifer	Laurentian-Acadian Pine-Hemlock-Hardwood Forest	15%	5,938,075	85,336	156,145	653,974	44.1	30.1	2.2%	43%	28,879	64%	53.3	0.34
Northern Hardwood & Conifer	Northeastern Coastal and Interior Pine-Oak Forest	16%	1,463,561	11,716	18,298	207,365	25.4	61.5	10.4%	10%	2,638	44%	43.9	0.14
Northern Hardwood & Conifer	Southern Atlantic Coastal Plain Mesic Hardwood Forest	12%	1,854,411	5,260	54,245	166,359	22.6	75.5	7.1%	3%	1,277	35%	33.4	-0.18
Northern Hardwood & Conifer	Southern Piedmont Mesic Forest	3%	2,383,958	2,092	2,311	77,211	30.1	58.7	2.8%	5%	2,780	49%	31.6	0.13
Alpine	Acadian-Appalachian Alpine Tundra	98%	8,177	6,212	727	1,079	45.8	3.6	0.0%	42%	3,949	95%	69.4	-0.15
Cliff and Talus	Acidic Cliff and Talus	48%	556,624	67,895	47,895	152,660	56.0	17.0	2.4%	4%	2,038	80%	64.2	0.56
Cliff and Talus	Calcareous Cliff and Talus	48%	55,977	13,355	5,294	8,364	62.9	17.8	2.0%	0%	612	84%	65.9	0.49
Cliff and Talus	Circumneutral Cliff and Talus	36%	55,570	3,266	4,719	11,962	43.3	33.1	5.9%	0%	408	71%	59.5	0.84
Coastal Grassland & Shrubland	Atlantic Coastal Plain Beach and Dune	39%	86,980	2,766	19,370	11,892	11.0	48.3	12.3%	30%	5,945	50%	5.1	-0.41
Coastal Grassland & Shrubland	Great Lakes Dune and Swale	65%	1,642	236	17	807	29.7	35.8	6.7%	0%	224	51%	15.1	0.02
Coastal Grassland & Shrubland	North Atlantic Coastal Plain Heathland and Grassland	30%	29,330	541	4,547	3,623	22.3	74.3	23.1%	4%	993	24%	18.7	-0.14
Glade, Barren and Savanna	Appalachian Shale Barrens	62%	5,013	881	427	1,796	46.9	30.6	3.2%	0%	296	67%	59.5	0.96
Glade, Barren and Savanna	Central Appalachian Alkaline Glade and Woodland	12%	407,362	6,594	6,757	33,992	31.1	61.6	3.4%	1%	1,190	59%	54.4	0.50
Glade, Barren and Savanna	Eastern Serpentine Woodland	20%	11,147	185	1,290	799	10.9	102.5	17.0%	0%	209	17%	30.0	0.14
Glade, Barren and Savanna	Great Lakes Alvar	12%	26,990	0	2,355	961	28.6	66.2	1.9%	15%	2,141	47%	23.4	-0.43
Glade, Barren and Savanna	Southern and Central Appalachian Mafic Glade and Barrens	41%	1,418	295	223	64	37.7	33.1	2.5%	0%	85	54%	63.1	0.22
Glade, Barren and Savanna	Southern Piedmont Glade and Barrens	0%	106	0	0	0	33.0	64.8	3.2%	0%	18	66%	43.4	0.86
Glade, Barren and Savanna	Southern Ridge and Valley Calcareous Glade and Woodland	10%	9,193	504	0	381	33.9	40.0	1.3%	0%	183	34%	36.4	0.42
Outcrop & Summit Scrub	Acidic Rocky Outcrop	56%	197,045	34,615	36,181	39,362	75.8	4.1	0.4%	2%	4,555	98%	69.8	0.16
Outcrop & Summit Scrub	Calcareous Rocky Outcrop	52%	50,685	13,684	5,617	6,840	74.7	7.2	0.2%	0%	136	97%	71.2	0.30
Outcrop & Summit Scrub	Southern Appalachian Grass and Shrub Bald	71%	3,187	1,814	26	435	76.6	10.3	0.2%	0%	641	54%	65.4	0.28
Outcrop & Summit Scrub	Southern Piedmont Granite Flatrock and Outcrop	29%	80	10	0	13	34.2	48.7	0.0%	0%	20	47%	29.2	0.20
Rocky Coast	Acadian-North Atlantic Rocky Coast	18%	6,574	71	452	693	24.3	42.9	13.6%	0%	81	42%	10.1	0.16

Appendix II. All condition metrics shown for habitat types in the upland macrogroups, in the forest patch type.

Upland Macrogroup	Habitat Summary Group	% Conserved	Habitat Acreage	GAP 1 (acres)	GAP 2 (acres)	GAP 3 (acres)	Average Local Connectedness	Average Landscape Condition Index	% of Habitat Predicted to Convert to Development by 2060	Percent of Habitat in patches > 1000 acres	Maximum Patch Size (acres)	% Core Area (100 meter buffer)	Average Stand Age	Average Landscape Complexity
Boreal Upland Forest	Acadian Sub-boreal Spruce Flat	30%	1,486,320	52,773	67,500	326,527	69.6	9.4	0.4%	1%	1,193	83%	55.9	0.01
Boreal Upland Forest	Central and Southern Appalachian Spruce-Fir Forest	87%	64,750	18,986	1,287	36,378	69.9	5.5	0.1%	36%	6,790	97%	65.2	0.23
Central Oak-Pine	Central and Southern Appalachian Montane Oak Forest	63%	145,836	26,855	4,230	61,256	56.3	13.2	0.2%	0%	902	97%	69.1	0.20
Central Oak-Pine	Central Appalachian Pine-Oak Rocky Woodland	38%	558,089	31,999	19,707	162,681	44.2	28.7	2.0%	0%	1,202	73%	62.6	0.36
Central Oak-Pine	North Atlantic Coastal Plain Maritime Forest	21%	114,479	1,476	12,076	10,982	25.8	68.9	22.1%	1%	385	26%	26.1	0.07
Central Oak-Pine	Northeastern Interior Pine Barrens	28%	41,147	1,059	3,089	7,550	34.5	36.8	3.2%	29%	1,247	52%	44.9	-0.03
Central Oak-Pine	Piedmont Hardpan Woodland and Forest	2%	48,087	49	73	1,038	10.1	111.4	9.1%	5%	1,239	39%	31.6	-0.26
Central Oak-Pine	Southern Appalachian Montane Pine Forest and Woodland	70%	33,322	11,697	934	10,618	60.4	14.0	0.4%	0%	228	90%	67.8	0.34
Central Oak-Pine	Southern Ridge and Valley / Cumberland Dry Calcareous Forest	10%	902,472	9,241	2,039	74,516	31.0	66.7	4.0%	20%	4,828	50%	46.2	0.61
Central Oak-Pine/Longleaf Pine	Southern Atlantic Coastal Plain Upland Longleaf Pine Woodland	27%	535	144	0	0	21.5	43.2	0.5%	0%	153	59%	16.7	-0.63
Northern Hardwood & Conifer	Glacial Marine & Lake Mesic Clayplain Forest	8%	231,686	874	1,588	16,085	25.2	72.6	2.5%	17%	4,192	44%	30.5	0.17
Northern Hardwood & Conifer	Laurentian-Acadian Northern Pine-(Oak) Forest	4%	14,102	1	31	477	32.7	51.9	2.3%	0%	362	63%	33.3	-0.13
Northern Hardwood & Conifer	Laurentian-Acadian Red Oak-Northern Hardwood Forest	19%	1,148,393	27,206	56,131	139,345	51.4	19.9	1.3%	25%	5,050	75%	59.9	0.44
Northern Hardwood & Conifer	North-Central Interior Beech-Maple Forest	7%	72,708	249	257	4,472	25.1	68.8	2.3%	0%	484	68%	43.3	0.07
Northern Hardwood & Conifer	South-Central Interior Mesophytic Forest	4%	3,438,270	5,099	28,645	118,661	37.9	41.1	4.7%	5%	5,040	54%	47.2	0.53
Northern Hardwood & Conifer	Southern and Central Appalachian Cove Forest	33%	978,640	80,628	27,291	217,386	48.9	20.8	0.9%	1%	1,905	54%	61.8	0.39
Northern Hardwood & Conifer	Southern Appalachian Northern Hardwood Forest	91%	12,637	3,913	0	7,574	62.6	15.6	0.0%	54%	4,441	78%	67.8	-0.12
Southern Oak-Pine	Central Atlantic Coastal Plain Maritime Forest	89%	6,102	4	519	4,907	24.4	65.7	19.7%	52%	2,447	72%	21.2	-0.43
Southern Oak-Pine	Southern Appalachian Low Elevation Pine Forest	7%	22,032	201	75	1,283	39.3	42.1	3.7%	0%	110	54%	45.6	0.77

Appendix III. All condition metrics shown for habitat types in the wetland macrogroups.

Wetland Macrogroup	Habitat Summary Group	% Conserved	Habitat Acreage	GAP 1 (acres)	GAP 2 (acres)	GAP 3 (acres)	Average Local Connectedness	Average Landscape Condition Index	% Predicted to Convert to Development by 2060	% of Habitat in patches > 1000 acres	Maximum Patch Size (acres)	% Core Area	Average Stand Age	Average Landscape Complexity
Tidal Marsh	Acadian Coastal Salt and Estuary Marsh	24%	29,102	239	2,287	4,471	28.8	41.2	3.2%	0%	832	60%	23.4	0.18
Northern Peatland	Acadian Maritime Bog	22%	5,212	189	825	125	50.7	14.2	0.4%	0%	206	92%	48.3	-0.12
Southern Bottomland Forest	Atlantic Coastal Plain Blackwater/Brownwater Stream Floodplain Forest	6%	161,633	8,029	446	1,520	23.9	71.1	4.7%	31%	3,841	58%	28.0	-0.40
Tidal Marsh	Atlantic Coastal Plain Embayed Region Tidal Freshwater/Brackish Marsh	69%	14,174	2,321	5,209	2,232	44.8	25.5	1.4%	39%	1,916	88%	8.0	-1.13
Coastal Plain Peatland	Atlantic Coastal Plain Northern Bog	72%	5,135	51	744	2,880	35.2	40.5	4.0%	24%	1,349	62%	46.9	-0.60
Coastal Plain Peatland	Atlantic Coastal Plain Peatland Pocosin and Canebrake	99%	2,408	1,202	1,051	121	66.8	1.1	0.0%	0%	895	100%	30.5	-1.47
Northern Peatland	Boreal-Laurentian Bog	41%	45,290	2,678	8,193	7,479	74.1	4.0	0.2%	18%	3,173	97%	52.4	-0.93
Northern Peatland	Boreal-Laurentian-Acadian Acidic Basin Fen	34%	397,710	21,364	34,690	79,196	70.6	7.5	0.4%	6%	3,118	90%	53.9	-0.07
Northern Swamp	Central Appalachian Stream and Riparian	3%	26,594	64	34	662	25.8	71.0	1.1%	0%	405	50%	32.4	0.26
Coastal Plain Swamp	Central Atlantic Coastal Plain Non-riverine Swamp and Wet Hardwood Forest	48%	189,100	1,779	80,317	8,874	45.9	48.2	5.2%	41%	78,723	72%	34.1	-1.08
Central Hardwood Swamp	Central Interior Highlands and Appalachian Sinkhole and Depression Pond	8%	1,405	60	13	42	11.4	139.5	13.9%	0%	15	20%	27.6	0.12
Central Hardwood Swamp	Glacial Marine & Lake Wet Clayplain Forest	9%	86,743	466	478	7,141	24.7	70.7	2.4%	0%	617	56%	30.1	-0.05
Northern Swamp	High Allegheny Headwater Wetland	52%	27,338	1,204	10,763	2,327	49.0	41.0	0.8%	28%	6,345	64%	49.8	0.39
Northern Swamp	Laurentian-Acadian Alkaline Conifer-Hardwood Swamp	20%	905,298	20,698	46,200	110,480	48.9	31.0	1.2%	4%	2,091	73%	49.7	0.07
Northern Peatland	Laurentian-Acadian Alkaline Fen	24%	205	4	0	45	39.1	42.8	0.3%	0%	48	66%	45.7	0.45
Emergent Marsh	Laurentian-Acadian Freshwater Marsh	22%	883,547	22,917	52,439	117,390	30.9	69.8	4.8%	0%	1,258	47%	33.6	0.05
Large River Floodplain	Laurentian-Acadian Large River Floodplain	25%	424,368	11,540	26,468	66,367	52.1	27.1	1.0%	25%	4,151	47%	47.2	0.02
Wet Meadow / Shrub Marsh	Laurentian-Acadian Wet Meadow-Shrub Swamp	26%	970,859	37,475	65,696	146,643	41.0	48.0	2.9%	0%	1,460	60%	44.2	0.10
Coastal Plain Swamp	North Atlantic Coastal Plain Basin Peat Swamp	54%	57,537	3,280	8,444	19,178	30.3	45.8	3.7%	8%	1,791	75%	49.3	-0.62
Coastal Plain Swamp	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest	19%	946,104	5,449	64,967	110,642	18.0	92.4	7.6%	14%	3,190	44%	37.2	-0.64
Tidal Marsh	North Atlantic Coastal Plain Brackish/Fresh & Oligohaline Tidal Marsh	15%	16,905	0	240	2,237	27.2	90.4	17.4%	7%	1,237	57%	10.4	-0.14
Large River Floodplain	North Atlantic Coastal Plain Large River Floodplain	20%	33,788	244	2,050	4,632	25.6	78.8	10.9%	0%	776	42%	32.7	-0.98
Coastal Plain Swamp	North Atlantic Coastal Plain Pitch Pine Lowland	52%	171,024	7,166	34,888	47,044	29.5	47.8	5.2%	6%	1,694	61%	52.8	-0.68
Coastal Plain Swamp	North Atlantic Coastal Plain Stream and River	5%	28,207	0	183	1,197	23.6	82.6	8.1%	4%	574	56%	34.5	0.21
Tidal Marsh	North Atlantic Coastal Plain Tidal Salt Marsh	46%	906,519	46,236	191,295	175,869	45.0	45.1	6.7%	49%	19,464	70%	7.6	-0.93
Coastal Plain Swamp	North Atlantic Coastal Plain Tidal Swamp	30%	191,857	3,815	26,085	28,202	33.5	60.1	7.3%	12%	3,555	56%	28.8	-0.77
Northern Swamp	North-Central Appalachian Acidic Swamp	19%	1,464,256	16,278	59,580	206,320	24.3	74.2	7.5%	3%	2,811	48%	39.8	0.22
Large River Floodplain	North-Central Appalachian Large River Floodplain	20%	246,528	2,874	17,552	29,006	18.0	86.0	6.3%	16%	3,512	41%	30.6	0.24
Northern Peatland	North-Central Interior and Appalachian Acidic Peatland	38%	82,637	1,781	7,090	22,749	33.0	47.3	2.2%	11%	2,839	41%	41.0	0.14
Northern Swamp	North-Central Interior and Appalachian Rich Swamp	12%	807,365	6,255	27,878	64,090	17.3	91.5	7.7%	5%	3,380	41%	34.7	0.13
Large River Floodplain	North-Central Interior Large River Floodplain	16%	68,877	483	1,475	8,824	20.0	69.7	2.4%	35%	2,249	43%	30.4	-0.21
Central Hardwood Swamp	North-Central Interior Wet Flatwoods	8%	79,781	187	1,886	3,933	10.7	122.4	14.6%	0%	219	43%	29.2	0.04
Northern Swamp	Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp	38%	1,290,295	98,922	146,254	247,978	67.2	11.2	0.4%	2%	1,976	83%	57.9	0.21
Central Hardwood Swamp	Piedmont Upland Depression Swamp	5%	21,024	0	36	942	19.6	87.5	6.2%	0%	154	38%	26.1	-0.21
Emergent Marsh	Piedmont-Coastal Plain Freshwater Marsh	6%	44,945	81	544	2,242	20.7	86.6	5.8%	0%	735	45%	22.7	-0.09
Large River Floodplain	Piedmont-Coastal Plain Large River Floodplain	9%	131,531	1,104	1,540	9,382	34.5	46.5	2.0%	47%	12,142	68%	31.5	-0.19
Wet Meadow / Shrub Marsh	Piedmont-Coastal Plain Shrub Swamp	7%	46,012	861	1,299	1,234	30.2	60.3	2.8%	0%	980	64%	28.4	-0.24
Coastal Plain Swamp	Southern Atlantic Coastal Plain Tidal Wooded Swamp	34%	12,785	2,364	1,407	545	28.3	63.3	4.4%	28%	1,140	59%	26.0	-1.08
Southern Bottomland Forest	Southern Piedmont Lake Floodplain Forest	6%	8,387	0	8	529	26.3	78.0	12.3%	0%	233	43%	19.6	0.04
Southern Bottomland Forest	Southern Piedmont Small Floodplain and Riparian Forest	6%	184,110	0	241	10,910	32.9	56.1	2.2%	1%	785	64%	31.6	0.24

Appendix IV. All metrics shown for stream habitats.

Habitat Type	% Conserved	Average Local Connectedness	Average Landscape Context Index	% of Habitat Predicted to be Developed by 2060	% Class 1: Undisturbed: < 0.5% impervious	% Class 2: Low impacts: 0.5-2% impervious	% Class 3: Moderately impacted: 2-10% impervious	% Class 4: Highly impacted: > 10% impervious	Impervious Index	Riparian Buffer Index	Total Dam Density: # / 100 miles	Risk of flow alteration index	Avg. Network Length (mi.)
Cold, Medium River	36%	60.9	21.1	6.1	95.0	5.0	0.0	0.0	105.0	8.0	5.8	196.4	1,054
Cool, Large River	12%	29.4	76.2	27.2	69.8	29.2	1.0	0.0	131.2	21.6	10.2	253.9	817
Cool, Medium River	14%	26.2	66.4	28.0	44.8	51.0	4.3	0.0	159.5	21.3	11.8	224.7	412
High Gradient, Cold, Headwaters and Creeks	26%	39.3	39.9	16.2	79.0	16.5	4.0	0.5	126.0	10.4	6.5	107.3	610
High Gradient, Cool, Headwaters and Creeks	13%	28.4	56.4	25.3	66.3	22.8	8.9	2.0	146.5	14.9	2.1	103.5	1,098
High Gradient, Warm, Headwaters and Creeks	6%	27.3	55.1	25.1	55.9	31.9	10.0	2.2	158.5	16.4	2.4	103.0	1,550
Low Gradient, Cold, Headwaters and Creeks	29%	68.4	15.9	4.6	85.3	13.8	1.0	0.0	115.7	3.0	3.4	108.0	597
Low Gradient, Cold, Small River	25%	55.5	25.3	6.4	77.6	22.4	0.0	0.0	122.4	6.9	2.8	138.1	479
Low Gradient, Cool, Headwaters and Creeks	11%	26.6	81.6	32.2	39.8	36.7	16.9	6.6	190.4	19.6	12.0	119.0	332
Low Gradient, Cool, Small River	13%	17.2	96.6	37.3	26.2	49.1	17.3	7.3	205.7	22.2	8.3	168.3	464
Low Gradient, Warm, Headwaters and Creeks	9%	17.2	93.8	45.7	37.0	33.9	18.2	11.0	203.2	19.7	7.3	113.4	875
Low Gradient, Warm, Small River	9%	20.8	79.7	38.5	34.8	41.1	18.7	5.4	194.7	19.6	3.5	152.0	1,022
Moderate Gradient, Cold, Headwaters and Creeks	18%	36.4	50.7	21.5	68.2	23.5	6.9	1.3	141.3	12.4	7.2	112.8	475
Moderate Gradient, Cold, Small River	24%	51.4	28.9	11.7	79.7	19.8	0.5	0.0	120.8	11.9	8.6	141.0	475
Moderate Gradient, Cool, Headwaters and Creeks	8%	14.0	103.7	48.8	35.8	36.3	20.0	7.9	200.1	26.9	7.8	110.4	669
Moderate Gradient, Cool, Small River	11%	19.2	83.3	36.5	44.4	40.2	13.8	1.6	172.7	23.8	13.4	164.3	710
Moderate Gradient, Warm, Headwaters and Creeks	4%	20.7	76.0	36.4	48.0	29.7	13.0	9.3	183.7	19.0	3.6	106.7	1,123
Moderate Gradient, Warm, Small River	8%	19.1	84.1	41.4	31.9	43.0	19.5	5.6	198.7	22.9	4.0	144.3	1,008
Tidal Headwaters and Creeks	13%	23.9	93.0	49.9	26.0	32.4	23.3	18.3	233.8	18.4	8.6	114.5	588
Tidal Large River	16%	20.2	69.4	60.3	4.4	60.9	33.9	0.8	231.1	25.9	1.0	288.1	1,229
Tidal Small and Medium River	18%	20.6	86.7	55.6	8.0	35.9	36.9	19.2	267.2	24.5	5.4	179.2	702
Warm, Large River	12%	17.1	93.6	41.6	10.6	72.3	16.6	0.6	207.1	29.9	4.4	275.3	1,437
Warm, Medium River	9%	19.9	89.4	40.6	26.2	50.5	21.8	1.5	198.5	23.8	5.0	211.7	1,109

Appendix V. Join Table: Minor road bounded blocks and wetlands.

Table Name: JoinTable_MinorBlocksandWetlandComplexes

This table contains the wetlands attributes for each minor road bounded block. These include maximum size of wetland complex, average size of wetland complex, total area of wetland complex, number of wetland complexes, and total acres of wetlands (both within and not in wetland complexes).

Min_Blk_Id	Minor Block ID this field links to Unit_MinorBlocks on the MB_ID field
Max_WetCom	Size of the largest Weltand complex in minor block (in meters squared)
Avg_WetCom	Average size of Wetland Complexes in minor block (in meters squared)
Total_WetC	Total Area of Wetland Complexes in minor block (in meters squared)
Num_WetCom	Number of Wetland Complexes in minor block
Area_Wetland	Total Area of Wetlands both in the complexes and not in complexes (those less than 5 acres)

Appendix VI. Join Table: Minor road bounded blocks and securement of habitat patches.

Table Name: JoinTable_MinorBlocksandSecuredLands.

This table contains the area (in meters squared) of Unprotected, GAP 1, GAP 2, GAP 1 & 2, GAP 3 for each habitat type in each minor block.

MB_ID	Minor Block ID this field links to Unit_MinorBlocks on the MB_ID field
H1_UP	Acadian Coastal Salt and Estuary Marsh UNPROTECTED meters squared
H2_UP	Acadian Low Elevation Spruce-Fir-Hardwood Forest UNPROTECTED meters squared
H3_UP	Acadian Maritime Bog UNPROTECTED meters squared
H4_UP	Acadian Sub-boreal Spruce Flat UNPROTECTED meters squared
H5_UP	Acadian-Appalachian Alpine Tundra UNPROTECTED meters squared
H6_UP	Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest UNPROTECTED meters squared
H7_UP	Acadian-North Atlantic Rocky Coast UNPROTECTED meters squared
H8_UP	Acidic Cliff and Talus UNPROTECTED meters squared
H9_UP	Acidic Rocky Outcrop UNPROTECTED meters squared
H11_UP	Allegheny-Cumberland Dry Oak Forest and Woodland UNPROTECTED meters squared
H12_UP	Appalachian (Hemlock)-Northern Hardwood Forest UNPROTECTED meters squared
H13_UP	Appalachian Shale Barrens UNPROTECTED meters squared
H14_UP	Atlantic Coastal Plain Beach and Dune UNPROTECTED meters squared
H15_UP	Atlantic Coastal Plain Blackwater/Brownwater Stream Floodplain Forest UNPROTECTED meters squared
H16_UP	Atlantic Coastal Plain Embayed Region Tidal Freshwater/Brackish Marsh UNPROTECTED meters squared
H17_UP	Atlantic Coastal Plain Northern Bog UNPROTECTED meters squared
H18_UP	Atlantic Coastal Plain Peatland Pocosin and Canebrake UNPROTECTED meters squared

H19_UP	Boreal-Laurentian Bog UNPROTECTED meters squared
H20_UP	Boreal-Laurentian-Acadian Acidic Basin Fen UNPROTECTED meters squared
H21_UP	Calcareous Cliff and Talus UNPROTECTED meters squared
H22_UP	Calcareous Rocky Outcrop UNPROTECTED meters squared
H23_UP	Central Appalachian Alkaline Glade and Woodland UNPROTECTED meters squared
H24_UP	Central Appalachian Dry Oak-Pine Forest UNPROTECTED meters squared
H25_UP	Central Appalachian Pine-Oak Rocky Woodland UNPROTECTED meters squared
H26_UP	Central Appalachian Stream and Riparian UNPROTECTED meters squared
H27_UP	Central Atlantic Coastal Plain Maritime Forest UNPROTECTED meters squared
H28_UP	Central Interior Highlands and Appalachian Sinkhole and Depression Pond UNPROTECTED meters squared
H29_UP	Central and Southern Appalachian Montane Oak Forest UNPROTECTED meters squared
H30_UP	Central and Southern Appalachian Spruce-Fir Forest UNPROTECTED meters squared
H31_UP	Circumneutral Cliff and Talus UNPROTECTED meters squared
H33_UP	Eastern Serpentine Woodland UNPROTECTED meters squared
H34_UP	Glacial Marine & Lake Mesic Clayplain Forest UNPROTECTED meters squared
H35_UP	Glacial Marine & Lake Wet Clayplain Forest UNPROTECTED meters squared
H36_UP	Great Lakes Alvar UNPROTECTED meters squared
H37_UP	Great Lakes Dune and Swale UNPROTECTED meters squared
H38_UP	High Allegheny Headwater Wetland UNPROTECTED meters squared
H39_UP	Laurentian-Acadian Alkaline Conifer-Hardwood Swamp UNPROTECTED meters squared
H40_UP	Laurentian-Acadian Alkaline Fen UNPROTECTED meters squared
H41_UP	Laurentian-Acadian Freshwater Marsh UNPROTECTED meters squared
H42_UP	Laurentian-Acadian Northern Hardwood Forest UNPROTECTED meters squared
H43_UP	Laurentian-Acadian Northern Pine-(Oak) Forest UNPROTECTED meters squared
H44_UP	Laurentian-Acadian Pine-Hemlock-Hardwood Forest UNPROTECTED meters squared
H45_UP	Laurentian-Acadian Red Oak-Northern Hardwood Forest UNPROTECTED meters squared
H46_UP	Laurentian-Acadian Wet Meadow-Shrub Swamp UNPROTECTED meters squared
H47_UP	North Atlantic Coastal Plain Basin Peat Swamp UNPROTECTED meters squared
H48_UP	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest UNPROTECTED meters squared
H49_UP	North Atlantic Coastal Plain Brackish/Fresh & Oligohaline Tidal Marsh UNPROTECTED meters squared
H50_UP	North Atlantic Coastal Plain Hardwood Forest UNPROTECTED meters squared
H51_UP	North Atlantic Coastal Plain Heathland and Grassland UNPROTECTED meters squared
H52_UP	North Atlantic Coastal Plain Large River Floodplain UNPROTECTED meters squared
H53_UP	North Atlantic Coastal Plain Maritime Forest UNPROTECTED meters squared
H54_UP	North Atlantic Coastal Plain Pitch Pine Barrens UNPROTECTED meters squared
H55_UP	North Atlantic Coastal Plain Pitch Pine Lowland UNPROTECTED meters squared
H56_UP	North Atlantic Coastal Plain Stream and River UNPROTECTED meters squared
H57_UP	North Atlantic Coastal Plain Tidal Salt Marsh UNPROTECTED meters squared
H58_UP	North Atlantic Coastal Plain Tidal Swamp UNPROTECTED meters squared
H59_UP	North-Central Appalachian Acidic Swamp UNPROTECTED meters squared
H60_UP	North-Central Appalachian Large River Floodplain UNPROTECTED meters squared
H61_UP	Northeastern Interior Pine Barrens UNPROTECTED meters squared
H62_UP	North-Central Interior Beech-Maple Forest UNPROTECTED meters squared

H63_UP	North-Central Interior Large River Floodplain UNPROTECTED meters squared
H64_UP	North-Central Interior Wet Flatwoods UNPROTECTED meters squared
H65_UP	North-Central Interior and Appalachian Acidic Peatland UNPROTECTED meters squared
H66_UP	North-Central Interior and Appalachian Rich Swamp UNPROTECTED meters squared
H67_UP	Northeastern Coastal and Interior Pine-Oak Forest UNPROTECTED meters squared
H68_UP	Northeastern Interior Dry-Mesic Oak Forest UNPROTECTED meters squared
H69_UP	Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp UNPROTECTED meters squared
H70_UP	Laurentian-Acadian Large River Floodplain UNPROTECTED meters squared
H71_UP	Open Water (NLCD-NHD open water) UNPROTECTED meters squared
H72_UP	Piedmont Hardpan Woodland and Forest UNPROTECTED meters squared
H73_UP	Piedmont Upland Depression Swamp UNPROTECTED meters squared
H74_UP	Piedmont-Coastal Plain Freshwater Marsh UNPROTECTED meters squared
H75_UP	Piedmont-Coastal Plain Large River Floodplain UNPROTECTED meters squared
H76_UP	Piedmont-Coastal Plain Shrub Swamp UNPROTECTED meters squared
H77_UP	Pine plantation / Horticultural pines UNPROTECTED meters squared
H78_UP	Ruderal shrubland & Grassland (NLCD 52/71) UNPROTECTED meters squared
H79_UP	Central Atlantic Coastal Plain Non-riverine Swamp and Wet Hardwood Forest UNPROTECTED meters squared
H80_UP	South-Central Interior Mesophytic Forest UNPROTECTED meters squared
H81_UP	Southern Appalachian Low Elevation Pine Forest UNPROTECTED meters squared
H82_UP	Southern Appalachian Montane Pine Forest and Woodland UNPROTECTED meters squared
H83_UP	Southern Appalachian Northern Hardwood Forest UNPROTECTED meters squared
H84_UP	Southern Appalachian Oak Forest UNPROTECTED meters squared
H85_UP	Southern Atlantic Coastal Plain Upland Longleaf Pine Woodland UNPROTECTED meters squared
H86_UP	Southern Atlantic Coastal Plain Mesic Hardwood Forest UNPROTECTED meters squared
H87_UP	Southern Atlantic Coastal Plain Tidal Wooded Swamp UNPROTECTED meters squared
H88_UP	Southern Piedmont Dry Oak-Pine Forest UNPROTECTED meters squared
H89_UP	Southern Piedmont Glade and Barrens UNPROTECTED meters squared
H90_UP	Southern Piedmont Granite Flatrock and Outcrop UNPROTECTED meters squared
H91_UP	Southern Piedmont Lake Floodplain Forest UNPROTECTED meters squared
H92_UP	Southern Piedmont Mesic Forest UNPROTECTED meters squared
H93_UP	Southern Piedmont Small Floodplain and Riparian Forest UNPROTECTED meters squared
H94_UP	Southern Ridge and Valley / Cumberland Dry Calcareous Forest UNPROTECTED meters squared
H95_UP	Southern Ridge and Valley Calcareous Glade and Woodland UNPROTECTED meters squared
H96_UP	Southern and Central Appalachian Cove Forest UNPROTECTED meters squared
H97_UP	Southern and Central Appalachian Mafic Glade and Barrens UNPROTECTED meters squared
H98_UP	Southern Appalachian Grass and Shrub Bald UNPROTECTED meters squared
H01_G1	Acadian Coastal Salt and Estuary Marsh PROTECTED GAP 1 meters squared
H02_G1	Acadian Low Elevation Spruce-Fir-Hardwood Forest PROTECTED GAP 1 meters squared
H03_G1	Acadian Maritime Bog PROTECTED GAP 1 meters squared
H04_G1	Acadian Sub-boreal Spruce Flat PROTECTED GAP 1 meters squared
H05_G1	Acadian-Appalachian Alpine Tundra PROTECTED GAP 1 meters squared
H06_G1	Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest PROTECTED GAP 1 meters squared
H07_G1	Acadian-North Atlantic Rocky Coast PROTECTED GAP 1 meters squared

H08_G1	Acidic Cliff and Talus PROTECTED GAP 1 meters squared
H09_G1	Acidic Rocky Outcrop PROTECTED GAP 1 meters squared
H11_G1	Allegheny-Cumberland Dry Oak Forest and Woodland PROTECTED GAP 1 meters squared
H12_G1	Appalachian (Hemlock)-Northern Hardwood Forest PROTECTED GAP 1 meters squared
H13_G1	Appalachian Shale Barrens PROTECTED GAP 1 meters squared
H14_G1	Atlantic Coastal Plain Beach and Dune PROTECTED GAP 1 meters squared
H15_G1	Atlantic Coastal Plain Blackwater/Brownwater Stream Floodplain Forest PROTECTED GAP 1 meters squared
H16_G1	Atlantic Coastal Plain Embayed Region Tidal Freshwater/Brackish Marsh PROTECTED GAP 1 meters squared
H17_G1	Atlantic Coastal Plain Northern Bog PROTECTED GAP 1 meters squared
H18_G1	Atlantic Coastal Plain Peatland Pocosin and Canebrake PROTECTED GAP 1 meters squared
H19_G1	Boreal-Laurentian Bog PROTECTED GAP 1 meters squared
H20_G1	Boreal-Laurentian-Acadian Acidic Basin Fen PROTECTED GAP 1 meters squared
H21_G1	Calcareous Cliff and Talus PROTECTED GAP 1 meters squared
H22_G1	Calcareous Rocky Outcrop PROTECTED GAP 1 meters squared
H23_G1	Central Appalachian Alkaline Glade and Woodland PROTECTED GAP 1 meters squared
H24_G1	Central Appalachian Dry Oak-Pine Forest PROTECTED GAP 1 meters squared
H25_G1	Central Appalachian Pine-Oak Rocky Woodland PROTECTED GAP 1 meters squared
H26_G1	Central Appalachian Stream and Riparian PROTECTED GAP 1 meters squared
H27_G1	Central Atlantic Coastal Plain Maritime Forest PROTECTED GAP 1 meters squared
H28_G1	Central Interior Highlands and Appalachian Sinkhole and Depression Pond PROTECTED GAP 1 meters squared
H29_G1	Central and Southern Appalachian Montane Oak Forest PROTECTED GAP 1 meters squared
H30_G1	Central and Southern Appalachian Spruce-Fir Forest PROTECTED GAP 1 meters squared
H31_G1	Circumneutral Cliff and Talus PROTECTED GAP 1 meters squared
H33_G1	Eastern Serpentine Woodland PROTECTED GAP 1 meters squared
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H37_G1	Great Lakes Dune and Swale PROTECTED GAP 1 meters squared
H38_G1	High Allegheny Headwater Wetland PROTECTED GAP 1 meters squared
H39_G1	Laurentian-Acadian Alkaline Conifer-Hardwood Swamp PROTECTED GAP 1 meters squared
H40_G1	Laurentian-Acadian Alkaline Fen PROTECTED GAP 1 meters squared
H41_G1	Laurentian-Acadian Freshwater Marsh PROTECTED GAP 1 meters squared
H42_G1	Laurentian-Acadian Northern Hardwood Forest PROTECTED GAP 1 meters squared
H43_G1	Laurentian-Acadian Northern Pine-(Oak) Forest PROTECTED GAP 1 meters squared
H44_G1	Laurentian-Acadian Pine-Hemlock-Hardwood Forest PROTECTED GAP 1 meters squared
H45_G1	Laurentian-Acadian Red Oak-Northern Hardwood Forest PROTECTED GAP 1 meters squared
H46_G1	Laurentian-Acadian Wet Meadow-Shrub Swamp PROTECTED GAP 1 meters squared
H47_G1	North Atlantic Coastal Plain Basin Peat Swamp PROTECTED GAP 1 meters squared
H48_G1	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest PROTECTED GAP 1 meters squared
H50_G1	North Atlantic Coastal Plain Hardwood Forest PROTECTED GAP 1 meters squared
H51_G1	North Atlantic Coastal Plain Heathland and Grassland PROTECTED GAP 1 meters squared
H52_G1	North Atlantic Coastal Plain Large River Floodplain PROTECTED GAP 1 meters squared
H53_G1	North Atlantic Coastal Plain Maritime Forest PROTECTED GAP 1 meters squared
H54_G1	North Atlantic Coastal Plain Pitch Pine Barrens PROTECTED GAP 1 meters squared

H55_G1	North Atlantic Coastal Plain Pitch Pine Lowland PROTECTED GAP 1 meters squared
H57_G1	North Atlantic Coastal Plain Tidal Salt Marsh PROTECTED GAP 1 meters squared
H58_G1	North Atlantic Coastal Plain Tidal Swamp PROTECTED GAP 1 meters squared
H59_G1	North-Central Appalachian Acidic Swamp PROTECTED GAP 1 meters squared
H60_G1	North-Central Appalachian Large River Floodplain PROTECTED GAP 1 meters squared
H61_G1	Northeastern Interior Pine Barrens PROTECTED GAP 1 meters squared
H62_G1	North-Central Interior Beech-Maple Forest PROTECTED GAP 1 meters squared
H63_G1	North-Central Interior Large River Floodplain PROTECTED GAP 1 meters squared
H64_G1	North-Central Interior Wet Flatwoods PROTECTED GAP 1 meters squared
H65_G1	North-Central Interior and Appalachian Acidic Peatland PROTECTED GAP 1 meters squared
H66_G1	North-Central Interior and Appalachian Rich Swamp PROTECTED GAP 1 meters squared
H67_G1	Northeastern Coastal and Interior Pine-Oak Forest PROTECTED GAP 1 meters squared
H68_G1	Northeastern Interior Dry-Mesic Oak Forest PROTECTED GAP 1 meters squared
H69_G1	Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp PROTECTED GAP 1 meters squared
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H79_G1	Central Atlantic Coastal Plain Non-riverine Swamp and Wet Hardwood Forest PROTECTED GAP 1 meters squared
H80_G1	South-Central Interior Mesophytic Forest PROTECTED GAP 1 meters squared
H81_G1	Southern Appalachian Low Elevation Pine Forest PROTECTED GAP 1 meters squared
H82_G1	Southern Appalachian Montane Pine Forest and Woodland PROTECTED GAP 1 meters squared
H83_G1	Southern Appalachian Northern Hardwood Forest PROTECTED GAP 1 meters squared
H84_G1	Southern Appalachian Oak Forest PROTECTED GAP 1 meters squared
H85_G1	Southern Atlantic Coastal Plain Upland Longleaf Pine Woodland PROTECTED GAP 1 meters squared
H86_G1	Southern Atlantic Coastal Plain Mesic Hardwood Forest PROTECTED GAP 1 meters squared
H87_G1	Southern Atlantic Coastal Plain Tidal Wooded Swamp PROTECTED GAP 1 meters squared
H88_G1	Southern Piedmont Dry Oak-Pine Forest PROTECTED GAP 1 meters squared
H90_G1	Southern Piedmont Granite Flatrock and Outcrop PROTECTED GAP 1 meters squared
H92_G1	Southern Piedmont Mesic Forest PROTECTED GAP 1 meters squared
H94_G1	Southern Ridge and Valley / Cumberland Dry Calcareous Forest PROTECTED GAP 1 meters squared
H95_G1	Southern Ridge and Valley Calcareous Glade and Woodland PROTECTED GAP 1 meters squared
H96_G1	Southern and Central Appalachian Cove Forest PROTECTED GAP 1 meters squared
H97_G1	Southern and Central Appalachian Mafic Glade and Barrens PROTECTED GAP 1 meters squared
H98_G1	Southern Appalachian Grass and Shrub Bald PROTECTED GAP 1 meters squared
H01_G2	Acadian Coastal Salt and Estuary Marsh PROTECTED GAP 2 meters squared
H02_G2	Acadian Low Elevation Spruce-Fir-Hardwood Forest PROTECTED GAP 2 meters squared
H03_G2	Acadian Maritime Bog PROTECTED GAP 2 meters squared
H04_G2	Acadian Sub-boreal Spruce Flat PROTECTED GAP 2 meters squared

H05_G2	Acadian-Appalachian Alpine Tundra PROTECTED GAP 2 meters squared
H06_G2	Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest PROTECTED GAP 2 meters squared
H07_G2	Acadian-North Atlantic Rocky Coast PROTECTED GAP 2 meters squared
H08_G2	Acidic Cliff and Talus PROTECTED GAP 2 meters squared
H09_G2	Acidic Rocky Outcrop PROTECTED GAP 2 meters squared
H11_G2	Allegheny-Cumberland Dry Oak Forest and Woodland PROTECTED GAP 2 meters squared
H12_G2	Appalachian (Hemlock)-Northern Hardwood Forest PROTECTED GAP 2 meters squared
H13_G2	Appalachian Shale Barrens PROTECTED GAP 2 meters squared
H14_G2	Atlantic Coastal Plain Beach and Dune PROTECTED GAP 2 meters squared
H15_G2	Atlantic Coastal Plain Blackwater/Brownwater Stream Floodplain Forest PROTECTED GAP 2 meters squared
H16_G2	Atlantic Coastal Plain Embayed Region Tidal Freshwater/Brackish Marsh PROTECTED GAP 2 meters squared
H17_G2	Atlantic Coastal Plain Northern Bog PROTECTED GAP 2 meters squared
H18_G2	Atlantic Coastal Plain Peatland Pocosin and Canebrake PROTECTED GAP 2 meters squared
H19_G2	Boreal-Laurentian Bog PROTECTED GAP 2 meters squared
H20_G2	Boreal-Laurentian-Acadian Acidic Basin Fen PROTECTED GAP 2 meters squared
H21_G2	Calcareous Cliff and Talus PROTECTED GAP 2 meters squared
H22_G2	Calcareous Rocky Outcrop PROTECTED GAP 2 meters squared
H23_G2	Central Appalachian Alkaline Glade and Woodland PROTECTED GAP 2 meters squared
H24_G2	Central Appalachian Dry Oak-Pine Forest PROTECTED GAP 2 meters squared
H25_G2	Central Appalachian Pine-Oak Rocky Woodland PROTECTED GAP 2 meters squared
H26_G2	Central Appalachian Stream and Riparian PROTECTED GAP 2 meters squared
H27_G2	Central Atlantic Coastal Plain Maritime Forest PROTECTED GAP 2 meters squared
H28_G2	Central Interior Highlands and Appalachian Sinkhole and Depression Pond PROTECTED GAP 2 meters squared
H29_G2	Central and Southern Appalachian Montane Oak Forest PROTECTED GAP 2 meters squared
H30_G2	Central and Southern Appalachian Spruce-Fir Forest PROTECTED GAP 2 meters squared
H31_G2	Circumneutral Cliff and Talus PROTECTED GAP 2 meters squared
H33_G2	Eastern Serpentine Woodland PROTECTED GAP 2 meters squared
H34_G2	Glacial Marine & Lake Mesic Clayplain Forest PROTECTED GAP 2 meters squared
H35_G2	Glacial Marine & Lake Wet Clayplain Forest PROTECTED GAP 2 meters squared
H36_G2	Great Lakes Alvar PROTECTED GAP 2 meters squared
H37_G2	Great Lakes Dune and Swale PROTECTED GAP 2 meters squared
H38_G2	High Allegheny Headwater Wetland PROTECTED GAP 2 meters squared
H39_G2	Laurentian-Acadian Alkaline Conifer-Hardwood Swamp PROTECTED GAP 2 meters squared
H41_G2	Laurentian-Acadian Freshwater Marsh PROTECTED GAP 2 meters squared
H42_G2	Laurentian-Acadian Northern Hardwood Forest PROTECTED GAP 2 meters squared
H43_G2	Laurentian-Acadian Northern Pine-(Oak) Forest PROTECTED GAP 2 meters squared
H44_G2	Laurentian-Acadian Pine-Hemlock-Hardwood Forest PROTECTED GAP 2 meters squared
H45_G2	Laurentian-Acadian Red Oak-Northern Hardwood Forest PROTECTED GAP 2 meters squared
H46_G2	Laurentian-Acadian Wet Meadow-Shrub Swamp PROTECTED GAP 2 meters squared
H47_G2	North Atlantic Coastal Plain Basin Peat Swamp PROTECTED GAP 2 meters squared
H48_G2	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest PROTECTED GAP 2 meters squared
H49_G2	North Atlantic Coastal Plain Brackish/Fresh & Oligohaline Tidal Marsh PROTECTED GAP 2 meters squared
H50_G2	North Atlantic Coastal Plain Hardwood Forest PROTECTED GAP 2 meters squared

H51_G2	North Atlantic Coastal Plain Heathland and Grassland PROTECTED GAP 2 meters squared
H52_G2	North Atlantic Coastal Plain Large River Floodplain PROTECTED GAP 2 meters squared
H53_G2	North Atlantic Coastal Plain Maritime Forest PROTECTED GAP 2 meters squared
H54_G2	North Atlantic Coastal Plain Pitch Pine Barrens PROTECTED GAP 2 meters squared
H55_G2	North Atlantic Coastal Plain Pitch Pine Lowland PROTECTED GAP 2 meters squared
H56_G2	North Atlantic Coastal Plain Stream and River PROTECTED GAP 2 meters squared
H57_G2	North Atlantic Coastal Plain Tidal Salt Marsh PROTECTED GAP 2 meters squared
H58_G2	North Atlantic Coastal Plain Tidal Swamp PROTECTED GAP 2 meters squared
H59_G2	North-Central Appalachian Acidic Swamp PROTECTED GAP 2 meters squared
H60_G2	North-Central Appalachian Large River Floodplain PROTECTED GAP 2 meters squared
H61_G2	Northeastern Interior Pine Barrens PROTECTED GAP 2 meters squared
H62_G2	North-Central Interior Beech-Maple Forest PROTECTED GAP 2 meters squared
H63_G2	North-Central Interior Large River Floodplain PROTECTED GAP 2 meters squared
H64_G2	North-Central Interior Wet Flatwoods PROTECTED GAP 2 meters squared
H65_G2	North-Central Interior and Appalachian Acidic Peatland PROTECTED GAP 2 meters squared
H66_G2	North-Central Interior and Appalachian Rich Swamp PROTECTED GAP 2 meters squared
H67_G2	Northeastern Coastal and Interior Pine-Oak Forest PROTECTED GAP 2 meters squared
H68_G2	Northeastern Interior Dry-Mesic Oak Forest PROTECTED GAP 2 meters squared
H69_G2	Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp PROTECTED GAP 2 meters squared
H70_G2	Laurentian-Acadian Large River Floodplain PROTECTED GAP 2 meters squared
H71_G2	Open Water (NLCD-NHD open water) PROTECTED GAP 2 meters squared
H72_G2	Piedmont Hardpan Woodland and Forest PROTECTED GAP 2 meters squared
H73_G2	Piedmont Upland Depression Swamp PROTECTED GAP 2 meters squared
H74_G2	Piedmont-Coastal Plain Freshwater Marsh PROTECTED GAP 2 meters squared
H75_G2	Piedmont-Coastal Plain Large River Floodplain PROTECTED GAP 2 meters squared
H76_G2	Piedmont-Coastal Plain Shrub Swamp PROTECTED GAP 2 meters squared
H77_G2	Pine plantation / Horticultural pines PROTECTED GAP 2 meters squared
H78_G2	Ruderal shrubland & Grassland (NLCD 52/71) PROTECTED GAP 2 meters squared
H79_G2	Central Atlantic Coastal Plain Non-riverine Swamp and Wet Hardwood Forest PROTECTED GAP 2 meters squared
H80_G2	South-Central Interior Mesophytic Forest PROTECTED GAP 2 meters squared
H81_G2	Southern Appalachian Low Elevation Pine Forest PROTECTED GAP 2 meters squared
H82_G2	Southern Appalachian Montane Pine Forest and Woodland PROTECTED GAP 2 meters squared
H83_G2	Southern Appalachian Northern Hardwood Forest PROTECTED GAP 2 meters squared
H84_G2	Southern Appalachian Oak Forest PROTECTED GAP 2 meters squared
H85_G2	Southern Atlantic Coastal Plain Upland Longleaf Pine Woodland PROTECTED GAP 2 meters squared
H86_G2	Southern Atlantic Coastal Plain Mesic Hardwood Forest PROTECTED GAP 2 meters squared
H87_G2	Southern Atlantic Coastal Plain Tidal Wooded Swamp PROTECTED GAP 2 meters squared
H88_G2	Southern Piedmont Dry Oak-Pine Forest PROTECTED GAP 2 meters squared
H89_G2	Southern Piedmont Glade and Barrens PROTECTED GAP 2 meters squared
H90_G2	Southern Piedmont Granite Flatrock and Outcrop PROTECTED GAP 2 meters squared
H91_G2	Southern Piedmont Lake Floodplain Forest PROTECTED GAP 2 meters squared
H92_G2	Southern Piedmont Mesic Forest PROTECTED GAP 2 meters squared
H93_G2	Southern Piedmont Small Floodplain and Riparian Forest PROTECTED GAP 2 meters squared

H94_G2	Southern Ridge and Valley / Cumberland Dry Calcareous Forest PROTECTED GAP 2 meters squared
H95_G2	Southern Ridge and Valley Calcareous Glade and Woodland PROTECTED GAP 2 meters squared
H96_G2	Southern and Central Appalachian Cove Forest PROTECTED GAP 2 meters squared
H97_G2	Southern and Central Appalachian Mafic Glade and Barrens PROTECTED GAP 2 meters squared
H98_G2	Southern Appalachian Grass and Shrub Bald PROTECTED GAP 2 meters squared
H1_G12	Acadian Coastal Salt and Estuary Marsh PROTECTED GAP 1 & 2 (biodiversity) m2
H2_G12	Acadian Low Elevation Spruce-Fir-Hardwood Forest PROTECTED GAP 1 & 2 (biodiversity) m2
H3_G12	Acadian Maritime Bog PROTECTED GAP 1 & 2 (biodiversity) m2
H4_G12	Acadian Sub-boreal Spruce Flat PROTECTED GAP 1 & 2 (biodiversity) m2
H5_G12	Acadian-Appalachian Alpine Tundra PROTECTED GAP 1 & 2 (biodiversity) m2
H6_G12	Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest PROTECTED GAP 1 & 2 (biodiversity) m2
H7_G12	Acadian-North Atlantic Rocky Coast PROTECTED GAP 1 & 2 (biodiversity) m2
H8_G12	Acidic Cliff and Talus PROTECTED GAP 1 & 2 (biodiversity) m2
H9_G12	Acidic Rocky Outcrop PROTECTED GAP 1 & 2 (biodiversity) m2
H10_G12	Agriculture (NLCD 81-82) PROTECTED GAP 1 & 2 (biodiversity) m2
H11_G12	Allegheny-Cumberland Dry Oak Forest and Woodland PROTECTED GAP 1 & 2 (biodiversity) m2
H12_G12	Appalachian (Hemlock)-Northern Hardwood Forest PROTECTED GAP 1 & 2 (biodiversity) m2
H13_G12	Appalachian Shale Barrens PROTECTED GAP 1 & 2 (biodiversity) m2
H14_G12	Atlantic Coastal Plain Beach and Dune PROTECTED GAP 1 & 2 (biodiversity) m2
H15_G12	Atlantic Coastal Plain Blackwater/Brownwater Stream Floodplain Forest PROTECTED GAP 1 & 2 (biodiversity) m2
H16_G12	Atlantic Coastal Plain Embayed Region Tidal Freshwater/Brackish Marsh PROTECTED GAP 1 & 2 (biodiversity) m2
H17_G12	Atlantic Coastal Plain Northern Bog PROTECTED GAP 1 & 2 (biodiversity) m2
H18_G12	Atlantic Coastal Plain Peatland Pocosin and Canebrake PROTECTED GAP 1 & 2 (biodiversity) m2
H19_G12	Boreal-Laurentian Bog PROTECTED GAP 1 & 2 (biodiversity) m2
H20_G12	Boreal-Laurentian-Acadian Acidic Basin Fen PROTECTED GAP 1 & 2 (biodiversity) m2
H21_G12	Calcareous Cliff and Talus PROTECTED GAP 1 & 2 (biodiversity) m2
H22_G12	Calcareous Rocky Outcrop PROTECTED GAP 1 & 2 (biodiversity) m2
H23_G12	Central Appalachian Alkaline Glade and Woodland PROTECTED GAP 1 & 2 (biodiversity) m2
H24_G12	Central Appalachian Dry Oak-Pine Forest PROTECTED GAP 1 & 2 (biodiversity) m2
H25_G12	Central Appalachian Pine-Oak Rocky Woodland PROTECTED GAP 1 & 2 (biodiversity) m2
H26_G12	Central Appalachian Stream and Riparian PROTECTED GAP 1 & 2 (biodiversity) m2
H27_G12	Central Atlantic Coastal Plain Maritime Forest PROTECTED GAP 1 & 2 (biodiversity) m2
H28_G12	Central Interior Highlands and Appalachian Sinkhole and Depression Pond PROTECTED GAP 1 & 2 (biodiversity) m2
H29_G12	Central and Southern Appalachian Montane Oak Forest PROTECTED GAP 1 & 2 (biodiversity) m2
H30_G12	Central and Southern Appalachian Spruce-Fir Forest PROTECTED GAP 1 & 2 (biodiversity) m2
H31_G12	Circumneutral Cliff and Talus PROTECTED GAP 1 & 2 (biodiversity) m2
H32_G12	Developed (NLCD 21-24 & 31) PROTECTED GAP 1 & 2 (biodiversity) m2
H33_G12	Eastern Serpentine Woodland PROTECTED GAP 1 & 2 (biodiversity) m2
H34_G12	Glacial Marine & Lake Mesic Clayplain Forest PROTECTED GAP 1 & 2 (biodiversity) m2
H35_G12	Glacial Marine & Lake Wet Clayplain Forest PROTECTED GAP 1 & 2 (biodiversity) m2
H36_G12	Great Lakes Alvar PROTECTED GAP 1 & 2 (biodiversity) m2
H37_G12	Great Lakes Dune and Swale PROTECTED GAP 1 & 2 (biodiversity) m2
H38_G12	High Allegheny Headwater Wetland PROTECTED GAP 1 & 2 (biodiversity) m2

H39_G12	Laurentian-Acadian Alkaline Conifer-Hardwood Swamp PROTECTED GAP 1 & 2 (biodiversity) m2
H40_G12	Laurentian-Acadian Alkaline Fen PROTECTED GAP 1 & 2 (biodiversity) m2
H41_G12	Laurentian-Acadian Freshwater Marsh PROTECTED GAP 1 & 2 (biodiversity) m2
H42_G12	Laurentian-Acadian Northern Hardwood Forest PROTECTED GAP 1 & 2 (biodiversity) m2
H43_G12	Laurentian-Acadian Northern Pine-(Oak) Forest PROTECTED GAP 1 & 2 (biodiversity) m2
H44_G12	Laurentian-Acadian Pine-Hemlock-Hardwood Forest PROTECTED GAP 1 & 2 (biodiversity) m2
H45_G12	Laurentian-Acadian Red Oak-Northern Hardwood Forest PROTECTED GAP 1 & 2 (biodiversity) m2
H46_G12	Laurentian-Acadian Wet Meadow-Shrub Swamp PROTECTED GAP 1 & 2 (biodiversity) m2
H47_G12	North Atlantic Coastal Plain Basin Peat Swamp PROTECTED GAP 1 & 2 (biodiversity) m2
H48_G12	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest PROTECTED GAP 1 & 2 (biodiversity) m2
H49_G12	North Atlantic Coastal Plain Brackish/Fresh & Oligohaline Tidal Marsh PROTECTED GAP 1 & 2 (biodiversity) m2
H50_G12	North Atlantic Coastal Plain Hardwood Forest PROTECTED GAP 1 & 2 (biodiversity) m2
H51_G12	North Atlantic Coastal Plain Heathland and Grassland PROTECTED GAP 1 & 2 (biodiversity) m2
H52_G12	North Atlantic Coastal Plain Large River Floodplain PROTECTED GAP 1 & 2 (biodiversity) m2
H53_G12	North Atlantic Coastal Plain Maritime Forest PROTECTED GAP 1 & 2 (biodiversity) m2
H54_G12	North Atlantic Coastal Plain Pitch Pine Barrens PROTECTED GAP 1 & 2 (biodiversity) m2
H55_G12	North Atlantic Coastal Plain Pitch Pine Lowland PROTECTED GAP 1 & 2 (biodiversity) m2
H56_G12	North Atlantic Coastal Plain Stream and River PROTECTED GAP 1 & 2 (biodiversity) m2
H57_G12	North Atlantic Coastal Plain Tidal Salt Marsh PROTECTED GAP 1 & 2 (biodiversity) m2
H58_G12	North Atlantic Coastal Plain Tidal Swamp PROTECTED GAP 1 & 2 (biodiversity) m2
H59_G12	North-Central Appalachian Acidic Swamp PROTECTED GAP 1 & 2 (biodiversity) m2
H60_G12	North-Central Appalachian Large River Floodplain PROTECTED GAP 1 & 2 (biodiversity) m2
H61_G12	Northeastern Interior Pine Barrens PROTECTED GAP 1 & 2 (biodiversity) m2
H62_G12	North-Central Interior Beech-Maple Forest PROTECTED GAP 1 & 2 (biodiversity) m2
H63_G12	North-Central Interior Large River Floodplain PROTECTED GAP 1 & 2 (biodiversity) m2
H64_G12	North-Central Interior Wet Flatwoods PROTECTED GAP 1 & 2 (biodiversity) m2
H65_G12	North-Central Interior and Appalachian Acidic Peatland PROTECTED GAP 1 & 2 (biodiversity) m2
H66_G12	North-Central Interior and Appalachian Rich Swamp PROTECTED GAP 1 & 2 (biodiversity) m2
H67_G12	Northeastern Coastal and Interior Pine-Oak Forest PROTECTED GAP 1 & 2 (biodiversity) m2
H68_G12	Northeastern Interior Dry-Mesic Oak Forest PROTECTED GAP 1 & 2 (biodiversity) m2
H69_G12	Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp PROTECTED GAP 1 & 2 (biodiversity) m2
H70_G12	Laurentian-Acadian Large River Floodplain PROTECTED GAP 1 & 2 (biodiversity) m2
H71_G12	Open Water (NLCD-NHD open water) PROTECTED GAP 1 & 2 (biodiversity) m2
H72_G12	Piedmont Hardpan Woodland and Forest PROTECTED GAP 1 & 2 (biodiversity) m2
H73_G12	Piedmont Upland Depression Swamp PROTECTED GAP 1 & 2 (biodiversity) m2
H74_G12	Piedmont-Coastal Plain Freshwater Marsh PROTECTED GAP 1 & 2 (biodiversity) m2
H75_G12	Piedmont-Coastal Plain Large River Floodplain PROTECTED GAP 1 & 2 (biodiversity) m2
H76_G12	Piedmont-Coastal Plain Shrub Swamp PROTECTED GAP 1 & 2 (biodiversity) m2
H77_G12	Pine plantation / Horticultural pines PROTECTED GAP 1 & 2 (biodiversity) m2
H78_G12	Ruderal shrubland & Grassland (NLCD 52/71) PROTECTED GAP 1 & 2 (biodiversity) m2
H79_G12	Central Atlantic Coastal Plain Non-riverine Swamp and Wet Hardwood Forest PROTECTED GAP 1 & 2 (biodiversity) m2
H80_G12	South-Central Interior Mesophytic Forest PROTECTED GAP 1 & 2 (biodiversity) m2
H81_G12	Southern Appalachian Low Elevation Pine Forest PROTECTED GAP 1 & 2 (biodiversity) m2

H82_G12	Southern Appalachian Montane Pine Forest and Woodland PROTECTED GAP 1 & 2 (biodiversity) m2
H83_G12	Southern Appalachian Northern Hardwood Forest PROTECTED GAP 1 & 2 (biodiversity) m2
H84_G12	Southern Appalachian Oak Forest PROTECTED GAP 1 & 2 (biodiversity) m2
H85_G12	Southern Atlantic Coastal Plain Upland Longleaf Pine Woodland PROTECTED GAP 1 & 2 (biodiversity) m2
H86_G12	Southern Atlantic Coastal Plain Mesic Hardwood Forest PROTECTED GAP 1 & 2 (biodiversity) m2
H87_G12	Southern Atlantic Coastal Plain Tidal Wooded Swamp PROTECTED GAP 1 & 2 (biodiversity) m2
H88_G12	Southern Piedmont Dry Oak-Pine Forest PROTECTED GAP 1 & 2 (biodiversity) m2
H89_G12	Southern Piedmont Glade and Barrens PROTECTED GAP 1 & 2 (biodiversity) m2
H90_G12	Southern Piedmont Granite Flatrock and Outcrop PROTECTED GAP 1 & 2 (biodiversity) m2
H91_G12	Southern Piedmont Lake Floodplain Forest PROTECTED GAP 1 & 2 (biodiversity) m2
H92_G12	Southern Piedmont Mesic Forest PROTECTED GAP 1 & 2 (biodiversity) m2
H93_G12	Southern Piedmont Small Floodplain and Riparian Forest PROTECTED GAP 1 & 2 (biodiversity) m2
H94_G12	Southern Ridge and Valley / Cumberland Dry Calcareous Forest PROTECTED GAP 1 & 2 (biodiversity) m2
H95_G12	Southern Ridge and Valley Calcareous Glade and Woodland PROTECTED GAP 1 & 2 (biodiversity) m2
H96_G12	Southern and Central Appalachian Cove Forest PROTECTED GAP 1 & 2 (biodiversity) m2
H97_G12	Southern and Central Appalachian Mafic Glade and Barrens PROTECTED GAP 1 & 2 (biodiversity) m2
H98_G12	Southern Appalachian Grass and Shrub Bald PROTECTED GAP 1 & 2 (biodiversity) m2
H1_G3	Acadian Coastal Salt and Estuary Marsh PROTECTED GAP 3 (multiple uses) m2
H2_G3	Acadian Low Elevation Spruce-Fir-Hardwood Forest PROTECTED GAP 3 (multiple uses) m2
H3_G3	Acadian Maritime Bog PROTECTED GAP 3 (multiple uses) m2
H4_G3	Acadian Sub-boreal Spruce Flat PROTECTED GAP 3 (multiple uses) m2
H5_G3	Acadian-Appalachian Alpine Tundra PROTECTED GAP 3 (multiple uses) m2
H6_G3	Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest PROTECTED GAP 3 (multiple uses) m2
H7_G3	Acadian-North Atlantic Rocky Coast PROTECTED GAP 3 (multiple uses) m2
H8_G3	Acidic Cliff and Talus PROTECTED GAP 3 (multiple uses) m2
H9_G3	Acidic Rocky Outcrop PROTECTED GAP 3 (multiple uses) m2
H10_G3	Agriculture (NLCD 81-82) PROTECTED GAP 3 (multiple uses) m2
H11_G3	Allegheny-Cumberland Dry Oak Forest and Woodland PROTECTED GAP 3 (multiple uses) m2
H12_G3	Appalachian (Hemlock)-Northern Hardwood Forest PROTECTED GAP 3 (multiple uses) m2
H13_G3	Appalachian Shale Barrens PROTECTED GAP 3 (multiple uses) m2
H14_G3	Atlantic Coastal Plain Beach and Dune PROTECTED GAP 3 (multiple uses) m2
H15_G3	Atlantic Coastal Plain Blackwater/Brownwater Stream Floodplain Forest PROTECTED GAP 3 (multiple uses) m2
H16_G3	Atlantic Coastal Plain Embayed Region Tidal Freshwater/Brackish Marsh PROTECTED GAP 3 (multiple uses) m2
H17_G3	Atlantic Coastal Plain Northern Bog PROTECTED GAP 3 (multiple uses) m2
H18_G3	Atlantic Coastal Plain Peatland Pocosin and Canebrake PROTECTED GAP 3 (multiple uses) m2
H19_G3	Boreal-Laurentian Bog PROTECTED GAP 3 (multiple uses) m2
H20_G3	Boreal-Laurentian-Acadian Acidic Basin Fen PROTECTED GAP 3 (multiple uses) m2
H21_G3	Calcareous Cliff and Talus PROTECTED GAP 3 (multiple uses) m2
H22_G3	Calcareous Rocky Outcrop PROTECTED GAP 3 (multiple uses) m2
H23_G3	Central Appalachian Alkaline Glade and Woodland PROTECTED GAP 3 (multiple uses) m2
H24_G3	Central Appalachian Dry Oak-Pine Forest PROTECTED GAP 3 (multiple uses) m2
H25_G3	Central Appalachian Pine-Oak Rocky Woodland PROTECTED GAP 3 (multiple uses) m2
H26_G3	Central Appalachian Stream and Riparian PROTECTED GAP 3 (multiple uses) m2

H27_G3	Central Atlantic Coastal Plain Maritime Forest PROTECTED GAP 3 (multiple uses) m2
H28_G3	Central Interior Highlands and Appalachian Sinkhole and Depression Pond PROTECTED GAP 3 (multiple uses) m2
H29_G3	Central and Southern Appalachian Montane Oak Forest PROTECTED GAP 3 (multiple uses) m2
H30_G3	Central and Southern Appalachian Spruce-Fir Forest PROTECTED GAP 3 (multiple uses) m2
H31_G3	Circumneutral Cliff and Talus PROTECTED GAP 3 (multiple uses) m2
H32_G3	Developed (NLCD 21-24 & 31) PROTECTED GAP 3 (multiple uses) m2
H33_G3	Eastern Serpentine Woodland PROTECTED GAP 3 (multiple uses) m2
H34_G3	Glacial Marine & Lake Mesic Clayplain Forest PROTECTED GAP 3 (multiple uses) m2
H35_G3	Glacial Marine & Lake Wet Clayplain Forest PROTECTED GAP 3 (multiple uses) m2
H36_G3	Great Lakes Alvar PROTECTED GAP 3 (multiple uses) m2
H37_G3	Great Lakes Dune and Swale PROTECTED GAP 3 (multiple uses) m2
H38_G3	High Allegheny Headwater Wetland PROTECTED GAP 3 (multiple uses) m2
H39_G3	Laurentian-Acadian Alkaline Conifer-Hardwood Swamp PROTECTED GAP 3 (multiple uses) m2
H40_G3	Laurentian-Acadian Alkaline Fen PROTECTED GAP 3 (multiple uses) m2
H41_G3	Laurentian-Acadian Freshwater Marsh PROTECTED GAP 3 (multiple uses) m2
H42_G3	Laurentian-Acadian Northern Hardwood Forest PROTECTED GAP 3 (multiple uses) m2
H43_G3	Laurentian-Acadian Northern Pine-(Oak) Forest PROTECTED GAP 3 (multiple uses) m2
H44_G3	Laurentian-Acadian Pine-Hemlock-Hardwood Forest PROTECTED GAP 3 (multiple uses) m2
H45_G3	Laurentian-Acadian Red Oak-Northern Hardwood Forest PROTECTED GAP 3 (multiple uses) m2
H46_G3	Laurentian-Acadian Wet Meadow-Shrub Swamp PROTECTED GAP 3 (multiple uses) m2
H47_G3	North Atlantic Coastal Plain Basin Peat Swamp PROTECTED GAP 3 (multiple uses) m2
H48_G3	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest PROTECTED GAP 3 (multiple uses) m2
H49_G3	North Atlantic Coastal Plain Brackish/Fresh & Oligohaline Tidal Marsh PROTECTED GAP 3 (multiple uses) m2
H50_G3	North Atlantic Coastal Plain Hardwood Forest PROTECTED GAP 3 (multiple uses) m2
H51_G3	North Atlantic Coastal Plain Heathland and Grassland PROTECTED GAP 3 (multiple uses) m2
H52_G3	North Atlantic Coastal Plain Large River Floodplain PROTECTED GAP 3 (multiple uses) m2
H53_G3	North Atlantic Coastal Plain Maritime Forest PROTECTED GAP 3 (multiple uses) m2
H54_G3	North Atlantic Coastal Plain Pitch Pine Barrens PROTECTED GAP 3 (multiple uses) m2
H55_G3	North Atlantic Coastal Plain Pitch Pine Lowland PROTECTED GAP 3 (multiple uses) m2
H56_G3	North Atlantic Coastal Plain Stream and River PROTECTED GAP 3 (multiple uses) m2
H57_G3	North Atlantic Coastal Plain Tidal Salt Marsh PROTECTED GAP 3 (multiple uses) m2
H58_G3	North Atlantic Coastal Plain Tidal Swamp PROTECTED GAP 3 (multiple uses) m2
H59_G3	North-Central Appalachian Acidic Swamp PROTECTED GAP 3 (multiple uses) m2
H60_G3	North-Central Appalachian Large River Floodplain PROTECTED GAP 3 (multiple uses) m2
H61_G3	Northeastern Interior Pine Barrens PROTECTED GAP 3 (multiple uses) m2
H62_G3	North-Central Interior Beech-Maple Forest PROTECTED GAP 3 (multiple uses) m2
H63_G3	North-Central Interior Large River Floodplain PROTECTED GAP 3 (multiple uses) m2
H64_G3	North-Central Interior Wet Flatwoods PROTECTED GAP 3 (multiple uses) m2
H65_G3	North-Central Interior and Appalachian Acidic Peatland PROTECTED GAP 3 (multiple uses) m2
H66_G3	North-Central Interior and Appalachian Rich Swamp PROTECTED GAP 3 (multiple uses) m2
H67_G3	Northeastern Coastal and Interior Pine-Oak Forest PROTECTED GAP 3 (multiple uses) m2
H68_G3	Northeastern Interior Dry-Mesic Oak Forest PROTECTED GAP 3 (multiple uses) m2
H69_G3	Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp PROTECTED GAP 3 (multiple uses) m2

H70_G3	Laurentian-Acadian Large River Floodplain PROTECTED GAP 3 (multiple uses) m2
H71_G3	Open Water (NLCD-NHD open water) PROTECTED GAP 3 (multiple uses) m2
H72_G3	Piedmont Hardpan Woodland and Forest PROTECTED GAP 3 (multiple uses) m2
H73_G3	Piedmont Upland Depression Swamp PROTECTED GAP 3 (multiple uses) m2
H74_G3	Piedmont-Coastal Plain Freshwater Marsh PROTECTED GAP 3 (multiple uses) m2
H75_G3	Piedmont-Coastal Plain Large River Floodplain PROTECTED GAP 3 (multiple uses) m2
H76_G3	Piedmont-Coastal Plain Shrub Swamp PROTECTED GAP 3 (multiple uses) m2
H77_G3	Pine plantation / Horticultural pines PROTECTED GAP 3 (multiple uses) m2
H78_G3	Ruderal shrubland & Grassland (NLCD 52/71) PROTECTED GAP 3 (multiple uses) m2
H79_G3	Central Atlantic Coastal Plain Non-riverine Swamp and Wet Hardwood Forest PROTECTED GAP 3 (multiple uses) m2
H80_G3	South-Central Interior Mesophytic Forest PROTECTED GAP 3 (multiple uses) m2
H81_G3	Southern Appalachian Low Elevation Pine Forest PROTECTED GAP 3 (multiple uses) m2
H82_G3	Southern Appalachian Montane Pine Forest and Woodland PROTECTED GAP 3 (multiple uses) m2
H83_G3	Southern Appalachian Northern Hardwood Forest PROTECTED GAP 3 (multiple uses) m2
H84_G3	Southern Appalachian Oak Forest PROTECTED GAP 3 (multiple uses) m2
H85_G3	Southern Atlantic Coastal Plain Upland Longleaf Pine Woodland PROTECTED GAP 3 (multiple uses) m2
H86_G3	Southern Atlantic Coastal Plain Mesic Hardwood Forest PROTECTED GAP 3 (multiple uses) m2
H87_G3	Southern Atlantic Coastal Plain Tidal Wooded Swamp PROTECTED GAP 3 (multiple uses) m2
H88_G3	Southern Piedmont Dry Oak-Pine Forest PROTECTED GAP 3 (multiple uses) m2
H89_G3	Southern Piedmont Glade and Barrens PROTECTED GAP 3 (multiple uses) m2
H90_G3	Southern Piedmont Granite Flatrock and Outcrop PROTECTED GAP 3 (multiple uses) m2
H91_G3	Southern Piedmont Lake Floodplain Forest PROTECTED GAP 3 (multiple uses) m2
H92_G3	Southern Piedmont Mesic Forest PROTECTED GAP 3 (multiple uses) m2
H93_G3	Southern Piedmont Small Floodplain and Riparian Forest PROTECTED GAP 3 (multiple uses) m2
H94_G3	Southern Ridge and Valley / Cumberland Dry Calcareous Forest PROTECTED GAP 3 (multiple uses) m2
H95_G3	Southern Ridge and Valley Calcareous Glade and Woodland PROTECTED GAP 3 (multiple uses) m2
H96_G3	Southern and Central Appalachian Cove Forest PROTECTED GAP 3 (multiple uses) m2
H97_G3	Southern and Central Appalachian Mafic Glade and Barrens PROTECTED GAP 3 (multiple uses) m2
H98_G3	Southern Appalachian Grass and Shrub Bald PROTECTED GAP 3 (multiple uses) m2

Appendix VII. Join Table: Minor road bounded blocks and habitat patches.

Table Name: JoinTable_MinorBlocksandHabitat

This table contains the total area, maximum patch size, average patch size, and number of patches for each habitat type for each minor road bounded block.

ID	Minor Block ID to link to Unit_MinorBlocks
H1_sum	Total Area in meters of Acadian Coastal Salt and Estuary Marsh
H1_max	Maximum Patch Size in meters of Acadian Coastal Salt and Estuary Marsh
H1_mean	Average Patch Size in meters of Acadian Coastal Salt and Estuary Marsh
H1_num	Number of Patch of Acadian Coastal Salt and Estuary Marsh
H2_sum	Total Area in meters of Acadian Low Elevation Spruce-Fir-Hardwood Forest
H2_max	Maximum Patch Size in meters of Acadian Low Elevation Spruce-Fir-Hardwood Forest
H2_mean	Average Patch Size in meters of Acadian Low Elevation Spruce-Fir-Hardwood Forest

H2_num	Number of Patch of Acadian Low Elevation Spruce-Fir-Hardwood Forest
H3_sum	Total Area in meters of Acadian Maritime Bog
H3_max	Maximum Patch Size in meters of Acadian Maritime Bog
H3_mean	Average Patch Size in meters of Acadian Maritime Bog
H3_num	Number of Patch of Acadian Maritime Bog
H4_sum	Total Area in meters of Acadian Sub-boreal Spruce Flat
H4_max	Maximum Patch Size in meters of Acadian Sub-boreal Spruce Flat
H4_mean	Average Patch Size in meters of Acadian Sub-boreal Spruce Flat
H4_num	Number of Patch of Acadian Sub-boreal Spruce Flat
H5_sum	Total Area in meters of Acadian-Appalachian Alpine Tundra
H5_max	Maximum Patch Size in meters of Acadian-Appalachian Alpine Tundra
H5_mean	Average Patch Size in meters of Acadian-Appalachian Alpine Tundra
H5_num	Number of Patch of Acadian-Appalachian Alpine Tundra
H6_sum	Total Area in meters of Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest
H6_max	Maximum Patch Size in meters of Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest
H6_mean	Average Patch Size in meters of Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest
H6_num	Number of Patch of Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest
H7_sum	Total Area in meters of Acadian-North Atlantic Rocky Coast
H7_max	Maximum Patch Size in meters of Acadian-North Atlantic Rocky Coast
H7_mean	Average Patch Size in meters of Acadian-North Atlantic Rocky Coast
H7_num	Number of Patch of Acadian-North Atlantic Rocky Coast
H8_sum	Total Area in meters of Acidic Cliff and Talus
H8_max	Maximum Patch Size in meters of Acidic Cliff and Talus
H8_mean	Average Patch Size in meters of Acidic Cliff and Talus
H8_num	Number of Patch of Acidic Cliff and Talus
H9_sum	Total Area in meters of Acidic Rocky Outcrop
H9_max	Maximum Patch Size in meters of Acidic Rocky Outcrop
H9_mean	Average Patch Size in meters of Acidic Rocky Outcrop
H9_num	Number of Patch of Acidic Rocky Outcrop
H10_sum	Total Area in meters of Agriculture (NLCD 81-82)
H10_max	Maximum Patch Size in meters of Agriculture (NLCD 81-82)
H10_mean	Average Patch Size in meters of Agriculture (NLCD 81-82)
H10_num	Number of Patch of Agriculture (NLCD 81-82)
H11_sum	Total Area in meters of Allegheny-Cumberland Dry Oak Forest and Woodland
H11_max	Maximum Patch Size in meters of Allegheny-Cumberland Dry Oak Forest and Woodland
H11_mean	Average Patch Size in meters of Allegheny-Cumberland Dry Oak Forest and Woodland
H11_num	Number of Patch of Allegheny-Cumberland Dry Oak Forest and Woodland
H12_sum	Total Area in meters of Appalachian (Hemlock)-Northern Hardwood Forest
H12_max	Maximum Patch Size in meters of Appalachian (Hemlock)-Northern Hardwood Forest
H12_mean	Average Patch Size in meters of Appalachian (Hemlock)-Northern Hardwood Forest
H12_num	Number of Patch of Appalachian (Hemlock)-Northern Hardwood Forest
H13_sum	Total Area in meters of Appalachian Shale Barrens
H13_max	Maximum Patch Size in meters of Appalachian Shale Barrens

H13_mean	Average Patch Size in meters of Appalachian Shale Barrens
H13_num	Number of Patch of Appalachian Shale Barrens
H14_sum	Total Area in meters of Atlantic Coastal Plain Beach and Dune
H14_max	Maximum Patch Size in meters of Atlantic Coastal Plain Beach and Dune
H14_mean	Average Patch Size in meters of Atlantic Coastal Plain Beach and Dune
H14_num	Number of Patch of Atlantic Coastal Plain Beach and Dune
H15_sum	Total Area in meters of Atlantic Coastal Plain Blackwater/Brownwater Stream Floodplain Forest
H15_max	Maximum Patch Size in meters of Atlantic Coastal Plain Blackwater/Brownwater Stream Floodplain Forest
H15_mean	Average Patch Size in meters of Atlantic Coastal Plain Blackwater/Brownwater Stream Floodplain Forest
H15_num	Number of Patch of Atlantic Coastal Plain Blackwater/Brownwater Stream Floodplain Forest
H16_sum	Total Area in meters of Atlantic Coastal Plain Embayed Region Tidal Freshwater/Brackish Marsh
H16_max	Maximum Patch Size in meters of Atlantic Coastal Plain Embayed Region Tidal Freshwater/Brackish Marsh
H16_mean	Average Patch Size in meters of Atlantic Coastal Plain Embayed Region Tidal Freshwater/Brackish Marsh
H16_num	Number of Patch of Atlantic Coastal Plain Embayed Region Tidal Freshwater/Brackish Marsh
H17_sum	Total Area in meters of Atlantic Coastal Plain Northern Bog
H17_max	Maximum Patch Size in meters of Atlantic Coastal Plain Northern Bog
H17_mean	Average Patch Size in meters of Atlantic Coastal Plain Northern Bog
H17_num	Number of Patch of Atlantic Coastal Plain Northern Bog
H18_sum	Total Area in meters of Atlantic Coastal Plain Peatland Pocosin and Canebrake
H18_max	Maximum Patch Size in meters of Atlantic Coastal Plain Peatland Pocosin and Canebrake
H18_mean	Average Patch Size in meters of Atlantic Coastal Plain Peatland Pocosin and Canebrake
H18_num	Number of Patch of Atlantic Coastal Plain Peatland Pocosin and Canebrake
H19_sum	Total Area in meters of Boreal-Laurentian Bog
H19_max	Maximum Patch Size in meters of Boreal-Laurentian Bog
H19_mean	Average Patch Size in meters of Boreal-Laurentian Bog
H19_num	Number of Patch of Boreal-Laurentian Bog
H20_sum	Total Area in meters of Boreal-Laurentian-Acadian Acidic Basin Fen
H20_max	Maximum Patch Size in meters of Boreal-Laurentian-Acadian Acidic Basin Fen
H20_mean	Average Patch Size in meters of Boreal-Laurentian-Acadian Acidic Basin Fen
H20_num	Number of Patch of Boreal-Laurentian-Acadian Acidic Basin Fen
H21_sum	Total Area in meters of Calcareous Cliff and Talus
H21_max	Maximum Patch Size in meters of Calcareous Cliff and Talus
H21_mean	Average Patch Size in meters of Calcareous Cliff and Talus
H21_num	Number of Patch of Calcareous Cliff and Talus
H22_sum	Total Area in meters of Calcareous Rocky Outcrop
H22_max	Maximum Patch Size in meters of Calcareous Rocky Outcrop
H22_mean	Average Patch Size in meters of Calcareous Rocky Outcrop
H22_num	Number of Patch of Calcareous Rocky Outcrop
H23_sum	Total Area in meters of Central Appalachian Alkaline Glade and Woodland
H23_max	Maximum Patch Size in meters of Central Appalachian Alkaline Glade and Woodland
H23_mean	Average Patch Size in meters of Central Appalachian Alkaline Glade and Woodland
H23_num	Number of Patch of Central Appalachian Alkaline Glade and Woodland
H24_sum	Total Area in meters of Central Appalachian Dry Oak-Pine Forest

H24_max	Maximum Patch Size in meters of Central Appalachian Dry Oak-Pine Forest
H24_mean	Average Patch Size in meters of Central Appalachian Dry Oak-Pine Forest
H24_num	Number of Patch of Central Appalachian Dry Oak-Pine Forest
H25_sum	Total Area in meters of Central Appalachian Pine-Oak Rocky Woodland
H25_max	Maximum Patch Size in meters of Central Appalachian Pine-Oak Rocky Woodland
H25_mean	Average Patch Size in meters of Central Appalachian Pine-Oak Rocky Woodland
H25_num	Number of Patch of Central Appalachian Pine-Oak Rocky Woodland
H26_sum	Total Area in meters of Central Appalachian Stream and Riparian
H26_max	Maximum Patch Size in meters of Central Appalachian Stream and Riparian
H26_mean	Average Patch Size in meters of Central Appalachian Stream and Riparian
H26_num	Number of Patch of Central Appalachian Stream and Riparian
H27_sum	Total Area in meters of Central Atlantic Coastal Plain Maritime Forest
H27_max	Maximum Patch Size in meters of Central Atlantic Coastal Plain Maritime Forest
H27_mean	Average Patch Size in meters of Central Atlantic Coastal Plain Maritime Forest
H27_num	Number of Patch of Central Atlantic Coastal Plain Maritime Forest
H28_sum	Total Area in meters of Central Interior Highlands and Appalachian Sinkhole and Depression Pond
H28_max	Maximum Patch Size in meters of Central Interior Highlands and Appalachian Sinkhole and Depression Pond
H28_mean	Average Patch Size in meters of Central Interior Highlands and Appalachian Sinkhole and Depression Pond
H28_num	Number of Patch of Central Interior Highlands and Appalachian Sinkhole and Depression Pond
H29_sum	Total Area in meters of Central and Southern Appalachian Montane Oak Forest
H29_max	Maximum Patch Size in meters of Central and Southern Appalachian Montane Oak Forest
H29_mean	Average Patch Size in meters of Central and Southern Appalachian Montane Oak Forest
H29_num	Number of Patch of Central and Southern Appalachian Montane Oak Forest
H30_sum	Total Area in meters of Central and Southern Appalachian Spruce-Fir Forest
H30_max	Maximum Patch Size in meters of Central and Southern Appalachian Spruce-Fir Forest
H30_mean	Average Patch Size in meters of Central and Southern Appalachian Spruce-Fir Forest
H30_num	Number of Patch of Central and Southern Appalachian Spruce-Fir Forest
H31_sum	Total Area in meters of Circumneutral Cliff and Talus
H31_max	Maximum Patch Size in meters of Circumneutral Cliff and Talus
H31_mean	Average Patch Size in meters of Circumneutral Cliff and Talus
H31_num	Number of Patch of Circumneutral Cliff and Talus
H32_sum	Total Area in meters of Developed (NLCD 21-24 & 31)
H32_max	Maximum Patch Size in meters of Developed (NLCD 21-24 & 31)
H32_mean	Average Patch Size in meters of Developed (NLCD 21-24 & 31)
H32_num	Number of Patch of Developed (NLCD 21-24 & 31)
H33_sum	Total Area in meters of Eastern Serpentine Woodland
H33_max	Maximum Patch Size in meters of Eastern Serpentine Woodland
H33_mean	Average Patch Size in meters of Eastern Serpentine Woodland
H33_num	Number of Patch of Eastern Serpentine Woodland
H34_sum	Total Area in meters of Glacial Marine & Lake Mesic Clayplain Forest
H34_max	Maximum Patch Size in meters of Glacial Marine & Lake Mesic Clayplain Forest
H34_mean	Average Patch Size in meters of Glacial Marine & Lake Mesic Clayplain Forest
H34_num	Number of Patch of Glacial Marine & Lake Mesic Clayplain Forest

H35_sum	Total Area in meters of Glacial Marine & Lake Wet Clayplain Forest
H35_max	Maximum Patch Size in meters of Glacial Marine & Lake Wet Clayplain Forest
H35_mean	Average Patch Size in meters of Glacial Marine & Lake Wet Clayplain Forest
H35_num	Number of Patch of Glacial Marine & Lake Wet Clayplain Forest
H36_sum	Total Area in meters of Great Lakes Alvar
H36_max	Maximum Patch Size in meters of Great Lakes Alvar
H36_mean	Average Patch Size in meters of Great Lakes Alvar
H36_num	Number of Patch of Great Lakes Alvar
H37_sum	Total Area in meters of Great Lakes Dune and Swale
H37_max	Maximum Patch Size in meters of Great Lakes Dune and Swale
H37_mean	Average Patch Size in meters of Great Lakes Dune and Swale
H37_num	Number of Patch of Great Lakes Dune and Swale
H38_sum	Total Area in meters of High Allegheny Headwater Wetland
H38_max	Maximum Patch Size in meters of High Allegheny Headwater Wetland
H38_mean	Average Patch Size in meters of High Allegheny Headwater Wetland
H38_num	Number of Patch of High Allegheny Headwater Wetland
H39_sum	Total Area in meters of Laurentian-Acadian Alkaline Conifer-Hardwood Swamp
H39_max	Maximum Patch Size in meters of Laurentian-Acadian Alkaline Conifer-Hardwood Swamp
H39_mean	Average Patch Size in meters of Laurentian-Acadian Alkaline Conifer-Hardwood Swamp
H39_num	Number of Patch of Laurentian-Acadian Alkaline Conifer-Hardwood Swamp
H40_sum	Total Area in meters of Laurentian-Acadian Alkaline Fen
H40_max	Maximum Patch Size in meters of Laurentian-Acadian Alkaline Fen
H40_mean	Average Patch Size in meters of Laurentian-Acadian Alkaline Fen
H40_num	Number of Patch of Laurentian-Acadian Alkaline Fen
H41_sum	Total Area in meters of Laurentian-Acadian Freshwater Marsh
H41_max	Maximum Patch Size in meters of Laurentian-Acadian Freshwater Marsh
H41_mean	Average Patch Size in meters of Laurentian-Acadian Freshwater Marsh
H41_num	Number of Patch of Laurentian-Acadian Freshwater Marsh
H42_sum	Total Area in meters of Laurentian-Acadian Northern Hardwood Forest
H42_max	Maximum Patch Size in meters of Laurentian-Acadian Northern Hardwood Forest
H42_mean	Average Patch Size in meters of Laurentian-Acadian Northern Hardwood Forest
H42_num	Number of Patch of Laurentian-Acadian Northern Hardwood Forest
H43_sum	Total Area in meters of Laurentian-Acadian Northern Pine-(Oak) Forest
H43_max	Maximum Patch Size in meters of Laurentian-Acadian Northern Pine-(Oak) Forest
H43_mean	Average Patch Size in meters of Laurentian-Acadian Northern Pine-(Oak) Forest
H43_num	Number of Patch of Laurentian-Acadian Northern Pine-(Oak) Forest
H44_sum	Total Area in meters of Laurentian-Acadian Pine-Hemlock-Hardwood Forest
H44_max	Maximum Patch Size in meters of Laurentian-Acadian Pine-Hemlock-Hardwood Forest
H44_mean	Average Patch Size in meters of Laurentian-Acadian Pine-Hemlock-Hardwood Forest
H44_num	Number of Patch of Laurentian-Acadian Pine-Hemlock-Hardwood Forest
H45_sum	Total Area in meters of Laurentian-Acadian Red Oak-Northern Hardwood Forest
H45_max	Maximum Patch Size in meters of Laurentian-Acadian Red Oak-Northern Hardwood Forest
H45_mean	Average Patch Size in meters of Laurentian-Acadian Red Oak-Northern Hardwood Forest

H45_num	Number of Patch of Laurentian-Acadian Red Oak-Northern Hardwood Forest
H46_sum	Total Area in meters of Laurentian-Acadian Wet Meadow-Shrub Swamp
H46_max	Maximum Patch Size in meters of Laurentian-Acadian Wet Meadow-Shrub Swamp
H46_mean	Average Patch Size in meters of Laurentian-Acadian Wet Meadow-Shrub Swamp
H46_num	Number of Patch of Laurentian-Acadian Wet Meadow-Shrub Swamp
H47_sum	Total Area in meters of North Atlantic Coastal Plain Basin Peat Swamp
H47_max	Maximum Patch Size in meters of North Atlantic Coastal Plain Basin Peat Swamp
H47_mean	Average Patch Size in meters of North Atlantic Coastal Plain Basin Peat Swamp
H47_num	Number of Patch of North Atlantic Coastal Plain Basin Peat Swamp
H48_sum	Total Area in meters of North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest
H48_max	Maximum Patch Size in meters of North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest
H48_mean	Average Patch Size in meters of North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest
H48_num	Number of Patch of North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest
H49_sum	Total Area in meters of North Atlantic Coastal Plain Brackish/Fresh & Oligohaline Tidal Marsh
H49_max	Maximum Patch Size in meters of North Atlantic Coastal Plain Brackish/Fresh & Oligohaline Tidal Marsh
H49_mean	Average Patch Size in meters of North Atlantic Coastal Plain Brackish/Fresh & Oligohaline Tidal Marsh
H49_num	Number of Patch of North Atlantic Coastal Plain Brackish/Fresh & Oligohaline Tidal Marsh
H50_sum	Total Area in meters of North Atlantic Coastal Plain Hardwood Forest
H50_max	Maximum Patch Size in meters of North Atlantic Coastal Plain Hardwood Forest
H50_mean	Average Patch Size in meters of North Atlantic Coastal Plain Hardwood Forest
H50_num	Number of Patch of North Atlantic Coastal Plain Hardwood Forest
H51_sum	Total Area in meters of North Atlantic Coastal Plain Heathland and Grassland
H51_max	Maximum Patch Size in meters of North Atlantic Coastal Plain Heathland and Grassland
H51_mean	Average Patch Size in meters of North Atlantic Coastal Plain Heathland and Grassland
H51_num	Number of Patch of North Atlantic Coastal Plain Heathland and Grassland
H52_sum	Total Area in meters of North Atlantic Coastal Plain Large River Floodplain
H52_max	Maximum Patch Size in meters of North Atlantic Coastal Plain Large River Floodplain
H52_mean	Average Patch Size in meters of North Atlantic Coastal Plain Large River Floodplain
H52_num	Number of Patch of North Atlantic Coastal Plain Large River Floodplain
H53_sum	Total Area in meters of North Atlantic Coastal Plain Maritime Forest
H53_max	Maximum Patch Size in meters of North Atlantic Coastal Plain Maritime Forest
H53_mean	Average Patch Size in meters of North Atlantic Coastal Plain Maritime Forest
H53_num	Number of Patch of North Atlantic Coastal Plain Maritime Forest
H54_sum	Total Area in meters of North Atlantic Coastal Plain Pitch Pine Barrens
H54_max	Maximum Patch Size in meters of North Atlantic Coastal Plain Pitch Pine Barrens
H54_mean	Average Patch Size in meters of North Atlantic Coastal Plain Pitch Pine Barrens
H54_num	Number of Patch of North Atlantic Coastal Plain Pitch Pine Barrens
H55_sum	Total Area in meters of North Atlantic Coastal Plain Pitch Pine Lowland
H55_max	Maximum Patch Size in meters of North Atlantic Coastal Plain Pitch Pine Lowland
H55_mean	Average Patch Size in meters of North Atlantic Coastal Plain Pitch Pine Lowland
H55_num	Number of Patch of North Atlantic Coastal Plain Pitch Pine Lowland
H56_sum	Total Area in meters of North Atlantic Coastal Plain Stream and River
H56_max	Maximum Patch Size in meters of North Atlantic Coastal Plain Stream and River

H56_mean	Average Patch Size in meters of North Atlantic Coastal Plain Stream and River
H56_num	Number of Patch of North Atlantic Coastal Plain Stream and River
H57_sum	Total Area in meters of North Atlantic Coastal Plain Tidal Salt Marsh
H57_max	Maximum Patch Size in meters of North Atlantic Coastal Plain Tidal Salt Marsh
H57_mean	Average Patch Size in meters of North Atlantic Coastal Plain Tidal Salt Marsh
H57_num	Number of Patch of North Atlantic Coastal Plain Tidal Salt Marsh
H58_sum	Total Area in meters of North Atlantic Coastal Plain Tidal Swamp
H58_max	Maximum Patch Size in meters of North Atlantic Coastal Plain Tidal Swamp
H58_mean	Average Patch Size in meters of North Atlantic Coastal Plain Tidal Swamp
H58_num	Number of Patch of North Atlantic Coastal Plain Tidal Swamp
H59_sum	Total Area in meters of North-Central Appalachian Acidic Swamp
H59_max	Maximum Patch Size in meters of North-Central Appalachian Acidic Swamp
H59_mean	Average Patch Size in meters of North-Central Appalachian Acidic Swamp
H59_num	Number of Patch of North-Central Appalachian Acidic Swamp
H60_sum	Total Area in meters of North-Central Appalachian Large River Floodplain
H60_max	Maximum Patch Size in meters of North-Central Appalachian Large River Floodplain
H60_mean	Average Patch Size in meters of North-Central Appalachian Large River Floodplain
H60_num	Number of Patch of North-Central Appalachian Large River Floodplain
H61_sum	Total Area in meters of Northeastern Interior Pine Barrens
H61_max	Maximum Patch Size in meters of Northeastern Interior Pine Barrens
H61_mean	Average Patch Size in meters of Northeastern Interior Pine Barrens
H61_num	Number of Patch of Northeastern Interior Pine Barrens
H62_sum	Total Area in meters of North-Central Interior Beech-Maple Forest
H62_max	Maximum Patch Size in meters of North-Central Interior Beech-Maple Forest
H62_mean	Average Patch Size in meters of North-Central Interior Beech-Maple Forest
H62_num	Number of Patch of North-Central Interior Beech-Maple Forest
H63_sum	Total Area in meters of North-Central Interior Large River Floodplain
H63_max	Maximum Patch Size in meters of North-Central Interior Large River Floodplain
H63_mean	Average Patch Size in meters of North-Central Interior Large River Floodplain
H63_num	Number of Patch of North-Central Interior Large River Floodplain
H64_sum	Total Area in meters of North-Central Interior Wet Flatwoods
H64_max	Maximum Patch Size in meters of North-Central Interior Wet Flatwoods
H64_mean	Average Patch Size in meters of North-Central Interior Wet Flatwoods
H64_num	Number of Patch of North-Central Interior Wet Flatwoods
H65_sum	Total Area in meters of North-Central Interior and Appalachian Acidic Peatland
H65_max	Maximum Patch Size in meters of North-Central Interior and Appalachian Acidic Peatland
H65_mean	Average Patch Size in meters of North-Central Interior and Appalachian Acidic Peatland
H65_num	Number of Patch of North-Central Interior and Appalachian Acidic Peatland
H66_sum	Total Area in meters of North-Central Interior and Appalachian Rich Swamp
H66_max	Maximum Patch Size in meters of North-Central Interior and Appalachian Rich Swamp
H66_mean	Average Patch Size in meters of North-Central Interior and Appalachian Rich Swamp
H66_num	Number of Patch of North-Central Interior and Appalachian Rich Swamp
H67_sum	Total Area in meters of Northeastern Coastal and Interior Pine-Oak Forest

H67_max	Maximum Patch Size in meters of Northeastern Coastal and Interior Pine-Oak Forest
H67_mean	Average Patch Size in meters of Northeastern Coastal and Interior Pine-Oak Forest
H67_num	Number of Patch of Northeastern Coastal and Interior Pine-Oak Forest
H68_sum	Total Area in meters of Northeastern Interior Dry-Mesic Oak Forest
H68_max	Maximum Patch Size in meters of Northeastern Interior Dry-Mesic Oak Forest
H68_num	Average Patch Size in meters of Northeastern Interior Dry-Mesic Oak Forest
H68_sum	Number of Patch of Northeastern Interior Dry-Mesic Oak Forest
H69_max	Total Area in meters of Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp
H69_mean	Maximum Patch Size in meters of Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp
H69_num	Average Patch Size in meters of Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp
H69_sum	Number of Patch of Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp
H70_max	Total Area in meters of Laurentian-Acadian Large River Floodplain
H70_mean	Maximum Patch Size in meters of Laurentian-Acadian Large River Floodplain
H70_num	Average Patch Size in meters of Laurentian-Acadian Large River Floodplain
H70_sum	Number of Patch of Laurentian-Acadian Large River Floodplain
H71_max	Total Area in meters of Open Water (NLCD-NHD open water)
H71_mean	Maximum Patch Size in meters of Open Water (NLCD-NHD open water)
H71_num	Average Patch Size in meters of Open Water (NLCD-NHD open water)
H71_sum	Number of Patch of Open Water (NLCD-NHD open water)
H72_max	Total Area in meters of Piedmont Hardpan Woodland and Forest
H72_mean	Maximum Patch Size in meters of Piedmont Hardpan Woodland and Forest
H72_num	Average Patch Size in meters of Piedmont Hardpan Woodland and Forest
H72_sum	Number of Patch of Piedmont Hardpan Woodland and Forest
H73_max	Total Area in meters of Piedmont Upland Depression Swamp
H73_mean	Maximum Patch Size in meters of Piedmont Upland Depression Swamp
H73_num	Average Patch Size in meters of Piedmont Upland Depression Swamp
H73_sum	Number of Patch of Piedmont Upland Depression Swamp
H74_max	Total Area in meters of Piedmont-Coastal Plain Freshwater Marsh
H74_mean	Maximum Patch Size in meters of Piedmont-Coastal Plain Freshwater Marsh
H74_num	Average Patch Size in meters of Piedmont-Coastal Plain Freshwater Marsh
H74_sum	Number of Patch of Piedmont-Coastal Plain Freshwater Marsh
H75_max	Total Area in meters of Piedmont-Coastal Plain Large River Floodplain
H75_num	Maximum Patch Size in meters of Piedmont-Coastal Plain Large River Floodplain
H75_sum	Average Patch Size in meters of Piedmont-Coastal Plain Large River Floodplain
H75_max	Number of Patch of Piedmont-Coastal Plain Large River Floodplain
H76_mean	Total Area in meters of Piedmont-Coastal Plain Shrub Swamp
H76_num	Maximum Patch Size in meters of Piedmont-Coastal Plain Shrub Swamp
H76_sum	Average Patch Size in meters of Piedmont-Coastal Plain Shrub Swamp
H76_max	Number of Patch of Piedmont-Coastal Plain Shrub Swamp
H77_mean	Total Area in meters of Pine plantation / Horticultural pines
H77_num	Maximum Patch Size in meters of Pine plantation / Horticultural pines
H77_sum	Average Patch Size in meters of Pine plantation / Horticultural pines
H77_max	Number of Patch of Pine plantation / Horticultural pines

H78_mean	Total Area in meters of Ruderal shrubland & Grassland (NLCD 52/71)
H78_num	Maximum Patch Size in meters of Ruderal shrubland & Grassland (NLCD 52/71)
H78_sum	Average Patch Size in meters of Ruderal shrubland & Grassland (NLCD 52/71)
H78_max	Number of Patch of Ruderal shrubland & Grassland (NLCD 52/71)
H79_mean	Total Area in meters of Central Atlantic Coastal Plain Non-riverine Swamp and Wet Hardwood Forest
H79_num	Maximum Patch Size in meters of Central Atlantic Coastal Plain Non-riverine Swamp and Wet Hardwood Forest
H79_sum	Average Patch Size in meters of Central Atlantic Coastal Plain Non-riverine Swamp and Wet Hardwood Forest
H79_max	Number of Patch of Central Atlantic Coastal Plain Non-riverine Swamp and Wet Hardwood Forest
H80_mean	Total Area in meters of South-Central Interior Mesophytic Forest
H80_num	Maximum Patch Size in meters of South-Central Interior Mesophytic Forest
H80_sum	Average Patch Size in meters of South-Central Interior Mesophytic Forest
H80_max	Number of Patch of South-Central Interior Mesophytic Forest
H81_mean	Total Area in meters of Southern Appalachian Low Elevation Pine Forest
H81_num	Maximum Patch Size in meters of Southern Appalachian Low Elevation Pine Forest
H81_sum	Average Patch Size in meters of Southern Appalachian Low Elevation Pine Forest
H81_max	Number of Patch of Southern Appalachian Low Elevation Pine Forest
H82_num	Total Area in meters of Southern Appalachian Montane Pine Forest and Woodland
H82_sum	Maximum Patch Size in meters of Southern Appalachian Montane Pine Forest and Woodland
H82_max	Average Patch Size in meters of Southern Appalachian Montane Pine Forest and Woodland
H82_mean	Number of Patch of Southern Appalachian Montane Pine Forest and Woodland
H83_num	Total Area in meters of Southern Appalachian Northern Hardwood Forest
H83_sum	Maximum Patch Size in meters of Southern Appalachian Northern Hardwood Forest
H83_max	Average Patch Size in meters of Southern Appalachian Northern Hardwood Forest
H83_mean	Number of Patch of Southern Appalachian Northern Hardwood Forest
H84_num	Total Area in meters of Southern Appalachian Oak Forest
H84_sum	Maximum Patch Size in meters of Southern Appalachian Oak Forest
H84_max	Average Patch Size in meters of Southern Appalachian Oak Forest
H84_mean	Number of Patch of Southern Appalachian Oak Forest
H85_num	Total Area in meters of Southern Atlantic Coastal Plain Upland Longleaf Pine Woodland
H85_sum	Maximum Patch Size in meters of Southern Atlantic Coastal Plain Upland Longleaf Pine Woodland
H85_max	Average Patch Size in meters of Southern Atlantic Coastal Plain Upland Longleaf Pine Woodland
H85_mean	Number of Patch of Southern Atlantic Coastal Plain Upland Longleaf Pine Woodland
H86_num	Total Area in meters of Southern Atlantic Coastal Plain Mesic Hardwood Forest
H86_sum	Maximum Patch Size in meters of Southern Atlantic Coastal Plain Mesic Hardwood Forest
H86_max	Average Patch Size in meters of Southern Atlantic Coastal Plain Mesic Hardwood Forest
H86_mean	Number of Patch of Southern Atlantic Coastal Plain Mesic Hardwood Forest
H87_num	Total Area in meters of Southern Atlantic Coastal Plain Tidal Wooded Swamp
H87_sum	Maximum Patch Size in meters of Southern Atlantic Coastal Plain Tidal Wooded Swamp
H87_max	Average Patch Size in meters of Southern Atlantic Coastal Plain Tidal Wooded Swamp
H87_mean	Number of Patch of Southern Atlantic Coastal Plain Tidal Wooded Swamp
H88_num	Total Area in meters of Southern Piedmont Dry Oak-Pine Forest
H88_sum	Maximum Patch Size in meters of Southern Piedmont Dry Oak-Pine Forest
H88_max	Average Patch Size in meters of Southern Piedmont Dry Oak-Pine Forest

H88_num	Number of Patch of Southern Piedmont Dry Oak-Pine Forest
H89_sum	Total Area in meters of Southern Piedmont Glade and Barrens
H89_max	Maximum Patch Size in meters of Southern Piedmont Glade and Barrens
H89_mean	Average Patch Size in meters of Southern Piedmont Glade and Barrens
H89_num	Number of Patch of Southern Piedmont Glade and Barrens
H90_sum	Total Area in meters of Southern Piedmont Granite Flatrock and Outcrop
H90_max	Maximum Patch Size in meters of Southern Piedmont Granite Flatrock and Outcrop
H90_mean	Average Patch Size in meters of Southern Piedmont Granite Flatrock and Outcrop
H90_num	Number of Patch of Southern Piedmont Granite Flatrock and Outcrop
H91_sum	Total Area in meters of Southern Piedmont Lake Floodplain Forest
H91_max	Maximum Patch Size in meters of Southern Piedmont Lake Floodplain Forest
H91_mean	Average Patch Size in meters of Southern Piedmont Lake Floodplain Forest
H91_num	Number of Patch of Southern Piedmont Lake Floodplain Forest
H92_sum	Total Area in meters of Southern Piedmont Mesic Forest
H92_max	Maximum Patch Size in meters of Southern Piedmont Mesic Forest
H92_mean	Average Patch Size in meters of Southern Piedmont Mesic Forest
H92_num	Number of Patch of Southern Piedmont Mesic Forest
H93_sum	Total Area in meters of Southern Piedmont Small Floodplain and Riparian Forest
H93_max	Maximum Patch Size in meters of Southern Piedmont Small Floodplain and Riparian Forest
H93_mean	Average Patch Size in meters of Southern Piedmont Small Floodplain and Riparian Forest
H93_num	Number of Patch of Southern Piedmont Small Floodplain and Riparian Forest
H94_sum	Total Area in meters of Southern Ridge and Valley / Cumberland Dry Calcareous Forest
H94_max	Maximum Patch Size in meters of Southern Ridge and Valley / Cumberland Dry Calcareous Forest
H94_mean	Average Patch Size in meters of Southern Ridge and Valley / Cumberland Dry Calcareous Forest
H94_num	Number of Patch of Southern Ridge and Valley / Cumberland Dry Calcareous Forest
H95_sum	Total Area in meters of Southern Ridge and Valley Calcareous Glade and Woodland
H95_max	Maximum Patch Size in meters of Southern Ridge and Valley Calcareous Glade and Woodland
H95_num	Average Patch Size in meters of Southern Ridge and Valley Calcareous Glade and Woodland
H95_sum	Number of Patch of Southern Ridge and Valley Calcareous Glade and Woodland
H96_max	Total Area in meters of Southern and Central Appalachian Cove Forest
H96_mean	Maximum Patch Size in meters of Southern and Central Appalachian Cove Forest
H96_num	Average Patch Size in meters of Southern and Central Appalachian Cove Forest
H96_sum	Number of Patch of Southern and Central Appalachian Cove Forest
H97_max	Total Area in meters of Southern and Central Appalachian Mafic Glade and Barrens
H97_mean	Maximum Patch Size in meters of Southern and Central Appalachian Mafic Glade and Barrens
H97_num	Average Patch Size in meters of Southern and Central Appalachian Mafic Glade and Barrens
H97_sum	Number of Patch of Southern and Central Appalachian Mafic Glade and Barrens
H98_max	Total Area in meters of Southern Appalachian Grass and Shrub Bald
H98_mean	Maximum Patch Size in meters of Southern Appalachian Grass and Shrub Bald
H98_num	Average Patch Size in meters of Southern Appalachian Grass and Shrub Bald
H98_sum	Number of Patch of Southern Appalachian Grass and Shrub Bald

Appendix VIII. Join Table: Minor road bounded blocks and metrics.
Table Name: JoinTable_MinorBlocksandMetrics

This table contains the metric scores for the minor road bounded blocks

Field Name	Field Definition
MB_ID	Minor Block ID to link to MB_ID in Unit_MinorBlocks
Unconserve	Amount unconserved
Gap_1_A	Amount of Minor Block Conserved in GAP 1 (Acres)
GAP1_P	Amount of Minor Block Conserved in GAP 1 (Percent)
GAP2_A	Amount of Minor Block Conserved in GAP 2 (Acres)
GAP2_P	Amount of Minor Block Conserved in GAP 2 (Percent)
GAP12_A	Amount of Minor Block Conserved in GAP 1 & 2 (Biodiversity) (Acres)
GAP12_P	Amount of Minor Block Conserved in GAP 1 & 2 (Biodiversity) (Percent) Note: if the acreage of the block is really small the percentage might be above 100
GAP3_A	Amount of Minor Block Conserved in GAP 3 (Multiple Uses) (Acres)
GAP3_P	Amount of Minor Block Conserved in GAP 3 (Multiple Uses) (Acres) – Note: if the acreage of the block is really small the percentage might be above 100
LCI_Avg	Landscape Context Index Average Score for Minor Block
Dev2060_A	Amount Predicted to be Developed in 2060 (Acres)
Dev2060_P	Amount Predicted to be Developed in 2060 (Percent)
StandAge_A	Stand Age Average (n years) for Minor Block
Core_A	Natural Core Amount in Acres for Minor Block
Core_P	Natural Core Amount as a percent for Minor Block
LocCon_avg	Local Connectedness Average Score
LandComp_A	Landscape Complexity Average Score
Resilience	Resilience Average Score using the 30 meter detailed grid stratified by setting and ecoregion
StandHeigh	Stand Height (in meters) for Minor Block
Biomass_Av	Biomass for Minor Block

Appendix IX. Join Table: Minor road bounded blocks and species.
Table Name: JoinTable_MinorBlockandSpecies

This table contains information on the species element occurrences that are within each minor road bounded block. Due to sensitivity and data sharing agreements, only block over 1000 acres contain species information.

Field Name	Field Definition
MB_ID	Minor Block ID to link to MB_ID in Unit_MinorBlocks
Sum_AMP	Total number of amphibian species occurrences
Sum_Bird	Total number of bird species occurrences

Sum_Fish	Total number of fish species occurrences
Sum_IV_Ins	Total number of invertebrate insect species occurrences
Sum_IV_Mol	Total number of invertebrate mollusk species occurrences
Sum_Mamm	Total number of mammal species occurrences
Sum_Plants	Total number of plant species occurrences
Sum_Reptil	Total number of reptile species occurrences
NU_Species	Number of unique species taxa in minor block
N_Species	Total number of species in the block

Appendix X. Join Table: Minor road bounded blocks and species.
Table Name: JoinTable_MinorBlockandStreams

This table contains join information to join the blocks to the stream reaches.

Field Name	Field Definition
COM_ID	Stream reach ID to link to COM_ID in Unit_Stream_Reach
MB_ID	Minor Block ID to link to MB_ID in Unit_MinorBlocks

Appendix XI. Feature class name: major road bounded blocks attribute table.

This table contains basic attributes for the major road bounded blocks. It contains classification information, state, ecoregion, lcc and Ids to link to minor block join tables and major blocks all.

Field Name	Field Definition
legntharea	legnth to area ratio
under5	flag if area is less than 5 acres
sliver	flag if length to area ratios (length/area) >0.01
MajorBlks	Flag if used in the natural major blocks
ME	Flag if this block intersects with the state of Maine
NH	Flag if this block intersects with the state of New Hampshire
VT	Flag if this block intersects with the state of Vermont
MA	Flag if this block intersects with the state of Massachuesets
CT	Flag if this block intersects with the state of Conneticut
RI	Flag if this block intersects with the state of Rhode Island
NY	Flag if this block intersects with the state of New York
PA	Flag if this block intersects with the state of Pennslyvania
WV	Flag if this block intersects with the state of West Virginia
NJ	Flag if this block intersects with the state of New Jersey
DE	Flag if this block intersects with the state of Deleaware
MD	Flag if this block intersects with the state of Maryland

VA	Flag if this block intersects with the state of Virginia
STATES	List of states that the block intersects
NAC	Flag if this block intersects with the ecoregion NAC
NAP	Flag if this block intersects with the ecoregion NAP
PED	Flag if this block intersects with the ecoregion PED
SBR	Flag if this block intersects with the ecoregion SBR
MAP	Flag if this block intersects with the ecoregion MAP
CAP	Flag if this block intersects with the ecoregion CAP
CBY	Flag if this block intersects with the ecoregion CBY
CRV	Flag if this block intersects with the ecoregion CRV
GTL	Flag if this block intersects with the ecoregion GTL
HAL	Flag if this block intersects with the ecoregion HAL
LNE	Flag if this block intersects with the ecoregion LNE
STL	Flag if this block intersects with the ecoregion STL
WAP	Flag if this block intersects with the ecoregion WAP
ECOREGION	List of ecoregions this block intersects
NALCC	Flag if this block intersects with NALCC
APPLCC	Flag if this block intersects with APPLCC
SALCC	Flag if this block intersects with SALCC
UMGLLCC	Flag if this block intersects with UMGLLCC
LCC	List of LCCs this block intersects
All_States	Flag used for queried if user wants to query all states
MB_Acres	Area in Acres of the major blocks
MJ_ALL_ID	ID of major block in BaseUnit_MajorBlocks_all
MJ_ID	ID of major block this links to MJ_ID in minor blocks

Appendix XII. Feature class name: minor road bounded blocks attribute table.
This table contains basic attributes for the road bounded blocks. It contains basic landcover information, state, ecoregion, lcc and Ids to link to minor block join tables and major blocks.

Field	Field Definition
acres	Size (in acres of the minor road bounded block)
m2_nat	Amount of Block that is natural in square meters (using 2001 NLCD)
m2_water	Amount of Block that is water in square meters (using 2001 NLCD)
m2_dev	Amount of Block that is developed in square meters (using 2001 NLCD)
m2_ag	Amount of Block that is agriculture in square meters (using 2001 NLCD)
Dev90	flag if the Block is over 90 Percent Devleoped (none of the blocks in Unit_minorblocks will be)
natunderac	flag if there is less than 1 acre of natural habitat (none of the blocks in Unit_minorblocks will be)
blocksforr	flag if this block is used in Unit_minorblocks (this will be 1 for all blocks)
oldID	ID from BaseUnit_MinorBlocks_all
ID	ID for this layer - this is what joins to all other tables

ME	Flag if this block intersects with the state of Maine
NH	Flag if this block intersects with the state of New Hampshire
VT	Flag if this block intersects with the state of Vermont
MA	Flag if this block intersects with the state of Massachuesets
CT	Flag if this block intersects with the state of Conneticut
RI	Flag if this block intersects with the state of Rhode Island
NY	Flag if this block intersects with the state of New York
PA	Flag if this block intersects with the state of Pennslyvania
WV	Flag if this block intersects with the state of West Virginia
NJ	Flag if this block intersects with the state of New Jersey
DE	Flag if this block intersects with the state of Deleaware
MD	Flag if this block intersects with the state of Maryland
VA	Flag if this block intersects with the state of Virginia
STATES	List of states that the block intersects
NAC	Flag if this block intersects with the ecoregion NAC
NAP	Flag if this block intersects with the ecoregion NAP
PED	Flag if this block intersects with the ecoregion PED
SBR	Flag if this block intersects with the ecoregion SBR
MAP	Flag if this block intersects with the ecoregion MAP
CAP	Flag if this block intersects with the ecoregion CAP
CBY	Flag if this block intersects with the ecoregion CBY
CRV	Flag if this block intersects with the ecoregion CRV
GTL	Flag if this block intersects with the ecoregion GTL
HAL	Flag if this block intersects with the ecoregion HAL
LNE	Flag if this block intersects with the ecoregion LNE
STL	Flag if this block intersects with the ecoregion STL
WAP	Flag if this block intersects with the ecoregion WAP
ECOREGION	List of ecoregions this block intersects
NALCC	Flag if this block intersects with NALCC
APPLCC	Flag if this block intersects with APPLCC
SALCC	Flag if this block intersects with SALCC
UMGLLCC	Flag if this block intersects with UMGLLCC
LCC	List of LCCs this block intersects
Major_Blk_Acres	Size of the Major Road Bounded Block the Minor Block falls within
MJ_ID	ID of the Major Road Bounded Block the Minor Block falls within

Appendix XIII. Feature class name: wetland complexes.
This table contains basic attributes for the Wetland Complexes. It contains imformation of the habiats included in the wetland complex, the total area of the wetland complex, the wetland complex ID, and the id to join the wetland complexes to the major block.

Field Name	Field Definition
VALUE_1	Area in m2 of Acadian Coastal Salt and Estuary Marsh
VALUE_3	Area in m2 of Acadian Maritime Bog
VALUE_15	Area in m2 of Atlantic Coastal Plain Blackwater/Brownwater Stream Floodplain Forest
VALUE_16	Area in m2 of Atlantic Coastal Plain Embayed Region Tidal Freshwater/Brackish Marsh
VALUE_17	Area in m2 of Atlantic Coastal Plain Northern Bog
VALUE_18	Area in m2 of Atlantic Coastal Plain Peatland Pocosin and Canebrake
VALUE_19	Area in m2 of Boreal-Laurentian Bog
VALUE_20	Area in m2 of Boreal-Laurentian-Acadian Acidic Basin Fen
VALUE_26	Area in m2 of Central Appalachian Stream and Riparian
VALUE_28	Area in m2 of Central Interior Highlands and Appalachian Sinkhole and Depression Pond
VALUE_35	Area in m2 of Glacial Marine & Lake Wet Clayplain Forest
VALUE_38	Area in m2 of High Allegheny Headwater Wetland
VALUE_39	Area in m2 of Laurentian-Acadian Alkaline Conifer-Hardwood Swamp
VALUE_40	Area in m2 of Laurentian-Acadian Alkaline Fen
VALUE_41	Area in m2 of Laurentian-Acadian Freshwater Marsh
VALUE_46	Area in m2 of Laurentian-Acadian Wet Meadow-Shrub Swamp
VALUE_47	Area in m2 of North Atlantic Coastal Plain Basin Peat Swamp
VALUE_48	Area in m2 of North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest
VALUE_49	Area in m2 of North Atlantic Coastal Plain Brackish/Fresh & Oligohaline Tidal Marsh
VALUE_52	Area in m2 of North Atlantic Coastal Plain Large River Floodplain
VALUE_55	Area in m2 of North Atlantic Coastal Plain Pitch Pine Lowland
VALUE_56	Area in m2 of North Atlantic Coastal Plain Stream and River
VALUE_57	Area in m2 of North Atlantic Coastal Plain Tidal Salt Marsh
VALUE_58	Area in m2 of Northeastern Interior Dry-Mesic Oak Forest
VALUE_59	Area in m2 of North-Central Appalachian Acidic Swamp
VALUE_60	Area in m2 of North-Central Appalachian Large River Floodplain
VALUE_63	Area in m2 of North-Central Interior Large River Floodplain
VALUE_64	Area in m2 of North-Central Interior Wet Flatwoods
VALUE_65	Area in m2 of North-Central Interior and Appalachian Acidic Peatland
VALUE_66	Area in m2 of North-Central Interior and Appalachian Rich Swamp
VALUE_69	Area in m2 of Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp
VALUE_70	Area in m2 of Laurentian-Acadian Large River Floodplain
VALUE_73	Area in m2 of Piedmont Upland Depression Swamp
VALUE_74	Area in m2 of Piedmont-Coastal Plain Freshwater Marsh
VALUE_75	Area in m2 of Piedmont-Coastal Plain Large River Floodplain

VALUE_76	Area in m2 of Piedmont-Coastal Plain Shrub Swamp
VALUE_79	Area in m2 of Central Atlantic Coastal Plain Non-riverine Swamp and Wet Hardwood Forest
VALUE_87	Area in m2 of Southern Atlantic Coastal Plain Tidal Wooded Swamp
VALUE_91	Area in m2 of Southern Piedmont Lake Floodplain Forest
VALUE_93	Area in m2 of Southern Piedmont Small Floodplain and Riparian Forest
acres	Total Acres of Wetland Complex
wetcom_id	Wetland Complex ID
MB_ID	Minor Block ID to link to MB_ID in Unit_MinorBlocks

Appendix XIV. Feature class name: unit_stream_reaches

This table contains basic attributes for the perennial stream and river reaches (drainage area >= 1 sq.mi.). It contains summary habitat classification information on the stream or river type, geography (state, ecoregion, watershed, LCC), and condition attributes including riparian secured land, riparian land cover, total upstream impervious surfaces, local catchment terrestrial connectivity, local catchment landscape context index, local catchment predicted development in 2060, number and types of dams, upstream dam water volume storage as a percent of mean annual flow, network length between dams, and number of road stream crossings.

Field Name	Field Definition	Source Dataset (if applicable)
COMID	Master COMID field	NHD Plus V1. USGS 2006
GNIS_NAME	reach name	NHD Plus V1. USGS 2006
LEN_M	length of segment in meters	calculated in ArcGIS 10.0
LEN_MI	length of segment in miles	calculated in ArcGIS 10.0
LAKE_FLAG	1 = segment is within a NHD Plus Lake polygon; it is lake habitat but was kept in the dataset to include all segments that were part of a functionally connected network. Sometimes dams are also located on the lowest part of these "lake" centerline reaches	calculated by TNC Eastern Conservation Science 2013
MACRO_GR	stream or river macrogroup from the Simplified Northeast Aquatic Habitat Classification	Northeast Habitat Guides: A Companion to the Terrestrial and Aquatic Habitat Maps: http://nature.ly/HabGuide
CLASS_58	code for the stream or river simplified type from the 58 level classification in the Simplified Northeast Aquatic Habitat Classification	Northeast Habitat Guides: A Companion to the Terrestrial and Aquatic Habitat Maps: http://nature.ly/HabGuide
DESC_58	descriptive name for the stream or river simplified type from the 58 level classification in the Simplified Northeast Aquatic Habitat Classification	Northeast Habitat Guides: A Companion to the Terrestrial and Aquatic Habitat Maps: http://nature.ly/HabGuide
SUM_23	code for the stream or river simplified type from the 23 level classification in the Simplified Northeast Aquatic Habitat Classification	Northeast Habitat Guides: A Companion to the Terrestrial and Aquatic Habitat Maps: http://nature.ly/HabGuide
DEC_23	descriptive name for the stream or river simplified type from the 23 level classification in the Simplified Northeast Aquatic Habitat Classification	Northeast Habitat Guides: A Companion to the Terrestrial and Aquatic Habitat Maps: http://nature.ly/HabGuide

Field Name	Field Definition	Source Dataset (if applicable)
PMAFSTOR	percent of mean annual flow volume capable of being stored behind dams upstream. Based on accumulated maximum storage values (and/or when max was blank we used the largest of listed normal storage or NID storage value) for all dams above a given reach and the mean annual flow volume at the reach from the NHD Plus V1 unit runnoff mean annual flow value	National Inventory of Dams with dam storage values. From Eastern Regional Dam Dataset. Martin and Apse 2011; dams _wuse_111103.shp
DAMSTOR_CL	Risk of Potential Flow Alteration from Upstream Dam Storage: based on percent of mean annual flow volume capable of being stored behind dams upstream. Dam storage class: Class 1: < 2% Very Low, Class 2: >= 2 < 10% Low, Class 3: >= 10 < 30% Moderate, Class 4: >= 30 < 50% High, Class 5: >= 50% Severe, -999 = unavailable	National Inventory of Dams with dam storage values (max and/or when max was blank used largest of normal or NID storage value). From Eastern Regional Dam Dataset. Martin and Apse 2011; dams _wuse_111103.shp
FC	Flood control dam on reach (0/1 for no/yes)	Eastern Regional Dam Dataset. Martin and Apse 2011; dams _wuse_111103.shp
H	Hydropower dam on reach (0/1 for no/yes)	Eastern Regional Dam Dataset. Martin and Apse 2011; dams _wuse_111103.shp
I	Irrigation dam on reach (0/1 for no/yes)	Eastern Regional Dam Dataset. Martin and Apse 2011; dams _wuse_111103.shp
OTHER0_15	Other dams, <= 15ft high on reach (0/1 for no/yes)	Eastern Regional Dam Dataset. Martin and Apse 2011; dams _wuse_111103.shp
OTHER15UP	Other dams, > 15ft high on reach (0/1 for no/yes)	Eastern Regional Dam Dataset. Martin and Apse 2011; dams _wuse_111103.shp
OTHER_UNK	Other dams, height unknown on reach (0/1 for no/yes)	Eastern Regional Dam Dataset. Martin and Apse 2011; dams _wuse_111103.shp
R	Recreation dam on reach (0/1 for no/yes)	Eastern Regional Dam Dataset. Martin and Apse 2011; dams _wuse_111103.shp
WS	Water Supply dam on reach (0/1 for no/yes)	Eastern Regional Dam Dataset. Martin and Apse 2011; dams _wuse_111103.shp
DAMTOTAL	Total number of above dams	Eastern Regional Dam Dataset. Martin and Apse 2011; dams _wuse_111103.shp
DAMDEN	density on that reach: total dams / miles of reach length	Eastern Regional Dam Dataset. Martin and Apse 2011; dams _wuse_111103.shp
ALEWIFE	alewife habitat : 0 = reach does not contain current freshwater habitat (spawning, overwintering), 1 = reach contains documented current freshwater habitat (spawning, overwintering), 2 = documented historical / reach contains likely restoration potential habitat	Northeast Regional Anadromous Fish Habitat. TNC. ; RegionAnadFish_073113. Martin and Apse 2011

Field Name	Field Definition	Source Dataset (if applicable)
AMSHAD	american shad habitat : 0 = reach does not contain current freshwater habitat (spawning, overwintering), 1 = reach contains documented current freshwater habitat (spawning, overwintering), 2 = documented historical / reach contains likely restoration potential habitat	Northeast Regional Anadromous Fish Habitat. TNC. ; RegionAnadFish_073113. Martin and Apse 2011
BLUEBACK	blueback herring habitat : 0 = reach does not contain current freshwater habitat (spawning, overwintering), 1 = reach contains documented current freshwater habitat (spawning, overwintering), 2 = documented historical / reach contains likely restoration potential habitat	Northeast Regional Anadromous Fish Habitat. TNC. ; RegionAnadFish_073113. Martin and Apse 2011
HICKSHAD	hickory shad habitat : 0 = reach does not contain current freshwater habitat (spawning, overwintering), 1 = reach contains documented current freshwater habitat (spawning, overwintering), 2 = documented historical / reach contains likely restoration potential habitat	Northeast Regional Anadromous Fish Habitat. TNC. ; RegionAnadFish_073113. Martin and Apse 2011
STRBASS	striped bass habitat : 0 = reach does not contain current freshwater habitat (spawning, overwintering), 1 = reach contains documented current freshwater habitat (spawning, overwintering), 2 = documented historical / reach contains likely restoration potential habitat	Northeast Regional Anadromous Fish Habitat. TNC. ; RegionAnadFish_073113. Martin and Apse 2011
ATLSTUR	atlantic sturgeon habitat : 0 = reach does not contain current freshwater habitat (spawning, overwintering), 1 = reach contains documented current freshwater habitat (spawning, overwintering), 2 = documented historical / reach contains likely restoration potential habitat	Northeast Regional Anadromous Fish Habitat. TNC. ; RegionAnadFish_073113. Martin and Apse 2011
ATLSALM	atlantic salmon habitat : 0 = reach does not contain current freshwater habitat (spawning, overwintering), 1 = reach contains documented current freshwater habitat (spawning, overwintering), 2 = documented historical / reach contains likely restoration potential habitat	Northeast Regional Anadromous Fish Habitat. TNC. ; RegionAnadFish_073113. Martin and Apse 2011
ANAD_SUM1	1 = reach contains documented current freshwater habitat (spawning, overwintering) for at least one of the following diadromous fish: alewife, american shad, blueback herring, hickory shad, striped bass, atlantic sturgeon, atlantic salmon	Northeast Regional Anadromous Fish Habitat. TNC. ; RegionAnadFish_073113. Martin and Apse 2011
ANAD_SUM2	2 = documented historical / reach contains likely restoration potential habitatfor at least one of the following diadromous fish: alewife, american shad, blueback herring, hickory shad, striped bass, atlantic sturgeon, atlantic salmon	Northeast Regional Anadromous Fish Habitat. TNC. ; RegionAnadFish_073113. Martin and Apse 2011

Field Name	Field Definition	Source Dataset (if applicable)
ANAD_SUM12	concatenation of the above two fields to highlight reaches with 1 = reach contains documented current freshwater habitat (spawning, overwintering), 2 = documented historical / reach contains likely restoration potential habitat, or 12 = both of the above for at least one of the following diadromous species alewife, american shad, blueback herring, hickory shad, striped bass, atlantic sturgeon, atlantic salmon	Northeast Regional Anadromous Fish Habitat. TNC. ; RegionAnadFish_073113. Martin and Apse 2011
BATNETID	the unique id of the functional network this reach is within	Northeast Funcationally Connected Networks; fcn_wuse1_curr_111103_d.shp TNC. Olivero and Anderson,2013
BATNET_MI	length in miles of the functional network this reach is within	Northeast Funcationally Connected Networks; fcn_wuse1_curr_111103_d.shp TNC. Olivero and Anderson,2013
FWRESCLASS	For all networks that contained at least 2 miles of rivers, they were coded with a resilience class.	Northeast Funcationally Connected Networks; fcn_wuse1_curr_111103_d.shp TNC. Olivero and Anderson,2013
EDU	Ecological Drainage Unit	Ecological Draiange Units of North America from TNC. ; EDUs_all_final_2011_03_30_usp.shp
FW_ECO	Freshwater Ecoregion	Freshwater Ecoregions of the World from WWF. 2008. ; feow_gis_usp.shp
TERR_ECO	Terrestrial Ecoregion	Terrestrial Ecoregions from TNC. ; ecocan_usalb.shp
LCC	Landscape Conservation Cooperative unit (FWS)	Landscape Conservation Cooperatives from FWS 2013; fws_LCC_usalb.shp
STATE	Primary state in which the reach falls. Based on the maximum number of acres in the 100m riparian buffer	TIGER 2012
STATE12	Primary state followed by a Secondary state for reaches which cross into another state. Based on the second maximum number of acres from the 100m riparian buffer.	TIGER 2012
HUC12	Hydrologic Unit Code 12, from USGS	12 Digit Watershed Boundary Dataset. USDA 2012
HUC12NAME	Hydrologic Unit Code 12, from USGS, text name	12 Digit Watershed Boundary Dataset. USDA 2012
HUC10	Hydrologic Unit Code 10, from USGS	10 Digit Watershed Boundary Dataset. USDA 2012
HUC10NAME	Hydrologic Unit Code 10, from USGS, text name	10 Digit Watershed Boundary Dataset. USDA 2012
HUC8	Hydrologic Unit Code 8, from USGS	8 Digit Watershed Boundary Dataset. USDA 2012
HUC8NAME	Hydrologic Unit Code 8, from USGS, text name	8 Digit Watershed Boundary Dataset. USDA 2012
HUC_6	Hydrologic Unit Code 6, from USGS	8 Digit Watershed Boundary Dataset. USDA 2012

Field Name	Field Definition	Source Dataset (if applicable)
HUC6NAME	Hydrologic Unit Code 6, from USGS, text name	8 Digit Watershed Boundary Dataset. USDA 2012
HUC_4	Hydrologic Unit Code 4, from USGS	8 Digit Watershed Boundary Dataset. USDA 2012
HUC4NAME	Hydrologic Unit Code 4, from USGS, text name	8 Digit Watershed Boundary Dataset. USDA 2012
HUC_2	Hydrologic Unit Code 2, from USGS	8 Digit Watershed Boundary Dataset. USDA 2012
HUC2NAME	Hydrologic Unit Code 2, from USGS	8 Digit Watershed Boundary Dataset. USDA 2012
PER_IMPO6A	Percent of upstream watershed area that is impervious surface. -999 is no data available.	NLCD 2006 Percent Developed Imperviousness. USGS 2011
IMPERV_CL	Upstream watershed Impervious surfaces class: Class 1: Undisturbed: >= 0 < 0.5 percent impervious, Class 2: Low impacts: >= 0.5 < 2 percent impervious, Class 3: Moderately impacted: >= 2 < 10 percent impervious, Class 4: Highly impacted: >= 10 percent impervious	NLCD 2006 Percent Developed Imperviousness. USGS 2011
RK_MEAN	Resistant kernel (Local Connectivity) zonal mean, calculated within a 100m riparian buffer	Local Connectivity Resistant Kernal Grid. TNC Eastern Conservation Science 2013
LCI_MEAN	Landscape Context Index mean. This field was calculated by tabulating areas between the 100m riparian buffer and a grid of landscape context for the region, with the mean extracted.	Landscape Context Index Grid. Tnc Eastern Conservation Science 2013
RDXSTM_NUM	Number of road-stream crossings on that reach. -999 indicates that reach is a size 2 or larger river	Source of roads
RDXSTM_DEN	Road-stream crossing density for the reach; number of crossings/miles	
PVALUE_21	% of the 100m riparian buffer in NLCD code 21 (low intensity residential). -999 indicates that the reach was not used in the analysis, because it was either a lake centerline or had < 1 sq. mi. upstream drainage.	NLCD 2006 Landcover. USGS 2011
PVALUE_22	% of the 100m riparian buffer in NLCD code 22 (medium intensity residential). -999 indicates that the reach was not used in the analysis, because it was either a lake centerline or had < 1 sq. mi. upstream drainage.	NLCD 2006 Landcover. USGS 2011
PVALUE_23	% of the 100m riparian buffer in NLCD code 23 (medium intensity residential). -999 indicates that the reach was not used in the analysis, because it was either a lake centerline or had < 1 sq. mi. upstream drainage.	NLCD 2006 Landcover. USGS 2011
PVALUE_24	% of the 100m riparian buffer in NLCD code 24 (high intensity developed). -999 indicates that the reach was not used in the analysis, because it was either a lake centerline or had < 1 sq. mi. upstream drainage.	NLCD 2006 Landcover. USGS 2011

Field Name	Field Definition	Source Dataset (if applicable)
PVALUE_31	% of the 100m riparian buffer in NLCD code 31 (non-Natural barrens). -999 indicates that the reach was not used in the analysis, because it was either a lake centerline or had < 1 sq. mi. upstream drainage.	NLCD 2006 Landcover. USGS 2011
PVALUE_32	% of the 100m riparian buffer in NLCD code 32 (natural barrens). -999 indicates that the reach was not used in the analysis, because it was either a lake centerline or had < 1 sq. mi. upstream drainage.	NLCD 2006 Landcover. USGS 2011; updated by TNC Eastern Conservation Science 2013.
PVALUE_41	% of the 100m riparian buffer in NLCD code 41 (Deciduous forest). -999 indicates that the reach was not used in the analysis, because it was either a lake centerline or had < 1 sq. mi. upstream drainage.	NLCD 2006 Landcover. USGS 2011
PVALUE_42	% of the 100m riparian buffer in NLCD code 42 (Coniferous forest). -999 indicates that the reach was not used in the analysis, because it was either a lake centerline or had < 1 sq. mi. upstream drainage.	NLCD 2006 Landcover. USGS 2011
PVALUE_43	% of the 100m riparian buffer in NLCD code 43 (Mixed forest). -999 indicates that the reach was not used in the analysis, because it was either a lake centerline or had < 1 sq. mi. upstream drainage.	NLCD 2006 Landcover. USGS 2011
PVALUE_52	% of the 100m riparian buffer in NLCD code 52 (Shrub/Scrub). -999 indicates that the reach was not used in the analysis, because it was either a lake centerline or had < 1 sq. mi. upstream drainage.	NLCD 2006 Landcover. USGS 2011
PVALUE_71	% of the 100m riparian buffer in NLCD code 71 (Grassland/Herbaceous). -999 indicates that the reach was not used in the analysis, because it was either a lake centerline or had < 1 sq. mi. upstream drainage.	NLCD 2006 Landcover. USGS 2011
PVALUE_81	% of the 100m riparian buffer in NLCD code 81 (Pasture/Hay). -999 indicates that the reach was not used in the analysis, because it was either a lake centerline or had < 1 sq. mi. upstream drainage.	NLCD 2006 Landcover. USGS 2011
PVALUE_82	% of the 100m riparian buffer in NLCD code 82 (Cultivated Crops). -999 indicates that the reach was not used in the analysis, because it was either a lake centerline or had < 1 sq. mi. upstream drainage.	NLCD 2006 Landcover. USGS 2011
PVALUE_90	% of the 100m riparian buffer in NLCD code 90 (Woody Wetlands). -999 indicates that the reach was not used in the analysis, because it was either a lake centerline or had < 1 sq. mi. upstream drainage.	NLCD 2006 Landcover. USGS 2011

Field Name	Field Definition	Source Dataset (if applicable)
PVALUE_95	% of the 100m riparian buffer in NLCD code 95 (Emergent Herbaceous Wetland). -999 indicates that the reach was not used in the analysis, because it was either a lake centerline or had < 1 sq. mi. upstream drainage.	NLCD 2006 Landcover. USGS 2011
PDEVTOT	Total % of the riparian buffer that is in developed classes (21-24, 31)	NLCD 2006 Landcover. USGS 2011
PLOWDEV	% of the 100m riparian buffer that is in low-intensity developed (classes 21-22, 32)	NLCD 2006 Landcover. USGS 2011
PMEDHIGH	% of the 100m riparian buffer that is in medium-high intensity developed (classes 23-24)	NLCD 2006 Landcover. USGS 2011
PAGR	% of the 100m riparian buffer that is in agricultural use (classes 81,82)	NLCD 2006 Landcover. USGS 2011
PFOR	% of the 100m riparian buffer that is forested (classes 41, 42, 43)	NLCD 2006 Landcover. USGS 2011
PWET	% of the 100m riparian buffer that is wetland (classes 90, 95)	NLCD 2006 Landcover. USGS 2011
POPEN	% of the 100m riparian buffer that is open natural (classes 32, 52, 71)	NLCD 2006 Landcover. USGS 2011
RIP_INDEX	Landscape summary impact for the 100m riparian buffer - calculated as: 0.5*% agriculture + 0.75*% low intensity developed + 1.0*% medium - high intensity developed	NLCD 2006 Landcover. USGS 2011
ACRE_21	Acres of the 100m riparian buffer in NLCD code 21 (developed open space). -999 indicates that the reach was not used in the analysis, because it was either a lake centerline, had < 1 sq. mi. upstream drainage, or was so short that its buffer was within the buffer of another longer reach that was >= 1 sq.mi.	NLCD 2006 Landcover. USGS 2011
ACRE_22	Acres of the 100m riparian buffer in NLCD code 22 (low intensity residential). -999 indicates that the reach was not used in the analysis, because it was either a lake centerline, had < 1 sq. mi. upstream drainage, or was so short that its buffer was within the buffer of another longer reach that was >= 1 sq.mi.	NLCD 2006 Landcover. USGS 2011
ACRE_23	Acres of the 100m riparian buffer in NLCD code 23 (medium intensity residential). -999 indicates that the reach was not used in the analysis, because it was either a lake centerline, had < 1 sq. mi. upstream drainage, or was so short that its buffer was within the buffer of another longer reach that was >= 1 sq.mi.	NLCD 2006 Landcover. USGS 2011
ACRE_24	Acres of the 100m riparian buffer in NLCD code 24 (high intensity developed). -999 indicates that the reach was not used in the analysis, because it was either a lake centerline, had < 1 sq. mi. upstream drainage, or was so short that its buffer was within the buffer of another longer reach that was >= 1 sq.mi.	NLCD 2006 Landcover. USGS 2011

Field Name	Field Definition	Source Dataset (if applicable)
ACRE_31	Acres of the 100m riparian buffer in NLCD code 31 (non-Natural barrens). -999 indicates that the reach was not used in the analysis, because it was either a lake centerline, had < 1 sq. mi. upstream drainage, or was so short that its buffer was within the buffer of another longer reach that was >= 1 sq.mi.	NLCD 2006 Landcover. USGS 2011
ACRE_32	Acres of the 100m riparian buffer in NLCD code 32 (natural barrens). -999 indicates that the reach was not used in the analysis, because it was either a lake centerline, had < 1 sq. mi. upstream drainage, or was so short that its buffer was within the buffer of another longer reach that was >= 1 sq.mi.	NLCD 2006 Landcover. USGS 2011
ACRE_41	Acres of the 100m riparian buffer in NLCD code 41 (Deciduous forest). -999 indicates that the reach was not used in the analysis, because it was either a lake centerline, had < 1 sq. mi. upstream drainage, or was so short that its buffer was within the buffer of another longer reach that was >= 1 sq.mi.	NLCD 2006 Landcover. USGS 2011
ACRE_42	Acres of the 100m riparian buffer in NLCD code 42 (Coniferous forest). -999 indicates that the reach was not used in the analysis, because it was either a lake centerline, had < 1 sq. mi. upstream drainage, or was so short that its buffer was within the buffer of another longer reach that was >= 1 sq.mi.	NLCD 2006 Landcover. USGS 2011
ACRE_43	Acres of the 100m riparian buffer in NLCD code 43 (Mixed forest). -999 indicates that the reach was not used in the analysis, because it was either a lake centerline, had < 1 sq. mi. upstream drainage, or was so short that its buffer was within the buffer of another longer reach that was >= 1 sq.mi.	NLCD 2006 Landcover. USGS 2011
ACRE_52	Acres of the 100m riparian buffer in NLCD code 52 (Shrub/Scrub). -999 indicates that the reach was not used in the analysis, because it was either a lake centerline, had < 1 sq. mi. upstream drainage, or was so short that its buffer was within the buffer of another longer reach that was >= 1 sq.mi.	NLCD 2006 Landcover. USGS 2011
ACRE_71	Acres of the 100m riparian buffer in NLCD code 71 (Grassland/Herbaceous). -999 indicates that the reach was not used in the analysis, because it was either a lake centerline, had < 1 sq. mi. upstream drainage, or was so short that its buffer was within the buffer of another longer reach that was >= 1 sq.mi.	NLCD 2006 Landcover. USGS 2011

Field Name	Field Definition	Source Dataset (if applicable)
ACRE_81	Acres of the 100m riparian buffer in NLCD code 81 (Pasture/Hay). -999 indicates that the reach was not used in the analysis, because it was either a lake centerline, had < 1 sq. mi. upstream drainage, or was so short that its buffer was within the buffer of another longer reach that was >= 1 sq.mi.	NLCD 2006 Landcover. USGS 2011
ACRE_82	Acres of the 100m riparian buffer in NLCD code 82 (Cultivated Crops). -999 indicates that the reach was not used in the analysis, because it was either a lake centerline, had < 1 sq. mi. upstream drainage, or was so short that its buffer was within the buffer of another longer reach that was >= 1 sq.mi.	NLCD 2006 Landcover. USGS 2011
ACRE_90	Acres of the 100m riparian buffer in NLCD code 90 (Woody Wetlands). -999 indicates that the reach was not used in the analysis, because it was either a lake centerline, had < 1 sq. mi. upstream drainage, or was so short that its buffer was within the buffer of another longer reach that was >= 1 sq.mi.	NLCD 2006 Landcover. USGS 2011
ACRE_95	Acres of the 100m riparian buffer in NLCD code 95 (Emergent Herbaceous Wetlands). -999 indicates that the reach was not used in the analysis, because it was either a lake centerline, had < 1 sq. mi. upstream drainage, or was so short that its buffer was within the buffer of another longer reach that was >= 1 sq.mi.	NLCD 2006 Landcover. USGS 2011
ACRES_UNSE	Acres of the 100m riparian buffer that are not secured from development	TNC Eastern Region Secured Lands 2011
ACRES_GAP1	Acres of the 100m riparian buffer that are in GAP 1 securement status.	TNC Eastern Region Secured Lands 2011
ACRES_GAP2	Acres of the 100m riparian buffer that are in GAP 2 securement status.	TNC Eastern Region Secured Lands 2011
ACRES_GAP3	Acres of the 100m riparian buffer that are in GAP 3 securement status.	TNC Eastern Region Secured Lands 2011
PGAP1	Percent of the 100m riparian buffer that are in GAP1 securement status	TNC Eastern Region Secured Lands 2011
PGAP2	Percent of the 100m riparian buffer that are in GAP2 securement status	TNC Eastern Region Secured Lands 2011
PGAP3	Percent of the 100m riparian buffer that are in GAP3 securement status	TNC Eastern Region Secured Lands 2011
PUNSEC	Percent of the 100m riparian buffer that are not secured for development.	TNC Eastern Region Secured Lands 2011
PSEC	Percent of the 100m riparian buffer that is in GAP 1, 2, or 3 land	TNC Eastern Region Secured Lands 2011

PDEV2001	Percent of local catchment in development or agriculture in 2001	Land Transformation Model Future Urban Land Cover Projections. Version 3.0 (Released May 1 ,2011). Human-Environment Modeling and Analysis Laboratory. Purdue University
PNAT2060	Percent of the local catchment predicted to be in natural cover in 2060	Land Transformation Model Future Urban Land Cover Projections. Version 3.0 (Released May 1 ,2011). Human-Environment Modeling and Analysis Laboratory. Purdue University
PDEVNEW	Percent of the local catchment predicted to have new development between 2001 and 2060	Land Transformation Model Future Urban Land Cover Projections. Version 3.0 (Released May 1 ,2011). Human-Environment Modeling and Analysis Laboratory. Purdue University
DISTRIBUTE	Indication of whether the reach is in a lake, has >= 1 sq. mi. upstream catchment, or has <1 mi.sq. upstream catchment.	calculated by TNC Eastern Conservation Science 2013
QRYIMP	1 = Low Impervious surface < 2%	calculated by TNC Eastern Conservation Science 2013
QRYDAM	1 = No dam on reach and upstream dam water storage volume as percent of mean annual flow <10%	calculated by TNC Eastern Conservation Science 2013
QRYRIP	1 = Low Riparian Development and Agriculture Impacts: Riparian index score <= 25	calculated by TNC Eastern Conservation Science 2013
QRYNET	1 = Minimum Linear Connectivity Length met: Funcational Network Length >= 10 miles for all systems except for tidal headwaters and creeks which have naturally small network lenghts and any functional network length was acceptable	calculated by TNC Eastern Conservation Science 2013
HIGHQUAL	River and Stream Reaches (no lake centerlines) in each of the above 4 Very High Quality Categorie s: "QRYNET" = 1 AND "QRYRIP" = 1 AND "QRYDAM" = 1 AND "QRYIMP" =1 AND "LAKE_FLAG" = 0	calculated by TNC Eastern Conservation Science 2013