A Map of Terrestrial Habitats of the Northeastern United States: Methods and Approach

The Nature Conservancy, Eastern Conservation Science

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Acknowledgements

This project reflects decades of work by many organizations and dedicated individuals who study and love the natural diversity of the Northeast and Mid-Atlantic. Without their hard work and willingness to share their knowledge the Northeast Terrestrial Habitat Map could not have been produced.

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CHAPTER

Introduction

1

Ecologists have long been interested in ecological communities, and mapping community distributions is a central activity of conservation biology. The resulting products are of great value in focusing conservation activities and evaluating their effectiveness. In the Northeastern United States, however, the majority of existing ecological community maps have been developed for relatively small areas (10 to 10,000 kilometers) using a variety of non-standard classification systems and mapping methods. To offset this pattern, there has been tremendous progress by the State Natural Heritage programs in creating and defining a standard set of natural communities for each state and mapping the locations of exemplary examples within the state (see list of state classifications appears at the end of this document). However, in spite of some level of recent convergence, the state classification systems still differ from each other in both concept and resolution. As a result, the region-wide distribution of most ecological communities in the Northeast remains largely unknown and unmapped.

The objective of this project was to provide a common, consistent map of terrestrial habitats for the Northeast and Mid-Atlantic region to guide wildlife management and conservation across jurisdictional borders, and aid in the implementation of State Wildlife Action Plans. Further, we wanted the map to inform The Nature Conservancy’s and other conservation efforts across the Northeast region by allowing users to assess the distribution and condition of the region’s habitats and implement cross-border conservation planning. Finally, our aim was to create a map that was compatible with similar efforts undertaken by the national GAP Analysis (Jennings 1996) and LANDFIRE (Rollins 2009) programs.

Our intent was to create a new map that was rigorously developed using all available information, and employing a process that was as data-driven as possible. Our methods describe the assembly of spatially comprehensive datasets of 71 ecological variables and the compilation of over 70,000 ecological community samples. Habitat classes in the map were tied directly to *The Northeast Terrestrial Habitat Classification System* (Gawler 2008), a standard classification system developed by NatureServe and reviewed and accepted by state agency biologists and Natural Heritage Program ecologists prior to the start of this mapping project. The classification describes 120 ecological systems occurring at a wide range of scales from small distinct patch-forming systems (e.g. a sparsely vegetated talus-slope) to extensive matrix-forming forest types. Every ecological community sample used in this analysis was tagged to this standard classifications system to allow for consistent mapping across the region, and the multi-scale aspect of the classification guided the development of our methods.

Background

Broad Scale Ecological Mapping in the Northeast

Efforts to classify and map vegetation and habitat types in the Northeast go back to Braun (1950) whose *Deciduous Forests of Eastern North America* described and mapped nine forest regions. A.W. Küchler (1964) published a similar “potential natural vegetation” classification and map for the lower 48 states, describing 35 vegetation associations for the east. Although a later revision (Küchler 1985) expanded the classification to 109 vegetation types, the level of mapping remained very coarse. The Society of

American Foresters “forest cover types” (Eyre 1980) recognizes 63 forest cover types for the Northeast but attempts to map them at regional scales are typically at very small scale, for example, the 1:7,500,000 National Atlas map (http://nationalatlas.gov/), which maps ten broad forest types for the region at a classification scale similar to NatureServe macro-groups (e.g. spruce-fir, oak-pine, maple-beech-birch).

In addition to vegetation mapping, there have been efforts to map integrated biophysical units for this region, such as the USDA-Forest Service’s *National Hierarchical Framework of Ecological Units* (ECOMAP 2007). Sections and Subsections, defined as areas with similar surface and subsurface geology, geomorphic process, coarse soil type, climate, and potential natural vegetation, have been delineated at scales from 1:500,000 to 1:1,000,000, and covering areas of several hundred thousand to several million acres. Land Type Associations, a finer level unit that nests within subsections, have been mapped in some states, but these have often been defined and mapped quite differently across state boundaries, making them less useful for cross-border analyses and planning.

In the last twenty years, NatureServe and some state Natural Heritage Programs have produced detailed maps of natural communities and National Vegetation Classification (NVC) plant associations at local scales on public lands or protected areas. The methods they used, involving airphoto interpretation and field sampling (Grossman et al.1994), do not lend themselves to regional scales due to the sheer amount of labor involved.

Recent advances in species distribution models have opened up new possibilities, however (Pearson 2007, Iverson et al. 2008, Hernandez et al. 2008, Howard 2006), and two efforts have taken advantage of improvements in modeling techniques and advances in satellite image analysis to map ecological systems at broad scales for the whole US: USGS’s National Gap Analysis Program (Jennings 1996) and USDA Forest Service’s LANDFIRE interagency program (Rollins 2009). The former has mapped NatureServe ecological systems in the states of the southeastern US (http://gapanalysis.usgs.gov/), and the latter has mapped them nationally, though with most attention given to forested habitats in the West. Our mapping effort sought to build on these efforts but to expand the number and type of ecological systems mapped, and to take advantage of new techniques of multi-factor habitat mapping for increased accuracy.

The NatureServe Ecological Systems Classification

NatureServe defines a terrestrial habitat as “the environment – physical and biological – that provides the necessary food, shelter, and other needs, of a species or groups of species” (Gawler 2008). Similarly, NatureServe defines an ecological system as a mosaic of plant community types that tend to co-occur within landscapes with similar ecological processes, similar substrates, and/or similar environmental gradients, in a pattern that repeats itself across landscapes (Comer et al. 2003). With respect to this project, we treated these two terms as interchangeable: a terrestrial habitat being a conceptual idea, and an ecological systems being a tangible classification unit that can be mapped on the ground. Ecological systems are designed to be mapped and are readily identifiable by conservation and resource managers in the field. Because they integrate multiple ecological factors related to biogeography— dominant vegetation, climate, landscape structure, and disturbance patterns— ecological systems offer a strong framework for organizing ecological information at multiple spatial scales. As such, they are much more information-rich than simple landcover, which reflects only coarse classes of vegetation structure or current land use.

NatureServe's ecological systems are conceived of as ranging from tens to thousands of hectares, and are expected to persist on the landscape for 50 to 100 years (Comer et al. 2003). They carry more ecological detail about the landscape than do land type associations, forest cover types, potential natural vegetation, or similar vegetation classifications. They are often thought of as being larger in geographic extent and more broadly defined than plant associations or the state Natural Heritage Programs' natural communities, but this is not always the case, because both are multi-scaled. Finer-scaled units based entirely on floristics (i.e. plant associations) have proven difficult to map out at broad scale, and to be of limited utility to planners and natural resource managers. In concept and in mapping, the larger systems provide an effective tool for the "coarse filter" approach to conservation planning, as they represent habitat for wide ranges of plant and animal species.

Mapping Scale

The Northeast Terrestrial Habitat Classification System (NETHCS) describes habitat types that occur at a variety of scales from very small (less than one hectare) to huge (greater than 10,000 hectares). This reflects the reality that biodiversity and biological organization itself occurs at a variety of spatial scales (Poiani et al. 2000, Anderson et al. 1999), and accommodating this range of scales was an important driver in the development of our mapping methods. The dominant, **matrix-forming** forest habitats in the Northeast, like Northern Hardwood or Northeast Interior Dry-Mesic Oak Forest, may cover many thousands of contiguous hectares, and are the background systems in which smaller scale upland and wetland systems are embedded. They show broad ecological amplitude, occurring over a range of topographies and geologic and edaphic types. **Large patch** habitats of from 50 to hundreds of hectares (e.g. cove forests, interior pine barren, sub-boreal spruce flat) nest within matrix types. They are generally associated with a particular environmental condition or ecological process that operates at smaller scales. **Small patch habitats** of just a few hectares, or less (cliff, basin wetland, serpentine barren), occur in distinct and discrete environments that have dominant effects on natural community development, and often support rare species with specialized ecological requirements. Some systems that tend to track river networks have a **linear** configuration, and can be small or large. This four-level size/shape characterization is flexible, as systems can occur at matrix scale in the center of their distribution and as a patch type at their range edge.

Naming conventions for ecological systems specify their home biogeographic region (NatureServe Division) and dominant cover type, or some indication of edaphic association or environmental setting. The three Divisions in the Northeastern US are the Laurentian-Acadian, the Central Interior and Appalachian, and the Atlantic Coastal Plain; examples of system designations are Central Appalachian Dry Oak-Pine Forest, North Atlantic Coastal Plain Pitch Pine Lowland, Appalachian Shale Barren, and Laurentian-Acadian Alkaline Conifer-Hardwood Swamp.

Ecological systems vary among ecoregions in the Northeast; for example, a dominant matrix forest type in one ecoregion might occur as small patches in another, or disappear entirely. We also understood in advance that some habitats in the classification would be difficult to map either because they occurred at too small a scale or because a credible model of their distribution required data we lacked, such as finely mapped soil types. Our first resource for the mapping project were documents prepared by NatureServe ecologists cataloguing ecological systems in the region, with information on home biogeographic range, distribution across subsections and states, scale of occurrence, composition and ecological setting. For more information on the NatureServe ecological system classification, go to http://www.natureserve.org/explorer.

CHAPTER

2

METHODS – DATA PREPARATION

Project Area

We mapped the entire Northeast and Mid-Atlantic region of the United States, covering 13 states (WV, VA, MD, DE, PA, NJ, NY, CT, RI, MA,VT, NH, ME). This is an area of almost 62 million hectares (155 million acres) spanning 11 degrees of latitude from the Virginia-North Carolina state line to Maine's northern border with Canada (Figure 1). The region is an area of tremendous physiographic, geologic, and biological diversity, and has a long human history as well. The ancient Appalachian Mountain chain is the oft-described "backbone" of the Northeast, connecting smaller ranges like the Cumberlands and Alleghenies of Virginia, West Virginia, and Pennsylvania, the Catskills and the Adirondacks of New York, the Green and White Mountains of northern New England. A number of large rivers steeped in American history drain the region, from the Penobscot and the Kennebec in Maine to the Potomac and the James in Virginia. Maritime and coastal plain lowlands, the low hills of the piedmont, and the more extreme mountain environments, all support a complex array of upland and wetland habitats. Seventy-eight percent of the region is currently in natural or semi-natural cover, 17% is in cropland or pasture (a figure that has been considerably higher historically in parts of the Northeast) and 5% is developed. The latter includes scores of large population centers, including the "megalopolis" (Gottman 1961) described as running from Boston to Washington DC.

The region's complex set of geophysical environments, including high granite mountains, limestone valleys, shale slopes, basalt ridges, silt or clay plains, coastal sand flats, and many others, determine the range and variety of habitats found (Anderson and Ferree 2012). These have formed as a result of geomorphic processes operating over vast time scales and relatively more recently, and over large and small spatial scales. A map of Northeastern habitats tracks our understanding of these settings and processes, and how they shape distributions of natural communities across Northeastern landscapes.

Structuring the Analysis - Ecoregions

We based our geographic mapping framework on The Nature Conservancy's ecoregions (TNC 2012, Groves 2003), which were developed from the USDA-Forest Service's spatially hierarchical classification of ecological map units (Avers 1994, Bailey 1995, ECOMAP 1993). Ecoregions are large areas of the earth's surface that are similar in vegetation patterns and faunal distributions (Figure 1). They are defined by climatic factors like precipitation and temperature patterns, along with large scale geologic and physiographic structure, soils, and vegetation cover types. We partitioned the Northeast into seven mapping regions along ecoregional lines, combining some adjacent regions when there were efficiencies to be gained and when it seemed ecologically reasonable to do so. The seven regions used in the mapping process are much smaller than, and largely nest within, the three NatureServe Divisions used as a regional framework for the habitat classification system (Figure 2). They were: 1) High Allegheny Plateau Ecoregion; 2) Lower New England/Northern Piedmont Ecoregion; 3) Northern Appalachian/Boreal

Forest and St. Lawrence-Champlain Valley Ecoregions; 4) North Atlantic Coast and Chesapeake Bay Lowlands Ecoregions; 5) Northern Lake Plain (Great Lakes); 6) Central Appalachian Forest (including southwestern Pennsylvania and all of West Virginia); and 7) the Piedmont and Mid-Atlantic Coast Ecoregions in Virginia.

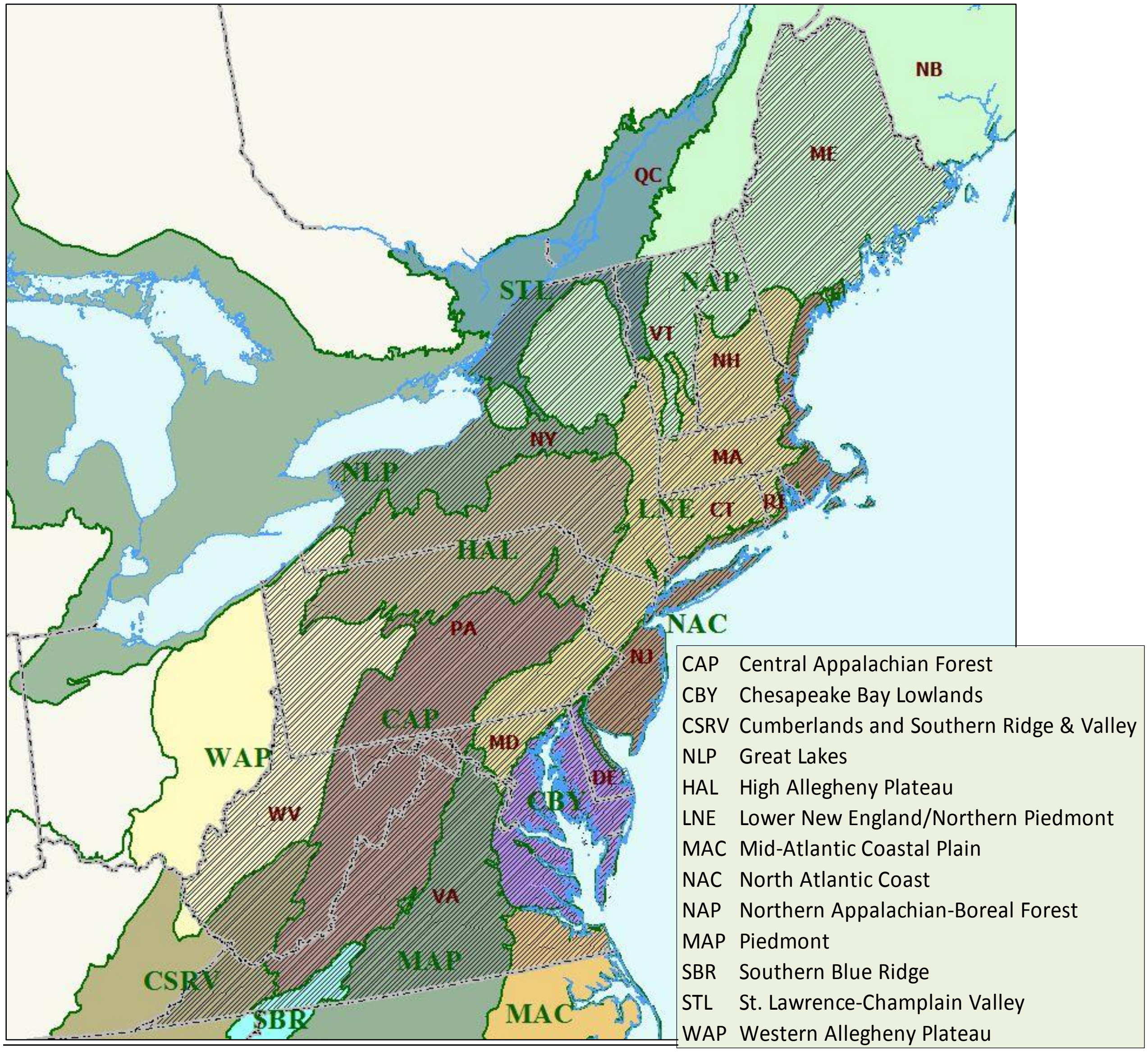


Figure 1: Ecoregions in the Northeast. The 13 state project area is symbolized with a diagonal hatch.

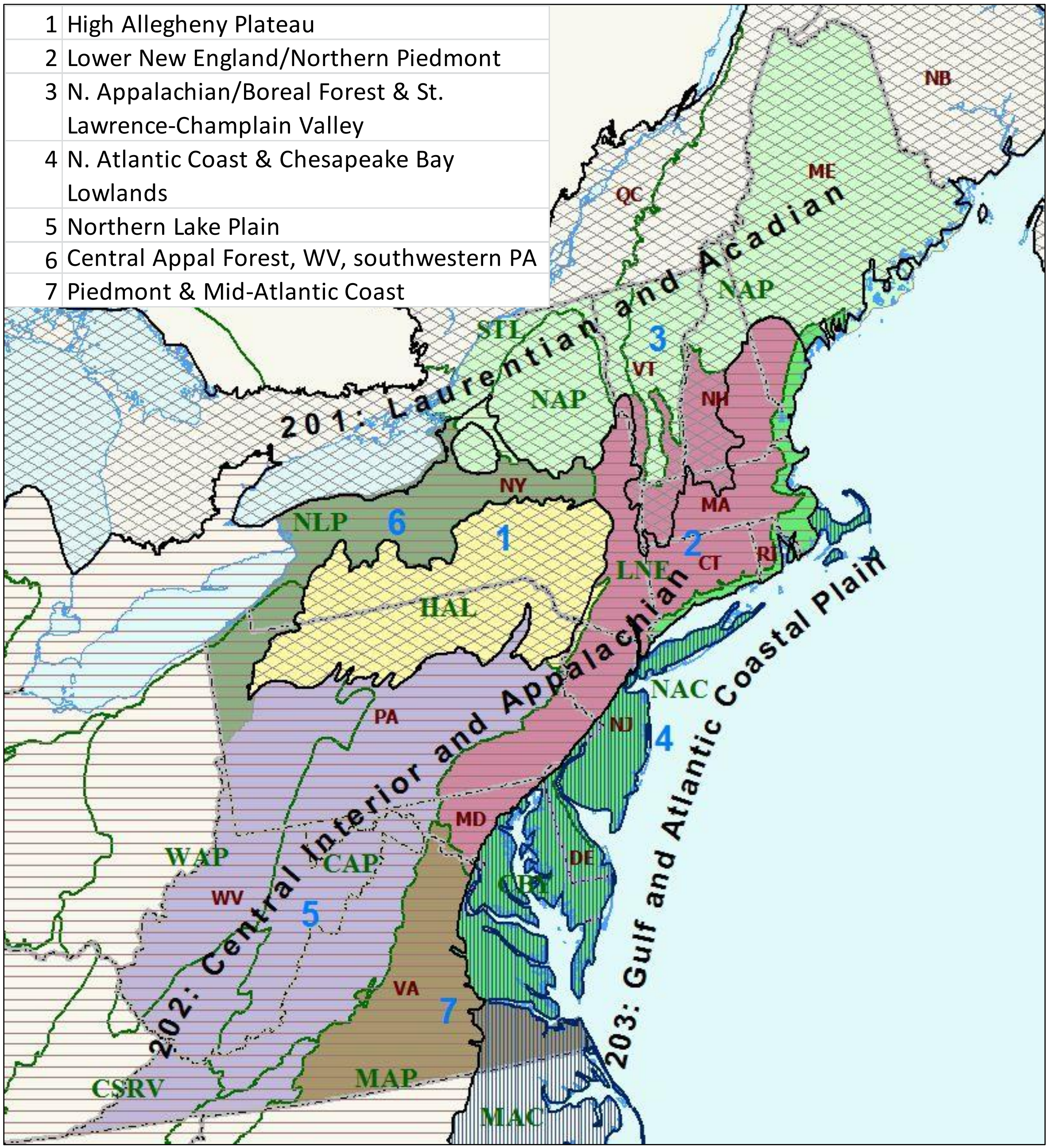


Figure 2: Seven mapping subregions for the Northeast Terrestrial Habitat Map project. Subregions are in color, and numbered in the order in which they were mapped. Overlay of the 3 regional NatureServe Divisions: Laurentian-Acadian in diagonal cross hatch, Central Interior and Appalachian in coarse horizontal hatch, and Gulf and Atlantic Coastal Plain in fine vertical hatch. Ecoregional lines in green, where they are not overlaid by division lines.

Overview of the Mapping Process

Within each ecoregion, we applied a consistent method, developed and refined over a three-year period, to create the terrestrial habitat map. We mapped the large-scale matrix-forming forest systems first, then the upland patch-scale systems that are embedded in the matrix, then the wetland systems. The wetland and patch systems were merged over the matrix systems to come up with the final ecoregional map.

The mapping process for each ecological region followed a seven step sequence:

1) Compile datasets of environmental variables for the region (topography and elevation, geology, climate, land cover, etc.)

2) Develop a list of ecological systems, then use literature and expert review to determine their distribution, scale, landscape pattern, and ecological character.

3) Compile plot samples of terrestrial habitats from Natural Heritage Programs, Forest Inventory Analysis points, and other sources. Crosswalk and tag all samples to the appropriate ecological system.

4) Develop distribution models for the matrix-forming forest habitats using a classification and regression tree analysis of classified plot samples on the environmental variables compiled in step 1.

5) Transfer the matrix forests information onto the landscape using landform-based units.

6) Develop distribution models for the upland patch systems (barrens, glades, cliffs, etc.) and wetland patch systems (swamps, marshes, bogs, etc.) using plot samples and relevant biophysical variables.

7) Assemble all models into one ecoregion-wide map and develop legend.

Environmental Variables

We compiled 71 ecological variables related to geography, geology, elevation and topography, climate, and landcover. All but a categorical aspect variable and ECOMAP section and subsection variables were continuous, and all but the geographic and climate variables were represented as 30 meter grids. These variables were all spatially continuous for the region, and were derived from a wide range of datasets compiled over a variety of scales (Appendix 1). Additionally, we used three datasets for regional wetlands and streams. The ecological variables used are known to have a direct (or indirect) bearing on the distribution of northeastern vegetation communities, and to explain biologically-important variation in the region (Beauvais et al. 2006). Because all variable datasets had to cover the entire study area in digital form, we were limited to regional-scale datasets. GIS processing steps for some derived variables and indices appear in Appendix 2.

Geography

We used latitude and longitude, and sections and subsections from the USDA-Forest Service’s ECOMAP classification (ECOMAP 2007).

Geology

We created a spatially comprehensive regional dataset of geology classes by obtaining digital bedrock layers in vector format for each state and grouping the bedrock units (from 100 to 350 units per state) into nine ecologically meaningful classes based on genesis, chemistry, weathering properties, and texture (see Anderson and Ferree 2012 for more detail). Seven classes were bedrock-based (acidic sedimentary, acidic shale, calcareous sedimentary, moderately calcareous sedimentary, acidic granitic, mafic, ultramafic) and two were based on surficial deposits (deep coarse sands, deep fine silts/clays). Individual source maps were compiled at scales ranging from 1:125,000 to 1:500,000. We gridded the classified maps for each state at 30 meter resolution, and assembled them all into one regional dataset.

Elevation and Topography

We compiled a regional elevation data layer directly from USGS 30 meter digital elevation models (DEMs). We used this dataset to quantify elevation, slope, aspect, and land position, and to create landforms (Appendix 3). The DEM was also used to quantify annual solar inputs for each 30 meter cell using the solar radiation tool in ARCGIS (ESRI, 2009). The calculation integrates topography, latitude, elevation, atmospheric effects, and daily and seasonal shifts of the sun angle to predict annual solar inputs in watt-hrs/m^2.

Climate

We compiled eight bioclimatic variables known to affect regional biogeographic patterns from the climate dataset WORLDCLIM (WORLDCLIM 1.4, 2005). They were calculated from monthly temperature and precipitation means recorded over a 30 year period, and include: annual range in temperature; maximum temperature in the warmest month; minimum temperature in the coldest month; mean annual precipitation; precipitation in the warmest quarter; mean temperature in the driest quarter; mean diurnal range in temperature [mean of monthly (max - min)]; and precipitation coefficient of variation. The parent and derived variables are grids at one kilometer resolution.

Landcover and Canopy Density

We used the National Land Cover Database (NLCD 2001), developed by a consortium of public agencies led by the USGS (MRLC 2001), as our primary measure of existing vegetation physiognomy and structure. The data uses a 15-class land cover classification scheme consistently across all 13 states of the Northeast at a spatial resolution of 30 meters. The NLCD is based primarily on the unsupervised classification of Landsat Enhanced Thematic Mapper circa 2001 satellite data. Estimates of canopy density were included with the NLCD 2001 and were developed based on Yang et al. (2001).

Water and Wetland Features

We used the National Hydrography Dataset Plus (NHDplus: USGS & US EPA, 2006) as the base data for regional stream networks. NHDplus is derived from stream data compiled at the nominal scale of 1:100,000, and has a number of “value-added” attributes that can be used to calculate such things as size of draining area for each stream reach. The National Wetlands Inventory (NWI) was used as base data for building models of wetland habitats, along with the two wetland classes in the NLCD2001. NWI wetland polygons were mapped from aerial imagery onto a base of USGS topographic quadrangles by the US Fish and Wildlife Service (USFWS 2008) and are intended to be used at scales of 1:24,000 or smaller.

For our purpose we converted the NWI vector dataset to a 30m grid. To help in the mapping of floodplain habitats, we compiled maps of the active river area (ARA, Sheldon 2009, based on Smith et al. 2008) for all small to large rivers. The active river area is the zone of dynamic interaction between the water and the land through which it flows, and includes the river meanderbelt, floodplain zone, riparian wetlands, and fluvial terraces.

Unavailable Data

We were unable to obtain certain spatial datasets related to habitat structure and soils (texture, pH, depth to restrictive layer), at the resolution needed for fine-scale, region-wide modeling. This limited the accuracy of the models for certain patch-scale communities that are defined in part by structure and soils (e.g. interior pine barren, various glades and woodlands, wet flatwoods).

Samples of each Habitat Type

We compiled over 70,000 field-collected samples of natural communities from a variety of sources, including state Natural Heritage Programs, the USDA-Forest Service Forest Inventory and Analysis Program, stand data from state and federal forests, and NatureServe vegetation maps. These data were in a variety of spatial formats ranging from points to polygons of various sizes and configurations (Figures 3a, b, & c). The level of information pertaining to species composition, ecological character, and relevant classification details varied widely among datasets as well. To create a consistent dataset for modeling purposes, we converted all polygon samples to points using centroids for small polygons under 100 acres; within larger polygons, we spatially stratified point samples, avoiding obviously inappropriate landcover and landscape features (low wet areas for dry oak forests, coniferous woods for hardwood systems, etc.).

Natural Heritage Program Data

Over 50,000 community “occurrences” were generously provided by the Eastern US State Natural Heritage programs for use in this project. Natural Heritage Programs build and maintain a spatial database of locations of plants, animals, and natural communities of high biodiversity value. Although the databases are typically focused on rare, threatened, or endangered communities, most states track the locations of high quality examples of common communities as well. The community locations are almost all derived from field inventory and each location is considered to be an occurrence of an “element of biodiversity” or an Element Occurrence (EO). At a minimum, a community occurrence had a point location and an assigned community type based on the state classification system. There was usually a quality rank and a brief description of the occurrence as well. A more detailed community occurrence may have information on the composition and structure of the community, a description of the site, and information on the occurrence’s landscape context and condition. Additionally, survey plots with just a point location and community name were available from many programs. Some states also perform vegetation mapping on public lands or in areas of great ecological interest, in which polygons represent the approximate boundary of natural communities of interest and these were incorporated also. Community occurrences, inventory plots, and natural community maps were freely shared by the Heritage programs and used with permission.

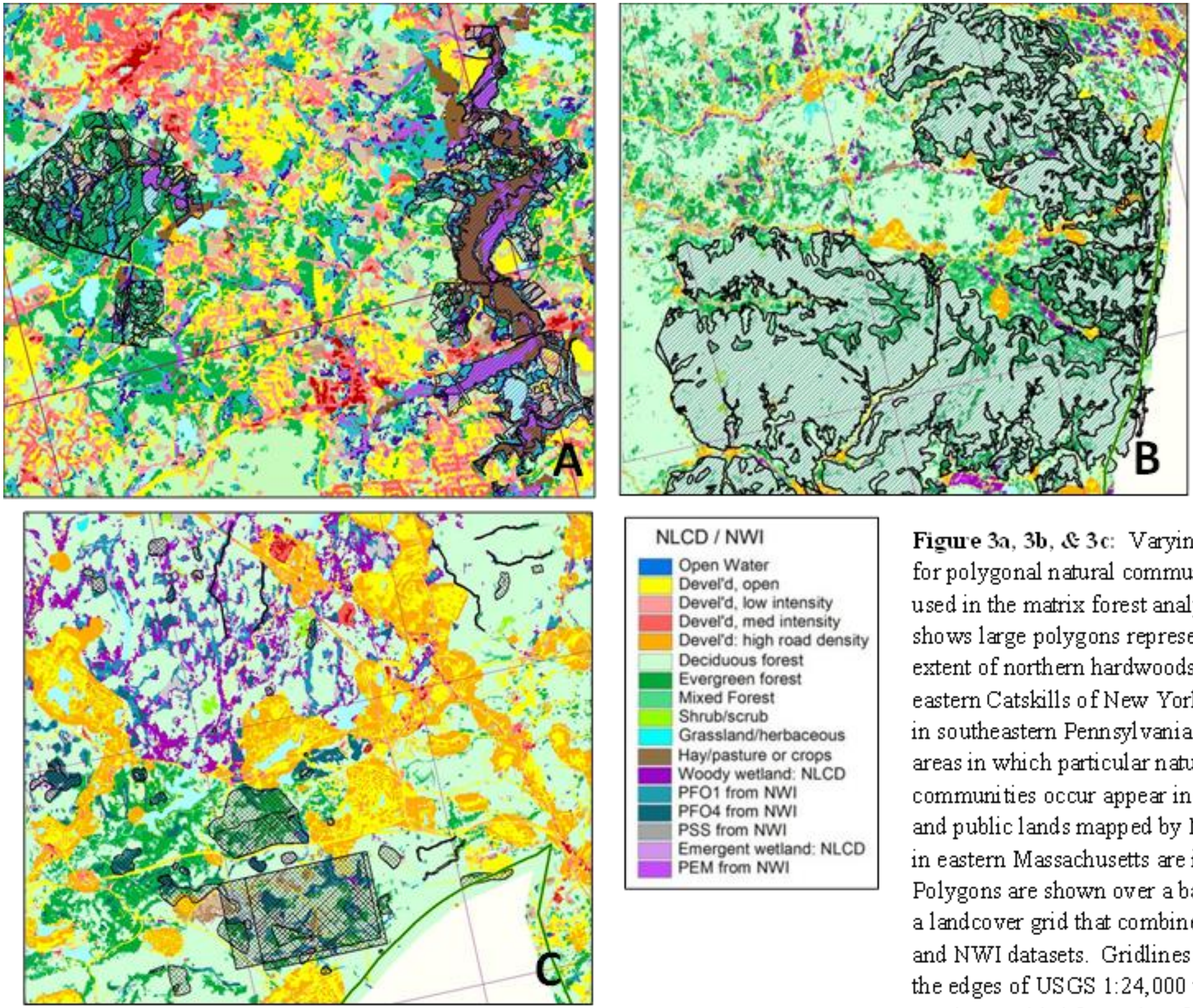


Figure 3a, 3b, & 3c: Varying formats for polygonal natural community data used in the matrix forest analysis. Fig. 3a shows large polygons representing the extent of northern hardwoods in the eastern Catskills of New York; polygons in southeastern Pennsylvania representing areas in which particular natural communities occur appear in Fig. 3b; and public lands mapped by NatureServe in eastern Massachusetts are in Fig. 3c. Polygons are shown over a background of a landcover grid that combines the NLCD and NWI datasets. Gridlines demarking the edges of USGS 1:24,000 topographic quads are added for scale reference.

NatureServe National Park Community Maps

NatureServe has created vegetation maps for public lands in the Northeast, including national parks, national historic sites, and national wildlife refuges, using a standard method and classification system (Grossman et al.1994). The data consists of polygons mapped to the plant association level of the National Vegetation Classification (NVC). Associations usually represent a finer level of ecological mapping than ecological systems, but can be aggregated up to the ecological system level.

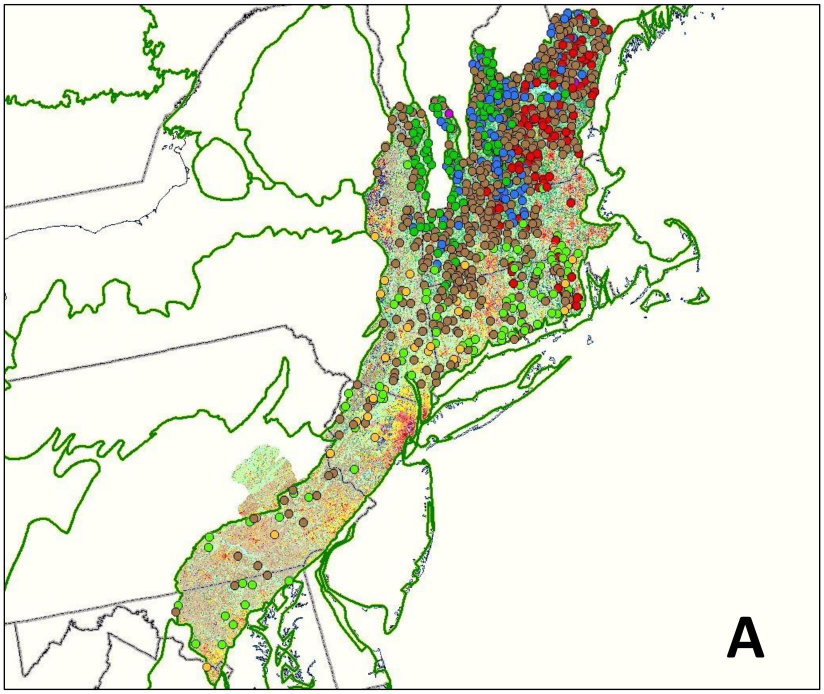
Federal and State Forest Stand Data

Spatial datasets of forest stands were provided by the Green and White Mountain National Forests in northern New England. Forest Service analysts assign stand polygons (mean size 41 acres in the Green Mountains and 53 acres in the White Mountains) to a forest type class such as White Pine/Northern Red Oak/White Ash, Northern White Cedar, or Sugar Maple/Beech/Yellow Birch/Red Spruce. The Pennsylvania Bureau of Forestry provided a similar spatial dataset for state lands in the southern High Allegheny and northern Central Appalachian Forest Ecoregions. Pennsylvania Forest stand polygons, averaging about 35 acres, carried a forest type designation similar to the national forest classes. Most state forest lands were not available in digital map format.

Forest Inventory and Analysis Plots

The USDA-Forest Service provided plot data for over 21,000 points in the Northeast. They collect these data on a rotating basis every few years from a set of randomly selected points nationwide as part of their Forest Inventory and Analysis (FIA) program. The FIA program maintains a sizable database of stand variables, including the basal area of individual tree species in each plot and a field-assigned and an algorithmically-assigned stand type. We obtained information on the exact location of each plot through a confidentiality agreement, as FIA data is typically not released with actual locations out of privacy concerns. These data were an excellent complement to data supplied by Heritage Programs, which do not collect as many records of common matrix-forming forest occurrences. Due to the random sampling scheme, many FIA plots represent disturbed areas, old fields, recently logged sites, and other non-natural and semi-natural areas. To adjust for this, we applied systematic criteria based on landcover and roads, along with stand variables related to stand age, tree sizes, stocking levels, total basal area, and overstory tree composition, to identify plots that were significantly altered from a natural state. These were removed from further analysis. The final set of FIA data points were unevenly distributed across ecoregions (Figure 4a).

In total, we compiled roughly 900 to 2000 useable FIA plots per ecoregion, fewer in the coastal plain where agriculture and urban/suburban development so often dominate the landscape. Combined sets of sample occurrences from all sources, for all ecoregions, showed similar uneven distribution, also reflecting patterns of land use (Figure 4b).



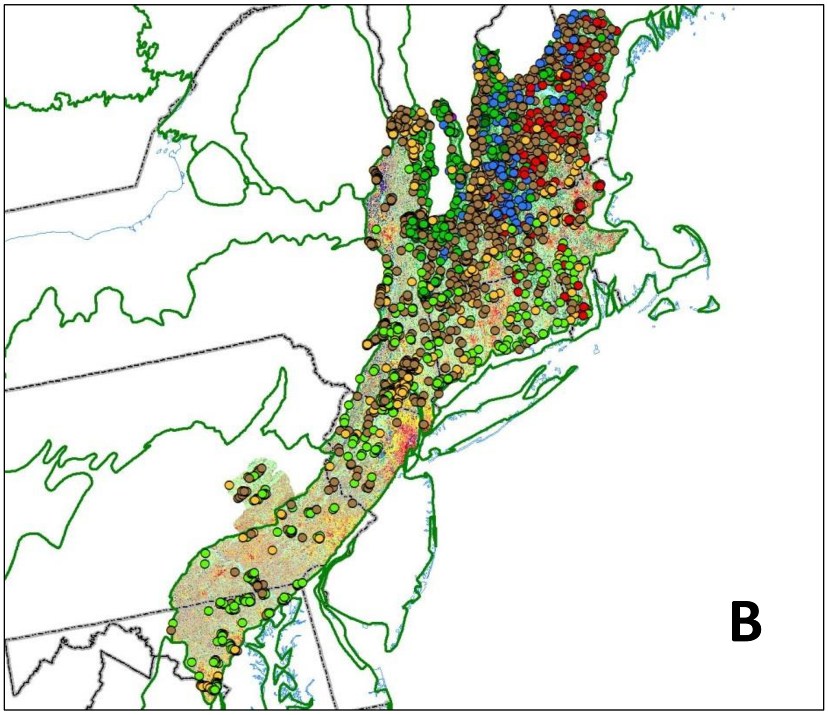


Figure 4 a &b: Known sample points for the Lower New England/Northern Piedmont Ecoregion (LNE). In Fig. 4a, FIA plots screened for "naturalness" show an uneven distribution, reflecting patterns of landuse across the largely humanized landscapes of this region. The pattern is denser, but the unevenness persists, when all known sample points from all sources are plotted (Fig. 4b).

Preparing the Samples

Assigning Samples to an Ecological System

All sample points had to be crosswalked and tagged to the appropriate ecological system in the Northeast Terrestrial Habitat Classification. We use the word “crosswalk” because we did not have the full plot data for each sample but only the community name that was assigned to the sample by the field ecologist who collected it. Thus, our goal was to map the elements from the original classification scheme to equivalent elements in the regional classification scheme, but because the classification schemes were not completely equivalent, this presented challenges. The various classifications were sometimes based on different ecological criteria, or on different spatial scales, and often the more precisely described natural communities could fit comfortably in several of the more broadly-described ecological systems. However, the correct location and crosswalk of the samples was critical to the mapping, as important aspects of ecological context can change dramatically in very short distances.

We approached the crosswalking of State Natural Heritage data systematically. First we developed a simple crosswalk tying state community names to the most likely ecological system, and we tagged all occurrences to ecological system based on the community name assigned to the plot samples. Next, we overlaid the tagged occurrences with range maps of each ecological system (by section or subsection, Gawler et al.2008) to identify samples out of the expected range. To help with problematic samples we overlaid all samples on the environmental variables, and attributed them with elevation, bedrock type, landform, topographic position, insolation, distance to water, land cover, canopy density, state, and geographic subsection. From this we could determine the typical environmental signature of a given community and identify anomalous occurrences that fell outside of the expected ecological signature. For instance, an occurrence representing a low elevation valley bottom forest that fell on a high ridge-top. Ecological signatures were found to be relatively consistent within a state, less so across states; but by combining the environmental information obtained at sample plot locations with the descriptive information collected by field ecologists on composition, structure, and ecological setting, we were usually able to assign occurrences to the most likely ecological system with a reasonable level of confidence. We were fortunate to have expert help from NatureServe staff and state NHP ecologists for crosswalking task, but in the end all samples were processed and checked through our own interpretation of these systems. Outlier samples that did not fit within the concept of the ecological system or were far outside the typical ecological signature were omitted.

To classify the FIA data into ecological system types, we ran a cluster analysis (PCORD, McCune and Grace 2011) using the attributes of overstory tree species composition, subsection of occurrence, elevation, slope, and topographic position, to aggregate plots with similar composition and environmental settings into groups. We then reviewed the groups and assigned them to one of the matrix-forming ecological system types based on their dominant characteristics. This approach was possible because the sample points contained the composition and abundance of all tree canopy species. Data from the state forests lacked this detail and were crosswalked into the ecological system classification based on the assigned forest type using the same method as for the Heritage element occurrences.

We often had to make decisions about the best-fit ecological system type for samples that could be reasonably attached to more than one habitat type. A state, for example, might put all their dry-mesic oak-hickory communities in one class but from the regional perspective the occurrences in different parts of the state might fit better in one of four different oak systems (e.g an occurrence on a protected lower slope in the northwestern part of the Virginia Piedmont may fit best in the Northeastern Interior Dry-Mesic Oak Forest; one on a warmer upper slope farther south might fit the Southern Piedmont system. When the crosswalk appeared ambiguous or too broad, we looked at the physiographic province of each occurrence, and its elevation, topographic setting, and substrate, to help identify the best crosswalk.

Most of the sample tagging effort was directed at matrix forest types which totaled from 1400 to 4000 per ecoregion. The tagging of large and small patch habitats was generally more straightforward reflecting their more precisely defined ecology. Likewise, the relationship of wetland occurrences from the states and the fairly broadly defined wetland ecological systems was also simpler, and enhanced by further information from the NWI attributes.

CHAPTER

3

Methods – Mapping the Habitats

We mapped the 15 matrix-forest habitat separately from the patch forming uplands and wetland habitats, and we describe the methods separately below. Out methods were explicitly developed to account for the multiple-scaled nature of the classification, and we expected that the environmental information would prove useful at varying scales. For example, the geographic variables, climate variables, and elevation, would likely be important for making broad-scale distinctions in possible habitat ranges; and that smaller-scale factors like local topography, insolation, and distance to water, would be more useful making distinctions at finer scales.

Matrix-forming Forest Types

Matrix-forming forests offered a particular challenge for modeling because of their wide ecological signatures and the subtle ways they grade into each other. The process we used to map these dominant forest systems was the most complex and time-consuming part of the project.

For each ecoregion, we began with a list of matrix-forming habitat types present in the ecoregion and a compiled set of sample points crosswalked to the appropriate types. In GIS, we constructed 100 acre circles around each sample point and overlaid them on the environmental variables to attribute them with the full set of 71 variables described above (Appendix 1, Figures 5a, 5b). We used 100 acre circles because the matrix forest systems by definition occupy large contiguous landscapes, and we wanted to take a landscape, rather than a pixel-by-pixel, approach to mapping them. Our intention was to use data from the surrounding 100 acre landscape to inform our prediction of the matrix forest type at that point. This is in contrast to building distribution models for single species or for small-patch habitats, when point-sampling environmental variables at the exact location of the known occurrences may be more appropriate.

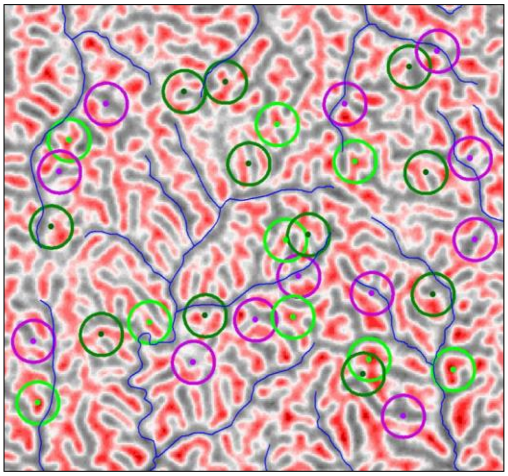


Figure 5a: 100 acre circles around plot samples that have been tagged to a matrix forest system type. In this stream- dissected Western Allegheny Plateau landscape in West Virginia, points and 100 acre circles for known occurrences of Central Appalachian Dry Oak-Pine Forest (CADOPF) are in light green, for Northeast Interior Dry-Mesic Oak Forest (NEIDMOF) are in darker green, and for South-Central Interior Mesophytic Forest (SCIMF) are in purple. The background gridded variable is a local mean of the land position index; darker greys indicate places on the landscape that are very low in relation to their surroundings, and dark reds are the tops of hills and ridges. If index values within the 100 acre circles for the 3 forest types tend to be different, this index could be a valuable predictive tool for habitat classification. See also Figures 8a-8d.

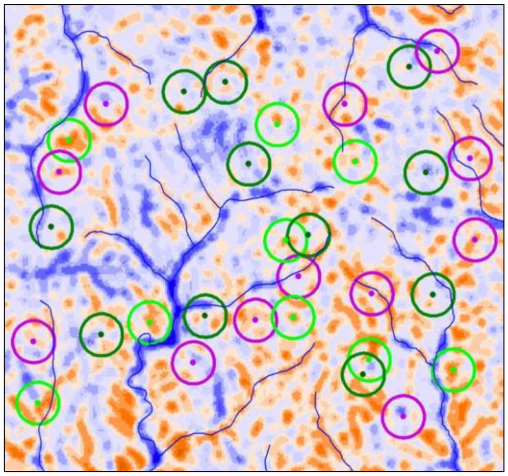


Figure 5b: The variable grid in this figure is a local mean of a rugosity index that tracks the topographic roughness of the landscape; cool colors signify a locally muted landscape structure, warm colors a more rugged landscape. Again, the ability to build accurate models for different systems occupying different landscape settings is enhanced when the contrast in variable values is high between the sampled habitat types. See also Figures 8a-8d.

Random Forest Classification

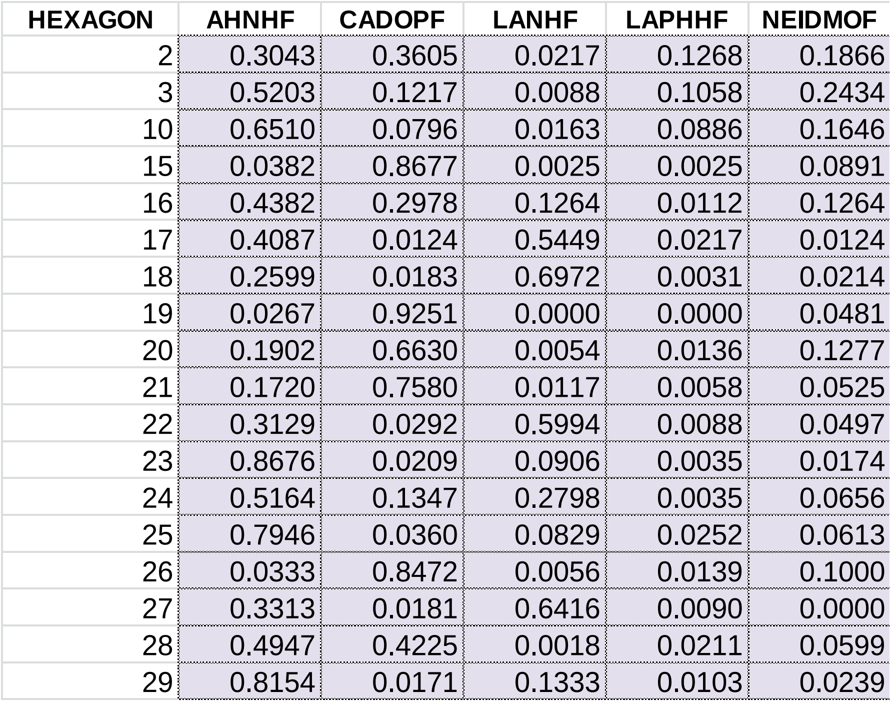
To determine which variables were the best discriminators of the various matrix forest types and to classify unknown areas into a forest type we used the classification and regression tree analysis package RandomForests (RF) in R (Liaw and Wiener 2002). RF is part of the family of models designed to differentiate among elements with different categorical classes (in this case habitat types) using a set of attributes provided by the user (in this case the ecological variables). The program differentiates the forest types among our classified forest samples based on the attributes of the 100-acre circles and then predicts the most likely matrix forest type for a set of unclassified 100-acre samples using the same attributes. RF has been used with good results for ecological mapping (Prasad et al. 2006; Leng at al. 2008; Cutler et al. 2007; Beauvais et al. 2006), and has been shown to be particularly adept at modeling complex, non-linear relationships among explanatory environmental variables. The method is robust to correlated variables and it accepts a mix of categorical and continuous variables.

The RF software uses binary recursive partitioning to build a decision tree that forces the members of the heterogeneous parent group (all samples) into a number of subgroups (samples of each matrix type) that are as homogeneous as possible, based on values for the variables supplied, in this case the environmental variables. The program gets its name because for every modeling run it builds many classification trees (a “forest”) using subsets of the full data and a randomly drawn subset of the environmental operated-supplied variables. At every decision tree node, it evaluates all possible numeric or categorical splits, for every variable available to it, selecting the environmental variable and actual value of that variable that result in the cleanest split in the occurrence classes at that node. The result is that one of the products of the model is an importance value for each environmental variable with respect to how important that variable is to differentiating between the types.

We fed the program all the 100-acre circles classified to their confirmed matrix type and containing their accompanying 71 ecological attributes. The program interprets the classified 100 acre circles of a given forest type as presences of that type and all occurrences of other types as absences. Thus, the software partitions the entire set of samples among all the possible matrix forest types and to generate the probabilities of occurrence for each type within each circle based on the environmental variables (Table 1). These probabilities were then used to translate the analysis output into a map of matrix forest systems.

A key feature in the RF program is a built-in accuracy assessment. The program withholds about a third of the total number of known sample occurrences during the construction of each of decision trees, and the withheld samples are used to evaluate the accuracy of each run. It does this by applying the predictive model to thus unused samples, predicting their forest type, and then quantifying the error. This internal error checking mechanism can be used to get an estimate of the classification error in the final model, and to understand which habitat types are the most likely to be confused.

We set the RF parameters to draw from the total of 71 environmental variables and use up to eight in each run. The results that gave the highest classification accuracies and greatest model stability over multiple model-building iterations generally had 800-1000 trees. We balanced the sample sizes to ensure an even distribution across types (see results and discussion).



HEXAGON	AHNHF	CADOPF	LANHF	LAPHHF	NEIDMOF
2	0.3043	0.3605	0.0217	0.1268	0.1866
3	0.5203	0.1217	0.0088	0.1058	0.2434
10	0.6510	0.0796	0.0163	0.0886	0.1646
15	0.0382	0.8677	0.0025	0.0025	0.0891
16	0.4382	0.2978	0.1264	0.0112	0.1264
17	0.4087	0.0124	0.5449	0.0217	0.0124
18	0.2599	0.0183	0.6972	0.0031	0.0214
19	0.0267	0.9251	0.0000	0.0000	0.0481
20	0.1902	0.6630	0.0054	0.0136	0.1277
21	0.1720	0.7580	0.0117	0.0058	0.0525
22	0.3129	0.0292	0.5994	0.0088	0.0497
23	0.8676	0.0209	0.0906	0.0035	0.0174
24	0.5164	0.1347	0.2798	0.0035	0.0656
25	0.7946	0.0360	0.0829	0.0252	0.0613
26	0.0333	0.8472	0.0056	0.0139	0.1000
27	0.3313	0.0181	0.6416	0.0090	0.0000
28	0.4947	0.4225	0.0018	0.0211	0.0599
29	0.8154	0.0171	0.1333	0.0103	0.0239

Table 1: Table of probabilities assigned by RandomForests to 100 acre hexagons representing unknown forest habitat types. Probabilities sum to 1 across rows. The "winning" habitat type for each hexagon is the one with the highest probability. Levels of confidence in classification outcomes, and the expected dominance of the "winning" habitat type in each hexagon, is reflected in the magnitude of the highest probability in each row. See results sections for forest code name which are derived from the first letter of each work (e.g. LANHF = Laurentian-Acadian Northern Hardwood Forest)

Predicting the Types onto the Landscape

To transfer the RF results from the 100 acre circles to a map of the region we created a set of 100-acre hexagons that covered and fully tessellated the full extent of the ecoregion (125,000 to 400,000 depending on ecoregion). Hexagons have been widely used in analyses of landscape pattern because they've been shown to be compact and efficient samplers of environmental phenomena (White et al. 1992, Birch et al. 2007). We attributed the hexagons with the same set of 71 variables calculated for the 100-acre circles around sample points, then used the RF models to score each unclassified hexagon with a set of probabilities that it belongs to a given matrix forest habitat type (Table 1). When all the hexagons had been scored, we created a continuous representation of the matrix forest distributions across the region by assigning each hexagon to the matrix forest system with the highest probability of occurrence (Figure 6).

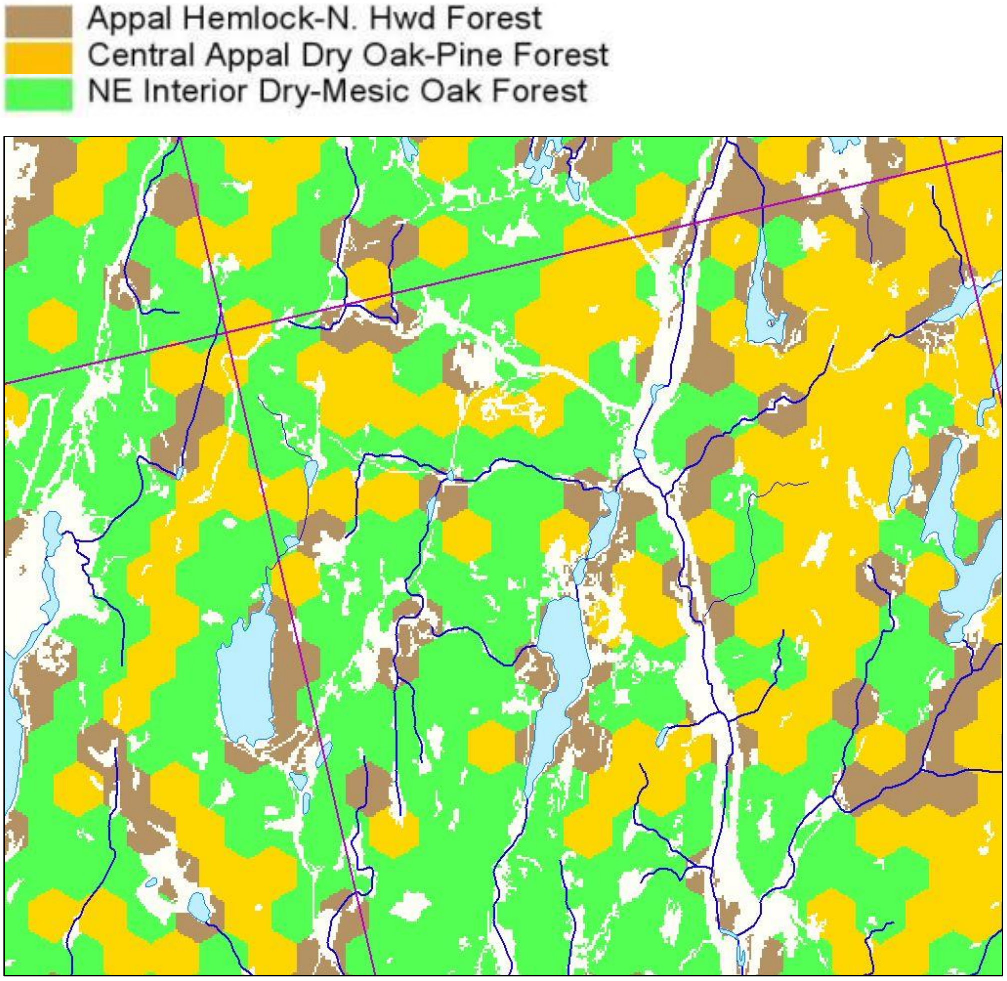
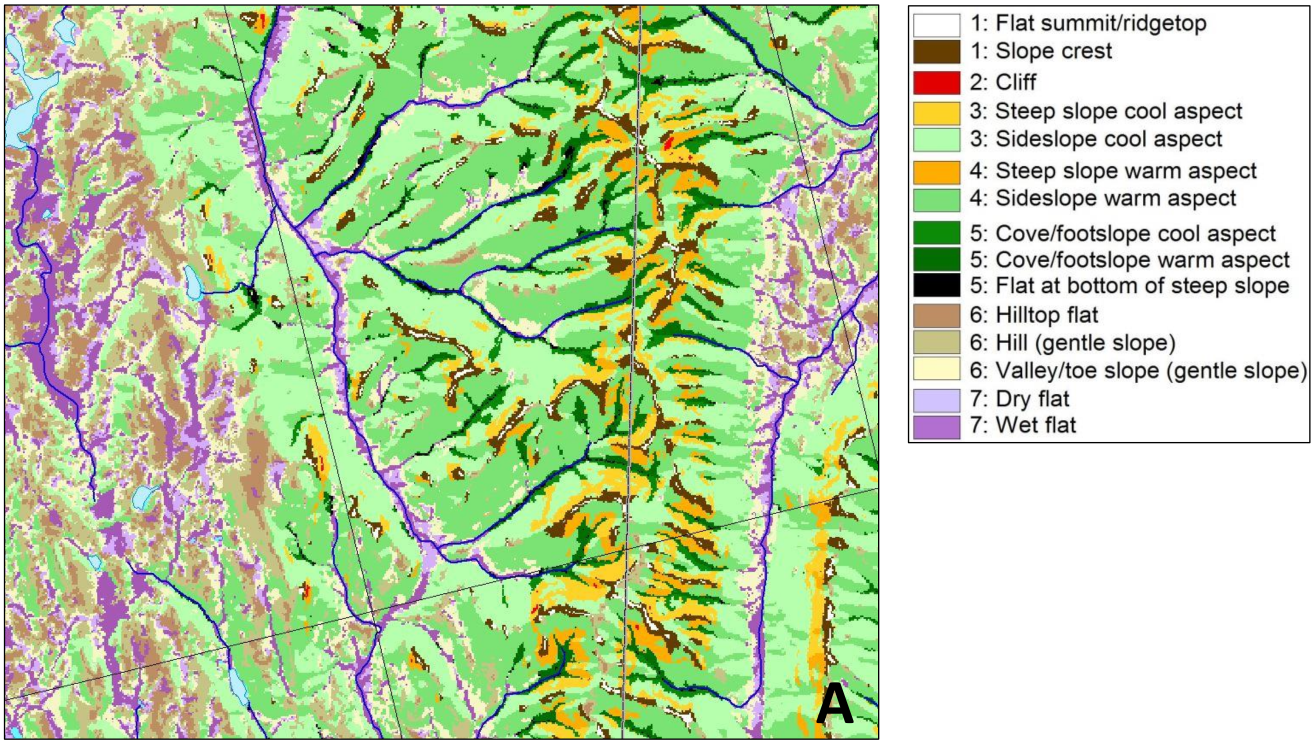


Figure 6: 100 acre hexagons classified to a matrix forest habitat type in an area in Harriman State Park in southeastern New York. White areas are developed or residential landcover. Gridlines demarking the edges of USGS 1:24,000 topographic quads are added for scale reference.

Transferring the Hexagon information to the Landform Units

The final step in mapping the matrix systems was to transfer the classification information from the 100 acre hexagons to corresponding natural landform units. In the Northeast, fine-scale landforms are uniquely suited as mapping units because they are relatively discrete facets of the landscape with homogenous ecological properties, and strongly determinant of ecological pattern and process across landscapes. They have been termed the anchor and control of terrestrial ecosystems (Rowe 1980), and the feature that contributes most to the unique ecological relationships and mappability of those systems (Bunnell and Johnson, ed., 1998). We created natural landforms, which we term “landscape units,” by simplifying our regional 15-part landform model of topographic features to a 7-part model (Figures 7a & 7b, Appendix 3). It was to these landscape units that we transferred the classification probabilities from the RandomForests analysis. .



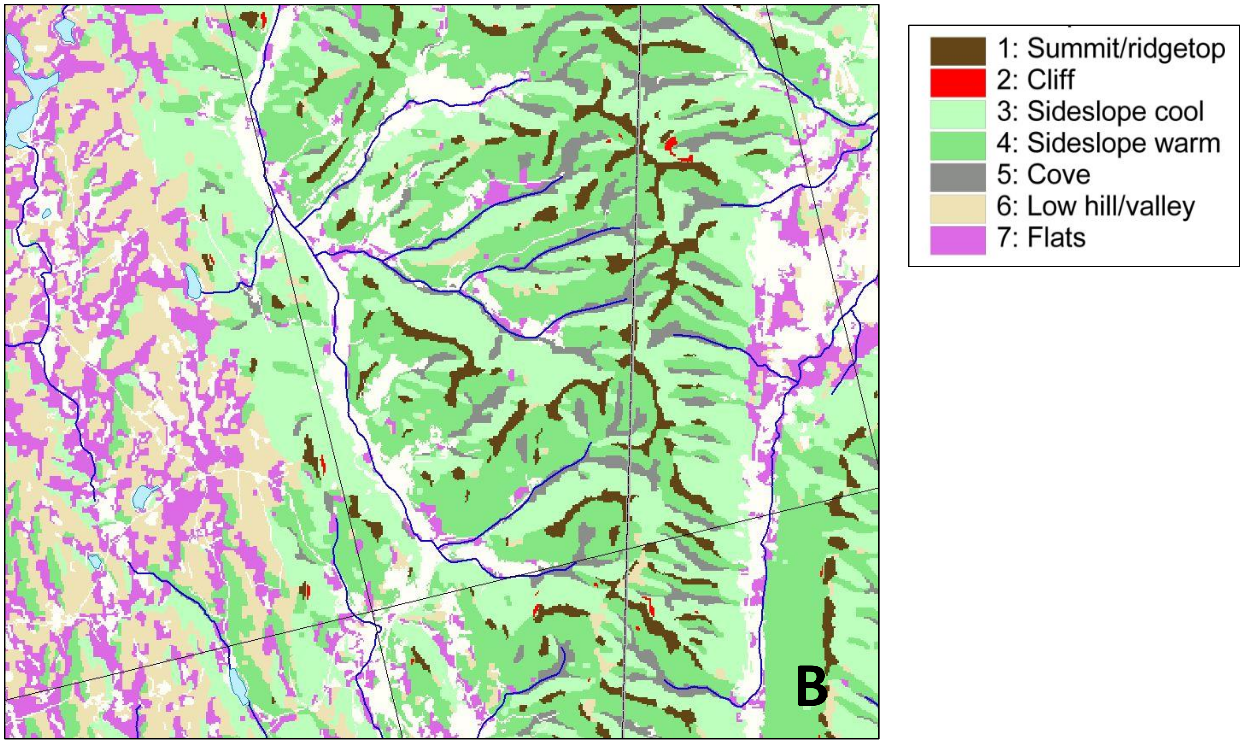


Figure 7a: 15-part regional landform model. The landscape units to which RandomForests-generated probabilities were transferred (Fig. 7b) were created by simplifying these landforms.

Figure 7b: Seven-part landscape unit model created from the more detailed landforms in Fig. 7a.

Transferring habitat assignments from 100 acre hexagons to landscape units was a two-step process. First we divided large landform units like the north-facing slope in Figure 7b into smaller units using the thematic segmentation function in the image processing program eCognition (Trimble 2011, Burnett C, Blaschke T 2003). We used its scaling parameter to limit output segments to a size roughly equivalent to our 100-acre hexagons or smaller. We then overlaid the classified hexagons on the landform unit segments, and identified the single hexagon that occupied the largest proportion of its area. We assigned the segment to the ecological system to which RF had classified that hexagon (Figure 8a, b, c).

In most cases the most likely forest type (highest probability out of all types) for each hexagon was clear; however, in some cases the “winning” probability did not exceed 0.5 and probabilities of occurrence for other matrix systems approached that of the winning system (Figure 9). Recognizing that these mixed probabilities were an ecological reality that in some cases represented a heterogeneous hexagon containing more than one matrix forest types, we developed a method to preserve this information and reflect those probabilities when the hexagon information was transferred to the landscape units.

The method was used where the hexagon overlapped more than one landform unit; it consisted of a set of decision rules to guides the assignments of ecological system types to the landform units within a hexagon. The rules were based on the ecological preferences of the matrix systems with the highest and second highest system probabilities in the hexagon and the type of landform units they overlapped. For example, consider a hexagon with close probabilities for Central Appalachian Dry Oak Pine Forest and Northeastern Interior Dry-Mesic Oak Forest (Figure 10). The first is a forest that prefers dry exposed settings and this was transferred directly to the dry warm landscape units in the hexagon: exposed summit and warm south-facing sideslope . The second system is found in more mesic settings and it was transferred to the cooler north-facing side slopes where it would most likely occur**.** In this way the information in a single hexagon was used to inform the transfer of two or more probable systems to the most appropriate landform unit. Figures 11a through 11d show how we partitioned and mapped aspects of landscape structure related to ecological patterns and processes. We used this structural information to guide the modeling and mapping of ecological systems.

In some cases we used a similar method within the overall distribution of a matrix forest habitat, to identify drier and moister variants, using the higher and lower land position ranges. In the final dataset those matrix types have drier, moister, and “typic” expressions that correspond to these land position differences.

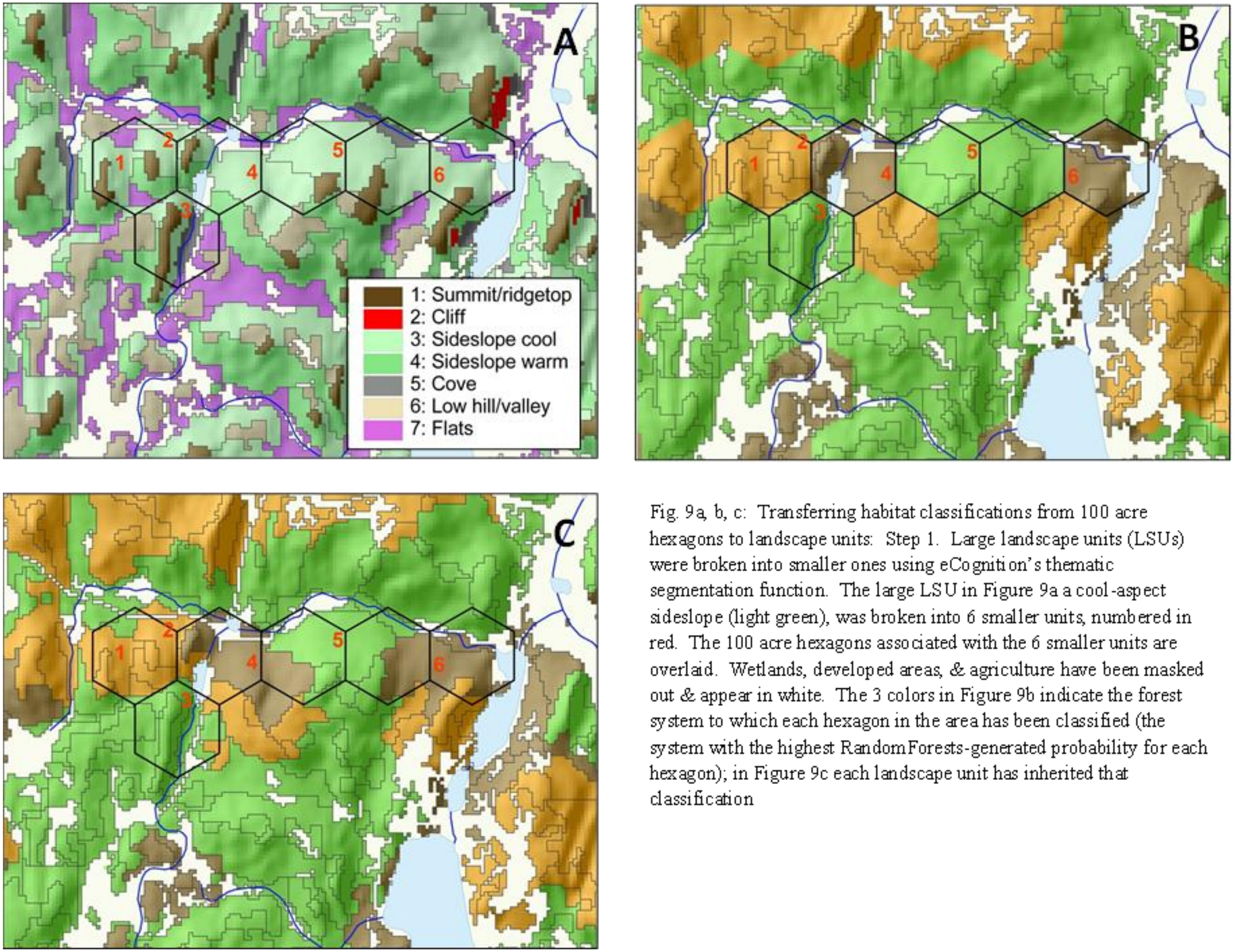


Fig. 9a, b, c: Transferring habitat classifications from 100 acre hexagons to landscape units: Step 1. Large landscape units (LSUs) were broken into smaller ones using eCognition's thematic segmentation function. The large LSU in Figure 9a a cool-aspect sideslope (light green), was broken into 6 smaller units, numbered in red. The 100 acre hexagons associated with the 6 smaller units are overlaid. Wetlands, developed areas, & agriculture have been masked out & appear in white. The 3 colors in Figure 9b indicate the forest system to which each hexagon in the area has been classified (the system with the highest RandomForests-generated probability for each hexagon); in Figure 9c each landscape unit has inherited that classification

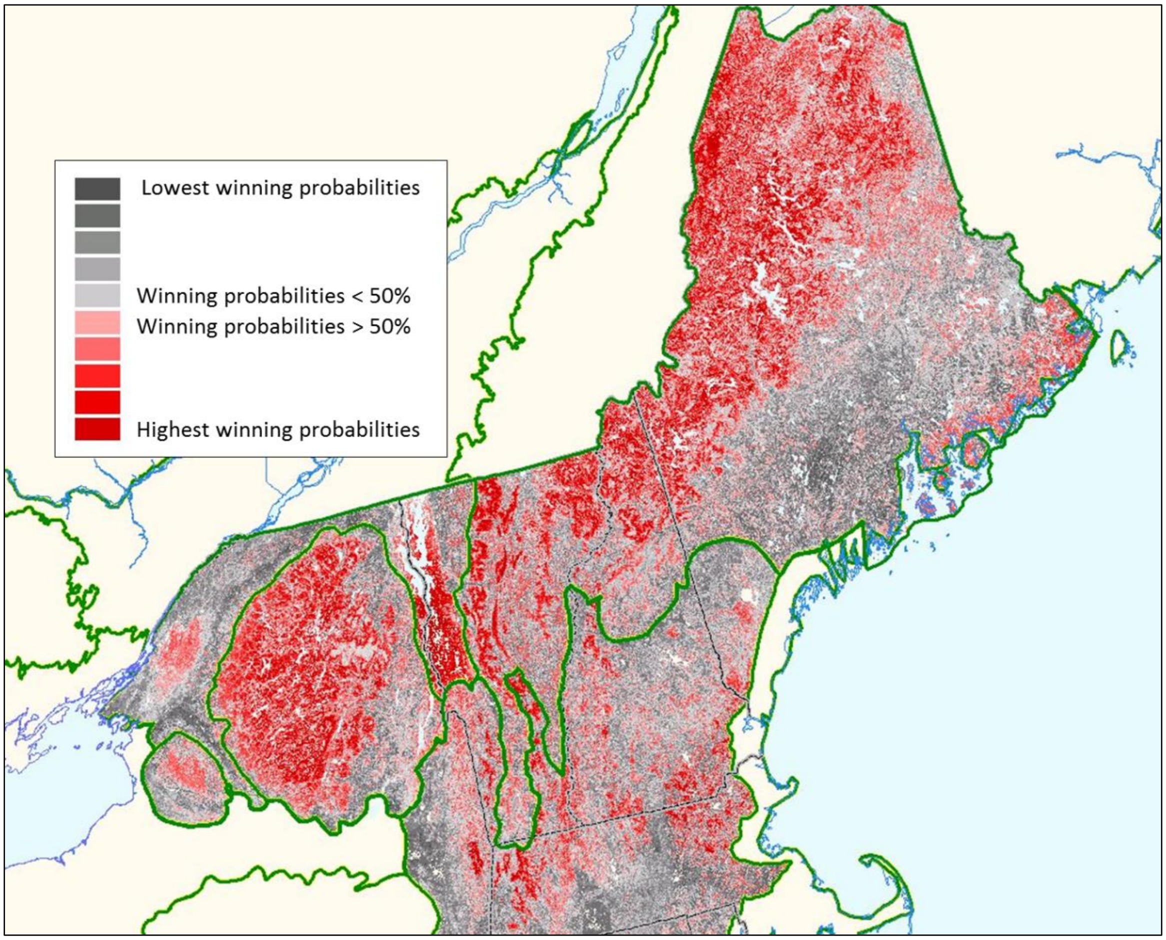


Figure 9: Maximum RandomForests-Calculated Probabilities for "Winning" Habitats in the 100 acre hexagons. In this map of northern New England & NY, the highest RandomForests-generated habitat probability for each hex is plotted: red tones indicate hexagons for which the "winning" habitat had a probability > 50% (highest probabilities in deepest shades of red); winning probabilities < 50% are in shades of grey. In the Northern Appalachian Ecoregion, less than 0.1 separated the highest and second highest system probabilities in 21% of the 100-acre hexagons; that number rose to 30% in the Central Appalachians and the rest of the large southwestern region. A habitat map for the Northeast should reflect those mixed probabilities.

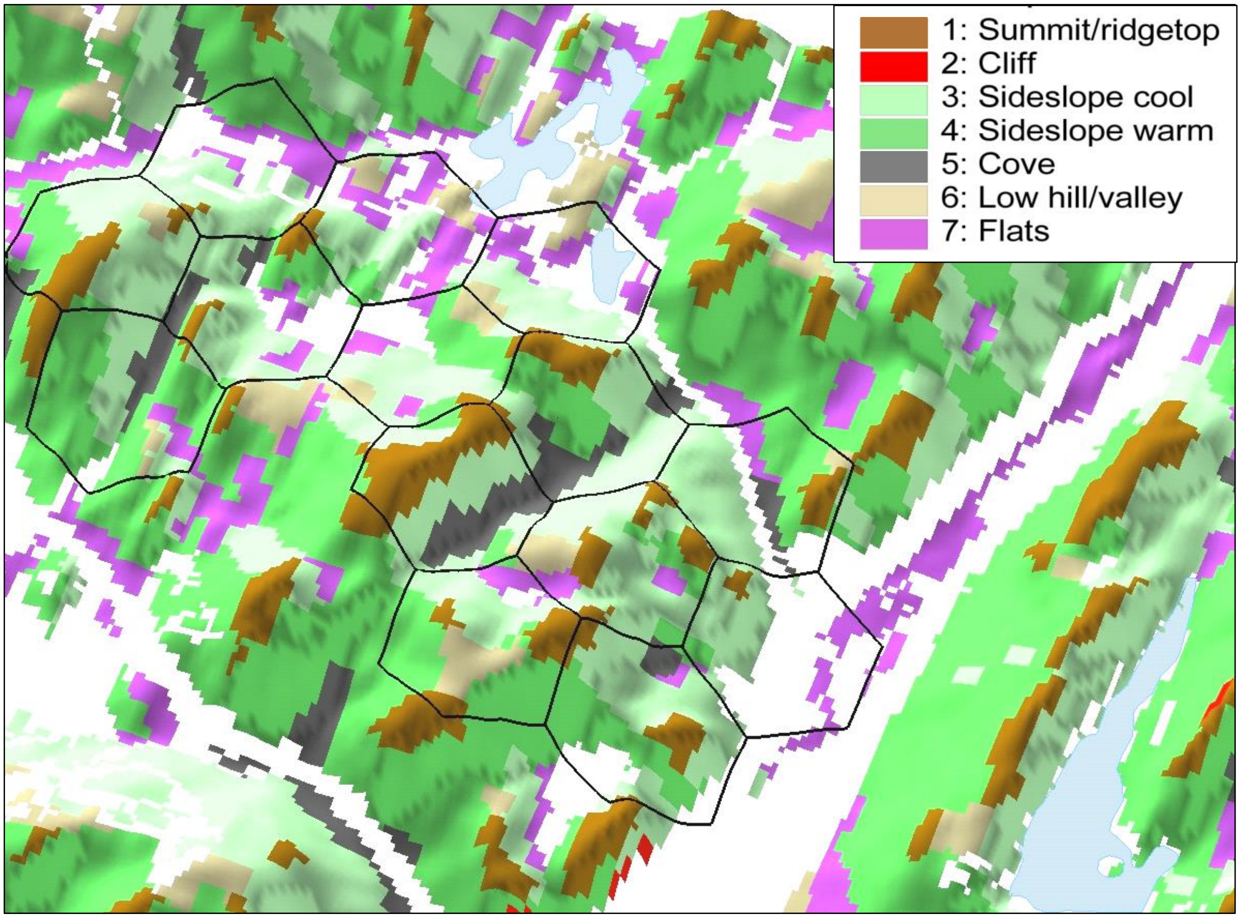


Figure 10: Transferring habitat classifications from 100 acre hexagons to landscape units (LSUs): Step 2. In this figure, classified LSUs and a few local hexagon shapes have been draped over a three dimensional model of a landscape in Harriman State Forest in southeastern New York. Dry, oaky hills are common in this area. The patches of probably dry, shallow-soiled summit (brown) and warm sideslope (deeper green) have given this hex its high Central Appalachian Dry Oak-Pine Forest (CADOPF) score, but there are also substantial acres of cooler slopes and protected coves that are unlikely settings for the dry oak-pine system. The cooler landscape units within this hexagon can be assigned to appropriate habitats other than CADOPF, such as the NE Interior Dry-Mesic Oak Forest or Appalachian (Hemlock-)Northern Hardwood Forest systems.

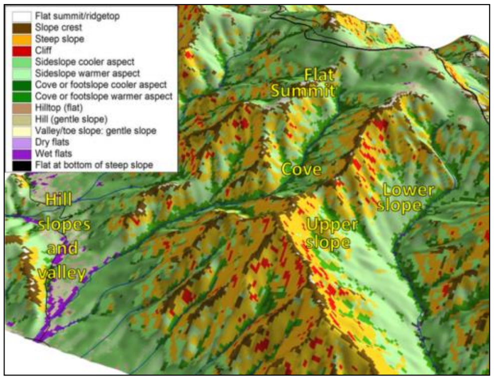


Figure 11a: The regional landform grid (30m cells), draped over a Blue Ridge digital elevation model. We simplified these to create the landscape units that we used to interpret matrix forest classification probabilities to the landscape (Figure 8d). Landforms are a composite unit built by combining slope and landscape position (see Appendix 3). The Blue Ridge Parkway northeast of Roanoke cuts across the top of the image from right to left, going southwest.

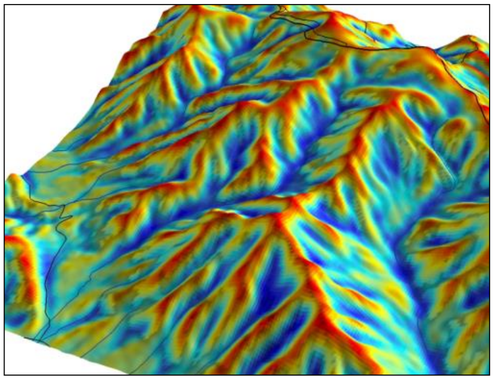


Figure. 11b: A draped 30m grid of land position index (LPI) values. LPI is one of the 2 components, with slope, of the landforms in Figure D1. The blue-to-red color gradient indicates low land position to high. At higher, more exposed land positions, soils tend to be thin and conditions dry; conversely, soils are deeper and conditions more moist on protected lower slopes and in coves.

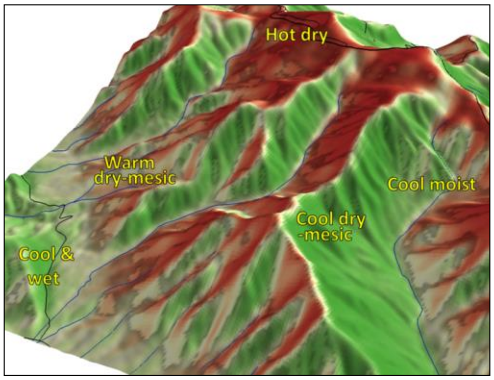


Figure 11c: A draped 30m grid of solar radiation values. The green-to-red color gradient indicates low solar inputs to high. Heat-loading is highest on south-to-west facing steep upper slopes and ridges, while north-facing slopes and shaded areas are protected from sun effects. Environmental conditions, ecological processes, and natural systems can vary dramatically with the variation in landscape structure show in this and the previous figure.

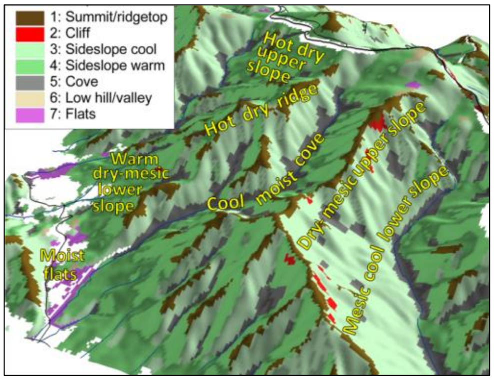


Figure 11d: Landscape units, a 7-part model simplified from the landforms in Figure 8a. The units integrate the ecological effects of landscape structure on solar input, moisture availability, soil formation, erosion and deposition, exposure and disturbance, animal movement and seed dispersal, nutrient cycling, and other processes that have strong effects on the distribution of natural communities. As such they are ideal spatial units to interpret RandomForests-generated classification probabilities to Northeastern landscapes.

Modeling Matrix Forest in the Coastal Plain and Lake Plain

In the heavily settled coastal plain and northern lake plain we used a simpler method to map the matrix forest. The method was closely related to the transfer of hexagon information to landform units described above, and was practical because in the Northern Atlantic Coastal Plain (the combined North Atlantic Coast and Chesapeake Bay Lowlands Ecoregions) and the Northern Lake Plain (Great Lakes ecoregion), there was little topographic relief or elevation gradient, and the distribution of major forest types followed a simpler pattern than in ecoregions with a broader elevation range and greater topographic diversity. Within these regions we subdivided the geography into subregions containing only two or three matrix types and then we mapped the forest types directly onto the landform units using the preferences of the forest types as described by NatureServe combined with land cover and ecological information information. Typically this involved the use of land position (a local mean of this metric enabled us to identify more sheltered or more convex parts of the landscape), land cover (NLCD 2006), an index of the degree of conifer dominance and a local mean of canopy cover, and an index of rugosity. We emphasize that although we mapped the most likely natural forest type in these regions, the remnant dominant forests in these populated regions are fragmented and highly altered.

Patch-forming System Types

Upland Systems

We modeled the 38 non-matrix upland ecological systems individually using a direct method based on the compiled samples of each system type and the ecological datasets. This was possible because many of the patch-forming systems have tight ecological signatures that correspond directly to certain ecological variables. For example, Laurentian-Acadian Acidic Cliffs can be roughly mapped using the landform model “cliff” and restricting it to those cliffs that occur on acidic bedrock (acidic granitic or acidic sedimentary) within the Laurentian-Acadian ecoregion. The models for most upland patch communities were somewhat more complex than this, but most began with a basic model using landforms or land position and were then further refined by other ecological variables (Table 2). To create each model we first developed an ecological signature for each upland patch-forming system by studying the NatureServe description and the published state classifications (see list at end of document), and consulted with experts to identify the key variables that may determine a system’s distribution. We then overlayed the samples on the ecological variables and examined the correspondence with those variables. Our goal was to create the simplest and most parsimonious model that was true to the concept and ecological signature of the system, and that captured most of the known occurrences, without over-mapping the system. When many samples appeared to occur outside the expected signature we added these outliers individually to the basic model rather than expanding the model to capture all of the outliers.

Table 2: Part 1 Sixteen small and large patch systems mapped in the Northern Appalachian/Boreal Forest and St. Lawrence-Champlain Valley Ecoregions. Columns represent the biophysical variables and indices used to create the system models.

System-code	System-name	Basic_model	Landcover	Local mean Conifer-wgt*	Local mean landscape position index**	Local sum topographic roughness values***	Landforms	Focalmean solar radiation****	Local RandomForest-assigned matrix forest system
201.57	Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest	lower elevation limit = (-100 * latitude) + 5129; upper elevation limit = (-83 * latitude) + 5150; latitude in decimal degrees, results in meters	Upland natural landcover, any class	moderate to high conifer cover (fmn2_conifwg2 ge 420)					
201.56	Acadian Sub-boreal Spruce Flat	Acadian Low-Elevation Spruce-Fir-Hardwood Forest model from matrix forest analysis	Natural landcover, any class	conifer cover (fmn2_conifwg2 ge 625)	landscape positions (fm4_lpos_nap ge 50)	depressional /basin settings (fsum3trivalue le 80)			
201.57	Acadian-Appalachian Alpine Tundra	to identify areas above upper elevation limit for spr-fir: upper elevation limit = (-83 * latitude) + 5150; latitude in decimal degrees, results in m; exclude any cliff-talus model occurrences	Any landcover class above montane spruce-fir-hardwood model; classes 32,52,71 within 10-cell distance of basic model						
202.600	Central Appalachian Pine-Oak Rocky Woodland	Basic model for high, exposed, dry, shallow-to-bedrock sites-- Fm4_lpos_nap le 4 or landform = 11 or (Fm4_lpos_nap le 10 & Solrad_nap_fm ge 95)	Upland natural landcover, any class		limit to high landscape positions: see Basic_model		highest/most exposed: see Basic_model	warmest/driest: see Basic_model	Hardwood Forest, Laurentian-Acadian Pine-Hemlock-Hardwood Forest, L-A Red Oak-Northern Hardwood Forest
202.59	Central Appalachian Dry Oak-Pine Forest	Basic model for high, exposed, dry, shallow-to-bedrock sites-- Fm4_lpos_nap le 4 or landform = 11 or (Fm4_lpos_nap le 10 & Solrad_nap_fm ge 95)	Upland natural landcover, any class		limit to high landscape positions: see Basic_model		highest/most exposed: see Basic_model	warmest/driest: see Basic_model	Appal (Hemlock)-N. Hardwood Forest, Laurentian-Acadian Pine-Hemlock-Hardwood Forest, L-A Red Oak-Northern Hardwood Forest
201.571	Northern Appalachian-Acadian Rocky Heath Outcrop	Basic model for high, exposed, dry, shallow-to-bedrock sites-- Fm4_lpos_nap le 4 or landform = 11 or (Fm4_lpos_nap le 10 & Solrad_nap_fm ge 95)	Upland natural landcover, any class		limit to high landscape positions: see Basic_model		highest/most exposed: see Basic_model	warmest/driest: see Basic_model	Laurentian-Acadian Northern Hardwood Forest
201.572	Laurentian-Acadian Calcareous Rocky Outcrop	Basic model for high, exposed, dry, shallow-to-bedrock sites-- Fm4_lpos_nap le 4 or landform = 11 or (Fm4_lpos_nap le 10 & Solrad_nap_fm ge 95)	Upland natural landcover, any class		limit to high landscape positions: see Basic_model		highest/most exposed: see Basic_model	warmest/driest: see Basic_model	Laurentian-Acadian Northern Hardwood Forest
201.019	Laurentian Acidic Rocky Outcrop	In our region, a system of few occurrences in northern New York; see "Supplemental" column at far right	Upland natural landcover, any class						
203	Glacial Marine & Lake Clayplain Forest: mesic		Upland forested natural landcover		limit to lower landscape position: fm4_lpos_nap ge 36				
201.721	Great Lakes Alvar	In our region, east of Lake Ontario in Jefferson Co., NY, and along shores of Lake Champlain only	Upland natural landcover, any class						
201.026	Great Lakes Dune and Swale	In our region, 4 degraded occurrences in western NY & northern Champlain Valley; see "Supplemental" column at far right	Any						
201.569	Laurentian-Acadian Acidic Cliff and Talus	Basic model for cliff & talus slopes-- all cliff landform (slope from 30m DEM >= 35 degrees), plus steep slopes (24-35 degrees) with reduced canopy (Fm_canopy2int <= 91)	Upland natural landcover, any class				Cliff, steep slope with reduced canopy cover: see Basic_model		Laurentian-Acadian Northern Hardwood Forest
201.570	Laurentian-Acadian Calcareous Cliff and Talus	Basic model for cliff & talus slopes-- all cliff landform (slope from 30m DEM >= 35 degrees), plus steep slopes (24-35 degrees) with reduced canopy (Fm_canopy2int <= 91)	Upland natural landcover, any class				Cliff, steep slope with reduced canopy cover: see Basic_model		Laurentian-Acadian Northern Hardwood Forest
202.601	North-Central Appal Acidic Cliff &Talus	Basic model for cliff & talus slopes-- all cliff landform (slope from 30m DEM >= 35 degrees), plus steep slopes (24-35 degrees) with reduced canopy (Fm_canopy2int <= 91)	Upland natural landcover, any class				Cliff, steep slope with reduced canopy cover: see Basic_model		Hardwood Forest, Laurentian-Acadian Pine-Hemlock-Hardwood Forest, L-A Red Oak-Northern Hardwood Forest
202.603	North-Central Appal Circumneutral Cliff & Talus	Basic model for cliff & talus slopes-- all cliff landform (slope from 30m DEM >= 35 degrees), plus steep slopes (24-35 degrees) with reduced canopy (Fm_canopy2int <= 91)	Upland natural landcover, any class				Cliff, steep slope with reduced canopy cover: see Basic_model		Hardwood Forest, Laurentian-Acadian Pine-Hemlock-Hardwood Forest, L-A Red Oak-Northern Hardwood
202.590	Northeastern Interior Pine Barrens	In NAP/STL, a system of remnant patches in northeastern NY and northwestern VT; see "Supplemental" column at far right	Upland natural landcover, any class						

Table 2: Part 2 Sixteen small and large patch systems mapped in the Northern Appalachian/Boreal Forest and St. Lawrence-Champlain Valley Ecoregions. Columns represent the biophysical variables and indices used to create the system models.

System-code	System-name	Subsection/Physiographic region	Elevation	Soils/sediments	Canopy cover (percent)	Focalmean canopy cover*****	Lithochem_index******	Supplemental	Model_tweaks
201.57	Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest		As defined by White-Cogbill montane spruce-fir model						GIS manipulations to generalize model occurrences, enforce MMU of 2 acres
201.56	Acadian Sub-boreal Spruce Flat								
201.57	Acadian-Appalachian Alpine Tundra		As defined by White-Cogbill montane spruce-fir model					Included NY, VT, ME Natural Heritage Program data for alpine areas	GIS manipulations to generalize MOs
202.600	Central Appalachian Pine-Oak Rocky Woodland	211Cb, 211Da, 211Dc, 211Ec, M211Ad, M211Ag, M211Ba, M211Bb, M211Cd, M211De	Maximum allowed elevation varies by subsection & local matrix forest type		Mean for model occurrence < 80 in Maine, < 92 elsewhere				GIS manipulations to generalize model occurrences, enforce MMU of 1 acre
202.59	Central Appalachian Dry Oak-Pine Forest	211Ca, 211Da, 211Dc, 211Ec,211Ed, 211Ee, 211Jb, M211Ad, M211Ag, M211Ba, M211Bb, M211Ca, M211Cd, M211Db, M211Dc, M211Dd, M211De	Maximum allowed elevation varies by subsection & local matrix forest type		Where this or 202.600 is possible, mean canopy cover >= 95 assigned here, < 95 to 202.600				GIS manipulations to generalize model occurrences, enforce MMU of 1 acre
201.571	Northern Appalachian-Acadian Rocky Heath Outcrop	All subsections except 211Ee, 211Ja, 211Ec, 211Eb	Minimum allowed elevation varies by subsection				index mean lt 11 or (index mean lt 13 & index max lt 33)		GIS manipulations to generalize model occurrences, enforce MMU of 1 acre
201.572	Laurentian-Acadian Calcareous Rocky Outcrop	All subsections except 211Ee, 211Ja, 211Ec, 211Eb	Minimum allowed elevation varies by subsection				Index mean >= 13 or (index mean >= 11 & index max >= 33)		GIS manipulations to generalize model occurrences, enforce MMU of 1 acre
201.019	Laurentian Acidic Rocky Outcrop	211Ea, 211Eb, 211Ec, 211Ee						Element Occurrences, 5 sites from data supplied by David	
203	Glacial Marine & Lake Clayplain Forest: mesic	211Ea, 211Ec, 211Ed, 211Ee, northwestern corner 221Bb	<= 170m	VT: fine (silt/clay) soils; NY: fine surficial sediments					GIS manipulations to generalize model occurrences, enforce MMU of 1 acre
201.721	Great Lakes Alvar	211Ec, southwestern corner of 211Ee				NY, lower canopy cover (Fm_canopy2int le 40); on Lake Champlain,			
201.026	Great Lakes Dune and Swale	211Ec, 211Jb						4 small sites from NY & VT NHPs	
201.569	Laurentian-Acadian Acidic Cliff and Talus	Any except 211Ea, 211Ec	Minimum allowed elevation varies by subsection				index mean lt 11 or (index mean lt 13 & index max lt 33)		GIS manipulations to generalize model occurrences, enforce MMU of 1 acre
201.570	Laurentian-Acadian Calcareous Cliff and Talus	Any except 211Ea, 211Ec	Minimum allowed elevation varies by subsection				Index mean >= 13 or (index mean >= 11 & index max >= 33)		GIS manipulations to generalize model occurrences, enforce MMU of 1 acre
202.601	North-Central Appal Acidic Cliff &Talus	Any	Maximum allowed elevation varies by subsection & local matrix forest type				index mean lt 11 or (index mean lt 13 & index max lt 33)		GIS manipulations to generalize model occurrences, enforce MMU of 1 acre
202.603	North-Central Appal Circumneutral Cliff & Talus	Any	Maximum allowed elevation varies by subsection & local matrix forest type				Index mean >= 13 or (index mean >= 11 & index max >= 33)		GIS manipulations to generalize model occurrences, enforce MMU of 1 acre
202.590	Northeastern Interior Pine Barrens	211Ec, M211Dc						& data supplied by David Hunt, 12 sites from VT NHP	

A worked example will illustrate the process of mapping the upland patch occurrences (Figure 12 and 13 a,b,c,d). The Appalachian Serpentine Woodland system is an edaphically controlled small-patch habitat that is restricted to ultramafic bedrock (e.g. serpentine, soapstone, pyroxenite, dunite, peridotite, talc schist). The example is from the Baltimore Mafic Complex, on the eastern part of the Maryland-Pennsylvania border above Chesapeake Bay, and area with a large formation of ultramafic bedrock and extensive serpentine woodlands.

- Bedrock: Ultramafic rocks are a necessary but not sufficient condition for community development
- Topography: Varied, excluding only alluvial
- Soils: Often shallow-to-bedrock, sometimes deeper; basic chemistry, nutrient-poor; often clayey
- Moisture: Xerophytic
- Vegetation: Thin canopy, often stunted mixed woodlands, grassy/herbaceous
- Disturbance: Fire, pine beetles
- Size: Couple to a few acres, to perhaps a few dozen
- Geography: Eastern PA and MD in the Lower Piedmont

Figure 12: A Small Patch Habitat: Appalachian Serpentine Woodland. Ecological conditions required for and characteristic of the system type. Photo by Tom Rawinski (Virginia Department of Conservation & Recreation Natural Heritage Program)

Figure 13a shows areas with ultramafic bedrock in cyan. We overlaid the NLCD land cover to identify areas in forest or woodland cover that had a canopy cover less than 90%, given the low canopy character of this system, and recognizing that fire suppression has probably allowed a heavier canopied community to replace some areas of serpentine woodland and barren (Figure 13b). In the next step we overlaid a grid of the streams and floodplain areas (Active River Areas, Sheldon 2009) and excluded areas within these moist alluvial zones (Figure 13c). The final model is the combination of these steps (Figure 13d), and likely over-maps the current extent of this rare system, which is further restricted to areas from which fire has not been excluded. However, the model delimits the area where serpentine woodland habitat is concentrated and may identify places where the reintroduction of fire could restore this habitat.

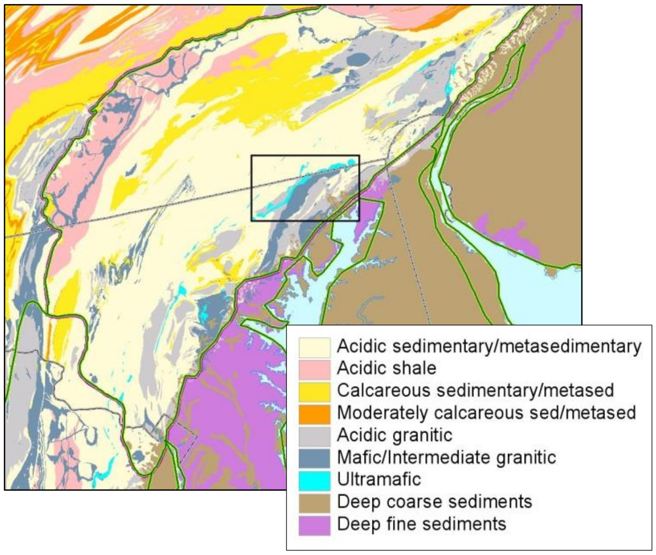


Figure 13a: The Baltimore Mafic Complex. Shaded in cyan, this as a large occurrence of ultramafic bedrock in the southern part of the Lower New England/Northern Piedmont Ecoregion, on the eastern part of the Maryland-Pennsylvania.

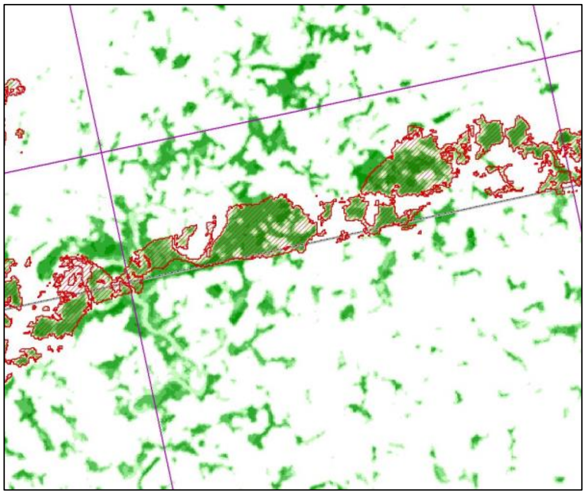


Figure 13b: Close-up of a portion of the Baltimore Mafic Complex. Areas of natural landcover (very little remains in this largely agricultural landscape) and occurrence of ultramafic bedrock are outlined in red. Shades of green indicate levels of canopy cover, with darker green for higher levels. Gridlines demarking the edges of USGS 1:24,000 topographic quads are added for scale reference.

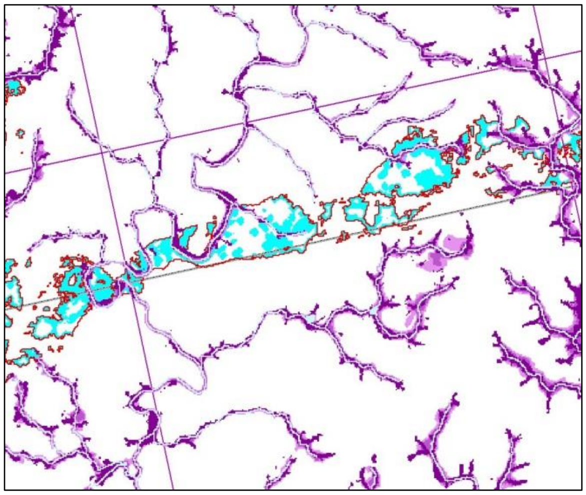


Figure 13c: Active River area exclusion. An active river area (ARA) grid (shades of purple) identifies moist alluvial areas that were excluded from the serpentine woodland model. Areas of natural landcover and occurrence of ultramafic bedrock are outlined in red, and low canopy areas within them are in cyan.

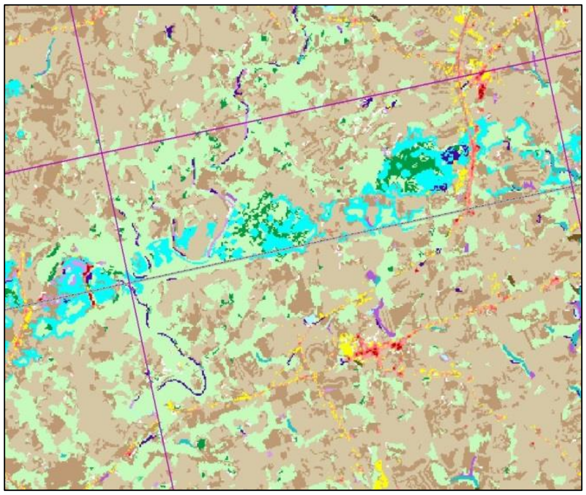


Figure 13d: The final model (in cyan) is probably an over mapping of the extent of this system; but it communicates an idea of where we can look for expressions of the serpentine woodland habitat, or places where a restoration of fire could help to bring back this uncommon system.

Wetland Systems

We mapped wetland systems using the National Wetlands Inventory (NWI) and National Land Cover Database (NLCD) wetlands as the base datasets. The NLCD is spatially comprehensive but only maps two wetland classes (forested wetland, emergent wetland) while the NWI is less comprehensive but makes finer distinctions in wetland types. To take advantage of the strengths of both datasets we combined them by gridding NWI polygons to 30 meter cells on a value that reflected their type, and merging them over the NLCD. Most NWI polygons are designated with a single wetland type but when they were given a mixed wetland type (e.g. deciduous/coniferous swamp) we assigned cells in a gridded polygon to the dominant type in that polygon which comes first in the NWI designation. This resulted in a combined NWI-NLCD dataset with seven wetland classes: forested deciduous swamp, forested coniferous swamp, scrub-shrub swamp, freshwater emergent marsh, tidal marsh, tidal swamp, and undifferentiated woody wetlands.

We removed errors from combined NWI-NLCD dataset by combining it with the landform grid and removing wetlands that were mapped on upland landforms (e.g. steeper slopes, cliffs, ridges). We extracted wetlands of all types into a single grid and used standard GIS manipulations to generalize them somewhat and break them into discrete units composed of one to many individual wetland types that we called “wetland complexes” (Table 3) The new grid of wetland complexes retained the type and amount of features in the parent dataset, included NWI types such as emergent marshes, deciduous forest, and shrub wetlands. Finally, we removed complexes that were less than 1 acre in size from the resulting dataset and split the wetland complexes into two groups: forested wetlands (forest cover >25%) and open wetland (forest cover <25%)

Mapping region	Number of wetland complexes	Mean size wetland complexes (acres)
High Allegheny Plateau Ecoregion	40,024	12.6
Lower New England/Northern Piedmont Ecoregion	103,714	16.4
Northern Appalachian/Boreal Forest & St. Lawrence-Champlain Valley Ecoregions	200,943	19.7
North Atlantic Coast/Chesapeake Bay Lowlands	227,256	13.9
Central Appalachians/Southwestern VA/Western WV/Southwestern PA	25,471	6.7
Northern Lake Plain (Great Lakes)	69,457	14.2
Virginia Piedmont & Mid-Atlantic Coast Ecoregions	33,138	27.8

Table 3: Wetland complexes in the 7 mapping subregions in the Northeast.

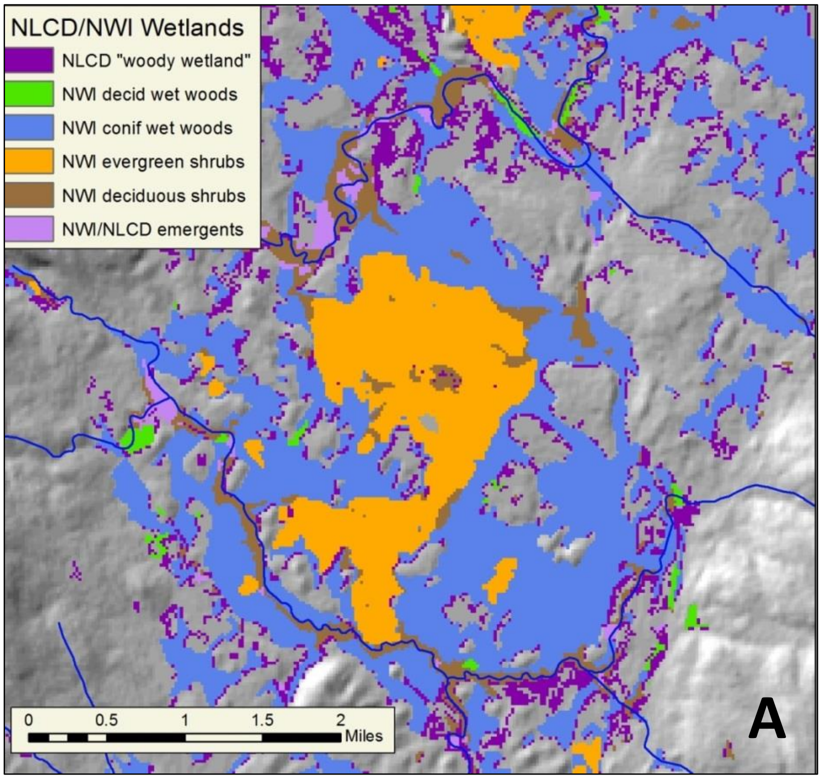
We assigned the wetland complexes to the ecological system types starting with the forested wetlands and using a method somewhat analogous to the one we used for the upland systems. First, we listed the dominant forested wetland types of the ecoregion and studied their ecological signatures in the literature and samples, and then we separated the set of forested wetland polygons into one of the possible types using logical breaks. We often included the results of the matrix-forming forest models to determine what type of forest matrix the polygon occurred in. For example, in the Northern Appalachian Ecoregion there were four dominant forested wetland systems, and these could be separated based on the surrounding matrix forest and the alkalinity of the bedrock using the following key:

- Surrounding Matrix = Northern Appalachian – Acadian
  - Acidic substrate (low alkalinity index)
    - *Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp*
  - Alkaline substrate (high alkalinity index)
    - *Laurentian-Acadian Alkaline Conifer-Hardwood Swamp*
- Surrounding Matrix = Appalachian
  - Acidic substrate (low alkalinity index)
    - *North-Central Appalachian Acidic Swamp*
  - Alkaline substrate (high alkalinity index)
    - *North-Central Interior and Appalachian Rich Swamp*

The ecological signature of each forested wetland was derived from the descriptive information on the range and ecological setting of each type (Gawler 2008). We assigned the forested wetland to one of the above four types using a proximity analysis of the area surrounding the complex to determine the surrounding matrix forest type and the alkalinity index described previously to determine the dominant alkalinity of the complex. We confirmed the system assignments by overlaying the Natural Heritage element occurrences and examining the accuracy of the predictive model (Figure 14a, b).

Models for freshwater marshes and shrub swamps were built by simply extracting emergent marsh and shrub-scrub wetland classes from the NWI-NLCD wetland dataset attributes and merging them over the background forested swamps. Tidal marshes and tidally-influenced swamps were similarly drawn from the wetland dataset attributes and superimposed on the background systems. We were not able to consistently distinguish tidal marsh levels of salinity using this method so we combined salt, brackish, and oligohaline/fresh marshes together for mapping purposes.

Peatland system models were the most challenging to identify in the wetland dataset. The NWI mapping of organic substrates, and water regimes that are characteristic of those habitats, are inconsistent, and there is little information on the presence of mosses and evergreen wetland shrubs that can be good indicators of bog and associated fen habitats. We begin with data from individual states included Natural Heritage Program known community occurrences and natural community maps and ecological and distributional information from NatureServe (Gawler 2008) to develop an ecological signature. For example, Atlantic Coastal Plain Northern Bogs have lower canopy cover than North Atlantic Coast Basin Peat Swamps, and are most often found in a pine barren landscape. This information was used to discriminate between these two similar systems using canopy cover and the previously created models of the upland pine barren system (Figure 14a, b).



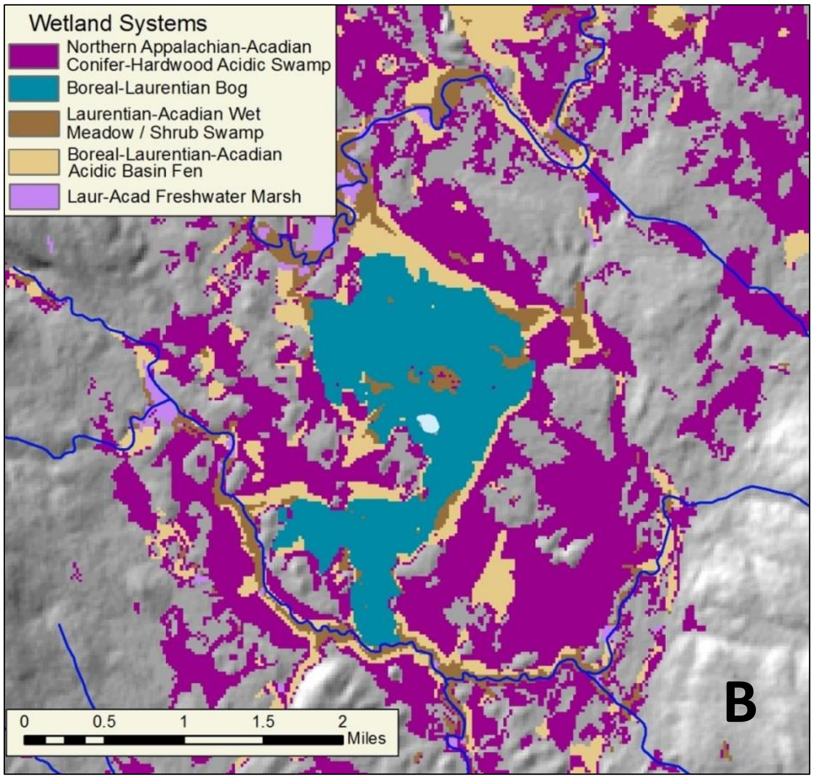


Figure 14a: A wetland complex in northern Maine (Northern Appalachian/Boreal Forest Ecoregion). Data is from the NWI-NLCD wetlands dataset from which all wetland complexes were built.

Figure 14b: Wetland systems mapped in the complex shown in Fig. 14a.

In order to identify floodplain and riparian wetlands we tagged the wetland occurrences with information indicating whether they were associated with streams, larger rivers, or lakes, or if they were isolated from the stream network. To determine this, we used a grid of Euclidean distance to the closest National Hydrography Dataset (NHD) features and the active river area grid (Sheldon 2009) that was built from a 30m digital elevation model on a base of the NHD. The NHD is compiled at a nominal scale of 1:100,000, and many smaller streams are not recorded; to alleviate the problem of characterizing some wetlands on lower order streams as "isolated", we calculated two indices related to shape that enabled us to more accurately attribute long linear wet areas that are very likely riparian zones, though no NHD stream reach is within them.

In the ecological systems dataset, the information on hydrological association for the most part is carried in a set of secondary fields in the attribute table. The primary attribute remains the primary habitat type (for example, North-Central Interior and Appalachian Rich Swamp) and the secondary fields allowed users to extract examples of that habitat that were in larger river floodplains or other hydrologic settings. Access to secondary attribute table fields (like SUMGRPNAME or DESC_R) enable users to extract habitats that are in large river floodplain habitats.

Several wetland systems that occur at very small scale (such as seepage wetlands, small scale fens that can occur within or at the edges of larger swamp or bog complexes, and coastal plain ponds) were found to be unmappable with existing datasets, and are assumed to be inclusions in the larger wetland complexes or upland systems in which they are embedded.

Results

CHAPTER

4

A total of 100 ecological systems are mapped in the regional habitat map (Table 4), and the final results are a map and dataset that may downloaded here: https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/edc/reportsdata/terrestrial/habitatmap/Pages/default.aspx

A table that splits out all systems' acreages by the states in which they occur appears in Appendix 4.

Table 4. Terrestrial habitats and their acreage in the region. The list is sorted alphabetically.

Terrestrial Habitat / Ecological System : Part 1	Acres
Acadian Coastal Salt and Estuary Marsh	30,066
Acadian Low Elevation Spruce-Fir-Hardwood Forest	5,523,188
Acadian Maritime Bog	5,235
Acadian Sub-boreal Spruce Flat	1,513,187
Acadian-Appalachian Alpine Tundra	8,185
Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest	1,084,480
Acadian-North Atlantic Rocky Coast	7,707
Allegheny-Cumberland Dry Oak Forest and Woodland	2,273,323
Appalachian (Hemlock)-Northern Hardwood Forest	21,007,943
Appalachian Shale Barrens	5,169
Atlantic Coastal Plain Beach and Dune	96,725
Atlantic Coastal Plain Blackwater/Brownwater Stream Floodplain Forest	164,137
Atlantic Coastal Plain Embayed Region Tidal Freshwater/Brackish Marsh	14,246
Atlantic Coastal Plain Northern Bog	5,260
Atlantic Coastal Plain Peatland Pocosin and Canebrake	2,409
Boreal-Laurentian Bog	45,397
Boreal-Laurentian-Acadian Acidic Basin Fen	401,409
Central and Southern Appalachian Montane Oak Forest	148,716
Central and Southern Appalachian Spruce-Fir Forest	64,957
Central Appalachian Alkaline Glade and Woodland	413,521
Central Appalachian Dry Oak-Pine Forest	3,845,583
Central Appalachian Pine-Oak Rocky Woodland	566,738
Central Appalachian Stream and Riparian	26,971
Central Atlantic Coastal Plain Maritime Forest	6,356
Central Atlantic Coastal Plain Non-riverine Swamp and Wet Hardwood Forest	191,995
Central Interior Acidic Cliff and Talus	84
Central Interior Calcareous Cliff and Talus	1,463
Central Interior Highlands and Appalachian Sinkhole and Depression Pond	1,458
Circumneutral Cliff and Talus	56,458
Cumberland Acidic Cliff and Rockhouse	91,654
Eastern Serpentine Woodland	11,954
Glacial Marine & Lake Mesic Clayplain Forest	236,862
Glacial Marine & Lake Wet Clayplain Forest	88,172
Great Lakes Alvar	27,657
Great Lakes Dune & Swale	1,805
High Allegheny Headwater Wetland	27,697
Laurentian Acidic Rocky Outcrop	6,328
Laurentian-Acadian Acidic Cliff and Talus	119,267
Laurentian-Acadian Alkaline Conifer-Hardwood Swamp	921,524
Laurentian-Acadian Alkaline Fen	206
Laurentian-Acadian Calcareous Cliff and Talus	51,011
Laurentian-Acadian Calcareous Rocky Outcrop	50,773
Laurentian-Acadian Freshwater Marsh	906,822
Laurentian-Acadian Large River Floodplain	431,636
Laurentian-Acadian Northern Hardwood Forest	12,740,840
Laurentian-Acadian Northern Pine-(Oak) Forest	14,328
Laurentian-Acadian Pine-Hemlock-Hardwood Forest	6,105,856
Laurentian-Acadian Red Oak-Northern Hardwood Forest	1,168,853
Laurentian-Acadian Wet Meadow-Shrub Swamp	990,156

Terrestrial Habitat / Ecological System : Part 2	Acres
N. Appalachian-Acadian Rocky Heath Outcrop	191,086
North Atlantic Coastal Plain Basin Peat Swamp	58,304
North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest	974,816
North Atlantic Coastal Plain Brackish/Fresh & Oligohaline Tidal Marsh	17,021
North Atlantic Coastal Plain Hardwood Forest	2,145,723
North Atlantic Coastal Plain Heathland and Grassland	32,838
North Atlantic Coastal Plain Large River Floodplain	35,493
North Atlantic Coastal Plain Maritime Forest	127,127
North Atlantic Coastal Plain Pitch Pine Barrens	491,573
North Atlantic Coastal Plain Pitch Pine Lowland	178,529
North Atlantic Coastal Plain Stream and River	28,786
North Atlantic Coastal Plain Tidal Salt Marsh	920,149
North Atlantic Coastal Plain Tidal Swamp	196,242
North-Central Appalachian Acidic Cliff and Talus	345,802
North-Central Appalachian Acidic Swamp	1,506,626
North-Central Appalachian Large River Floodplain	254,874
North-Central Interior and Appalachian Acidic Peatland	83,793
North-Central Interior and Appalachian Rich Swamp	830,863
North-Central Interior Beech-Maple Forest	73,136
North-Central Interior Large River Floodplain	70,573
North-Central Interior Wet Flatwoods	81,975
Northeastern Coastal and Interior Pine-Oak Forest	1,538,150
Northeastern Interior Dry-Mesic Oak Forest	17,040,329
Northeastern Interior Pine Barrens	42,744
Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp	1,312,031
Piedmont Hardpan Woodland and Forest	49,432
Piedmont Upland Depression Swamp	21,649
Piedmont-Coastal Plain Freshwater Marsh	45,762
Piedmont-Coastal Plain Large River Floodplain	133,335
Piedmont-Coastal Plain Shrub Swamp	46,469
South-Central Interior Mesophytic Forest	3,556,213
Southern and Central Appalachian Cove Forest	1,018,463
Southern and Central Appalachian Mafic Glade and Barrens	1,456
Southern Appalachian Grass and Shrub Bald	3,199
Southern Appalachian Low Elevation Pine Forest	22,355
Southern Appalachian Montane Cliff and Talus	6,852
Southern Appalachian Montane Pine Forest and Woodland	33,535
Southern Appalachian Northern Hardwood Forest	12,833
Southern Appalachian Oak Forest	2,887,721
Southern Atlantic Coastal Plain Mesic Hardwood Forest	1,935,075
Southern Atlantic Coastal Plain Tidal Wooded Swamp	12,983
Southern Atlantic Coastal Plain Upland Longleaf Pine Woodland	579
Southern Interior Calcareous Cliff	3,913
Southern Piedmont Dry Oak-Pine Forest	1,797,056
Southern Piedmont Glade and Barrens	107
Southern Piedmont Granite Flatrock and Outcrop	83
Southern Piedmont Lake Floodplain Forest	8,611
Southern Piedmont Mesic Forest	2,439,102
Southern Piedmont Small Floodplain and Riparian Forest	186,288
Southern Ridge and Valley / Cumberland Dry Calcareous Forest	917,654
Southern Ridge and Valley Calcareous Glade and Woodland	9,794
Total Natural Systems	**105,234,869**

Matrix-forming Forest Habitats

The final map identifies 15 matrix-forming forest types for the region and for these systems we were able to look systematically at the importance of ecological variables used to differentiate between them and in the classification error inherent in each models.

The variables of highest importance varied among ecoregions but consistently climate and landform and/or topographic variables predominate in the top ten. For example, in both Lower New England and the Central Appalachians the top ten ranked variables included subsection, longitude, latitude, maximum temperature in the warmest month, minimum temperature in the coldest month, and precipitation in the warmest quarter (Table 5)**.** The two regions differed in that % conifer, % deciduous and elevation mean were of high importance for Lower New England forests, while land position and mean distance to streams were important for the Central Appalachian types. The importance of a given variable also varied considerably among the habitat types. For example, elevation mean was important for Laurentian-Acadian Northern Hardwood Forest but unimportant for Appalachian Hemlock-Northern Hardwood Forest. Geology variables that were very important for the upland patch and wetland systems scored low (below 25th in order) for matrix-types, likely reflecting the fact that these widespread dominant forests had broad ecological tolerances.

Table 5: Important variables for mapping matrix forests. The table list the top ten variables in Lower New England and the Central Appalachian Ecoregion.

Lower New England	AHNHF	CADOPF	LANHF	LAPHHF	NECIPOF	NEIDMOF	AVG	**Central Appalachians**	AHNHF	CADOPF	NEIDMOF	SCIMF	AVG
% Conifer	0.05	1.16	1.46	2.66	3.2	1.31	1.64	Landposition-mean	0.97	0.88	0.66	1.37	0.97
Subsection	0.43	1.21	1.47	2.27	2.57	1.2	1.53	Longitude	1.12	0.68	0.52	1.17	0.87
Longitude	0.16	1.03	1.64	2.05	3.13	1.1	1.52	Subsection	1	0.74	0.47	1.27	0.87
Elevation mean	0.29	1.11	2.57	1.37	2.76	0.94	1.51	Min temp-coldest month	1.12	0.58	0.42	1.09	0.80
% Deciduous	0.11	1.03	0.88	2.66	2.93	1.11	1.45	Latitude	1.05	0.57	0.5	1.07	0.80
Max temp-warmest month	0.21	1.03	2.03	1.5	2.49	0.86	1.35	Mean temp-driest quarter	0.97	0.64	0.42	1	0.76
Min temp-coldest month	0.33	1.11	1.86	2	1.37	1.11	1.30	Precipitation-warmest quarter	1.05	0.67	0.33	0.85	0.73
Latitude	0.47	0.87	1.8	1.51	1.57	1.16	1.23	Section	0.8	0.57	0.36	1.09	0.71
Mean temp-driest quarter	0.18	0.98	1.91	2.02	1.32	0.96	1.23	Mean distance to stream	0.65	0.54	0.4	1.21	0.70
Precipitation-warmest quarte	0.25	1.04	1.8	0.19	2.56	0.71	1.09	Max temp- warmest month	1.02	0.53	0.32	0.82	0.67

Accuracy of the final matrix models was estimated through the internal RF process that withholds a third of the matrix forest known occurrences from every decision tree it builds during a many-treed model-building run, and then uses them to perform an internal cross-validation procedure. RF calculates an overall model error rate for each system by classifying the withheld data using the decision trees created without them, and reporting the proportion of times that the withheld known cases are classified to an incorrect system, and repeating this process for each run. Classification error averaged 0.29 and ranged from a low of 0.19 for South Atlantic Coastal Plain Mesic Hardwood Forest (SACPMHF) to a high of 0.52 in the Northern Appalachians for Laurentian Acadian Pine-Hemlock-Hardwood Forest (LAPHHF), which was often confused with Appalachian Hemlock-Northern Hardwood Forest and Laurentian-Acadian Northern Hardwood Forest: two types with which it shares many affinities (Table 6).

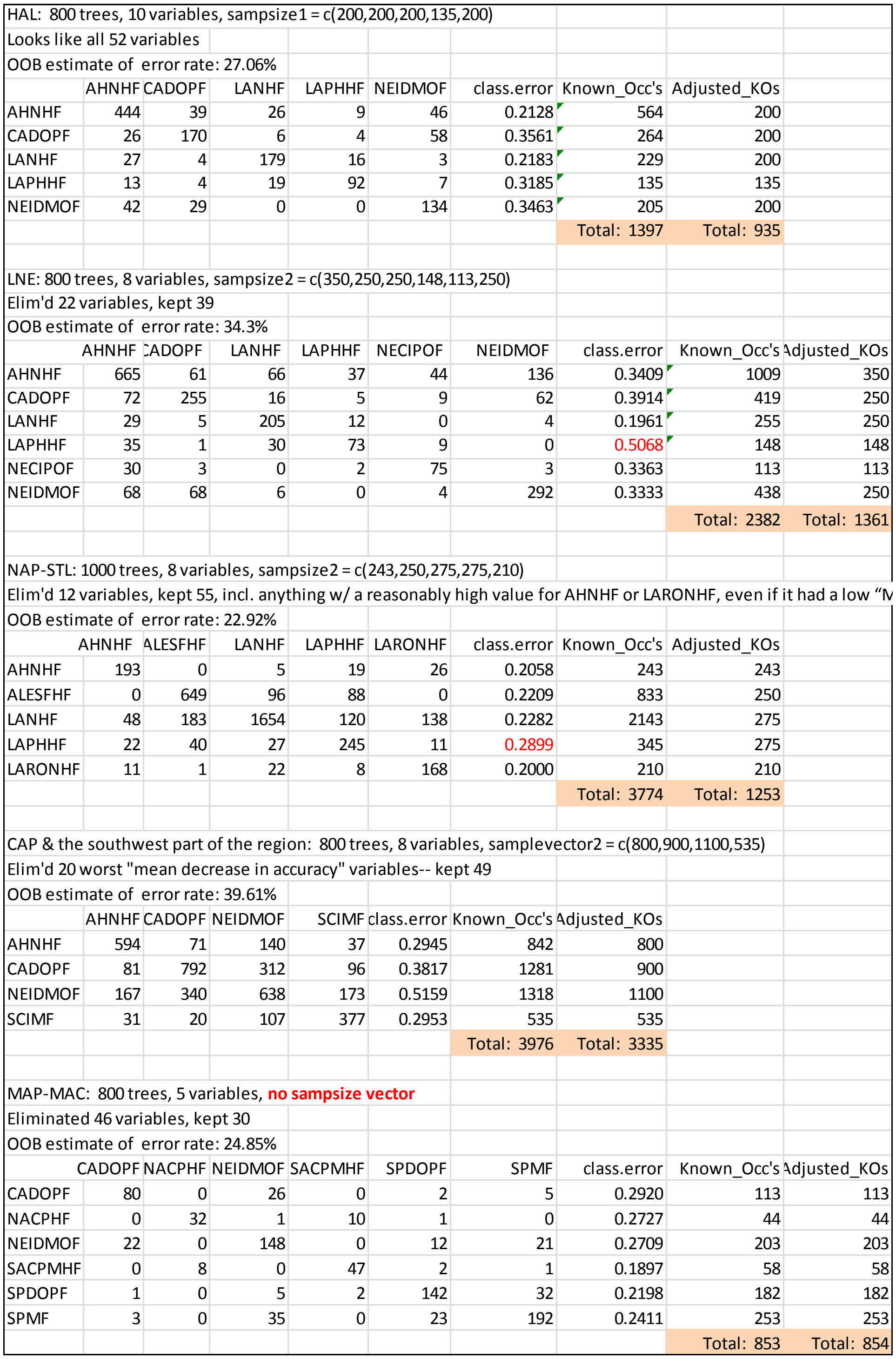
Accuracy of the models was improved when we balanced the number of samples per type. Prior to balancing the sample numbers in the High Allegheny ecoregion error levels for the Appalachian

(Hemlock-) Northern Hardwood Forest (AHNHF) with 564 known sample points was is under 10%, while the mean error level for the other four systems, which average only 208 known occurrences was 27% higher. The error rate for the Northeastern Interior Dry-Mesic Oak Forest (NEIDMOF) system was a full 43% higher. This was because a class with proportionally high sample numbers tends to co-opt classification space at the expense of other classes. The broader the environmental space granted to the strongest forest class by RF, the higher the number of its occurrences will be seen to be in the "correct", habitat-defining ecological setting. Conversely, as the ecological gradient space allotted to more weakly sampled occurrences is constricted, more of them will be seen to fall outside of that gradient space, and they will be classified, inaccurately, to another habitat type. After we balanced the number of samples in the second run the resulting error rates were more balanced, with the worst rate only 14% higher than the best (Table 7).

In these examples the following shorthand codes are used for the ecological system name

AAMSFHF	Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest
ACDOFW	Allegheny-Cumberland Dry Oak Forest and Woodland
AHNHF	Appalachian (Hemlock)-Northern Hardwood Forest
ALESFHF	Acadian Low Elevation Spruce-Fir-Hardwood Forest
CADOPF	Central Appalachian Dry Oak-Pine Forest
LANHF	Laurentian-Acadian Northern Hardwood Forest
LAPHHF	Laurentian-Acadian Pine-Hemlock-Hardwood Forest
NACPHF	North Atlantic Coastal Plain Hardwood Forest
NACPPPB	North Atlantic Coastal Plain Pitch Pine Barrens
NCIPOF	Northeastern Coastal and Interior Pine-Oak Forest
NEIDMOF	Northeastern Interior Dry-Mesic Oak Forest
SACPMHF	Southern Atlantic Coastal Plain Mesic Hardwood Forest
SAOF	Southern Appalachian Oak Forest
SCIMF	South-Central Interior Mesophytic Forest
SPDOPF	Southern Piedmont Dry Oak-Pine Forest
SPMF	Southern Piedmont Mesic Forest

Table 6: Comparison of error rates across ecoregions and system type.



HAL: 800 trees, 10 variables, sampsize1 = c(200,200,200,135,200)
Looks like all 52 variables
OOB estimate of error rate: 27.06%

	AHNHF	CADOPF	LANHF	LAPHHF	NEIDMOF	class.error	Known_Occ's	Adjusted_KOs
AHNHF	444	39	26	9	46	0.2128	564	200
CADOPF	26	170	6	4	58	0.3561	264	200
LANHF	27	4	179	16	3	0.2183	229	200
LAPHHF	13	4	19	92	7	0.3185	135	135
NEIDMOF	42	29	0	0	134	0.3463	205	200
							Total: 1397	Total: 935

LNE: 800 trees, 8 variables, sampsize2 = c(350,250,250,148,113,250)
Elim'd 22 variables, kept 39
OOB estimate of error rate: 34.3%

	AHNHF	CADOPF	LANHF	LAPHHF	NECIPOF	NEIDMOF	class.error	Known_Occ's	Adjusted_KOs
AHNHF	665	61	66	37	44	136	0.3409	1009	350
CADOPF	72	255	16	5	9	62	0.3914	419	250
LANHF	29	5	205	12	0	4	0.1961	255	250
LAPHHF	35	1	30	73	9	0	0.5068	148	148
NECIPOF	30	3	0	2	75	3	0.3363	113	113
NEIDMOF	68	68	6	0	4	292	0.3333	438	250
								Total: 2382	Total: 1361

NAP-STL: 1000 trees, 8 variables, sampsize2 = c(243,250,275,275,210)
Elim'd 12 variables, kept 55, incl. anything w/ a reasonably high value for AHNHF or LARONHF, even if it had a low “
OOB estimate of error rate: 22.92%

	AHNHF	ALESFHF	LANHF	LAPHHF	LARONHF	class.error	Known_Occ's	Adjusted_KOs
AHNHF	193	0	5	19	26	0.2058	243	243
ALESFHF	0	649	96	88	0	0.2209	833	250
LANHF	48	183	1654	120	138	0.2282	2143	275
LAPHHF	22	40	27	245	11	0.2899	345	275
LARONHF	11	1	22	8	168	0.2000	210	210
							Total: 3774	Total: 1253

CAP & the southwest part of the region: 800 trees, 8 variables, samplevector2 = c(800,900,1100,535)
Elim'd 20 worst "mean decrease in accuracy" variables-- kept 49
OOB estimate of error rate: 39.61%

	AHNHF	CADOPF	NEIDMOF	SCIMF	class.error	Known_Occ's	Adjusted_KOs
AHNHF	594	71	140	37	0.2945	842	800
CADOPF	81	792	312	96	0.3817	1281	900
NEIDMOF	167	340	638	173	0.5159	1318	1100
SCIMF	31	20	107	377	0.2953	535	535
						Total: 3976	Total: 3335

MAP-MAC: 800 trees, 5 variables, **no sampsize vector**
Eliminated 46 variables, kept 30
OOB estimate of error rate: 24.85%

	CADOPF	NACPHF	NEIDMOF	SACPMHF	SPDOPF	SPMF	class.error	Known_Occ's	Adjusted_KOs
CADOPF	80	0	26	0	2	5	0.2920	113	113
NACPHF	0	32	1	10	1	0	0.2727	44	44
NEIDMOF	22	0	148	0	12	21	0.2709	203	203
SACPMHF	0	8	0	47	2	1	0.1897	58	58
SPDOPF	1	0	5	2	142	32	0.2198	182	182
SPMF	3	0	35	0	23	192	0.2411	253	253
								Total: 853	Total: 854

Table 7: The effect of balancing sample counts on classification error. This example is from the High Allegheny Ecoregion.

Error Estimates- High Allegheny Ecoregion		
	Unbalanced	Balanced
System	Error Estimates	Error Estimates
AHNHF	0.0957	0.213
CADOPF	0.3977	0.356
LANHF	0.2314	0.218
LAPHHF	0.3185	0.319
NEIDMOF	0.5268	0.346
mean	**0.31402**	**0.2904**

Patch-forming Upland and Wetland Habitats

A total of 85 upland large or small patch habitats and wetland habitats were mapped. The accuracy of the patch models was measured only by the degree to which the model captured the known occurrences of the habitat. However, because we consciously restricted the models to prevent over-mapping (which will always produce better occurrence capture), and because the known occurrences represented only a small portion of the true extent it is difficult to assess the true accuracy of each model. The best test would be is how well the model captures the true signature of the habitat type and how accurately the spatial models maps that signature. The accuracy of the wetland classification was further dependent on the accuracy of the type-assignment within the NWI maps.

CHAPTER

5

Discussion

The Northeastern Terrestrial Habitat Map and the Northeast Terrestrial Habitat Classification System were developed as a comprehensive and standardized representation of habitats for wildlife that would be consistent across states and consistent with other regional classification and mapping efforts. These habitat systems are intended to be applicable at medium and large scales, and to supplement the finer-scale approaches used within states for specific projects and needs. The map was meant to provide a common base for characterizing wildlife habitats across states, to facilitate interstate communication about habitats, and to promote an understanding of terrestrial and aquatic biodiversity patterns across the region. The map is not intended to replace or override state classifications or habitat types (which, in many cases, can be much more detailed), but rather to put them into a broader context (Gawler 2008).

The final product maps 121 habitats and types that are extensive and cover areas in the 1000s of acres, as well as small, specific-environment types that may cover only an acre or two. We emphasize to users of the Northeast Terrestrial Habitat map that each mapped habitat was based on a predictive model**.** Specifically, what is being mapped is the distribution of ecological environments more likely to support the specific habitat shown than any of the other alternative habitats. The root information that each model is based on was a set of known sample occurrences and a set of biophysical attributes that were correlated with the distribution of those occurrences. If the map has been constructed well, the models will represent these habitats in approximately the right proportion on the landscape, and in approximately the right configuration. If the map finds users and uses regionally, and proves to be a help in wildlife management and habitat conservation at broad scales, it will be because the ecological systems are mapped not perfectly but plausibly. Additionally, we hope that the ecological systems themselves prove to be a useful theoretical and practical construct into which land managers and ecologists can comfortably fit their understanding of the natural world.

In constructing the map we relied heavily on 70,000+ habitat samples that were originally compiled for other reasons and were not classified to *The Northeast Terrestrial Habitat Classification System.* The correct classification of the samples was a critical and time consuming step in the mapping process. Samples of natural communities that were ecologically related but named and described somewhat differently between adjacent states were always problematic. For example, New York recognizes several patch-forming upland communities that fall into a group of xeric to sub-xeric, shallow-soiled woodlands or forests on calcareous bedrock (Edinger et al. 2002). These include oak openings, alvar woodlands, red cedar rocky summits, northern white cedar rocky summits, red cedar barrens and limestone woodlands, each with its own distribution and signature within New York. The Vermont Natural Heritage Program also identifies several similar calcareous natural communities: limestone bluff cedar-pine forest, red cedar woodland, a calcareous variant of dry oak-hickory-hop hornbeam, a transition hardwoods limestone forest, and a northern hardwood limestone forest (Thompson and Sorenson 2000). Conceivably, samples of these communities could be considered to fit the concept of three different systems: Central Appalachian Alkaline Glade and Woodland, Laurentian-Acadian Calcareous Rocky Outcrop, Great Lakes

Alvar, or they could be calcareous expression of several matrix forest types. To sort out the linkages and differences among all these communities and determine the appropriate system, we needed to look at the geographic ranges, the spatial scale at which they occur, and the finer details of environmental context, like topographic position, insolation, and geologic substrate. In this case, an interesting outcome was that, on review, Vermont ecologists recognized their limestone bluff cedar-pine forest community as related to the Great Lake native communities, and suggested that we tag them to the Great Lakes Alvar system. This called for a slight expansion of the Alvar concept, but formed a link that makes real biogeographic and ecological sense. This slight expansion of an ecological system concept was not uncommon, and as a result the classification was improved by the mapping effort.

Confusion between similar systems was not only a challenge in the tagging of samples but also in the mapping of closely related habitats. The relative RF error rates found when mapping matrix-forming forest types explain a lot about classification difficulties inherent in discriminating between similar habitats. For example, the error matrix for the High Allegheny Ecoregion showed that during model cross-validation procedures, an average of 24% of the 246 Central Appalachian Dry Oak Pine Forest samples were classified to Northeast Interior Dry-Mesic Oak Forest, a system with which it shares many landscapes and part of a mesic-to-dry moisture gradient. These two forest types can be difficult to tell apart even in the field so this error is more acceptable then if the Dry Oak Pine Forest samples were classified to Appalachian Hemlock –Northern Hardwood forest, for example, which is characteristic of very different environment. Thus the raw error rates don't always indicate the acceptability of the error especially for systems for which there is authentic overlap in the environmental signatures.

Several mapping problems arose related to ecological systems that were defined too generally or that were well defined in one geographic region but had no system counterpart in the other regions where similar communities occurred. An example of the first problem is the Laurentian-Acadian Freshwater Marsh. This system was broadly defined and mapped across the entire map region, reflecting the fact that the setting and composition of the habitat is surprisingly consistent across states and it does not show strong geographic variants. Thus the geographic descriptor in the system name (Laurentian-Acadian) does not encompass the full distribution of the type because it is found beyond the Laurentian-Acadian region. The reverse problem sometimes occurred when two ecologically similar system were subdivided based on a geographic division such as an ecoregion boundary. In these cases the transition on the map is unavoidably sharp while in reality there is a gradual transition from one system to the other across a broad fuzzy boundary.

The second issue of unequal system coverage is most obvious in the incomplete mapping of habitats associated with stream riparian zones. Some regions, such as the North Atlantic Coastal Plain, had these systems defined as a primary habitat type but others did not, and thus the riparian systems are mapped in some regions and not in others. We got around this to some extent by adding secondary classification attributes to the attribute table so users could search for stream related habitats.

Our mapping results confirmed our expectation that some variables (climate, subsection, longitude/latitude, elevation) were more useful for broad-scale distinctions in habitat ranges, and that other smaller-scale factors that operate at smaller scale, like local topography, insolation, and distance to water were more useful for making fine-scale distinctions. In the RF models, a few variables actually had negative importance, meaning that classification results were better if they were left out of the analysis altogether. In fact, using the top 25 variables only made a little last-step incremental improvement in the confusion matrix suggesting that although the software is robust to correlated variables, using a smaller set actually gave better results.

We were unable to obtain certain spatial datasets related to habitat structure and distribution, like reliable fine-scale soils data (texture, pH, depth to restrictive layer) or fires history, as the information was not available region-wide. This limited the accuracy of the models for certain patch-scale communities that are defined in part by structure and soils (e.g. Interior Pine Barren, Wet Flatwood). For some of the small patch systems we had information on known locations, but we could not successfully model the occurrences because none of our environmental information was fine enough to create a realistic model. An example of this was the extremely small and patchy Laurentian-Acadian Alkaline Fen system. In this case we were not able to map the full distribution, so the map is incomplete with respect to these systems (these types marked with an asterisk in the result tables).

We are grateful to the many scientists and conservationist who contributed their expertise and data to this project. In spite of its limitations, this map represents a big step forward in unifying a large body of on-the-ground work in classifying and mapping eastern habitats consistently across the region. It is critical that we understand these habitats, and the ecological consequences and vulnerabilities associated with climate change, within a multi-state context. A consistent definition, description, and accurate dataset of habitat types will help conservationists understand where conservation is most needed. To this end we created an accompanying guide to the habitats mapped in this dataset that describes each system, its ecological setting, associated wildlife and rare species, and current condition. This information creates a foundation for further research by providing common definitions and mapping of terrestrial habitat types across political borders, allowing states and provinces to identify habitats consistently across those borders. The document *Northeast Habitat Guides: A companion to the terrestrial and aquatic habitat maps.* (Anderson et al.2013) can be downloaded at:
https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/edc/

We hope the map and accompanying resources provide fundamental tools for evaluating the distribution and condition of habitats and for assessing the implications of future land use change and climate variability. And, that these tools are valuable to agencies charged with managing wildlife and habitat, and to conservationists interested in protecting the full spectrum of natural diversity.

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APPENDIX

1

Biophysical Variables

Biophysical variables attributed to known sample occurrences and 100 acre hexagons

Geographic and climate variables and distance-to-NHD water are measured at the sample points and at the centers of the 100 acre hexagons; all other variables are summaries for the 100 acre circles around known sample points or the 100 acre hexagons tesselated across the region.

Var_name	Var_descrip	Units	Source	Date	Scale
GEOGRAPHIC					
LAT	Latitude	Decimal degrees	ArcInfo "addxy" function	NA	NA
LONG	Longitude	Decimal degrees	ArcInfo "addxy" function	NA	NA
SECTION	ECOMAP Section	Section code (character)	USDA-Forest Service	2007	1:500,000- 1:1M
SUBSECTION	ECOMAP Subsection	Subsection code (character)	USDA-Forest Service	2007	1:500,000- 1:1M
CLIMATE					
TEMP_ANNRG	Temperature: annual range	Degrees C * 10	WorldClim (www.worldclim.org)	2004	1km cells
TEMP_MAXWM	Max temperature in the warmest month	Degrees C * 10	WorldClim (www.worldclim.org)	2004	1km cells
TEMP_MINCM	Min temperature in the coldest month	Degrees C * 10	WorldClim (www.worldclim.org)	2004	1km cells
TEMP_MDQ	Mean temp driest quarter	Degrees C * 10	WorldClim (www.worldclim.org)	2004	1km cells
TEMP_MDR	Temperature: mean diurnal range	Degrees C * 10	WorldClim (www.worldclim.org)	2004	1km cells
PRECIP_MA	Precipitation: mean annual	mm	WorldClim (www.worldclim.org)	2004	1km cells
PRECIP_WQ	Precipitation: warmest quarter	mm	WorldClim (www.worldclim.org)	2004	1km cells
PRECIP_CV	Precipitation: coefficient of variation: seasonality of precipitation	unitless	WorldClim (www.worldclim.org)	2004	1km cells
ELEVATION/TOPOGRAPHIC					
ELEV_MEAN	Mean elevation of 100 acre circle	meters	USGS 30m DEM	2006	30m cells
ELEV_RANGE	Elevation range within 100 acre circle	meters	USGS 30m DEM	2006	30m cells
ELEV_STDEV	Standard deviation of elevation	meters	USGS 30m DEM	2006	30m cells
SLOPE_MEAN	Mean slope	degrees	Arc Grid "slope" function & USGS 30m DEM	2006	30m cells
SLOPE_RNG	Range in slope	degrees	Arc Grid "slope" function & USGS 30m DEM	2006	30m cells
SLOPE_STD	Standard deviation of slope	degrees	Arc Grid "slope" function & USGS 30m DEM	2006	30m cells
ASP_T_MEAN	Mean of transformed aspect (numeric): closeness to/distance from SW aspect	unitless	Arc Grid "aspect" function & USGS 30m DEM	2006	30m cells
ASP_DOM	Dominant aspect (categorical)	8 points of the compass	Arc Grid "aspect" function & USGS 30m DEM	2006	30m cells
SAI_MEAN	Mean slope-aspect index	unitless	Arc Grid "hillshade" function & USGS 30m DEM	2006	30m cells
SAI_RANGE	Range slope-aspect index	unitless	Arc Grid "hillshade" function & USGS 30m DEM	2006	30m cells
SOLRAD_MIN	Min value of annual cumulative solar radiation	(watt-hrs/sq. m.)	ArcGIS "solar radiation" tool & USGS 30m DEM	2006	90m cells
SOLRAD_MAX	Max value of annual cum. solar radiation	(watt-hrs/sq. m.)	ArcGIS "solar radiation" tool & USGS 30m DEM	2006	90m cells
SOLRAD_RNG	Range of solar radiation values	(watt-hrs/sq. m.)	ArcGIS "solar radiation" tool & USGS 30m DEM	2006	90m cells
SOLRADMEAN	Mean annual cumulative solar radiation	(watt-hrs/sq. m.)	ArcGIS "solar radiation" tool & USGS 30m DEM	2006	90m cells

Var_name	Var_descrip	Units	Source	Date	Scale
LANDFORM					
P_SUMMIT	Pct summit landform type	percent	TNC landforms, from USGS 30m DEM*	2009	30m cells
P_STEEP	Pct steep landform type	percent	TNC landforms, from USGS 30m DEM*	2009	30m cells
P_SUMMSTP	Pct summit/steep landform types combined	percent	TNC landforms, from USGS 30m DEM*	2009	30m cells
P_SS_WARM	Pct sideslope warm aspect	percent	TNC landforms, from USGS 30m DEM*	2009	30m cells
P_SS_COOL	Pct sideslope cool aspect	percent	TNC landforms, from USGS 30m DEM*	2009	30m cells
P_COVE	Pct cove landforms	percent	TNC landforms, from USGS 30m DEM*	2009	30m cells
P_HILLS	Pct low hill/valley landforms	percent	TNC landforms, from USGS 30m DEM*	2009	30m cells
P_DRYFLAT	Pct dry flats	percent	TNC landforms, from USGS 30m DEM*	2009	30m cells
P_WETFLAT	Pct wet flats	percent	TNC landforms, from USGS 30m DEM*	2009	30m cells
P_WATER	Pct combined NLCD & NHD open water	percent	NLCD (Nat'l Landcover Dataset), NHD (Nat'l Hydrography Dataset)	2001, 2007	30m cells
LPOS_MEAN	Mean value land position index	unitless	USGS 30m DEM	2006	30m cells
LPOS_MAX	Max value land position index	unitless	USGS 30m DEM	2006	30m cells
LPOS_MIN	Min value land position index	unitless	USGS 30m DEM	2006	30m cells
LPOS_RANGE	Range of land position index values	unitless	USGS 30m DEM	2006	30m cells
LPOS_STDEV	Std deviation of land position index values	unitless	USGS 30m DEM	2006	30m cells
GEOLOGY					
P_100	Pct acidic sedimentary substrate	percent	State bedrock geology maps	various: 1961-2003	1:100,000-1:500,000
P_200	Pct acidic shale substrate	percent	State bedrock geology maps	various: 1961-2003	1:100,000-1:500,000
P_100200	Pct 100/200 combined	percent	State bedrock geology maps	various: 1961-2003	1:100,000-1:500,000
P_300	Pct calcareous substrate	percent	State bedrock geology maps	various: 1961-2003	1:100,000-1:500,000
P_400	Pct moderately calcareous substrate	percent	State bedrock geology maps	various: 1961-2003	1:100,000-1:500,000
P_300400	Pct mod calc/calc substrate combined	percent	State bedrock geology maps	various: 1961-2003	1:100,000-1:500,000
P_500	Pct granitic/gneissic substrate	percent	State bedrock geology maps	various: 1961-2003	1:100,000-1:500,000
P_600	Pct intermed granitic/mafic substrate	percent	State bedrock geology maps	various: 1961-2003	1:100,000-1:500,000
P_700	Pct ultramafic substrate	percent	State bedrock geology maps	various: 1961-2003	1:100,000-1:500,000
P_800	Pct unconsolidated coarse sediments	percent	State bedrock geology maps	various: 1961-2003	1:100,000-1:500,000
P_900	Pct unconsolidated fine sediments	percent	State bedrock geology maps	various: 1961-2003	1:100,000-1:500,000

Var_name	Var_descrip	Units	Source	Date	Scale
LANDCOVER					
P_DECID	Pct deciduous land cover	percent	NLCD 2001 (Nat'l Landcover Dataset); NLCD 2006 for Piedmont & Mid-Atlantic Coast Ecoregions in Virginia	2001/2006	30m cells
P_CONIF	Pct coniferous land cover	percent	NLCD 2001 (Nat'l Landcover Dataset); NLCD 2006 for Piedmont & Mid-Atlantic Coast Ecoregions in Virginia	2001/2006	30m cells
P_MIXED	Pct conif-decid mixed landcover	percent	NLCD 2001 (Nat'l Landcover Dataset); NLCD 2006 for Piedmont & Mid-Atlantic Coast Ecoregions in Virginia	2001/2006	30m cells
P_CONIFMIX	Pct conif & mixed landcover combined	percent	NLCD 2001 (Nat'l Landcover Dataset); NLCD 2006 for Piedmont & Mid-Atlantic Coast Ecoregions in Virginia	2001/2006	30m cells
P_OPENBARE	Pct open/bare landcover	percent	NLCD 2001 (Nat'l Landcover Dataset); NLCD 2006 for Piedmont & Mid-Atlantic Coast Ecoregions in Virginia	2001/2006	30m cells
P_FORWET	Pct forested wetland landcover	percent	NLCD 2001 (Nat'l Landcover Dataset); NLCD 2006 for Piedmont & Mid-Atlantic Coast Ecoregions in Virginia	2001/2006	30m cells
P_OPENWET	Pct open wetland landcover	percent	NLCD (Nat'l Landcover Dataset) 2001; NLCD 2006 for Piedmont & Mid-Atlantic Coast Ecoregions in Virginia	2001/2006	30m cells
OTHER					
CANOPYMEAN	Mean canopy cover	percent	NLCD	2001	30m cells
CANOPY_RNG	Range of canopy cover values	percent	NLCD	2001	30m cells
CANOPY_STD	Std deviation of canopy cover values	percent	NLCD	2001	30m cells
D2NHD_MIN	Min distance to NHD river/lake/reservoir	meters	NHDplus (Nat'l Hydrography Dataset) & Arc Grid "Eucdistance" function	2006	1:100,000
D2NHD_MEAN	Mean distance to NHD river/lake/reservoir	meters	NHDplus (Nat'l Hydrography Dataset) & Arc Grid "Eucdistance" function	2006	1:100,000

***TNC landforms: SEE APPENDIX 3**

SEE APPENDIX 2 FOR TECHNICAL INFORMATION ON THE DERIVATION OF 9 OF THE VARIABLES/INDICES USED TO CREATE SYSTEM MODELS

Variables Used to Model Ecological Systems: Technical Information

APPENDIX

2

Land position index (LPI): This index is one of the 2 structural components (along with slope) of the 30m landforms that were built for the Northeastern US in 2009. It is a unitless number calculated from values in a digital elevation model (DEM) that indicates the position of every point on the landscape surface in relation to its surroundings. For each digital elevation model point, it is calculated as a distance-weighted mean of the elevation differences between that point and all other elevation model points within a user-specified radius:

$$LPI_o = \left[\sum_{1,n} (z_i - z_o) / d_i \right] / n,$$

where z_o = elevation of the focal point whose LPI is being calculated,
z_i = elevation of point i of n model points within the specified search radius of the focal point,
d_i = horizontal distance between the focal point and point i, and
n = the total number of model points within the specified search distance.

If the point being evaluated is in a valley, surrounding model points will be mostly higher than the focal point and the index will have a positive value. Negative values indicate that the focal point is close to a ridge top or summit, and values approaching zero indicate low relief or a mid-slope position. Values typically vary between about -1 and 1. We used digital elevation model points up to a maximum horizontal distance of 180m from the focal cell (equivalent to six 30m DEM cells) to calculate the LPI for that focal cell.

Here is the aml used to create the LPI:

```
* landpos_NAP410.aml
/* 4/1/10: landpos_nap410.aml: Run lpos index for NAP/STL--
allows
/*     you to make a mid-slope cut between upper & lower sideslope
/* -- Also makes grids LPOS6_X10000 & LPOS6_SL100 (if the
search_rad
/*    variable is set to 6), & FM4_LPOS_NAP, to help with modeling


/* Calculates landposition based on the elevation of each cell in
/* relation to its neighbors--> determines mean elev at progressively
/* farther distance from model cell (up to specified search radius),
/* subtracts model cell elev from mean at each radius and divides by
/* the distance from model cell, calcs mean result for all radii.
/* ---- RUN IN GRID ----

&severity &error &routine bailout
```

```
&wo C:\Data\NE_HabMapping\sw_region\grids
&sv dem = c:/data/division/grids/NED30_2006US
setcell 30
&sv cellsize = 30
setwindow  mask_sw_buff2  mask_SW_buff
  /* mask_sw_buff2 is a 1000m buffer of ../covs/SW_region_bdy,
  /* & mask_SW_buff is the 600m buffer you've been using for
  /* extent and grid registration all along
setmask mask_sw_buff2

&sv search_rad = 6
&sv lposgrid = lpos%search_rad%_311

&if ^ [exists %lposgrid% -grid] &then
  &call calc_LPI

setwindow mask_sw_buff  mask_SW_buff
setmask mask_sw_buff

&type /&Calculating LPOS%search_rad%X10000_2 grid...
LPOS%search_rad%X10000_2 = int((%lposgrid% * 10000) + 0.5)
   /* the first lpos6_x10000 & lpos6_sl100 grids were made from an
   /* lpos6 grid with extent & mask for a 600m buffer of the region
   /* boundary-- this lpos6_311 grid had a 1000m buffer, so
subsequent
   /* grids derived from it w/ a 600m buffer will avoid anomalies
   /* around the region periphery

&type /&Calculating LPOS%search_rad%_SL100_2 grid...
LPOS%search_rad%_SL100_2 =
slice(LPOS%search_rad%X10000_2,eqarea,100)

&type /&Calculating FM4_LPOS_SW_2 grid...
FM4_LPOS_SW_2 =
int(focalmean(LPOS%search_rad%_SL100_2,circle,4) + 0.5)

&call exit
&ret


/***** ROUTINE CALC_LPI
&routine calc_LPI
&sv rout = calc_lpi


&type /&Date/time at start: [date -vfull]
&type Calculating landpos index for big area that includes SW region
&type Search radius is %search_rad% cells.../&
```

```
/***** Run focalmean for each radius and create sum-to-date grid
&do i = 1 &to %search_rad%
  &type /&Calculating (inverse) distance wgt'd mean elev difference ~
at radius of %i% cells.../&
  &if %i% = %search_rad% &then
    &type ...Last one.../&
  elev%i%x = ( focalmean(%dem%,annulus,%i%,%i%) - ~
        %dem% ) / ( %i% * %cellsize% )
  &if %i% = 2 &then
    &do
      elev%i%sum = elev[calc %i% - 1]x + elev%i%x
      kill (! elev[calc %i% - 1]x  elev%i%x !) all
    &end
  &if %i% gt 2 &then
    &do
      elev%i%sum = elev[calc %i% - 1]sum + elev%i%x
      kill (! elev[calc %i% - 1]sum elev%i%x !) all
    &end
  &if %i% = %search_rad% &then
    &do
      &type /&Calculating %lposgrid% index grid.../&
      %lposgrid% = elev%i%sum / %search_rad%
      kill elev%i%sum
    &end
&end
&ret


/****** BAILOUT ROUTINE
&routine bailout
&severity &error &ignore

&type /&Date/time at bailout: [date -vfull]/&
&call exit
&ret &error /&Bailing out of routine %rout%...

/********* EXIT ROUTINE
&routine exit
&severity &error &ignore
```

Local mean of LPI values: Taking means of local LPI values is a tool for landscape generalization, useful when certain ecological systems are known to occupy particularly high or low parts of the landscape. We executed 3 steps in the ArcInfo Grid module (ESRI, 2008), multiplying LPI values by 10,000, standardizing those values over a range from 1 to 100, and running a “focalmean” within a circular radius of four 30m cells:

LPOS6_X10000 = int((lpos_grid * 10000) + 0.5) ← gives an integer grid

```
LPOS6_SL100 = slice(LPOS6_X10000,eqarea,100)    ← slices the values of LPOS6_X10000 into 100
levels
                                                                  using equal area divisions
FM4_LPOS_NAP = int(focalmean(LPOS6_SL100,circle,4) + 0.5)   ← unitless values 1-100
```

<u>Landforms</u>: SEE App3_Landforms.doc— how landforms are built

<u>Local mean of solar radiation</u>: Useful for identifying areas of the landscape where high or low solar inputs may be important determinants of habitat distributions. The original solar radiation grid was compiled as a 90m grid due to intensive computer requirements, and like the land position index grid was standardized to values from 1-100. The focalmean was performed in a 30m processing environment, and the final grid of local mean solar inputs is therefore a 30m grid. We used a two cell circular window to perform the local function on the 90m grid:

```
fm2_solrad = int(focalmean(solrad_grid,circle,2,data) + 0.5)    ← gives an integer grid with values 1-100
```

<u>Local mean conifer cover</u>: The level of conifer dominance is an important distinguishing feature for several ecological systems. The following Grid statement generates a useful tool for modeling areas of high or low conifer in forested areas; limiting the focalmean to wooded areas only (NLCD-NWI values 41, 42, 43, 90, 91, 92: no open natural areas, developed cover, or water) prevents misleading average conifer cover values at the interface of wooded and non-wooded areas. The Grid syntax is:

```
Fmn2_conifwgt = setnull(NLCD-NWI ^ in {41,42,43,90,91,92}, int(
(focalmean(NLCDNWI_nap8.conif_wgt,
                        circle,2) * 100) + 0.5) )    ← gives unitless integer values in the range of 1-1000
```

<u>Topographic roughness index (TRI)</u>: We attached topographic roughness values from 0 to 10 to the landforms in our regional landform grid (flats are 0 at one end of the scale, cliffs are 10 at the other), and used these values in two ways. First, we multiplied those values by 100 (in Grid, TRI_VAL_X_100 = Landform30.TRI_values * 100) and attributed the 100 acre circles around known occurrences and the tessellated 100 acre hexagons with the mean of those values over the 100 acres. This “topographic roughness index” was one of the variables we fed into the RandomForests analysis. We also found a local sum of TRI values to be helpful modeling topographic depressions and basins, or low moist areas adjacent to streamways. The Grid formulation is:

```
Fsum3trivalue = focalsum(Landform30.tri_values,circle,3)    <-- values 0-290
```

<u>Local mean canopy cover</u>: The raw values in the 30m grid of percent canopy cover that was released with the 2001 NLCD were difficult to interpret for modeling purposes, but a focalmean with a 2-cell window often revealed a useful pattern of low to high canopy cover zones. In the Grid syntax, non-natural landcover (NLCD-NWI <= 31 or NLCD-NWI = 81 or 82) is excluded from the focalmean, preventing misleading values at the interface of natural and non-natural cover types:

```
Fm2_canopyint = setnull(NLCD-NWI  le 31 or NLCD-NWI in {81,82}, int(focalmean
(Canopy_grid,circle,2,data) + 0.5) )
```

Transformed aspect: When the ArcInfo Grid "aspect" function is applied to a DEM, it gives values from 0 to 360 degrees, indicating the compass direction that cells in the grid are facing (0 and 360 are north; values of -1 in the output grid indicate a flat surface at that cell). The following trigonometric function, when applied to the aspect grid, generate an output grid of "transformed aspect." On this grid, higher numbers attach to warmer aspects, lower numbers to cooler aspects, making it more useful for quantitative analysis:

```
Aspect_trns = con(slope_grid lt 3, 0, int( 1000 * ( ( ( 1 - cos((aspect_grid - 45)/ deg ) ) / 2 ) + 0.0005 ) ) )
```

In this Grid formulation, cells with a slope of less than 3 degrees are set to 0; "deg" is the constant for conversion of degrees to radians; and the final unitless integer values range from 1 to 1000.

Lithochemistry index: Compiled regional bedrock geology from state geological survey maps. Attached relative "calcareousness" value to bedrock types and to combinations of bedrock and deep coarse or fine sediments that mantle the bedrock, where they exist. Took a 10-cell focal mean of the calc values; e.g.:

```
fm10_calcval = int(focalmean(calc_val_nap,circle,10,data) + 0.5)
calcindex_tmp = int( (100 * fm10_calcval / 300) + 0.5 )    /* standardize to 0-100
```

Because the 10-cell focalmean can average away originally high calc scores on calcareous bedrock, burn those original calc values back in; e.g.:

```
 CALC_INDEX = con(GEOL208D_NAP1 == 300,100,GEOL208D_NAP1 ==
400,65,(GEOL208D_NAP1 == 600
                    or GEOL208D_NAP1 == 700),33,calcindex_tmp)
```

```
HERE ARE THE DECISION RULES FOR ASSIGNMENT TO LITHOCHEM CLASSES-- used them
/*** for cliff-talus occurrences in Cliff-tal3_rg & ridgetop occ's in Ridgetop4sys5:

/*** "Calc": Calcind_mx = 100 & Calcind_mn [that's "mean"] ge 65: & set a "flag" item to
/***                   some number gt 0 for these
/*** "Circumneut":  "flag" = 0 & mean = 65 & max ne 100: set flag to a positive number
/***                "flag" = 0 & max ge 33 & mean ge 11: set flag to a positive number
/***                "flag" = 0 & mean ge 13 & mean lt 65: set flag to a positive number
/*** "Acidic": everything else (flag = 0)
```

Landforms

APPENDIX

3

Introduction

Stanley Rowe called landform "the anchor and control of terrestrial ecosystems." It breaks up broad landscapes into local topographic units, and in doing so provides for (more detailed) meso- and microclimatic expression of (more general) macroclimatic character. It is largely responsible for local variation in solar radiation, soil development, moisture availability, and susceptibility to wind and other disturbance. As one of the five "genetic influences" in the process of soil formation, it is tightly tied to rates of erosion and deposition, and therefore to soil depth, texture, and nutrient availability. These are, with moisture, the primary edaphic controllers of plant productivity and species distributions. If the other four influences on soil formation (climate, time, parent material, and biota) are constant over a given space, it is variation in landform that drives variation in the distribution and composition of natural communities.

Of the environmental variables discussed here, it is landform that most resists quantification. Landform is a compound measure, which can be decomposed into the primary terrain attributes of elevation, slope, aspect, surface curvature, and upslope catchment area. The wide availability and improving quality of digital elevation data has made the quantification of primary terrain attributes a simple matter. Compound topographic indices have been derived from these primary attributes to model various ecological processes. We adopted the Fels and Matson (1997) approach to landform modeling. They describe a metric that combines information on slope and landscape position to define topographic units such as ridges, sideslopes, coves, and flats on the landscape. That approach is described here: feel free to skip over the details, to the set of defined landforms that emerges from the process (Figure 1 below).

Model construction

The parent dataset for the two grids used to construct the landforms is the 1 arc-second (30 meter) National Elevation Dataset digital elevation model (DEM) of the USGS. Step one was to derive a grid of discrete slope classes relevant to the landscapes of ecoregions in the Northeast. We remapped slopes to create classes of 0-2˚ (0.0-3.5%), 2-6˚ (3.5–10.5%), 6-24˚ (10.5–44.5%), 24-35˚ (44.5-70.0%), and >35˚ (>70.0%) (vertical axes of Figure1). Ground checks have shown that, because slopes derived from the NED dataset are averaged over 30 meters, raster cells in the 2 steepest elevation classes contain actual terrain slopes of from about 35 to 60 degrees (in the 24-35˚ class) and 60 to 90 degrees (in the steepest class).

The next step was the calculation of a landscape position index (LPI), a unitless measure of the position of a point on the landscape surface in relation to its surroundings. It is calculated, for each elevation model point, as a distance-weighted mean of the elevation differences between that point and all other elevation model points within a user-specified radius:

$$LPI_o = \left[\sum_{1,n} (z_i - z_o) / d_i \right] / n,$$

where z_o = elevation of the focal point whose LPI is being calculated,

z_i = elevation of point i of n model points within the specified search radius of the focal point,

d_i = horizontal distance between the focal point and point i, and

n = the total number of model points within the specified search distance.

If the point being evaluated is in a valley, surrounding model points will be mostly higher than the focal point and the index will have a positive value. Negative values indicate that the focal point is close to a ridge top or summit, and values approaching zero indicate low relief or a mid-slope position (Fig. 1).

The specified search distance, sometimes referred to as the "fractal dimension" of the landscape, is half of the average ridge-to-stream distance. We used two methods to fix this distance for each subsection within the region, one digital and one analog. The "curvature" function of the ArcInfo Grid module uses the DEM to calculate change in slope ("slope of the slope") in the landscape. This grid, when displayed as a stretched grayscale image, highlights valley and ridge structure, the "bones" of the landscape, and ridge-to-stream distances can be sampled on-screen. For our analog approach we used 7.5' USGS topographic quadsheets. In each case, we averaged several measurements of ridge-to-stream distances, in landscapes representative of the subsection, to obtain the fractal dimension. This dimension can vary considerably from one subsection to another.

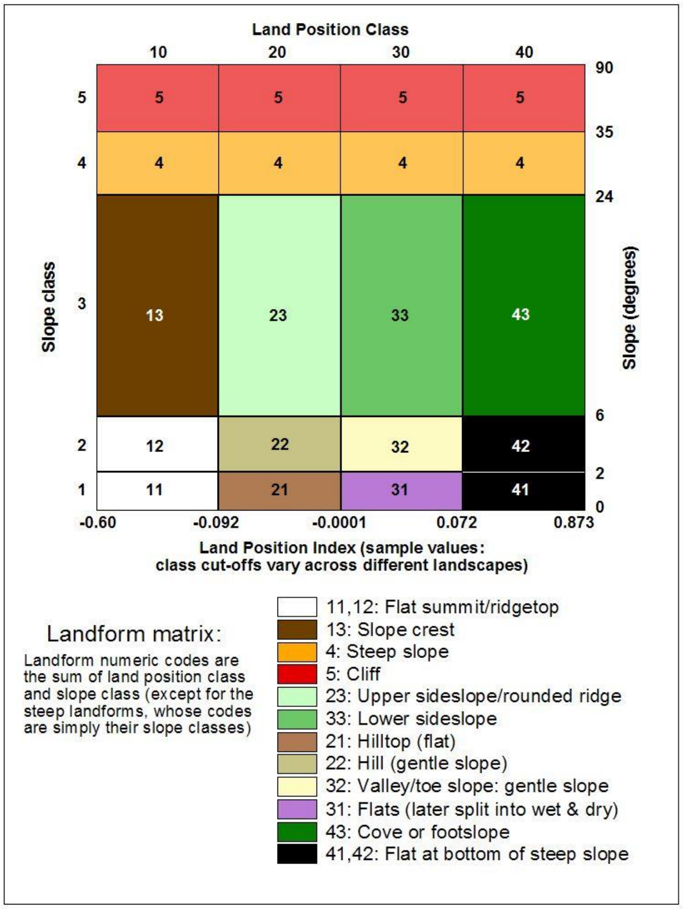
There is a third approach to fixing the landscape fractal dimension. A semivariogram of a clip of the DEM for a typical portion of the regional landscape can be constructed— it quantifies the spatial autocorrelation of the digital elevation points by calculating the squared difference in elevation between each and every pair of points in the landscape, then plotting half that squared difference (the “semivariance”) against the distance of separation. A model is then fitted to the empirical semiovariogram “cloud of points.” (This model is used to guide the prediction of unknown points in a kriging interpolation.) The form of the model is typically an asymptotic curve that rises fairly steeply and evenly near the origin (high spatial autocorrelation for points near one another) and flattens out at a semivariance “sill” value, beyond which distance there is little or no correlation between points. Though the sill distance, in the subsections where we tried this approach, was 2 or 3 times the “fractal distance” as measured with the first 2 methods, the relationship between the two was fairly consistent. The DEM semivariogram could prove to be a useful landscape analysis tool with a little more experimentation.

The next step was to divide the grid of continuous LPI values into discrete classes of high, moderately high, moderately low, and low landscape position. Histograms of the landscape position grid values were examined, a first set of break values selected, and the resulting classes visualized and evaluated. We did this for several different types of landscapes (rolling hills, steeply cut mountainsides, kame complexes in a primarily wet landscape, broad valleys), in areas of familiar geomorphology. The process was repeated many times, until we felt that the class breaks accurately caught the structure of the land, in each of the different landscape types. Success was measured by how well the four index classes represented the following landscape features:

> High landscape position (very convex): sharp ridges, summits, knobs, bluffs
>
> Moderately high landscape position: upper side slopes, rounded summits and ridges, low hills and kamic convexities
>
> Moderately low landscape position: lower sideslopes and toe slopes, gentle valleys and draws, broad flats
>
> Low landscape position (very concave): steeply cut stream beds and coves, and flats at the foot of steep slopes

We assigned values 1-5 to the five slope classes, and 10, 20, 30, and 40 to the four LPI classes. Following Fels and Matson (1997), we summed the grids to produce a matrix of values (Fig. 1), and gave descriptive names to landforms that corresponded to matrix values. We collapsed all units in slope classes 4 and 5 into "steep" and "cliff" units, respectively. The ecological significance of these units, which are generally small and thinly distributed, lies in their very steepness, regardless of where they occur on the landscape.

Fig. 1: Formulation of landform models from land position and slope classes.



Landform numeric codes are the sum of land position class and slope class (except for the steep landforms, whose codes are simply their slope classes)

Recognizing the ecological importance of separating occurrences of “flats” (0-2˚ slope) into primarily dry areas and areas of higher moisture availability, we calculated a simple moisture index that maps variation in moisture accumulation and soil residence time. We used National Wetlands Inventory datasets to calibrate the index and set a wet/dry threshold, then applied it to the flats landform to make the split. The formula for the moisture index is:

$$\text{Moist\_index} = \ln\left[(\text{flow\_accumulation} + 1)/(\text{slope} + 1)\right]$$

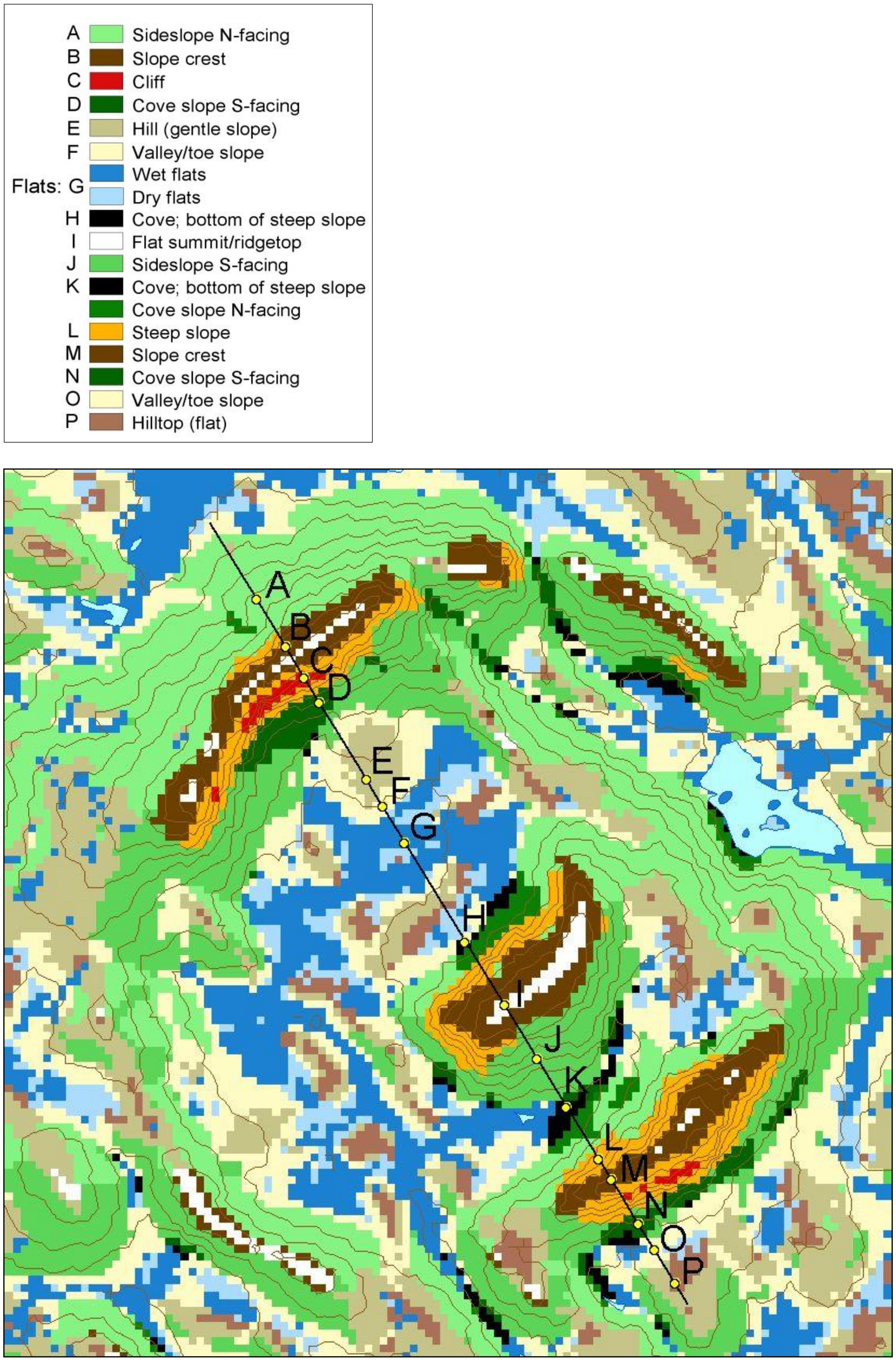
Grids for both flow accumulation and slope were derived from the DEM by ArcInfo Grid functions of the same names.

For the ecoregional ELU dataset, upper and lower sideslopes are combined, and a simple ecologically relevant aspect split is embedded in the sideslope and cove slope landforms (Figure 2 and Table 3).

Last, waterbodies from the National Hydrography Dataset (NHD), which was compiled at a scale of 1:100,000 and is available for the whole region, were incorporated into the landform layer with codes 51 (broader river reaches represented as polygons) and 52 (lakes, ponds, and reservoirs). Single-line stream and river arcs from the NHD were not burned into the landforms-- only those river reaches that are mapped as polygons.

Landform units for an area of varied topography in southeastern New Hampshire are shown in map view in Figure 2.

Fig. 2: Landforms in Pawtuckaway State Park, NH



System Types by State

APPENDIX

4

SUMGRPNUM	SUMGRPNAME	ES_CODE_S_	System_type	STATE	ACRES_ST	ACRES_TOTL	PCT_TOTAL
2	Acadian Low Elevation Spruce-Fir-Hardwood Forest [ALESPHF]	201.565	1 - Matrix forest	MA	554	5523188	0.01
2	Acadian Low Elevation Spruce-Fir-Hardwood Forest [ALESPHF]	201.565	1 - Matrix forest	ME	4818901	5523188	87.25
2	Acadian Low Elevation Spruce-Fir-Hardwood Forest [ALESPHF]	201.565	1 - Matrix forest	NH	177618	5523188	3.22
2	Acadian Low Elevation Spruce-Fir-Hardwood Forest [ALESPHF]	201.565	1 - Matrix forest	NY	306636	5523188	5.55
2	Acadian Low Elevation Spruce-Fir-Hardwood Forest [ALESPHF]	201.565	1 - Matrix forest	VT	219433	5523188	3.97
11	Allegheny-Cumberland Dry Oak Forest and Woodland [ACDOFW]	202.359	1 - Matrix forest	PA	60875	2273323	2.68
11	Allegheny-Cumberland Dry Oak Forest and Woodland [ACDOFW]	202.359	1 - Matrix forest	VA	500461	2273323	22.01
11	Allegheny-Cumberland Dry Oak Forest and Woodland [ACDOFW]	202.359	1 - Matrix forest	WV	1700037	2273323	74.78
12	Appalachian (Hemlock)-Northern Hardwood Forest [AHNHF]	202.593	1 - Matrix forest	CT	584675	21007943	2.78
12	Appalachian (Hemlock)-Northern Hardwood Forest [AHNHF]	202.593	1 - Matrix forest	DC	1293	21007943	0.01
12	Appalachian (Hemlock)-Northern Hardwood Forest [AHNHF]	202.593	1 - Matrix forest	DE	3615	21007943	0.02
12	Appalachian (Hemlock)-Northern Hardwood Forest [AHNHF]	202.593	1 - Matrix forest	MA	1146767	21007943	5.46
12	Appalachian (Hemlock)-Northern Hardwood Forest [AHNHF]	202.593	1 - Matrix forest	MD	282250	21007943	1.34
12	Appalachian (Hemlock)-Northern Hardwood Forest [AHNHF]	202.593	1 - Matrix forest	ME	458232	21007943	2.18
12	Appalachian (Hemlock)-Northern Hardwood Forest [AHNHF]	202.593	1 - Matrix forest	NH	1198506	21007943	5.71
12	Appalachian (Hemlock)-Northern Hardwood Forest [AHNHF]	202.593	1 - Matrix forest	NJ	127388	21007943	0.61
12	Appalachian (Hemlock)-Northern Hardwood Forest [AHNHF]	202.593	1 - Matrix forest	NY	7077256	21007943	33.69
12	Appalachian (Hemlock)-Northern Hardwood Forest [AHNHF]	202.593	1 - Matrix forest	PA	8223011	21007943	39.14
12	Appalachian (Hemlock)-Northern Hardwood Forest [AHNHF]	202.593	1 - Matrix forest	RI	11946	21007943	0.06
12	Appalachian (Hemlock)-Northern Hardwood Forest [AHNHF]	202.593	1 - Matrix forest	VA	137952	21007943	0.66
12	Appalachian (Hemlock)-Northern Hardwood Forest [AHNHF]	202.593	1 - Matrix forest	VT	618426	21007943	2.94
12	Appalachian (Hemlock)-Northern Hardwood Forest [AHNHF]	202.593	1 - Matrix forest	WV	1124998	21007943	5.36
24	Central Appalachian Dry Oak-Pine Forest [CADOPF]	202.591	1 - Matrix forest	CT	27965	3845583	0.73
24	Central Appalachian Dry Oak-Pine Forest [CADOPF]	202.591	1 - Matrix forest	DC	4	3845583	0.00

SUMGRPNUM	SUMGRPNAME	ES_CODE_S_	System_type	STATE	ACRES_ST	ACRES_TOTL	PCT_TOTAL
24	Central Appalachian Dry Oak-Pine Forest [CADOPF]	202.591	1 - Matrix forest	DE	164	3845583	0.00
24	Central Appalachian Dry Oak-Pine Forest [CADOPF]	202.591	1 - Matrix forest	MA	48101	3845583	1.25
24	Central Appalachian Dry Oak-Pine Forest [CADOPF]	202.591	1 - Matrix forest	MD	127589	3845583	3.32
24	Central Appalachian Dry Oak-Pine Forest [CADOPF]	202.591	1 - Matrix forest	ME	4783	3845583	0.12
24	Central Appalachian Dry Oak-Pine Forest [CADOPF]	202.591	1 - Matrix forest	NH	15155	3845583	0.39
24	Central Appalachian Dry Oak-Pine Forest [CADOPF]	202.591	1 - Matrix forest	NJ	23304	3845583	0.61
24	Central Appalachian Dry Oak-Pine Forest [CADOPF]	202.591	1 - Matrix forest	NY	316556	3845583	8.23
24	Central Appalachian Dry Oak-Pine Forest [CADOPF]	202.591	1 - Matrix forest	PA	1496411	3845583	38.91
24	Central Appalachian Dry Oak-Pine Forest [CADOPF]	202.591	1 - Matrix forest	RI	939	3845583	0.02
24	Central Appalachian Dry Oak-Pine Forest [CADOPF]	202.591	1 - Matrix forest	VA	982191	3845583	25.54
24	Central Appalachian Dry Oak-Pine Forest [CADOPF]	202.591	1 - Matrix forest	VT	25032	3845583	0.65
24	Central Appalachian Dry Oak-Pine Forest [CADOPF]	202.591	1 - Matrix forest	WV	777295	3845583	20.21
42	Laurentian-Acadian Northern Hardwood Forest [LANHF]	201.564	1 - Matrix forest	CT	4925	12740840	0.04
42	Laurentian-Acadian Northern Hardwood Forest [LANHF]	201.564	1 - Matrix forest	MA	304993	12740840	2.39
42	Laurentian-Acadian Northern Hardwood Forest [LANHF]	201.564	1 - Matrix forest	ME	4652966	12740840	36.52
42	Laurentian-Acadian Northern Hardwood Forest [LANHF]	201.564	1 - Matrix forest	NH	1148133	12740840	9.01
42	Laurentian-Acadian Northern Hardwood Forest [LANHF]	201.564	1 - Matrix forest	NJ	114	12740840	0.00
42	Laurentian-Acadian Northern Hardwood Forest [LANHF]	201.564	1 - Matrix forest	NY	4476228	12740840	35.13
42	Laurentian-Acadian Northern Hardwood Forest [LANHF]	201.564	1 - Matrix forest	PA	6236	12740840	0.05
42	Laurentian-Acadian Northern Hardwood Forest [LANHF]	201.564	1 - Matrix forest	VT	2147189	12740840	16.85
44	Laurentian-Acadian Pine-Hemlock-Hardwood Forest [LAPHHF]	201.563	1 - Matrix forest	CT	4	6105856	0.00
44	Laurentian-Acadian Pine-Hemlock-Hardwood Forest [LAPHHF]	201.563	1 - Matrix forest	MA	158288	6105856	2.59
44	Laurentian-Acadian Pine-Hemlock-Hardwood Forest [LAPHHF]	201.563	1 - Matrix forest	ME	2683690	6105856	43.95
44	Laurentian-Acadian Pine-Hemlock-Hardwood Forest [LAPHHF]	201.563	1 - Matrix forest	NH	846525	6105856	13.86
44	Laurentian-Acadian Pine-Hemlock-Hardwood Forest [LAPHHF]	201.563	1 - Matrix forest	NY	1543360	6105856	25.28

SUMGRPNUM	SUMGRPNAME	ES_CODE_S_	System_type	STATE	ACRES_ST	ACRES_TOTL	PCT_TOTAL
44	Laurentian-Acadian Pine-Hemlock-Hardwood Forest [LAPHHF]	201.563	1 - Matrix forest	PA	102359	6105856	1.68
44	Laurentian-Acadian Pine-Hemlock-Hardwood Forest [LAPHHF]	201.563	1 - Matrix forest	VT	771628	6105856	12.64
50	North Atlantic Coastal Plain Hardwood Forest [NACPHF]	203.475	1 - Matrix forest	CT	193799	2145723	9.03
50	North Atlantic Coastal Plain Hardwood Forest [NACPHF]	203.475	1 - Matrix forest	DC	686	2145723	0.03
50	North Atlantic Coastal Plain Hardwood Forest [NACPHF]	203.475	1 - Matrix forest	DE	72016	2145723	3.36
50	North Atlantic Coastal Plain Hardwood Forest [NACPHF]	203.475	1 - Matrix forest	MA	263917	2145723	12.30
50	North Atlantic Coastal Plain Hardwood Forest [NACPHF]	203.475	1 - Matrix forest	MD	390566	2145723	18.20
50	North Atlantic Coastal Plain Hardwood Forest [NACPHF]	203.475	1 - Matrix forest	ME	76302	2145723	3.56
50	North Atlantic Coastal Plain Hardwood Forest [NACPHF]	203.475	1 - Matrix forest	NH	35848	2145723	1.67
50	North Atlantic Coastal Plain Hardwood Forest [NACPHF]	203.475	1 - Matrix forest	NJ	307885	2145723	14.35
50	North Atlantic Coastal Plain Hardwood Forest [NACPHF]	203.475	1 - Matrix forest	NY	87829	2145723	4.09
50	North Atlantic Coastal Plain Hardwood Forest [NACPHF]	203.475	1 - Matrix forest	PA	10635	2145723	0.50
50	North Atlantic Coastal Plain Hardwood Forest [NACPHF]	203.475	1 - Matrix forest	RI	64470	2145723	3.00
50	North Atlantic Coastal Plain Hardwood Forest [NACPHF]	203.475	1 - Matrix forest	RI	857	2145723	0.04
50	North Atlantic Coastal Plain Hardwood Forest [NACPHF]	203.475	1 - Matrix forest	VA	640913	2145723	29.87
54	North Atlantic Coastal Plain Pitch Pine Barrens [NACPPPB]	203.269	1 - Matrix forest	MA	101289	491573	20.61
54	North Atlantic Coastal Plain Pitch Pine Barrens [NACPPPB]	203.269	1 - Matrix forest	NJ	326484	491573	66.42
54	North Atlantic Coastal Plain Pitch Pine Barrens [NACPPPB]	203.269	1 - Matrix forest	NY	60019	491573	12.21
54	North Atlantic Coastal Plain Pitch Pine Barrens [NACPPPB]	203.269	1 - Matrix forest	RI	3391	491573	0.69
54	North Atlantic Coastal Plain Pitch Pine Barrens [NACPPPB]	203.269	1 - Matrix forest	RI	391	491573	0.08
67	Northeastern Coastal and Interior Pine-Oak Forest [NECIPOF]	203.999	1 - Matrix forest	CT	38448	1538150	2.50
67	Northeastern Coastal and Interior Pine-Oak Forest [NECIPOF]	203.999	1 - Matrix forest	MA	403154	1538150	26.21
67	Northeastern Coastal and Interior Pine-Oak Forest [NECIPOF]	203.999	1 - Matrix forest	ME	391659	1538150	25.46
67	Northeastern Coastal and Interior Pine-Oak Forest [NECIPOF]	203.999	1 - Matrix forest	NH	654806	1538150	42.57
67	Northeastern Coastal and Interior Pine-Oak Forest [NECIPOF]	203.999	1 - Matrix forest	RI	50082	1538150	3.26
68	Northeastern Interior Dry-Mesic Oak Forest [NEIDMOF]	202.592	1 - Matrix forest	CT	965528	17040329	5.67
68	Northeastern Interior Dry-Mesic Oak Forest [NEIDMOF]	202.592	1 - Matrix forest	DC	1541	17040329	0.01
68	Northeastern Interior Dry-Mesic Oak Forest [NEIDMOF]	202.592	1 - Matrix forest	DE	8127	17040329	0.05
68	Northeastern Interior Dry-Mesic Oak Forest [NEIDMOF]	202.592	1 - Matrix forest	MA	242887	17040329	1.43
68	Northeastern Interior Dry-Mesic Oak Forest [NEIDMOF]	202.592	1 - Matrix forest	MD	678929	17040329	3.98
68	Northeastern Interior Dry-Mesic Oak Forest [NEIDMOF]	202.592	1 - Matrix forest	NJ	559849	17040329	3.29

SUMGRPNUM	SUMGRPNAME	ES_CODE_S_	System_type	STATE	ACRES_ST	ACRES_TOTL	PCT_TOTAL
68	Northeastern Interior Dry-Mesic Oak Forest [NEIDMOF]	202.592	1 - Matrix forest	NY	1811602	17040329	10.63
68	Northeastern Interior Dry-Mesic Oak Forest [NEIDMOF]	202.592	1 - Matrix forest	PA	6264759	17040329	36.76
68	Northeastern Interior Dry-Mesic Oak Forest [NEIDMOF]	202.592	1 - Matrix forest	RI	179487	17040329	1.05
68	Northeastern Interior Dry-Mesic Oak Forest [NEIDMOF]	202.592	1 - Matrix forest	VA	2588472	17040329	15.19
68	Northeastern Interior Dry-Mesic Oak Forest [NEIDMOF]	202.592	1 - Matrix forest	WV	3732285	17040329	21.90
84	Southern Appalachian Oak Forest [SAOF]	202.886	1 - Matrix forest	VA	1430743	2887721	49.55
84	Southern Appalachian Oak Forest [SAOF]	202.886	1 - Matrix forest	WV	1438594	2887721	49.82
86	Southern Atlantic Coastal Plain Mesic Hardwood Forest [SACPMHF]	203.242	1 - Matrix forest	DC	1123	1935075	0.06
86	Southern Atlantic Coastal Plain Mesic Hardwood Forest [SACPMHF]	203.242	1 - Matrix forest	DE	107687	1935075	5.57
86	Southern Atlantic Coastal Plain Mesic Hardwood Forest [SACPMHF]	203.242	1 - Matrix forest	MD	568824	1935075	29.40
86	Southern Atlantic Coastal Plain Mesic Hardwood Forest [SACPMHF]	203.242	1 - Matrix forest	NJ	137706	1935075	7.12
86	Southern Atlantic Coastal Plain Mesic Hardwood Forest [SACPMHF]	203.242	1 - Matrix forest	PA	139	1935075	0.01
86	Southern Atlantic Coastal Plain Mesic Hardwood Forest [SACPMHF]	203.242	1 - Matrix forest	VA	1116958	1935075	57.72
88	Southern Piedmont Dry Oak-Pine Forest [SPDOPF]	202.339	1 - Matrix forest	VA	1796986	1797056	100.00
92	Southern Piedmont Mesic Forest {SPMF]	202.342	1 - Matrix forest	MD	5230	2439102	0.21
92	Southern Piedmont Mesic Forest {SPMF]	202.342	1 - Matrix forest	VA	2433743	2439102	99.78
4	Acadian Sub-boreal Spruce Flat	201.562	2 - Patch: lrg/small	MA	91	1513187	0.01
4	Acadian Sub-boreal Spruce Flat	201.562	2 - Patch: lrg/small	ME	1324647	1513187	87.54
4	Acadian Sub-boreal Spruce Flat	201.562	2 - Patch: lrg/small	NH	43968	1513187	2.91
4	Acadian Sub-boreal Spruce Flat	201.562	2 - Patch: lrg/small	NY	98498	1513187	6.51
4	Acadian Sub-boreal Spruce Flat	201.562	2 - Patch: lrg/small	VT	45974	1513187	3.04
5	Acadian-Appalachian Alpine Tundra	201.567	2 - Patch: lrg/small	ME	3624	8185	44.28
5	Acadian-Appalachian Alpine Tundra	201.567	2 - Patch: lrg/small	NH	4160	8185	50.82
5	Acadian-Appalachian Alpine Tundra	201.567	2 - Patch: lrg/small	NY	285	8185	3.48
5	Acadian-Appalachian Alpine Tundra	201.567	2 - Patch: lrg/small	VT	115	8185	1.41
6	Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest	201.566	2 - Patch: lrg/small	MA	605	1084480	0.06
6	Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest	201.566	2 - Patch: lrg/small	ME	417357	1084480	38.48
6	Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest	201.566	2 - Patch: lrg/small	NH	351367	1084480	32.40
6	Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest	201.566	2 - Patch: lrg/small	NY	213418	1084480	19.68
6	Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest	201.566	2 - Patch: lrg/small	VT	101699	1084480	9.38
7	Acadian-North Atlantic Rocky Coast	201.573	2 - Patch: lrg/small	CT	417	7707	5.41
7	Acadian-North Atlantic Rocky Coast	201.573	2 - Patch: lrg/small	MA	2626	7707	34.07
7	Acadian-North Atlantic Rocky Coast	201.573	2 - Patch: lrg/small	ME	3146	7707	40.82
7	Acadian-North Atlantic Rocky Coast	201.573	2 - Patch: lrg/small	NH	211	7707	2.74
7	Acadian-North Atlantic Rocky Coast	201.573	2 - Patch: lrg/small	NY	242	7707	3.14
7	Acadian-North Atlantic Rocky Coast	201.573	2 - Patch: lrg/small	RI	914	7707	11.86
7	Acadian-North Atlantic Rocky Coast	201.573	2 - Patch: lrg/small	RI	150	7707	1.95
8	Acidic Cliff and Talus	202.309, 201.569, 202.330, 202.601, 202.689	2 - Patch: lrg/small	CT	2074	563659	0.37
8	Acidic Cliff and Talus	202.309, 201.569, 202.330, 202.601, 202.689	2 - Patch: lrg/small	DE	4	563659	0.00

SUMGRPNUM	SUMGRPNAME	ES_CODE_S_	System_type	STATE	ACRES_ST	ACRES_TOTL	PCT_TOTAL
8	Acidic Cliff and Talus	202.309, 201.569, 202.330, 202.601, 202.689	2 - Patch: lrg/small	MA	6149	563659	1.09
8	Acidic Cliff and Talus	202.309, 201.569, 202.330, 202.601, 202.689	2 - Patch: lrg/small	MD	437	563659	0.08
8	Acidic Cliff and Talus	202.309, 201.569, 202.330, 202.601, 202.689	2 - Patch: lrg/small	ME	35030	563659	6.21
8	Acidic Cliff and Talus	202.309, 201.569, 202.330, 202.601, 202.689	2 - Patch: lrg/small	NH	35117	563659	6.23
8	Acidic Cliff and Talus	202.309, 201.569, 202.330, 202.601, 202.689	2 - Patch: lrg/small	NJ	2675	563659	0.47
8	Acidic Cliff and Talus	202.309, 201.569, 202.330, 202.601, 202.689	2 - Patch: lrg/small	NY	107433	563659	19.06
8	Acidic Cliff and Talus	202.309, 201.569, 202.330, 202.601, 202.689	2 - Patch: lrg/small	PA	204784	563659	36.33
8	Acidic Cliff and Talus	202.309, 201.569, 202.330, 202.601, 202.689	2 - Patch: lrg/small	RI	3	563659	0.00
8	Acidic Cliff and Talus	202.309, 201.569, 202.330, 202.601, 202.689	2 - Patch: lrg/small	VA	43024	563659	7.63
8	Acidic Cliff and Talus	202.309, 201.569, 202.330, 202.601, 202.689	2 - Patch: lrg/small	VT	34676	563659	6.15
8	Acidic Cliff and Talus	202.309, 201.569, 202.330, 202.601, 202.689	2 - Patch: lrg/small	WV	90424	563659	16.04
9	Acidic Rocky Outcrop	201.019, 201.571	2 - Patch: lrg/small	CT	91	197414	0.05
9	Acidic Rocky Outcrop	201.019, 201.571	2 - Patch: lrg/small	MA	5006	197414	2.54
9	Acidic Rocky Outcrop	201.019, 201.571	2 - Patch: lrg/small	ME	53694	197414	27.20
9	Acidic Rocky Outcrop	201.019, 201.571	2 - Patch: lrg/small	NH	50311	197414	25.49
9	Acidic Rocky Outcrop	201.019, 201.571	2 - Patch: lrg/small	NY	44372	197414	22.48
9	Acidic Rocky Outcrop	201.019, 201.571	2 - Patch: lrg/small	VT	43941	197414	22.26
13	Appalachian Shale Barrens	202.598	2 - Patch: lrg/small	MD	2163	5169	41.85
13	Appalachian Shale Barrens	202.598	2 - Patch: lrg/small	PA	407	5169	7.87
13	Appalachian Shale Barrens	202.598	2 - Patch: lrg/small	VA	1728	5169	33.43
13	Appalachian Shale Barrens	202.598	2 - Patch: lrg/small	WV	871	5169	16.85
14	Atlantic Coastal Plain Beach and Dune	203.264/203.301	2 - Patch: lrg/small	CT	2896	96725	2.99
14	Atlantic Coastal Plain Beach and Dune	203.264/203.301	2 - Patch: lrg/small	DE	4074	96725	4.21
14	Atlantic Coastal Plain Beach and Dune	203.264/203.301	2 - Patch: lrg/small	MA	35604	96725	36.81
14	Atlantic Coastal Plain Beach and Dune	203.264/203.301	2 - Patch: lrg/small	MD	3182	96725	3.29
14	Atlantic Coastal Plain Beach and Dune	203.264/203.301	2 - Patch: lrg/small	ME	4444	96725	4.59
14	Atlantic Coastal Plain Beach and Dune	203.264/203.301	2 - Patch: lrg/small	NH	882	96725	0.91
14	Atlantic Coastal Plain Beach and Dune	203.264/203.301	2 - Patch: lrg/small	NJ	9986	96725	10.32
14	Atlantic Coastal Plain Beach and Dune	203.264/203.301	2 - Patch: lrg/small	NY	20889	96725	21.60
14	Atlantic Coastal Plain Beach and Dune	203.264/203.301	2 - Patch: lrg/small	RI	2971	96725	3.07
14	Atlantic Coastal Plain Beach and Dune	203.264/203.301	2 - Patch: lrg/small	RI	800	96725	0.83
14	Atlantic Coastal Plain Beach and Dune	203.264/203.301	2 - Patch: lrg/small	VA	10966	96725	11.34
21	Calcareous Cliff and Talus	202.356, 201.570, 202.690	2 - Patch: lrg/small	MA	1868	56387	3.31
21	Calcareous Cliff and Talus	202.356, 201.570, 202.690	2 - Patch: lrg/small	ME	7886	56387	13.99
21	Calcareous Cliff and Talus	202.356, 201.570, 202.690	2 - Patch: lrg/small	NH	3757	56387	6.66
21	Calcareous Cliff and Talus	202.356, 201.570, 202.690	2 - Patch: lrg/small	NY	21975	56387	38.97

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21	Calcareous Cliff and Talus	202.356, 201.570, 202.690	2 - Patch: lrg/small	PA	118	56387	0.21
21	Calcareous Cliff and Talus	202.356, 201.570, 202.690	2 - Patch: lrg/small	VA	3892	56387	6.90
21	Calcareous Cliff and Talus	202.356, 201.570, 202.690	2 - Patch: lrg/small	VT	15737	56387	27.91
21	Calcareous Cliff and Talus	202.356, 201.570, 202.690	2 - Patch: lrg/small	WV	1020	56387	1.81
22	Calcareous Rocky Outcrop	201.572	2 - Patch: lrg/small	ME	10745	50773	21.16
22	Calcareous Rocky Outcrop	201.572	2 - Patch: lrg/small	NH	3018	50773	5.94
22	Calcareous Rocky Outcrop	201.572	2 - Patch: lrg/small	NY	20024	50773	39.44
22	Calcareous Rocky Outcrop	201.572	2 - Patch: lrg/small	VT	16986	50773	33.45
23	Central Appalachian Alkaline Glade and Woodland	202.602	2 - Patch: lrg/small	CT	92	413521	0.02
23	Central Appalachian Alkaline Glade and Woodland	202.602	2 - Patch: lrg/small	MA	202	413521	0.05
23	Central Appalachian Alkaline Glade and Woodland	202.602	2 - Patch: lrg/small	MD	25055	413521	6.06
23	Central Appalachian Alkaline Glade and Woodland	202.602	2 - Patch: lrg/small	ME	183	413521	0.04
23	Central Appalachian Alkaline Glade and Woodland	202.602	2 - Patch: lrg/small	NH	15	413521	0.00
23	Central Appalachian Alkaline Glade and Woodland	202.602	2 - Patch: lrg/small	NJ	144	413521	0.03
23	Central Appalachian Alkaline Glade and Woodland	202.602	2 - Patch: lrg/small	NY	1297	413521	0.31
23	Central Appalachian Alkaline Glade and Woodland	202.602	2 - Patch: lrg/small	PA	118779	413521	28.72
23	Central Appalachian Alkaline Glade and Woodland	202.602	2 - Patch: lrg/small	VA	110939	413521	26.83
23	Central Appalachian Alkaline Glade and Woodland	202.602	2 - Patch: lrg/small	VT	2464	413521	0.60
23	Central Appalachian Alkaline Glade and Woodland	202.602	2 - Patch: lrg/small	WV	154346	413521	37.32
25	Central Appalachian Pine-Oak Rocky Woodland	202.600	2 - Patch: lrg/small	CT	4925	566738	0.87
25	Central Appalachian Pine-Oak Rocky Woodland	202.600	2 - Patch: lrg/small	DC	4	566738	0.00
25	Central Appalachian Pine-Oak Rocky Woodland	202.600	2 - Patch: lrg/small	DE	24	566738	0.00
25	Central Appalachian Pine-Oak Rocky Woodland	202.600	2 - Patch: lrg/small	MA	8545	566738	1.51
25	Central Appalachian Pine-Oak Rocky Woodland	202.600	2 - Patch: lrg/small	MD	28084	566738	4.96
25	Central Appalachian Pine-Oak Rocky Woodland	202.600	2 - Patch: lrg/small	ME	4009	566738	0.71
25	Central Appalachian Pine-Oak Rocky Woodland	202.600	2 - Patch: lrg/small	NH	7739	566738	1.37
25	Central Appalachian Pine-Oak Rocky Woodland	202.600	2 - Patch: lrg/small	NJ	8243	566738	1.45
25	Central Appalachian Pine-Oak Rocky Woodland	202.600	2 - Patch: lrg/small	NY	24140	566738	4.26
25	Central Appalachian Pine-Oak Rocky Woodland	202.600	2 - Patch: lrg/small	PA	310507	566738	54.79

SUMGRPNUM	SUMGRPNAME	ES_CODE_S_	System_type	STATE	ACRES_ST	ACRES_TOTL	PCT_TOTAL
25	Central Appalachian Pine-Oak Rocky Woodland	202.600	2 - Patch: lrg/small	RI	38	566738	0.01
25	Central Appalachian Pine-Oak Rocky Woodland	202.600	2 - Patch: lrg/small	VA	93656	566738	16.53
25	Central Appalachian Pine-Oak Rocky Woodland	202.600	2 - Patch: lrg/small	VT	6189	566738	1.09
25	Central Appalachian Pine-Oak Rocky Woodland	202.600	2 - Patch: lrg/small	WV	70182	566738	12.38
27	Central Atlantic Coastal Plain Maritime Forest	203.261	2 - Patch: lrg/small	VA	6295	6356	99.04
29	Central and Southern Appalachian Montane Oak Forest	202.596	2 - Patch: lrg/small	VA	126512	148716	85.07
29	Central and Southern Appalachian Montane Oak Forest	202.596	2 - Patch: lrg/small	WV	21369	148716	14.37
30	Central and Southern Appalachian Spruce-Fir Forest	202.028	2 - Patch: lrg/small	VA	6401	64957	9.85
30	Central and Southern Appalachian Spruce-Fir Forest	202.028	2 - Patch: lrg/small	WV	58555	64957	90.14
31	Circumneutral Cliff and Talus	202.603	2 - Patch: lrg/small	CT	1842	56458	3.26
31	Circumneutral Cliff and Talus	202.603	2 - Patch: lrg/small	MA	3683	56458	6.52
31	Circumneutral Cliff and Talus	202.603	2 - Patch: lrg/small	MD	407	56458	0.72
31	Circumneutral Cliff and Talus	202.603	2 - Patch: lrg/small	ME	858	56458	1.52
31	Circumneutral Cliff and Talus	202.603	2 - Patch: lrg/small	NH	1011	56458	1.79
31	Circumneutral Cliff and Talus	202.603	2 - Patch: lrg/small	NJ	1389	56458	2.46
31	Circumneutral Cliff and Talus	202.603	2 - Patch: lrg/small	NY	15195	56458	26.91
31	Circumneutral Cliff and Talus	202.603	2 - Patch: lrg/small	PA	9865	56458	17.47
31	Circumneutral Cliff and Talus	202.603	2 - Patch: lrg/small	VA	7439	56458	13.18
31	Circumneutral Cliff and Talus	202.603	2 - Patch: lrg/small	VT	6359	56458	11.26
31	Circumneutral Cliff and Talus	202.603	2 - Patch: lrg/small	WV	8408	56458	14.89
33	Eastern Serpentine Woodland	202.347	2 - Patch: lrg/small	DE	10	11954	0.08
33	Eastern Serpentine Woodland	202.347	2 - Patch: lrg/small	MD	6040	11954	50.53
33	Eastern Serpentine Woodland	202.347	2 - Patch: lrg/small	PA	3976	11954	33.26
33	Eastern Serpentine Woodland	202.347	2 - Patch: lrg/small	VA	1929	11954	16.14
34	Glacial Marine & Lake Mesic Clayplain Forest	202.998	2 - Patch: lrg/small	NY	204882	236862	86.50
34	Glacial Marine & Lake Mesic Clayplain Forest	202.998	2 - Patch: lrg/small	VT	31980	236862	13.50
36	Great Lakes Alvar	201.721	2 - Patch: lrg/small	NY	26659	27657	96.39
36	Great Lakes Alvar	201.721	2 - Patch: lrg/small	VT	998	27657	3.61
37	Great Lakes Dune and Swale	201.026, 201.726	2 - Patch: lrg/small	NY	1337	1805	74.07
37	Great Lakes Dune and Swale	201.026, 201.726	2 - Patch: lrg/small	PA	461	1805	25.54
37	Great Lakes Dune and Swale	201.026, 201.726	2 - Patch: lrg/small	VT	6	1805	0.33
43	Laurentian-Acadian Northern Pine-(Oak) Forest	201.719	2 - Patch: lrg/small	NY	14328	14328	100.00
45	Laurentian-Acadian Red Oak-Northern Hardwood Forest	201.564	2 - Patch: lrg/small	MA	6569	1168853	0.56
45	Laurentian-Acadian Red Oak-Northern Hardwood Forest	201.564	2 - Patch: lrg/small	ME	601550	1168853	51.46
45	Laurentian-Acadian Red Oak-Northern Hardwood Forest	201.564	2 - Patch: lrg/small	NH	114404	1168853	9.79
45	Laurentian-Acadian Red Oak-Northern Hardwood Forest	201.564	2 - Patch: lrg/small	NY	96974	1168853	8.30
45	Laurentian-Acadian Red Oak-Northern Hardwood Forest	201.564	2 - Patch: lrg/small	VT	349357	1168853	29.89

SUMGRPNUM	SUMGRPNAME	ES_CODE_S_	System_type	STATE	ACRES_ST	ACRES_TOTL	PCT_TOTAL
45	Laurentian-Acadian Red Oak-Northern Hardwood Forest	201.564	2 - Patch: lrg/small	ME	601550	1168853	51.46
45	Laurentian-Acadian Red Oak-Northern Hardwood Forest	201.564	2 - Patch: lrg/small	NH	114404	1168853	9.79
45	Laurentian-Acadian Red Oak-Northern Hardwood Forest	201.564	2 - Patch: lrg/small	NY	96974	1168853	8.30
45	Laurentian-Acadian Red Oak-Northern Hardwood Forest	201.564	2 - Patch: lrg/small	VT	349357	1168853	29.89
51	North Atlantic Coastal Plain Heathland and Grassland	203.895	2 - Patch: lrg/small	CT	1371	32838	4.18
51	North Atlantic Coastal Plain Heathland and Grassland	203.895	2 - Patch: lrg/small	MA	20684	32838	62.99
51	North Atlantic Coastal Plain Heathland and Grassland	203.895	2 - Patch: lrg/small	NH	38	32838	0.12
51	North Atlantic Coastal Plain Heathland and Grassland	203.895	2 - Patch: lrg/small	NY	7580	32838	23.08
51	North Atlantic Coastal Plain Heathland and Grassland	203.895	2 - Patch: lrg/small	RI	3164	32838	9.64
51	North Atlantic Coastal Plain Heathland and Grassland	203.895	2 - Patch: lrg/small	RI	2	32838	0.01
53	North Atlantic Coastal Plain Maritime Forest	203.302	2 - Patch: lrg/small	CT	5511	127127	4.34
53	North Atlantic Coastal Plain Maritime Forest	203.302	2 - Patch: lrg/small	DE	1233	127127	0.97
53	North Atlantic Coastal Plain Maritime Forest	203.302	2 - Patch: lrg/small	MA	32938	127127	25.91
53	North Atlantic Coastal Plain Maritime Forest	203.302	2 - Patch: lrg/small	MD	1157	127127	0.91
53	North Atlantic Coastal Plain Maritime Forest	203.302	2 - Patch: lrg/small	ME	32258	127127	25.37
53	North Atlantic Coastal Plain Maritime Forest	203.302	2 - Patch: lrg/small	NH	774	127127	0.61
53	North Atlantic Coastal Plain Maritime Forest	203.302	2 - Patch: lrg/small	NJ	1267	127127	1.00
53	North Atlantic Coastal Plain Maritime Forest	203.302	2 - Patch: lrg/small	NY	29959	127127	23.57
53	North Atlantic Coastal Plain Maritime Forest	203.302	2 - Patch: lrg/small	RI	7038	127127	5.54
53	North Atlantic Coastal Plain Maritime Forest	203.302	2 - Patch: lrg/small	RI	929	127127	0.73
53	North Atlantic Coastal Plain Maritime Forest	203.302	2 - Patch: lrg/small	VA	14062	127127	11.06
61	Northeastern Interior Pine Barrens	202.590	2 - Patch: lrg/small	CT	147	42744	0.34
61	Northeastern Interior Pine Barrens	202.590	2 - Patch: lrg/small	MA	2049	42744	4.79
61	Northeastern Interior Pine Barrens	202.590	2 - Patch: lrg/small	ME	9152	42744	21.41
61	Northeastern Interior Pine Barrens	202.590	2 - Patch: lrg/small	NH	5721	42744	13.38
61	Northeastern Interior Pine Barrens	202.590	2 - Patch: lrg/small	NY	22912	42744	53.60
61	Northeastern Interior Pine Barrens	202.590	2 - Patch: lrg/small	RI	2228	42744	5.21
61	Northeastern Interior Pine Barrens	202.590	2 - Patch: lrg/small	VT	534	42744	1.25
62	North-Central Interior Beech-Maple Forest	202.693	2 - Patch: lrg/small	NY	30834	73136	42.16
62	North-Central Interior Beech-Maple Forest	202.693	2 - Patch: lrg/small	PA	41814	73136	57.17
72	Piedmont Hardpan Woodland and Forest	202.268	2 - Patch: lrg/small	MD	217	49432	0.44
72	Piedmont Hardpan Woodland and Forest	202.268	2 - Patch: lrg/small	VA	49215	49432	99.56
80	South-Central Interior Mesophytic Forest	202.887	2 - Patch: lrg/small	PA	533071	3556213	14.99
80	South-Central Interior Mesophytic Forest	202.887	2 - Patch: lrg/small	VA	232932	3556213	6.55
80	South-Central Interior Mesophytic Forest	202.887	2 - Patch: lrg/small	WV	2777711	3556213	78.11

SUMGRPNUM	SUMGRPNAME	ES_CODE_S_	System_type	STATE	ACRES_ST	ACRES_TOTL	PCT_TOTAL
81	Southern Appalachian Low Elevation Pine Forest	202.332	2 - Patch: lrg/small	VA	22258	22355	99.57
81	Southern Appalachian Low Elevation Pine Forest	202.332	2 - Patch: lrg/small	WV	4	22355	0.02
82	Southern Appalachian Montane Pine Forest and Woodland	202.331	2 - Patch: lrg/small	MD	159	33535	0.47
82	Southern Appalachian Montane Pine Forest and Woodland	202.331	2 - Patch: lrg/small	PA	1079	33535	3.22
82	Southern Appalachian Montane Pine Forest and Woodland	202.331	2 - Patch: lrg/small	VA	25280	33535	75.38
82	Southern Appalachian Montane Pine Forest and Woodland	202.331	2 - Patch: lrg/small	WV	7014	33535	20.92
83	Southern Appalachian Northern Hardwood Forest	202.029	2 - Patch: lrg/small	VA	12753	12833	99.38
85	Southern Atlantic Coastal Plain Upland Longleaf Pine Woodland	203.241/203.281	2 - Patch: lrg/small	VA	579	579	100.00
89	Southern Piedmont Glade and Barrens	202.328	2 - Patch: lrg/small	VA	107	107	100.00
90	Southern Piedmont Granite Flatrock and Outcrop	202.329	2 - Patch: lrg/small	VA	83	83	100.00
94	Southern Ridge and Valley / Cumberland Dry Calcareous Forest	202.457	2 - Patch: lrg/small	VA	882546	917654	96.17
94	Southern Ridge and Valley / Cumberland Dry Calcareous Forest	202.457	2 - Patch: lrg/small	WV	31853	917654	3.47
95	Southern Ridge and Valley Calcareous Glade and Woodland	202.024	2 - Patch: lrg/small	VA	9195	9794	93.88
95	Southern Ridge and Valley Calcareous Glade and Woodland	202.024	2 - Patch: lrg/small	WV	224	9794	2.29
96	Southern and Central Appalachian Cove Forest	202.373	2 - Patch: lrg/small	MD	271	1018463	0.03
96	Southern and Central Appalachian Cove Forest	202.373	2 - Patch: lrg/small	VA	443232	1018463	43.52
96	Southern and Central Appalachian Cove Forest	202.373	2 - Patch: lrg/small	WV	571375	1018463	56.10
97	Southern and Central Appalachian Mafic Glade and Barrens	202.348	2 - Patch: lrg/small	MD	47	1456	3.23
97	Southern and Central Appalachian Mafic Glade and Barrens	202.348	2 - Patch: lrg/small	VA	1409	1456	96.77
98	Southern Appalachian Grass and Shrub Bald	202.294	2 - Patch: lrg/small	WV	3199	3199	100.00
1	Acadian Coastal Salt and Estuary Marsh	201.578, 201.579	3 - Wetland	ME	30066	30066	100.00
3	Acadian Maritime Bog	201.580	3 - Wetland	ME	5235	5235	100.00
15	Atlantic Coastal Plain Blackwater/Brownwater Stream Floodplain Forest	203.247/203.248	3 - Wetland	VA	163615	164137	99.68
16	Atlantic Coastal Plain Embayed Region Tidal Freshwater/Brackish Marsh	203.259/203.260	3 - Wetland	VA	13052	14246	91.62
17	Atlantic Coastal Plain Northern Bog	203.893	3 - Wetland	MA	936	5314	17.61
17	Atlantic Coastal Plain Northern Bog	203.893	3 - Wetland	NJ	4093	5314	77.02
17	Atlantic Coastal Plain Northern Bog	203.893	3 - Wetland	NY	285	5314	5.36
18	Atlantic Coastal Plain Peatland Pocosin and Canebrake	203.267	3 - Wetland	VA	2255	2409	93.61
19	Boreal-Laurentian Bog	103.581	3 - Wetland	ME	37387	45397	82.36

SUMGRPNUM	SUMGRPNAME	ES_CODE_S_	System_type	STATE	ACRES_ST	ACRES_TOTL	PCT_TOTAL
19	Boreal-Laurentian Bog	103.581	3 - Wetland	NY	7857	45397	17.31
19	Boreal-Laurentian Bog	103.581	3 - Wetland	VT	153	45397	0.34
20	Boreal-Laurentian-Acadian Acidic Basin Fen	201.583	3 - Wetland	MA	717	401409	0.18
20	Boreal-Laurentian-Acadian Acidic Basin Fen	201.583	3 - Wetland	ME	313441	401409	78.09
20	Boreal-Laurentian-Acadian Acidic Basin Fen	201.583	3 - Wetland	NH	7326	401409	1.83
20	Boreal-Laurentian-Acadian Acidic Basin Fen	201.583	3 - Wetland	NY	73480	401409	18.31
20	Boreal-Laurentian-Acadian Acidic Basin Fen	201.583	3 - Wetland	VT	6443	401409	1.61
26	Central Appalachian Stream and Riparian	202.609	3 - Wetland	MD	836	26971	3.10
26	Central Appalachian Stream and Riparian	202.609	3 - Wetland	VA	26133	26971	96.89
28	Central Interior Highlands and Appalachian Sinkhole and Depression Pond	202.018	3 - Wetland	MD	232	1458	15.91
28	Central Interior Highlands and Appalachian Sinkhole and Depression Pond	202.018	3 - Wetland	NJ	8	1458	0.55
28	Central Interior Highlands and Appalachian Sinkhole and Depression Pond	202.018	3 - Wetland	PA	653	1458	44.79
28	Central Interior Highlands and Appalachian Sinkhole and Depression Pond	202.018	3 - Wetland	VA	415	1458	28.46
28	Central Interior Highlands and Appalachian Sinkhole and Depression Pond	202.018	3 - Wetland	WV	150	1458	10.29
35	Glacial Marine & Lake Wet Clayplain Forest	202.997	3 - Wetland	NY	74085	88172	84.02
35	Glacial Marine & Lake Wet Clayplain Forest	202.997	3 - Wetland	VT	14087	88172	15.98
38	High Allegheny Headwater Wetland	202.069	3 - Wetland	MD	4144	27697	14.96
38	High Allegheny Headwater Wetland	202.069	3 - Wetland	PA	112	27697	0.40
38	High Allegheny Headwater Wetland	202.069	3 - Wetland	VA	3	27697	0.01
38	High Allegheny Headwater Wetland	202.069	3 - Wetland	WV	23438	27697	84.62
39	Laurentian-Acadian Alkaline Conifer-Hardwood Swamp	201.575	3 - Wetland	CT	86	921524	0.01
39	Laurentian-Acadian Alkaline Conifer-Hardwood Swamp	201.575	3 - Wetland	MA	4261	921524	0.46
39	Laurentian-Acadian Alkaline Conifer-Hardwood Swamp	201.575	3 - Wetland	ME	520141	921524	56.44
39	Laurentian-Acadian Alkaline Conifer-Hardwood Swamp	201.575	3 - Wetland	NH	7362	921524	0.80
39	Laurentian-Acadian Alkaline Conifer-Hardwood Swamp	201.575	3 - Wetland	NY	345765	921524	37.52
39	Laurentian-Acadian Alkaline Conifer-Hardwood Swamp	201.575	3 - Wetland	VT	43900	921524	4.76
40	Laurentian-Acadian Alkaline Fen	201.585	3 - Wetland	MA	23	206	11.17
40	Laurentian-Acadian Alkaline Fen	201.585	3 - Wetland	ME	6	206	2.91
40	Laurentian-Acadian Alkaline Fen	201.585	3 - Wetland	NH	81	206	39.32
40	Laurentian-Acadian Alkaline Fen	201.585	3 - Wetland	VT	96	206	46.60
41	Laurentian-Acadian Freshwater Marsh	201.594	3 - Wetland	CT	16322	906822	1.80
41	Laurentian-Acadian Freshwater Marsh	201.594	3 - Wetland	DC	60	906822	0.01
41	Laurentian-Acadian Freshwater Marsh	201.594	3 - Wetland	DE	21772	906822	2.40
41	Laurentian-Acadian Freshwater Marsh	201.594	3 - Wetland	MA	56997	906822	6.29
41	Laurentian-Acadian Freshwater Marsh	201.594	3 - Wetland	MD	52877	906822	5.83
41	Laurentian-Acadian Freshwater Marsh	201.594	3 - Wetland	ME	226012	906822	24.92
41	Laurentian-Acadian Freshwater Marsh	201.594	3 - Wetland	NH	48647	906822	5.36
41	Laurentian-Acadian Freshwater Marsh	201.594	3 - Wetland	NJ	98808	906822	10.90
41	Laurentian-Acadian Freshwater Marsh	201.594	3 - Wetland	NY	224018	906822	24.70
41	Laurentian-Acadian Freshwater Marsh	201.594	3 - Wetland	PA	48783	906822	5.38
41	Laurentian-Acadian Freshwater Marsh	201.594	3 - Wetland	RI	4905	906822	0.54
41	Laurentian-Acadian Freshwater Marsh	201.594	3 - Wetland	RI	202	906822	0.02
41	Laurentian-Acadian Freshwater Marsh	201.594	3 - Wetland	VA	61226	906822	6.75
41	Laurentian-Acadian Freshwater Marsh	201.594	3 - Wetland	VT	39373	906822	4.34

SUMGRPNUM	SUMGRPNAME	ES_CODE_S_	System_type	STATE	ACRES_ST	ACRES_TOTL	PCT_TOTAL
41	Laurentian-Acadian Freshwater Marsh	201.594	3 - Wetland	WV	6766	906822	0.75
46	Laurentian-Acadian Wet Meadow-Shrub Swamp	201.582	3 - Wetland	CT	23346	990156	2.36
46	Laurentian-Acadian Wet Meadow-Shrub Swamp	201.582	3 - Wetland	DE	11617	990156	1.17
46	Laurentian-Acadian Wet Meadow-Shrub Swamp	201.582	3 - Wetland	MA	76719	990156	7.75
46	Laurentian-Acadian Wet Meadow-Shrub Swamp	201.582	3 - Wetland	MD	29045	990156	2.93
46	Laurentian-Acadian Wet Meadow-Shrub Swamp	201.582	3 - Wetland	ME	297092	990156	30.00
46	Laurentian-Acadian Wet Meadow-Shrub Swamp	201.582	3 - Wetland	NH	59732	990156	6.03
46	Laurentian-Acadian Wet Meadow-Shrub Swamp	201.582	3 - Wetland	NJ	68354	990156	6.90
46	Laurentian-Acadian Wet Meadow-Shrub Swamp	201.582	3 - Wetland	NY	293993	990156	29.69
46	Laurentian-Acadian Wet Meadow-Shrub Swamp	201.582	3 - Wetland	PA	39799	990156	4.02
46	Laurentian-Acadian Wet Meadow-Shrub Swamp	201.582	3 - Wetland	RI	5048	990156	0.51
46	Laurentian-Acadian Wet Meadow-Shrub Swamp	201.582	3 - Wetland	RI	86	990156	0.01
46	Laurentian-Acadian Wet Meadow-Shrub Swamp	201.582	3 - Wetland	VA	40239	990156	4.06
46	Laurentian-Acadian Wet Meadow-Shrub Swamp	201.582	3 - Wetland	VT	42135	990156	4.26
46	Laurentian-Acadian Wet Meadow-Shrub Swamp	201.582	3 - Wetland	WV	2928	990156	0.30
47	North Atlantic Coastal Plain Basin Peat Swamp	203.522	3 - Wetland	CT	2480	59280	4.18
47	North Atlantic Coastal Plain Basin Peat Swamp	203.522	3 - Wetland	DE	4850	59280	8.18
47	North Atlantic Coastal Plain Basin Peat Swamp	203.522	3 - Wetland	MA	11830	59280	19.96
47	North Atlantic Coastal Plain Basin Peat Swamp	203.522	3 - Wetland	MD	867	59280	1.46
47	North Atlantic Coastal Plain Basin Peat Swamp	203.522	3 - Wetland	ME	654	59280	1.10
47	North Atlantic Coastal Plain Basin Peat Swamp	203.522	3 - Wetland	NH	1158	59280	1.95
47	North Atlantic Coastal Plain Basin Peat Swamp	203.522	3 - Wetland	NJ	35594	59280	60.04
47	North Atlantic Coastal Plain Basin Peat Swamp	203.522	3 - Wetland	NY	97	59280	0.16
47	North Atlantic Coastal Plain Basin Peat Swamp	203.522	3 - Wetland	RI	1750	59280	2.95
48	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest	203.520	3 - Wetland	DC	81	1006705	0.01
48	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest	203.520	3 - Wetland	DE	151995	1006705	15.10
48	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest	203.520	3 - Wetland	MA	3	1006705	0.00
48	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest	203.520	3 - Wetland	MD	337000	1006705	33.48
48	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest	203.520	3 - Wetland	NJ	269703	1006705	26.79
48	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest	203.520	3 - Wetland	NY	18828	1006705	1.87
48	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest	203.520	3 - Wetland	NY	6	1006705	0.00

SUMGRPNUM	SUMGRPNAME	ES_CODE_S_	System_type	STATE	ACRES_ST	ACRES_TOTL	PCT_TOTAL
48	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest	203.520	3 - Wetland	NY	4	1006705	0.00
48	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest	203.520	3 - Wetland	PA	5883	1006705	0.58
48	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest	203.520	3 - Wetland	RI	640	1006705	0.06
48	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest	203.520	3 - Wetland	VA	222562	1006705	22.11
49	North Atlantic Coastal Plain Brackish/Fresh & Oligohaline Tidal Marsh	203.894/203.516	3 - Wetland	VA	17021	17021	100.00
55	North Atlantic Coastal Plain Pitch Pine Lowland	203.374	3 - Wetland	NJ	181103	181103	100.00
56	North Atlantic Coastal Plain Stream and River	203.070	3 - Wetland	VA	28786	28786	100.00
57	North Atlantic Coastal Plain Tidal Salt Marsh	203.519	3 - Wetland	CT	18538	920149	2.01
57	North Atlantic Coastal Plain Tidal Salt Marsh	203.519	3 - Wetland	DC	123	920149	0.01
57	North Atlantic Coastal Plain Tidal Salt Marsh	203.519	3 - Wetland	DE	85390	920149	9.28
57	North Atlantic Coastal Plain Tidal Salt Marsh	203.519	3 - Wetland	MA	67165	920149	7.30
57	North Atlantic Coastal Plain Tidal Salt Marsh	203.519	3 - Wetland	MD	245844	920149	26.72
57	North Atlantic Coastal Plain Tidal Salt Marsh	203.519	3 - Wetland	ME	3901	920149	0.42
57	North Atlantic Coastal Plain Tidal Salt Marsh	203.519	3 - Wetland	NH	7214	920149	0.78
57	North Atlantic Coastal Plain Tidal Salt Marsh	203.519	3 - Wetland	NJ	228320	920149	24.81
57	North Atlantic Coastal Plain Tidal Salt Marsh	203.519	3 - Wetland	NY	49270	920149	5.35
57	North Atlantic Coastal Plain Tidal Salt Marsh	203.519	3 - Wetland	PA	1637	920149	0.18
57	North Atlantic Coastal Plain Tidal Salt Marsh	203.519	3 - Wetland	RI	8466	920149	0.92
57	North Atlantic Coastal Plain Tidal Salt Marsh	203.519	3 - Wetland	RI	117	920149	0.01
57	North Atlantic Coastal Plain Tidal Salt Marsh	203.519	3 - Wetland	VA	204164	920149	22.19
58	North Atlantic Coastal Plain Tidal Swamp	203.282	3 - Wetland	DC	86	196242	0.04
58	North Atlantic Coastal Plain Tidal Swamp	203.282	3 - Wetland	DE	11563	196242	5.89
58	North Atlantic Coastal Plain Tidal Swamp	203.282	3 - Wetland	MA	2	196242	0.00
58	North Atlantic Coastal Plain Tidal Swamp	203.282	3 - Wetland	MD	84022	196242	42.82
58	North Atlantic Coastal Plain Tidal Swamp	203.282	3 - Wetland	NJ	41727	196242	21.26
58	North Atlantic Coastal Plain Tidal Swamp	203.282	3 - Wetland	NY	1507	196242	0.77
58	North Atlantic Coastal Plain Tidal Swamp	203.282	3 - Wetland	PA	1278	196242	0.65
58	North Atlantic Coastal Plain Tidal Swamp	203.282	3 - Wetland	VA	56056	196242	28.56
59	North-Central Appalachian Acidic Swamp	202.604	3 - Wetland	CT	112098	1506626	7.44
59	North-Central Appalachian Acidic Swamp	202.604	3 - Wetland	DC	147	1506626	0.01
59	North-Central Appalachian Acidic Swamp	202.604	3 - Wetland	DE	358	1506626	0.02
59	North-Central Appalachian Acidic Swamp	202.604	3 - Wetland	MA	272658	1506626	18.10
59	North-Central Appalachian Acidic Swamp	202.604	3 - Wetland	MD	15084	1506626	1.00
59	North-Central Appalachian Acidic Swamp	202.604	3 - Wetland	ME	61843	1506626	4.10
59	North-Central Appalachian Acidic Swamp	202.604	3 - Wetland	NH	85992	1506626	5.71
59	North-Central Appalachian Acidic Swamp	202.604	3 - Wetland	NJ	86029	1506626	5.71
59	North-Central Appalachian Acidic Swamp	202.604	3 - Wetland	NY	573212	1506626	38.05
59	North-Central Appalachian Acidic Swamp	202.604	3 - Wetland	PA	213327	1506626	14.16
59	North-Central Appalachian Acidic Swamp	202.604	3 - Wetland	RI	67732	1506626	4.50
59	North-Central Appalachian Acidic Swamp	202.604	3 - Wetland	VA	4111	1506626	0.27
59	North-Central Appalachian Acidic Swamp	202.604	3 - Wetland	VT	10238	1506626	0.68
59	North-Central Appalachian Acidic Swamp	202.604	3 - Wetland	WV	3060	1506626	0.20

SUMGRPNUM	SUMGRPNAME	ES_CODE_S_	System_type	STATE	ACRES_ST	ACRES_TOTL	PCT_TOTAL
60	North-Central Appalachian Large River Floodplain	202.605, 201.574, 201.575, 201.582, 201.594, 202.604	3 - Wetland	CT	4024	254874	1.58
60	North-Central Appalachian Large River Floodplain	202.605, 201.574, 201.575, 201.582, 201.594, 202.604	3 - Wetland	DC	92	254874	0.04
60	North-Central Appalachian Large River Floodplain	202.605, 201.574, 201.575, 201.582, 201.594, 202.604	3 - Wetland	DE	81	254874	0.03
60	North-Central Appalachian Large River Floodplain	202.605, 201.574, 201.575, 201.582, 201.594, 202.604	3 - Wetland	MA	10055	254874	3.95
60	North-Central Appalachian Large River Floodplain	202.605, 201.574, 201.575, 201.582, 201.594, 202.604	3 - Wetland	MD	3703	254874	1.45
60	North-Central Appalachian Large River Floodplain	202.605, 201.574, 201.575, 201.582, 201.594, 202.604	3 - Wetland	ME	11038	254874	4.33
60	North-Central Appalachian Large River Floodplain	202.605, 201.574, 201.575, 201.582, 201.594, 202.604	3 - Wetland	NH	4654	254874	1.83
60	North-Central Appalachian Large River Floodplain	202.605, 201.574, 201.575, 201.582, 201.594, 202.604	3 - Wetland	NJ	9841	254874	3.86
60	North-Central Appalachian Large River Floodplain	202.605, 201.574, 201.575, 201.582, 201.594, 202.604	3 - Wetland	NY	142678	254874	55.98
60	North-Central Appalachian Large River Floodplain	202.605, 201.574, 201.575, 201.582, 201.594, 202.604	3 - Wetland	PA	59976	254874	23.53
60	North-Central Appalachian Large River Floodplain	202.605, 201.574, 201.575, 201.582, 201.594, 202.604	3 - Wetland	RI	19	254874	0.01
60	North-Central Appalachian Large River Floodplain	202.605, 201.574, 201.575, 201.582, 201.594, 202.604	3 - Wetland	VA	3293	254874	1.29
60	North-Central Appalachian Large River Floodplain	202.605, 201.574, 201.575, 201.582, 201.594, 202.604	3 - Wetland	VT	3437	254874	1.35
60	North-Central Appalachian Large River Floodplain	202.605, 201.574, 201.575, 201.582, 201.594, 202.604	3 - Wetland	WV	1982	254874	0.78
63	North-Central Interior Large River Floodplain	201.582, 201.594, 202.604, 202.605	3 - Wetland	MD	314	70573	0.44
63	North-Central Interior Large River Floodplain	201.582, 201.594, 202.604, 202.605	3 - Wetland	NY	20645	70573	29.25
63	North-Central Interior Large River Floodplain	201.582, 201.594, 202.604, 202.605	3 - Wetland	PA	37534	70573	53.18
63	North-Central Interior Large River Floodplain	201.582, 201.594, 202.604, 202.605	3 - Wetland	VA	1671	70573	2.37
63	North-Central Interior Large River Floodplain	201.582, 201.594, 202.604, 202.605	3 - Wetland	WV	9906	70573	14.04
64	North-Central Interior Wet Flatwoods	202.700	3 - Wetland	CT	9284	81975	11.33
64	North-Central Interior Wet Flatwoods	202.700	3 - Wetland	MA	9632	81975	11.75
64	North-Central Interior Wet Flatwoods	202.700	3 - Wetland	ME	2790	81975	3.40
64	North-Central Interior Wet Flatwoods	202.700	3 - Wetland	NH	1963	81975	2.39
64	North-Central Interior Wet Flatwoods	202.700	3 - Wetland	NJ	6289	81975	7.67
64	North-Central Interior Wet Flatwoods	202.700	3 - Wetland	NY	49031	81975	59.81
64	North-Central Interior Wet Flatwoods	202.700	3 - Wetland	PA	1050	81975	1.28
64	North-Central Interior Wet Flatwoods	202.700	3 - Wetland	VT	1767	81975	2.16
65	North-Central Interior and Appalachian Acidic Peatland	202.606	3 - Wetland	CT	599	83793	0.71
65	North-Central Interior and Appalachian Acidic Peatland	202.606	3 - Wetland	MA	4208	83793	5.02

SUMGRPNUM	SUMGRPNAME	ES_CODE_S_	System_type	STATE	ACRES_ST	ACRES_TOTL	PCT_TOTAL
65	North-Central Interior and Appalachian Acidic Peatland	202.606	3 - Wetland	ME	4844	83793	5.78
65	North-Central Interior and Appalachian Acidic Peatland	202.606	3 - Wetland	NH	2897	83793	3.46
65	North-Central Interior and Appalachian Acidic Peatland	202.606	3 - Wetland	NJ	164	83793	0.20
65	North-Central Interior and Appalachian Acidic Peatland	202.606	3 - Wetland	NY	38104	83793	45.47
65	North-Central Interior and Appalachian Acidic Peatland	202.606	3 - Wetland	PA	30169	83793	36.00
65	North-Central Interior and Appalachian Acidic Peatland	202.606	3 - Wetland	RI	355	83793	0.42
65	North-Central Interior and Appalachian Acidic Peatland	202.606	3 - Wetland	VT	2452	83793	2.93
66	North-Central Interior and Appalachian Rich Swamp	202.605	3 - Wetland	CT	61371	830863	7.39
66	North-Central Interior and Appalachian Rich Swamp	202.605	3 - Wetland	DC	19	830863	0.00
66	North-Central Interior and Appalachian Rich Swamp	202.605	3 - Wetland	DE	28	830863	0.00
66	North-Central Interior and Appalachian Rich Swamp	202.605	3 - Wetland	MA	97088	830863	11.69
66	North-Central Interior and Appalachian Rich Swamp	202.605	3 - Wetland	MD	4223	830863	0.51
66	North-Central Interior and Appalachian Rich Swamp	202.605	3 - Wetland	ME	50977	830863	6.14
66	North-Central Interior and Appalachian Rich Swamp	202.605	3 - Wetland	NH	28309	830863	3.41
66	North-Central Interior and Appalachian Rich Swamp	202.605	3 - Wetland	NJ	65857	830863	7.93
66	North-Central Interior and Appalachian Rich Swamp	202.605	3 - Wetland	NY	477217	830863	57.44
66	North-Central Interior and Appalachian Rich Swamp	202.605	3 - Wetland	PA	28123	830863	3.38
66	North-Central Interior and Appalachian Rich Swamp	202.605	3 - Wetland	RI	5679	830863	0.68
66	North-Central Interior and Appalachian Rich Swamp	202.605	3 - Wetland	VA	1932	830863	0.23
66	North-Central Interior and Appalachian Rich Swamp	202.605	3 - Wetland	VT	8934	830863	1.08
66	North-Central Interior and Appalachian Rich Swamp	202.605	3 - Wetland	WV	1096	830863	0.13
69	Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp	201.574	3 - Wetland	CT	220	1312031	0.02
69	Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp	201.574	3 - Wetland	MA	26940	1312031	2.05
69	Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp	201.574	3 - Wetland	ME	640968	1312031	48.85
69	Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp	201.574	3 - Wetland	NH	45814	1312031	3.49
69	Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp	201.574	3 - Wetland	NY	549273	1312031	41.86
69	Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp	201.574	3 - Wetland	PA	2	1312031	0.00
69	Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp	201.574	3 - Wetland	VT	48798	1312031	3.72

SUMGRPNUM	SUMGRPNAME	ES_CODE_S_	System_type	STATE	ACRES_ST	ACRES_TOTL	PCT_TOTAL
70	Laurentian-Acadian Large River Floodplain	201.587, 103.588, 201.574, 201.575, 201.582, 201.594, 202.604	3 - Wetland	ME	253569	431636	58.75
70	Laurentian-Acadian Large River Floodplain	201.587, 103.588, 201.574, 201.575, 201.582, 201.594, 202.604	3 - Wetland	NH	12349	431636	2.86
70	Laurentian-Acadian Large River Floodplain	201.587, 103.588, 201.574, 201.575, 201.582, 201.594, 202.604	3 - Wetland	NY	116563	431636	27.00
70	Laurentian-Acadian Large River Floodplain	201.587, 103.588, 201.574, 201.575, 201.582, 201.594, 202.604	3 - Wetland	VT	49119	431636	11.38
73	Piedmont Upland Depression Swamp	202.335, 202.336	3 - Wetland	MD	507	21649	2.34
73	Piedmont Upland Depression Swamp	202.335, 202.336	3 - Wetland	VA	21053	21649	97.25
74	Piedmont-Coastal Plain Freshwater Marsh	202.595	3 - Wetland	MD	951	45762	2.08
74	Piedmont-Coastal Plain Freshwater Marsh	202.595	3 - Wetland	VA	44790	45762	97.88
75	Piedmont-Coastal Plain Large River Floodplain	202.324, 202.577, 202.595, 202.608, 203.250	3 - Wetland	MD	3965	133335	2.97
75	Piedmont-Coastal Plain Large River Floodplain	202.324, 202.577, 202.595, 202.608, 203.250	3 - Wetland	VA	127444	133335	95.58
76	Piedmont-Coastal Plain Shrub Swamp	202.577	3 - Wetland	MD	330	46469	0.71
76	Piedmont-Coastal Plain Shrub Swamp	202.577	3 - Wetland	VA	46121	46469	99.25
79	Central Atlantic Coastal Plain Non-riverine Swamp and Wet Hardwood Forest	203.304	3 - Wetland	VA	187646	191995	97.73
87	Southern Atlantic Coastal Plain Tidal Wooded Swamp	203.240	3 - Wetland	VA	12564	12983	96.77
91	Southern Piedmont Lake Floodplain Forest	202.325	3 - Wetland	VA	8563	8611	99.44
93	Southern Piedmont Small Floodplain and Riparian Forest	202.323	3 - Wetland	MD	3722	186288	2.00
93	Southern Piedmont Small Floodplain and Riparian Forest	202.323	3 - Wetland	VA	182370	186288	97.90
10	Agriculture (NLCD 81-82)	80	4 - Other	CT	273490	27885687	0.98
10	Agriculture (NLCD 81-82)	80	4 - Other	DC	910	27885687	0.00
10	Agriculture (NLCD 81-82)	80	4 - Other	DE	625456	27885687	2.24
10	Agriculture (NLCD 81-82)	80	4 - Other	MA	350506	27885687	1.26
10	Agriculture (NLCD 81-82)	80	4 - Other	MD	2484959	27885687	8.91
10	Agriculture (NLCD 81-82)	80	4 - Other	ME	802186	27885687	2.88
10	Agriculture (NLCD 81-82)	80	4 - Other	NH	257259	27885687	0.92
10	Agriculture (NLCD 81-82)	80	4 - Other	NJ	907874	27885687	3.26
10	Agriculture (NLCD 81-82)	80	4 - Other	NY	6929366	27885687	24.85
10	Agriculture (NLCD 81-82)	80	4 - Other	PA	7176009	27885687	25.73
10	Agriculture (NLCD 81-82)	80	4 - Other	RI	42517	27885687	0.15
10	Agriculture (NLCD 81-82)	80	4 - Other	VA	5709740	27885687	20.48
10	Agriculture (NLCD 81-82)	80	4 - Other	VT	845593	27885687	3.03
10	Agriculture (NLCD 81-82)	80	4 - Other	WV	1438072	27885687	5.16

SUMGRPNUM	SUMGRPNAME	ES_CODE_S_	System_type	STATE	ACRES_ST	ACRES_TOTL	PCT_TOTAL
32	Developed (NLCD 21-24 & 31)	20	4 - Other	CT	729962	15711642	4.65
32	Developed (NLCD 21-24 & 31)	20	4 - Other	DC	33046	15711642	0.21
32	Developed (NLCD 21-24 & 31)	20	4 - Other	DE	130494	15711642	0.83
32	Developed (NLCD 21-24 & 31)	20	4 - Other	MA	1212291	15711642	7.72
32	Developed (NLCD 21-24 & 31)	20	4 - Other	MD	819385	15711642	5.22
32	Developed (NLCD 21-24 & 31)	20	4 - Other	ME	765087	15711642	4.87
32	Developed (NLCD 21-24 & 31)	20	4 - Other	NH	450936	15711642	2.87
32	Developed (NLCD 21-24 & 31)	20	4 - Other	NJ	1227887	15711642	7.82
32	Developed (NLCD 21-24 & 31)	20	4 - Other	NY	2927176	15711642	18.63
32	Developed (NLCD 21-24 & 31)	20	4 - Other	NY	18	15711642	0.00
32	Developed (NLCD 21-24 & 31)	20	4 - Other	NY	7	15711642	0.00
32	Developed (NLCD 21-24 & 31)	20	4 - Other	PA	3407092	15711642	21.69
32	Developed (NLCD 21-24 & 31)	20	4 - Other	RI	197993	15711642	1.26
32	Developed (NLCD 21-24 & 31)	20	4 - Other	VA	2300325	15711642	14.64
32	Developed (NLCD 21-24 & 31)	20	4 - Other	VT	326827	15711642	2.08
32	Developed (NLCD 21-24 & 31)	20	4 - Other	WV	1144007	15711642	7.28
71	Open Water (NLCD-NHD open water)	11	4 - Other	CT	279787	11515806	2.43
71	Open Water (NLCD-NHD open water)	11	4 - Other	DC	4528	11515806	0.04
71	Open Water (NLCD-NHD open water)	11	4 - Other	DE	181860	11515806	1.58
71	Open Water (NLCD-NHD open water)	11	4 - Other	MA	1544299	11515806	13.41
71	Open Water (NLCD-NHD open water)	11	4 - Other	MD	1403738	11515806	12.19
71	Open Water (NLCD-NHD open water)	11	4 - Other	ME	2208057	11515806	19.17
71	Open Water (NLCD-NHD open water)	11	4 - Other	NH	246282	11515806	2.14
71	Open Water (NLCD-NHD open water)	11	4 - Other	NJ	502948	11515806	4.37
71	Open Water (NLCD-NHD open water)	11	4 - Other	NY	2176188	11515806	18.90
71	Open Water (NLCD-NHD open water)	11	4 - Other	NY	8	11515806	0.00
71	Open Water (NLCD-NHD open water)	11	4 - Other	NY	3	11515806	0.00
71	Open Water (NLCD-NHD open water)	11	4 - Other	PA	425894	11515806	3.70
71	Open Water (NLCD-NHD open water)	11	4 - Other	RI	298457	11515806	2.59
71	Open Water (NLCD-NHD open water)	11	4 - Other	VA	1411734	11515806	12.26
71	Open Water (NLCD-NHD open water)	11	4 - Other	VT	244565	11515806	2.12
71	Open Water (NLCD-NHD open water)	11	4 - Other	WV	146060	11515806	1.27
77	Pine plantation / Horticultural pines	9999	4 - Other	MD	1018	1132337	0.09
77	Pine plantation / Horticultural pines	9999	4 - Other	VA	1125703	1132337	99.41
78	Shrubland & grassland (NLCD 52/71)	5271	4 - Other	CT	5098	1745085	0.29
78	Shrubland & grassland (NLCD 52/71)	5271	4 - Other	MA	18020	1745085	1.03
78	Shrubland & grassland (NLCD 52/71)	5271	4 - Other	MD	4904	1745085	0.28
78	Shrubland & grassland (NLCD 52/71)	5271	4 - Other	ME	22633	1745085	1.30
78	Shrubland & grassland (NLCD 52/71)	5271	4 - Other	NH	4111	1745085	0.24
78	Shrubland & grassland (NLCD 52/71)	5271	4 - Other	NJ	52	1745085	0.00
78	Shrubland & grassland (NLCD 52/71)	5271	4 - Other	NY	463588	1745085	26.57
78	Shrubland & grassland (NLCD 52/71)	5271	4 - Other	PA	159711	1745085	9.15
78	Shrubland & grassland (NLCD 52/71)	5271	4 - Other	RI	3189	1745085	0.18
78	Shrubland & grassland (NLCD 52/71)	5271	4 - Other	VA	892855	1745085	51.16
78	Shrubland & grassland (NLCD 52/71)	5271	4 - Other	WV	159425	1745085	9.14