MAPPING THE FIVE-S's

Tools and data for the quantitative and spatial evaluation of
Systems
Stresses
Sources
Strategies
and Success
in the East/Northeast divisions

FIRST DRAFT: (INCOMPLETE)
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For review by the matrix forest* and aquatic** working groups

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MAPPING THE FIVE-S's

Tools for spatial, quantitative Site Conservation Planning in the East/Northeast divisions

Objective: *As the Nature Conservancy moves towards working at larger scale sites, an understanding of the spatial structure of specific landscapes, systems and stresses becomes critical to conservation success. Additionally there is a need to perform these analyses in a rapid quantitative format to achieve our ten year goals.* The objective of this document is to: 1) unite the general concepts laid out in the Five-S framework document (TNC 2000) with the quantitative data and ecological criteria developed during the ecoregional planning process and 2) provide illustrative examples of how an understanding of the spatial structure of systems and stresses have been used to develop effective conservation strategies, 3) develop a data platform that connects fine-scale, site specific information (typically collected by the state) to the existing ecoregional spatial framework to maximize the effectiveness of both.

Background: The new data landscape: The challenge of ecoregional conservation has stimulated an unparalleled growth in data development and ecological understanding among the science foundations of the Nature Conservancy. Simultaneously there has been a rapid development in research and thinking in conservation biology and related fields. New understanding, such as of the role of biological legacies in maintaining the long-term viability of ecological systems, the pervasiveness of source-sink dynamics among species populations and the importance of multi-scale landscape functions have re-emphasized the critical importance of land based conservation. Additionally the science has highlighted the need for understanding the spatial structure of landscapes, systems and stresses to develop innovative protection tools applicable at a variety of scales.

Fortunately, the last decade has also seen tremendous growth in spatial data availability and analysis tools that are capable of quantifying both the complex ecological patterns and the spatial structure of the stresses that threaten them. Although TNC has a long and valuable history of scientists providing "expert opinion", understanding the complexity of interacting ecological systems across multiple spatial and temporal scales is beyond what most individual scientists (me, at least) can interpret without data and analysis. Thus we have moved towards a science department that is capable of integrating field knowledge with sophisticated analysis tools to process data, model ecological processes and predict the outcomes of various management scenarios. Putting current and correct information into the hands of conservation planners, deal-makers and strategists will increase our success in meeting the mission of total biodiversity conservation.

In the E/NE divisions, ecoregional planning is essentially a massive compilation of ecological data for each ecoregion (perhaps the largest ever performed by a single organization). Many of the new data sets augment our previous data resources but differ in several ways from the more selective and semi-static information that the organization is accustomed to. First, they are spatially comprehensive, quantitative, and multi-scale (users can zoom-in or zoom-out across any point of the ecoregion). Second, they are easily transferable to state offices in digital format and can be manipulated freely for site conservation planning and mapping. Third, they may usefully serve as a background framework for collecting finer-scale data or attaching tabular information to particular ecological features or points. Fourth, they are improving at a very fast pace, with upgrades, revisions, and finer resolution maps becoming available almost monthly. Table 1 provides a list of the data sets that are currently compiled for each ecoregion and available through ECS. The table also lists complementary data sets that are probably best compiled site-by-site though the Field Offices and Heritage Programs. By working together we can accomplish much more towards our common goal, as data collection and compilation requires staff time and equipment.

The following maps display examples of ecoregion wide data sets that are now (or by Dec. 20001) available "off-the-shelf," (Table 1) as well as site specific data and maps developed by state offices for site conservation planning and ecoregional implementation in the East and Northeast division.

1: Systems

"The foundation for successful repair lies in understanding the natural processes and ecological systems being repaired" E.W. Schuff

a) **Ecological Land Units and Biophysical features:** Ecological land units (ELUs) express the underlying physical features that structure a site. Each ELU depicts a unique combination between four factors:

Bedrock geology (derived from state geology maps)
Surficial geology (derived from state and regional maps)
Topography (derived from digital elevation and flow accumulation models)
Elevation Zone (derived from ecological literature and DEMs)

To a large extent, the distribution of the ELUs determines the types and distribution of biodiversity features across a site. For example the ecological land unit "high elevation summit on acidic granitic bedrock" is tightly associated with a particular set of communities and species.

Studying and mapping the ELUs at a site informs the practitioner of how ecological processes and resources are distributed across the site. For instance, the ELU map of A.P. Hill matrix block in Chesapeake Bay (Map 1a.1) reveals that the SW portion of the site is composed primarily of low dry flats on silt or clay with gentle swales flanking the west-flowing streams. Coastal plain seepage bogs and swamps are closely associated with the swales. On the NE portion, more deeply cut, east-flowing streams form a complex of slopes, rounded summits and draws, with generally more extensive wetland development around the streams. Mesic hardwood forests are

Table 1. DATA SOURCES	Ecoregion	Site by Site		
DATA COVERAGE	Completed for whole ecoregion by ECS	Compiled site-by-site usually by the State	Joint	Compiled during ecoregional planning Year 1 or 2
Bedrock geology	X	X		Y1
Surficial geology	X	X		Y1
Digital elevation models: 30 & 90m	X	X		Y1
Landforms 30 & 90 meter	X			Y1 (90) Y2 (30)
ELUs	X			Y1
Landcover 30 meter	X			Y1
Ecological Systems/Communities map	X			Y2
Ecological Community book	X			Y1
Hydrography (DLG,RF3)	X	X		Y1
Aquatic macrohabitats	X			Y1/2
Aquatic systems	X			Y1/2
Dams & diversions	X	X		Y1/2
Toxic release points	X	X		Y1/2
Roads (Tiger & GDT)	X	X		Y1
Road/water–bounded blocks	X			Y1
Element occurrences (not distributable)	X			Y1
Managed areas (ranked)	X	?		Y1
Population growth trends	X			Y1
Soils (county)		X		
Land ownership		X		
Forest history, condition, structure		X		
Exotics		X		
Development trends		X		
Heritage survey info		X		
Detailed roads: traffic volume, surface, Canopy cover		X		
Stream habitat (fine-scale) pool, riffle, Run, canopy cover etc		X		
Fire models: fuel loads, burn units etc.		X		
Disturbance models			x	
Time sequence			x	
Hydrology models			x	

associated with side slopes in this region. A simplified map of 90 m ELUs for the Berkshires region (Map 1a.2) illustrates an area with rich biodiversity due to complex bedrock and topographic features.

Ecological land units are composed of relatively stable physical features (similar to the "enduring features" of Noss 1997) and are unlikely to change over long time frames even if the communities and species that inhabit them do. By combining ELUs with roads and trail data a very efficient field sampling strategy, known as gradsect analysis ("gradient sectioning" Austin 199x), may be developed for assessing large sites. Gradsect analysis in conjunction with aerial photo interpretation and field sampling is widely used for developing fine-scale community maps. The methodology is the basis of the TNC/ABI mapping effort on the US national parks (NBS ref).

b) **Land-cover Maps:** Land-cover maps illustrate broad patterns in land use but lack the fine detail of the fine-scale community maps. The example Multi-resolution land cover (MRLC) map (Map 1b.1 Long Lakes region) was developed by the EPA from satellite imagery. Although the twelve cover classes are coarsely defined, the resolution (30meters) and accuracy of units is relatively high.

c) Communities/Ecological Systems: Ecological system maps (Map 1c.1) are a form of aggregated natural community map constructed by intelligently merging the land-cover maps with the ecological land units (e.g. conifer forest on acidic granitic wet flats at mid elevations). The combination units are subsequently linked to the communities described in the ecoregional classification (Fig 1c.1).

Ecological systems maps give shape and substance to the target occurrences identified by the ecoregional planning process. Moreover they are useful in developing *a comprehensive set* of communities and system targets for the site (step 4A.1 in SCP manual). In the Long Lake example (Map 1c.1) the labels identify natural community occurrences that are displayed on the map as recognizable features rather than points. For instance, consider the black spruce wooded bog adjacent to Raquette lake in the lower left quadrant (Marion river bog). On the map, the feature can be understood in the context of a network of bogs, fens, spruce flats and terrestrial matrix forest types with which it occurs.

Each ecological system may be measured and contrasted against the viability criteria for the community type (step 4C in SCP manual). For example, consider the size criteria for black spruce wooded bog systems (Fig 1c.2 & 1c.3). For this type of peatland, most examples in the Northern Appalachians are about 5 acres (mode), half of them are under 20 acres (median), the average size of those tracked in the heritage data bases is 75 acres and the largest are over 1100 acres. The size criteria chart (Fig 1c.3) suggests that small fires and flood disturbances are generally limited to moderate damage with severe disturbance patches usually under 5 acres (bogs with peat over 2 m deep have persisted in place for 1000s of years). Breeding species associated with this system range from butterflies and small mammals to a variety of birds with larger breeding territory needs. At 600 acres, Marion bog should be adequate in size for multiple breeding territories of olive-sided flycatchers, ringed-necked ducks and all other species to the left of the fat arrow. Thus the occurrence is well above the size criteria set for this system. Additionally the occurrence has a good landscape context being surrounded by a mosaic of natural communities although bordered on one side by a paved road.

Similarly, small patch communities such as the alkaline cliff just below the center of the map can be assessed and evaluated against the size and landscape criteria for that type (Fig 1c.4 & 1c.5).

The size and landscape context, particularly the proximity and adjacency of this community to other related communities, matrix blocks, roads and developed or agricultural lands can be estimated with reasonable accuracy from these data. However, *condition* is currently difficult to evaluate using remote information and in most cases will require a field survey. For those occurrences with completed heritage surveys, the attributes can be attached to the map polygons. For example the NY heritage database contains a detailed description of Marion bog's species composition and condition. As the bog occurs both within a matrix site as well as on land managed as "low use" by the state of New York it may likely considered a conserved target in the ecoregional portfolio.

d) **Aquatic stream macrohabitats, lakes, aquatic systems and watersheds** A map of all streams and lakes in the ecoregion is developed during the ecoregional planning process and available for site planning (Map 1d.1 A P Hill matrix site). Each stream segment is joined and coded with flow direction such that water movement through the network can be estimated and compiled along with stream order and size. It is possible to measure the accumulated effects of multiple dams, road stream crossings and toxic release points (see "stresses" below). As with the terrestrial communities, the stream networks, lakes and watersheds may be overlaid on the ELUs to develop aquatic system types that are conceptually equivalent to their terrestrial counterparts. Systems are further subdivided into physical macrohabitats that have biological meaning (Map 1d.1). For example in Lower New England, mussels and most dragonfly genera are associated with "low-elevation, low-gradient, mid-sized rivers in alkaline substrate" while brook trout and most stonefly genera are associated with "mid-elevation, high-gradient, acidic headwater streams." Tabular information collected on the aquatic system occurrences during the expert interview process or collected from state DEPs (e.g. lake depth, lake chemistry) may be attached to specific aquatic features by linking a tabular data base to the digital layers. Field assessment of fine-scale features such as the distribution of pools, riffles, runs, canopy cover, woody debris etc may be collected by the states and linked to the digital coverages.

e) **Coarse-scale Ecological Systems** The Five-S framework recommends aggregating complexes of communities into coarser scale ecological systems that are used to develop eight focal conservation targets. The focal targets represent aggregates of communities, aquatic features and species that require similar processes and co-occur together on the ground. The example map (Map 1e.1) illustrates the same Long Lake region as Map 1c.1, but "aggregated-up" into a few coarse-scale system targets (this scale of aggregation produces about 36 types for the whole ecoregion). Aggregating targets allows the planner to focus on critical larger scale processes that operate in the landscape beyond the scale of some of the individual targets.

2) Stresses and Sources

a) **Fragmentation 1: Roads and road buffers** The ecological implication of roads as both conduits and barriers are discussed under the companion document "multiple-scale conservation of matrix forest". The example map (Map 2a.1 Berkshire Plateau roads), illustrates the spatial extent of the road effect zone (Forman 2000) distributed across roads of different size (600 m for primary roads to 0 m for local trails). Fine-scale road information such as traffic volume, surface and surface condition, canopy cover, etc. may be needed to fully understand the distribution of road impacts across a site. This information may be collected by the state scientists and attached directly to each road segment. Field survey forms for collecting road information have been developed by some teams during the matrix-block selection process (Appendix).

b) **Fragmentation 2: Development and Agriculture.** Combining the land-cover map with the coarse scale ecological system map provides an estimate of the proportion of each ecological system that remains in a natural/semi-natural state or has been converted to agriculture or developed land. This allows for a quantitative measure of the current state or relative threat among system types. In the Blueberry hill / Bomaseen matrix blocks (Map 2b.1 and Table 2b.1), streams and wet flats have been 30-47% altered. Even more critically, features on flat fine-grained alluvial deposits at very-low elevations (e.g. clay plain forests) have been 56-60% altered even within the blocks.

c) **Population change.** This map (Map2c.1) shown for the whole Lower New England/Northern Piedmont ecoregion illustrates the rates and directions of population change across each township over 7 years. Knowing these trajectories around each site can help assess the future threats or opportunities for conservation action.

d) **Forest condition.** Implementing conservation for interior forest targets requires a knowledge of where the smaller scale systems and targets are located within the forest blocks (EVU Map 1c.1). Additionally it requires and understanding of how the current forest condition varies across the matrix block, particularly where the high condition areas or severely degraded regions are. Developing a map of forest condition that illustrate how the areas that retain the greatest biological legacy are distributed can direct the planners to which tracts of land need attention and what conservation strategy to apply. Currently this level of detail needs to be developed by the states, on a site by site basis, using a combination of aerial photos, ground survey, GPS and logging history maps. Field forms and examples are available from several projects (Appendix).

e) **Aquatic condition.** Restoration of aquatic systems require that hydrologic networks exhibit adequate water flow, natural flooding regimes, appropriate stream chemistry, natural sedimentation rates and sufficient debris inputs (see accompanying document "Implementing ecoregional conservation for aquatic systems in the East/Northeast division"). Map 2e.1 illustrates the location of various size dams, stream-road crossings, toxic release points, and agricultural or developed land patches in relation to the stream network. The map highlights the relative intactness of the aquatic system within the matrix block as opposed to the surrounding lands.

f) **Exotic Species.** Preliminary analysis of rolled-up site conservation plans indicate that exotic species are the #1 threat to a number of systems. Map 2f.1 illustrates a map of exotic-free zones across the Berkshire-Taconic matrix block based on a sampling protocol developed by Frank Lowenstein (Appendix)

3) Strategies.

a) Identifying and Developing Conservation Zones: The data layers described above may be intersected to analyze the spatial patterns between the systems, stress and sources. This type of overlay analysis and the development of conservation strategies is the forte of GIS spatial analysis (a whole sub-field of ecology "spatial ecology" is developing around it). A robust general approach is to combine the information from the system and stress analysis to identify critical conservation zones (Fig 3a.1). Subsequently maps of ownership patterns (Map 3a.1, 3a.2) and opportunities (e.g. dam re-licensing, etc.) may be overlaid on the system/stress data to developed conservation strategies. A number of state projects in the NE/E have used this approach to good effect as illustrated in the example maps from the Berkshire-Taconics (Map 3a.4), the upper St. John (Map 3a.5) and the NY dwarf pine barrens (Map3a.6). The latter is not a matrix site but a mosaic of patch communities driven by current and historic fire regimes. Historic fires from various years are outlined and mapped along with the outline of the 1995 Sunrise Fire (Jordan, 1996). The short-term effects of the 1995 fire can clearly be seen on the vegetation, The long-term effects of the previous fires are less evident.

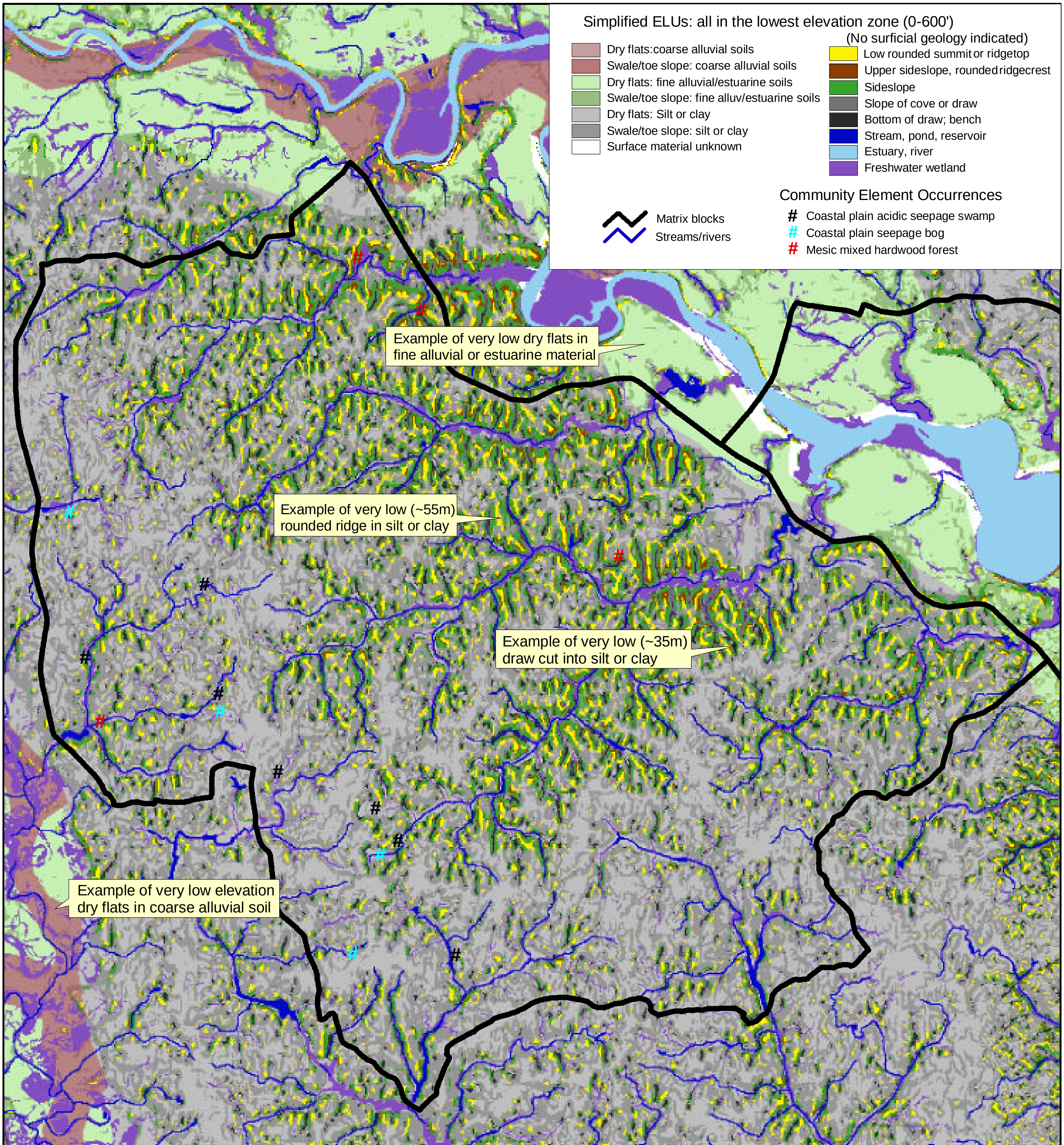
4) Success *(this section needs fleshing out, below are two basic ideas)*

a. Viable systems. Viability, as defined by the resistance and resilience of a system over time is a dynamic state that reflects the interaction of a system with disturbances and stress. Conservation strategies that focus on upgrading key condition attributes of the system such as restoring biological legacies, limiting of removing fragmenting features and restoring a clean, free-flowing stream/lake network will help the system maintain itself along a given trajectory by increasing its resistance and resilience. However, given a scenario of rapid climate change, shifts in species distributions and increased disturbances, the map of long term conservation success for a site is not a known entity (e.g. a particular proportion of current community types). Rather the spatial data developed for the ecoregion/site may be used to develop alternate scenarios and quantitative models that test how a viable functioning system might respond to changes. ELUs may be used to model how fire, wind, flooding is be distributed across the landscape. From these models, potential changes in community distribution patterns and transitional states may be examined.

b. Conservation across all sites: Missing portfolio sites, Non-action sites, Partner sites, Managed lands. It is now possible to realistically develop a conservation success strategy that includes all the targets and features of a full ecoregional plan. For example Map 4b.1illustrates all the existing conservation lands within the Northern Appalachian ecoregion grouped by management status. By overlaying this map on the ecological systems map (Map 1b.1) or the ecological land units (map 1a.1, 1a.2) we can derive a quantitative estimate of how much/many of each feature occurs on managed lands. Ecological maps of the existing managed sites as well as an analysis of how each site contributes to an overall conservation portfolio for the ecoregion may be developed and provided to the owners (regardless of whether the site was included in the first iteration). The analysis could include information on the viability criteria and management recommendations. ECS is already engaged in providing baseline data sets to our partners (ELUs, roads, blocks, stream macrohabitats) with the hope that if they adopt our data and criteria they may come up with similar conclusions about where the critical places for conservation are.

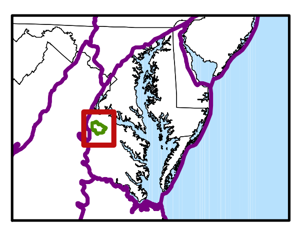
APPENDIX

(Example field forms for ecological system and matrix forest assessment)



Simplified ELUs and Distribution of 3 Types of Community EOs

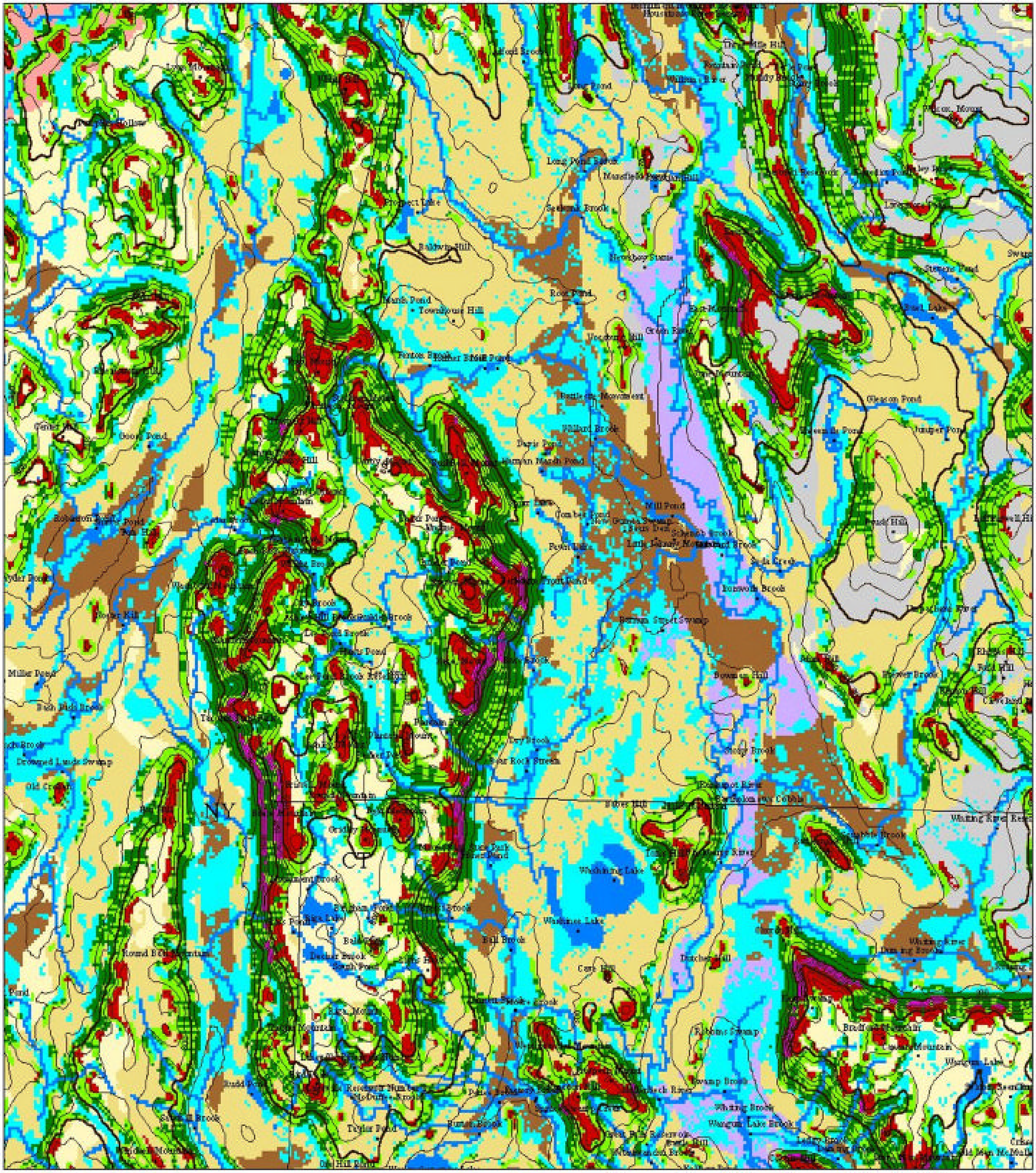
A.P. Hill Matrix Block: Chesapeake Bay Lowlands Ecoregion



Scale 1:130,000

1 0 1 2 3 Miles

Data Sources:
ELUs: TNC ECS 30 m. draft, February 2001.
Ecoregion boundaries; TNC/ECS based on USFS Keys et. al) subsections & NHP data.
Element occurrences from VA Natural Heritage Program, used with permission.
Map produced by TNC/ECS GIS, March, 2001.



Taconics / Southern Berkshires: Ecological Land Units

Ecological land units:

Slopes:
- cliff
- upper slope/summit
- sideslope
- cove

Wet flats and aquatic:
- wet flat/slope bottom
- stream/river/lake

Dry flats:

dry flats on shallow till over bedrock:
- acidic sed/metased
- acidic shale
- acid granitic mafic
- ultra mafic
- calcareous/mod calc

dry flats on deep sediment:
- coarse grain
- fine grain lake deposit

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State line

Contours:
- 30 m
- 150 m

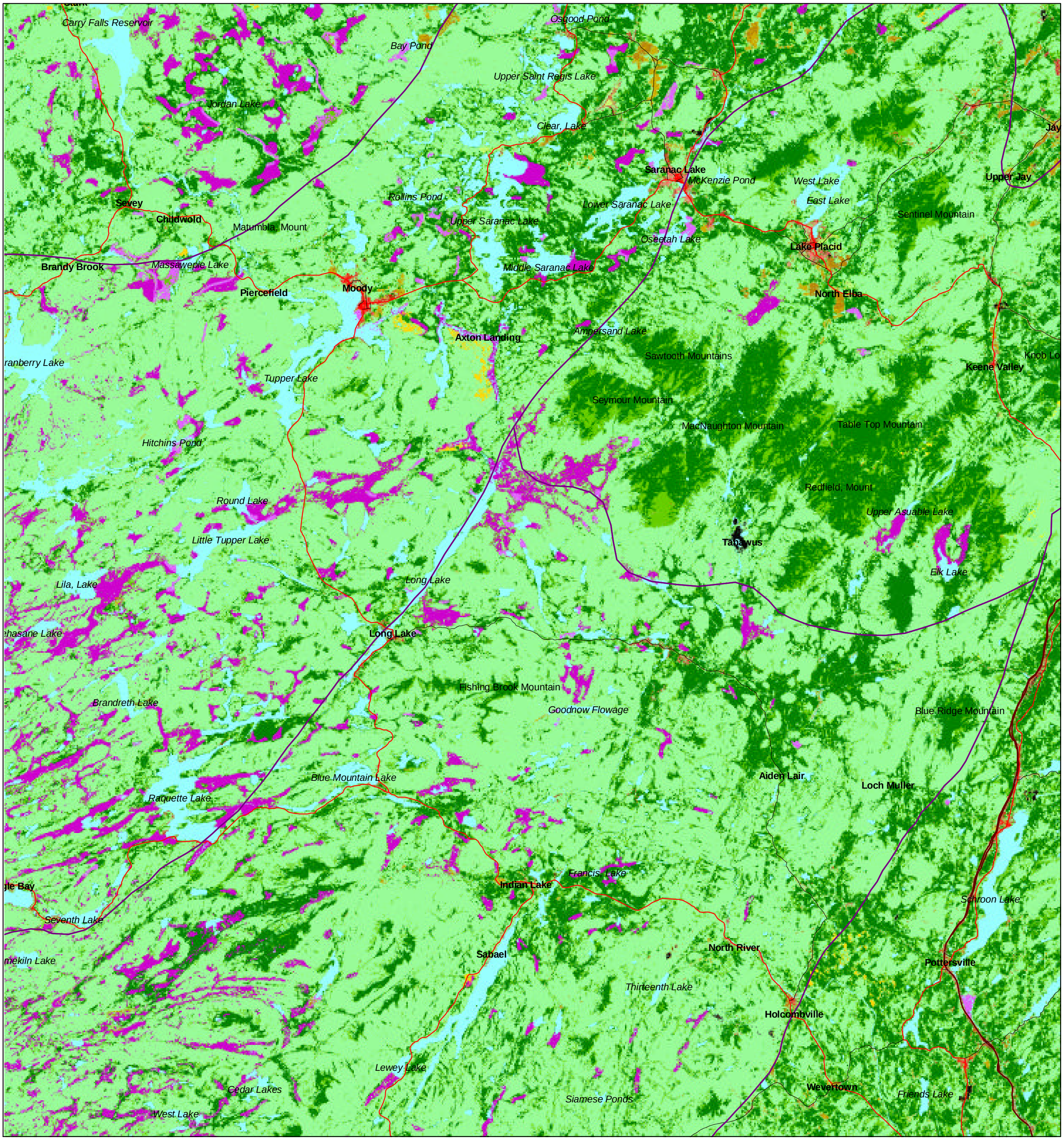
N

SCALE 1 : 150,000

1 0 1 2 Km

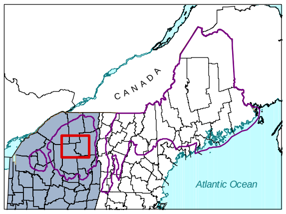
1 0 1 Miles

DATA SOURCES:
ELUs and contours derived from USGS 90m DEM by TNC.
Named places: USGS GNIS, 1:24K.
Political boundaries: ESRI ArcData 1:100K.
Map produced by TNC Eastern Conservation Science GIS, 5/18/00.



Land Cover 1992

Five Ponds & High Peaks Matrix Blocks - Long Lake Region, NY



N

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Scale 1:460,000

0 5 10 15 Miles

- Deciduous forest
- Evergreen forest
- Mixed Forest
- Forested wetland
- Emergent herbaceous wetland
- Open Water
- Agriculture
- Transitional barren/bare rock
- High intensity residentia/commercial

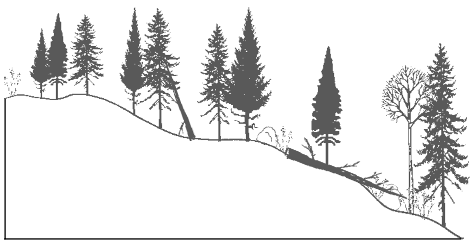
Data Sources:
Land Cover; USGS/EPA NLCD 30m, c. 1992.
Ecoregion Subsections; USFS Bailey/TNC.
Roads; ESRI ArcCD 1:100K.
Map produced by TNC/ECS GIS March/01.

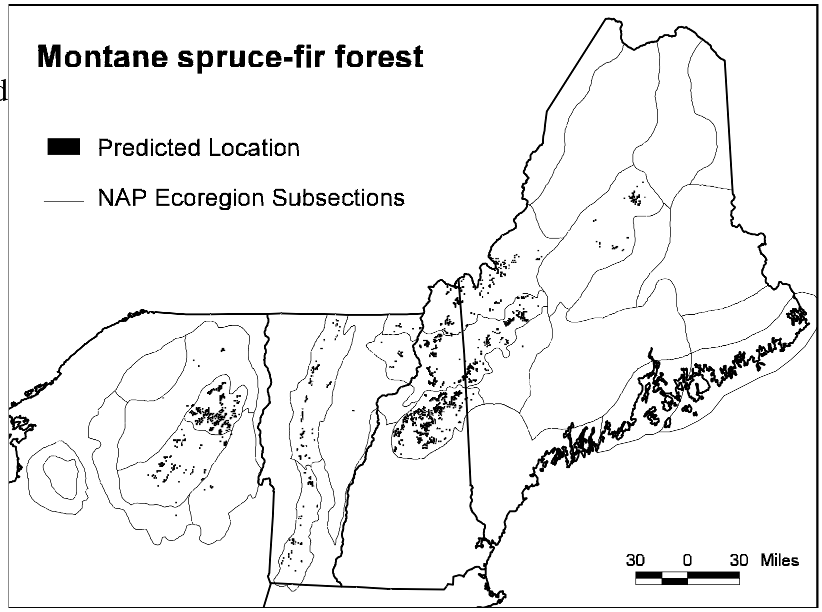
Montane spruce-fir forest

Picea rubens - Abies balsamea - Sorbus americana forest

Concept

Restricted, high elevation coniferous forests characterized by a mixture of red spruce, balsam fir and various amounts of mountain birch or yellow birch. Matrix forest of elevations between 2500 ft. - 4200 ft., patchy elsewhere, where appropriate conditions occur.





Vegetation Description

Canopy: red spruce (Picea rubens) and balsam fir (Abies balsamea). Canopy associates: heartleaf birch (Betula cordifolia), yellow birch (B. alleghaniensis), black spruce (Picea mariana). Sparse subcanopy layer of mountain ash (Sorbus americana), showy ash (Sorbus decora), Bartram's shadbush (Amelanchier bartramiana).
Shrubs: mountain holly (Nemopanthus mucronatus), velvetleaf blueberry (Vaccinium myrtilloides), creeping snowberry (Gaultheria hispidula).
Herbaceous: wood sorrel (Oxalis acetosella), starflower (Trientalis borealis), Canada mayflower (Maianthemum canadense), bluebead lily (Clintonia borealis), twinflower (Linnaea borealis), goldthread (Coptis groenlandica), bunchberry (Cornus canadensis), spinulose wood fern (Dryopteris campyloptera), intermediate fern (D. intermedia), broad beech fern (Phegopteris connectilis) and shining clubmoss (Huperzia lucidula).
Non-vascular plants: well developed ground layer of mosses: Bazzania trilobata, Dicranium scoparium, Hypnum curvifolium, Pleurozium shreberi and Ptilium crista-castensis.

Maine: subalpine spruce fir, and spruce slope forest (varient of this)

New Hampshire: High elevation mountain spruce-fir forest, 1:1 w

New York: Mountain Spruce -Fir Forest, 1:1 w

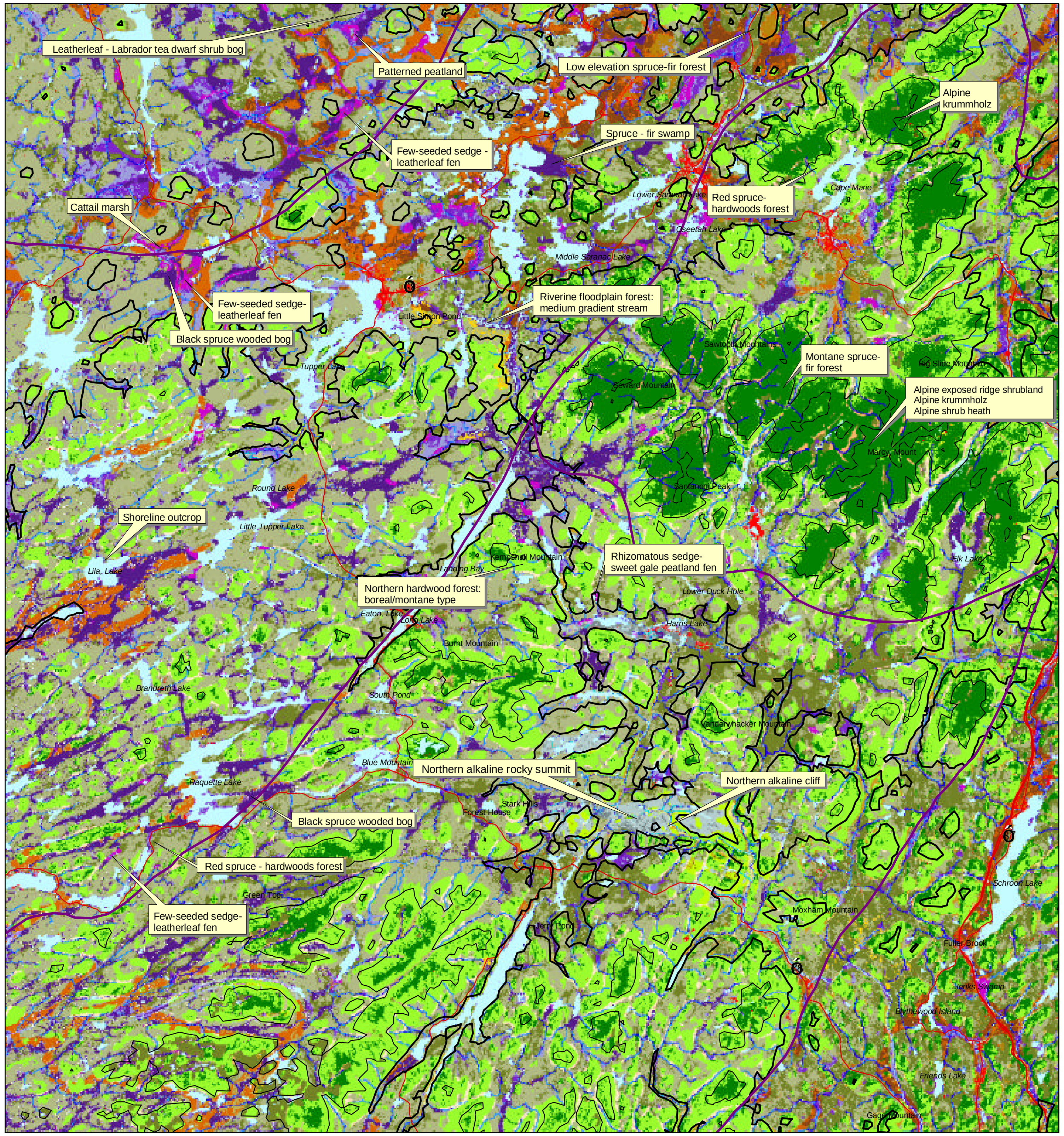
Vermont: Montane Spruce Fir, part of, which also includes Abies balsamea type

Environmental setting

Forest of upper mountain slopes and ridgetops generally above 2500 ft. Associated with high winds, cold temperatures and shallow, acidic, nutrient poor soils.

Associates

Characteristic species: Sharp-shinned Hawk, Merlin, Spruce Grouse, Northern Hawk-owl, Great Gray Owl, Three-toed Woodpecker, Black-backed Woodpecker, Olive-sided Flycatcher, Yellow-bellied Flycatcher, Gray Jay, Boreal Chickadee, Red-breasted Nuthatch, Golden-crowned Kinglet, Ruby-crowned Kinglet, Swainson's Thrush, Hermit Thrush, Blue-headed Vireo, Nashville Warbler, Northern Parula, Yellow Warbler, Magnolia Warbler, Cape May Warbler, Yellow-rumped Warbler, Blackburnian Warbler, Bay-breasted Warbler, Blackpoll Warbler, Canada Warbler, Dark-eyed Junco, Pine Grosbeak, Purple Finch, Red Crossbill, White-winged Crossbill, Pine Siskin. **Typical species:** Bald Eagle, Northern Goshawk, Golden Eagle, Ruffed Grouse, Boreal Owl, Northern Saw-whet Owl, Yellow-bellied Sapsucker, Hairy Woodpecker, Alder Flycatcher, Least Flycatcher, Purple Martin, Tree Swallow, Northern Rough-winged Swallow, Bank Swallow, Cliff Swallow, Barn Swallow, Common Raven, Black-capped Chickadee, Winter Wren, Veery, Bicknell's Thrush, Bohemian Waxwing, Northern Shrike, Red-eyed Vireo, Tennessee Warbler, Black-throated Blue Warbler, Black-throated Green Warbler, Palm Warbler, Black-and-white Warbler, American Redstart, Ovenbird, Northern Waterthrush, Mourning Warbler, Common Yellowthroat, Wilson's Warbler, Rose-breasted Grosbeak, American Tree Sparrow, Lincoln's Sparrow, White-throated Sparrow, Rusty Blackbird, Common Redpoll, Hoary Redpoll, American Goldfinch, Evening Grosbeak, Rock vole, Red-backed vole, Long-tailed shrew, Red squirrel, Northern flying squirrel, Porcupine, Marten



Fine Scale Ecological Systems (Simplified)

Five Ponds & High Peaks Matrix Blocks - Long Lake Region, NY

N

Scale 1:460,000

0 5 10 15 Miles

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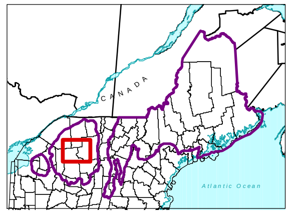
- 800 Ft.
- 1700 Ft.
- 2500 Ft.
- 4000 Ft.
- Primary roads
- Ecoregional subsections



Data Sources:
Map EVU; TNC ECS 90 m. draft August, 2000.
Ecoregion boundaries; TNC/ECS based on USFS (Keys et. al) subsections & NHP data.
Map produced by TNC/ECS GIS April, 2001.

Legend - INCOMPLETE DRAFT

OPEN WATER | AGRICULTURE | DEVELOPED

NAP Ecological System Units - DRAFT LEGEND
(communities listed are the highest probability types)

ACIDIC or NEUTRAL

DECIDUOUS FOREST ON DRY ACIDIC TILL FLATS
VERY LOW: Red oak-northern hardwood forest; Successional northern hardwood forest
LOW: Low elevation spruce-fir forest; Successional spruce-fir forest; Eastern hemlock-white pine-red spruce; Red pine-white pine forest
MID: Northern hardwood forest: boreal/montane type
HIGH: Red spruce hardwoods

CONIFER OR MIXED FOREST ON DRY ACIDIC TILL FLATS
VERY LOW: Eastern hemlock-white pine-red spruce; Successional spruce-fir forest; Maritime spruce-fir forest (coast only)
LOW: Low elevation spruce-fir forest; Successional spruce-fir forest; Eastern hemlock-white pine-red spruce; Red pine-white pine forest
MID: Low elevation spruce-fir forest; Red spruce-hardwoods forest; Successional spruce-fir forest
HIGH: Montane spruce-fir forest

DECIDUOUS FOREST ON ACIDIC SUMMITS AND SLOPES
LOW:Northern hardwood forest: boreal/montane type; Rich northern hardwood forest; Low elevation spruce-fir forest; Successional spruce-fir forest; Eastern hemlock-white pine-red spruce; White pine-Northern hardwood forest Successional northern hardwood forest
MID: Northern hardwood forest: boreal/montane type; Successional northern hardwoods
HIGH: Successional spruce-fir forest; Red spruce hardwoods (north slopes)

CONIFER OR MIXED FOREST ON ACIDIC SUMMITS AND SLOPES
LOW: Low elevation spruce-fir forest; Successional spruce-fir forest; Eastern hemlock-white pine-red spruce; White pine-Northern hardwood forest; Hemlock-hardwood forest (north slopes)
MID: Red spruce-hardwoods forest; Low elevation spruce-fir forest; Successional spruce-fir forest (north slopes)
HIGH: Montane spruce-fir forest; Montane fir forest
VERY HIGH: Alpine krummholz; Montane fir forest

DECIDUOUS FOREST ON DRY COARSE SANDY FLATS
VERY LOW/LOW: Red oak-northern hardwood forest; early successional forest

CONIFER OR MIXED FOREST ON DRY COARSE SANDY FLATS
VERY LOW: Pitch pine forest; Pitch pine -heath barrens; Eastern hemlock-white pine-red spruce
LOW: Eastern hemlock-white pine-red spruce

CONIFER OR MIXED FOREST ON DRY FINE GRAINED STRATIFIED SEDIMENT FLATS
VERY LOW: Eastern hemlock-white pine-red spruce; Maritime spruce-fir forest (coast only); Successional spruce-fir forest

DECIDUOUS FOREST ON DRY FINE GRAINED STRATIFIED SEDIMENT FLATS
VERY LOW: Riverine floodplain forest: terraces

BARRENS OR TRANSITIONAL FOREST ON ACIDIC FLATS AND SLOPE BOTTOMS
ALL ELEV: Early successional forest / clearcut;
VERY LOW/LOW: Jack pine heath barren; Pitch pine heath barren

DECIDUOUS FOREST ON ACIDIC RAVINES & SLOPEBOTTOMS
LOW/MID: Maple-beech-birch northern hardwood forest

CONIFER OR MIXED FOREST ON ACIDIC RAVINES & SLOPEBOTTOMS
VERY LOW/LOW: Hemlock - yellow birch forest

DECIDUOUS FOREST ON ACIDIC WET FLATS
LOW: Northern red maple swamp; Black gum-red maple swamp; Riverine floodplain forest: medium gradient stream; Lakeside/large riverbottom floodplain forest

CONIFER OR MIXED FOREST ON ACIDIC WET FLATS
VERY LOW: Black spruce -Larch bog forest; Hemlock-hardwood swamp; Spruce-fir swamp
LOW/MID: Red maple - conifer acidic swamp; Black spruce -Larch bog forest; Spruce-fir swamp

ACIDIC WOODED WETLAND
VERY LOW: Black spruce wooded bog; Leatherleaf-Labrador tea dwarf shrub bog; Few-seeded sedge - leatherleaf fen; Maritime crowberry bog
LOW/MID: Leatherleaf-Labrador tea dwarf shrub bog; Peatland moss lawn/mud bottom; Few-seeded sedge - eatherleaf fen; Peatland lagg (northern, non-streamside)

ACIDIC EMERGENT WETLAND
LOW/MID: Few seeded sedge - leatherleaf fen; cattail marsh

DECIDUOUS FOREST ON ACIDIC STREAMSIDES, AND LAKESHORES
LOW/MID: Northern red maple swamp; Northern hardwood forest

CONIFER OR MIXED FOREST ON ACIDIC STREAMSIDES, AND LAKESHORES
VERY LOW: Hemlock-hardwood forest
LOW: Hemlock-hardwood forest
MID: Red spruce-hardwoods forest

OPEN SUMMITS, CRESTS AND SIDESLOPES
VERY HIGH: Alpine exposed ridge; Alpine shrub heath; Alpine meadow; Bare rock; Alpine krumholz

CALCAREOUS

DECIDUOUS FOREST ON DRY CALCAREOUS TILL FLATS
VERY LOW: Red oak-northern hardwood forest; Successional oak-pine forest
LOW: Rich northern hardwood forest; Successional northern hardwood forest; Northern hardwood forest: boreal/montane type

CONIFER OR MIXED FOREST ON DRY CALCAREOUS TILL FLATS
VERY LOW: Eastern hemlock-white pine-red spruce
LOW: Eastern hemlock-white pine-red spruce;

DECIDUOUS FOREST ON CALCAREOUS SUMMITS AND SLOPES
LOW: Rich northern hardwood forest; Successional northern hardwood forest; Northern hardwood forest: boreal/montane type

CONIFER OR MIXED FOREST ON CALCAREOUS SUMMITS AND SLOPES
LOW: Red pine-white pine forest; northern alkaline rocky summit; northern alkaline cliff

CONIFER OR MIXED FOREST ON CALCAREOUS WET FLATS
VERY LOW/LOW: Northern white cedar peatland swamp

CALCAREOUS WOODED WETLAND
VERY LOW/LOW: Leatherleaf-Labrador tea dwarf shrub bog; Slender sedge - leatherleaf fen

CALCAREOUS EMERGENT WETLAND
VERY LOW/LOW: Slender sedge - alkaline fen; Tussock sedge meadow; bulrush deepwater marsh

DECIDUOUS FOREST ON CALCAREOUS STREAMSIDES AND LAKESHORES
VERY LOW/LOW: Rich northern hardwood forest; Riverine terrace forest

CONIFER OR MIXED FOREST ON CALCAEREOUS STREAMSIDES, AND LAKESHORES
VERY LOW/LOW: Northern white cedar peatland swamp; Northern white cedar seepage forest

ULTRAMAFIC

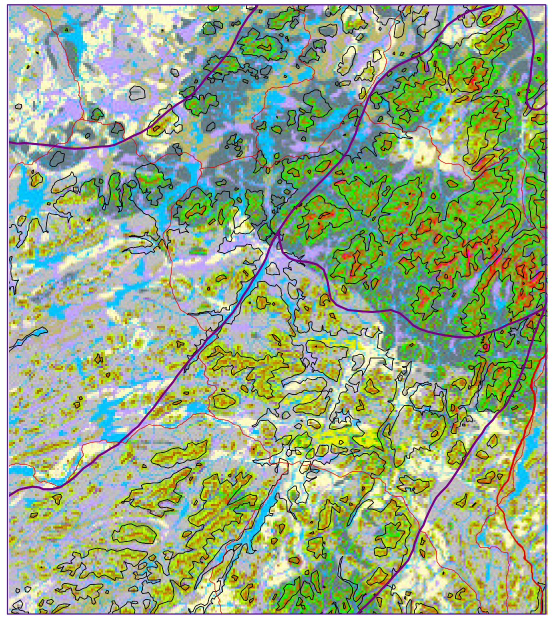
CONIFER
LOW/MID: Northern serpentine barren

DECIDUOUS
LOW/MID: Northern serpentine barren

Elevation Classes:

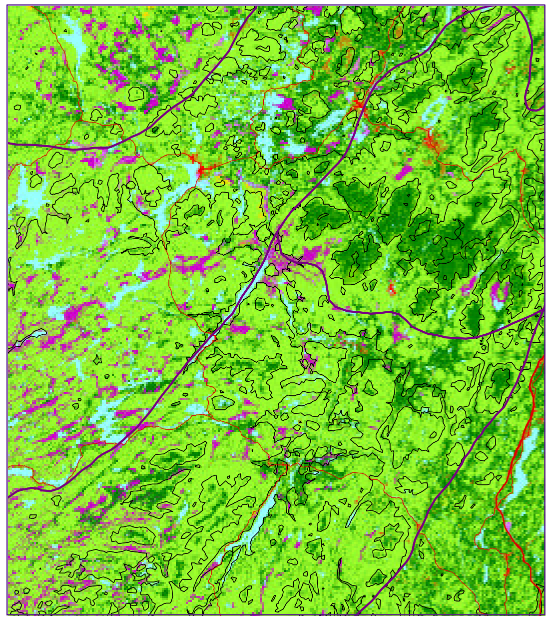
0 - 800 Ft = Very low elevation
800 - 1,700 Ft = Low elevation
1,700 - 2,500 Ft = Mid elevation
2,500 - 4,000 Ft = High elevation
+ 4,000 = Very high elevation

Ecological Land Units (90m)



- Cliff
- Sideslope
- Steep slope
- Slope crest
- Upper slope
- Flat summit
- Cove
- Dry flat - fine grained sed.
- Dry flat - coarse grained sed.
- Wet flat
- Slope bottom
- Stream, Lake
- Dry flat till - calc. / mod. calcareous
- Dry flat till - acidic sed / meta sed
- Dry flat till - acidic shale
- Dry flat till - acidic granitic
- Dry flat till - mafic / interm. granitic
- Dry flat till - ultramafic

MRLC 1991-1993 Land Cover (30m)



- Open Water
- Developed
- Bare rock/sand
- Transitional barren
- Hay/pasture
- Deciduous forest & shrubland
- Evergreen forest
- Mixed Forest
- Forested wetland
- Emergent herbaceous wetland

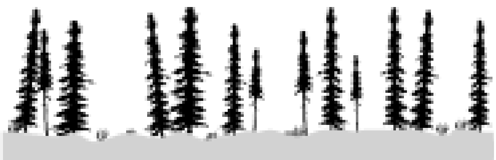
Data Sources:
ELU; TNC Eastern Conservation Science from surface modelling of 90m USGS DEM data, surficial/bedrock geology, and land cover wetlands.
Land Cover; EPA./USGS/Hughes MRLC 30m. classified Landsat TM imagery DRAFT 1991-93.

Black spruce wooded bog

Picea mariana - Larix larcina / Ledum groenlandicum / Carex trisperma / Sphagnum spp. woodland

Concept

Wooded peatland characterized by tree-sized black spruce (Picea mariana) over a dwarf shrub strata of leatherleaf, labrador tea and three-seeded sedge. Typical wooded bog of the Northern Appalachians.



Vegetation Description

Canopy: open canopy of wooded fens and partly forested bogs dominated by black spruce (Picea mariana). Associates include scattered larch (Larix laricina).
Shrubs: ericaceous species: labrador tea (Ledum groenlandicum), leatherleaf (Chamaedaphne calyculata), (Andromeda polifolia), swamp laurel (Kalmia polifolia).
Herbs: three seeded sedge (Carex trisperma), (Gaultheria hispidula), (Maianthemum trifolium) and cotton-grass (Eriophorum vaginatum).
Non-vascular: Sphagnum mosses (Sphagnum fuscum), (Sphagnum angustifolium), and (Sphagnum magellanicum), with scattered feathermosses (Pleurozium schreberi), (Dicranum undulatum), and (Polytrichum strictum),

Maine: dwarf shrub bog, in part; may include some P8, forested bog)

New Hampshire: Picea mariana-Larix larcina/Ledum-Rhododendron candense/ Spagnum
Saturated

New York: Black spruce - tamarack bog

Vermont: Black spruce bog

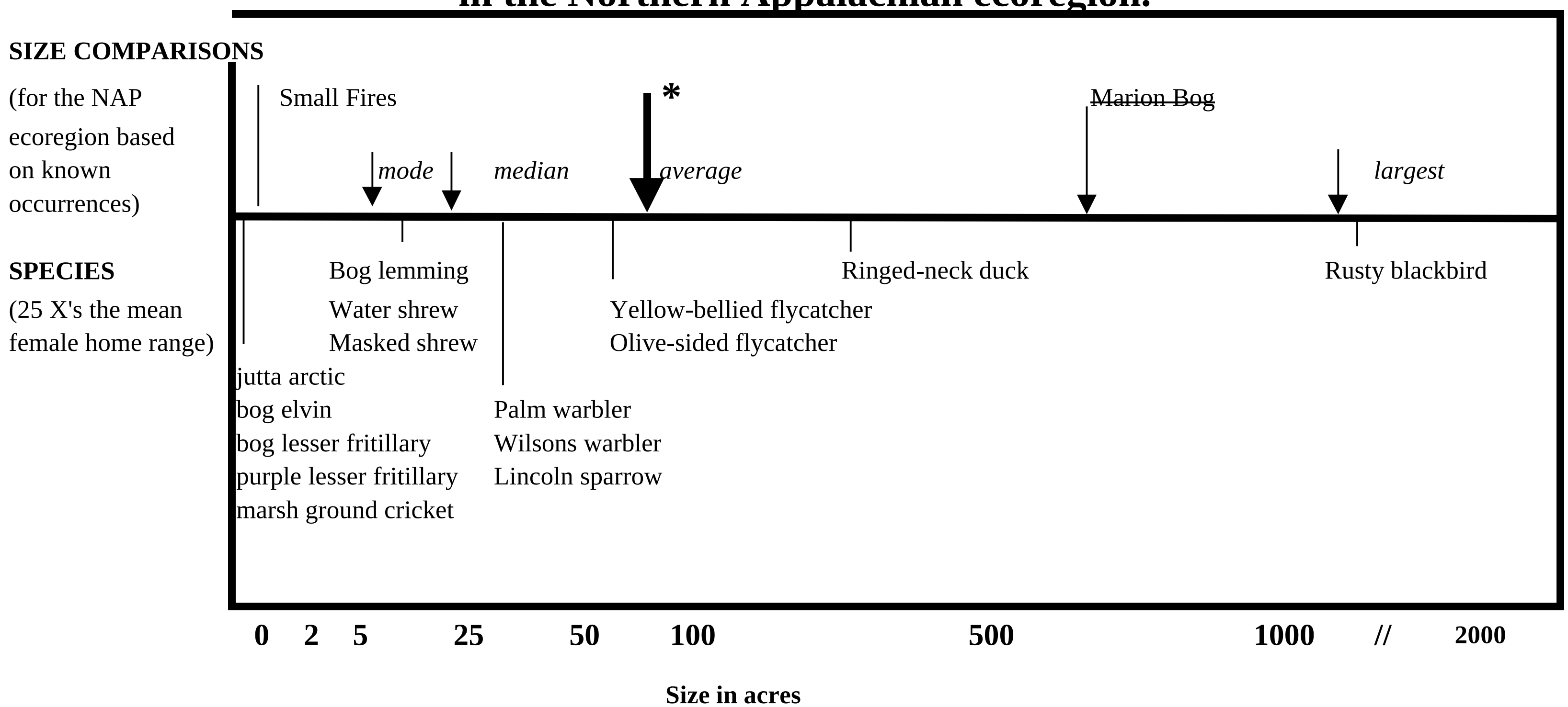
Environmental setting

Peat accumulating wet flats, depressions and basins in southernmost areas of the ecoregion. Concentrated in areas of acidic bedrock but may occur over any type of bedrock or soil where cold temperatures and saturated condition prevents peat decomposition. The substrate consists of deep, fibric peat prevents free reproduction except by vegetative layering by spruce or larch on dryer raised hummocks.

Associates

Characteristic species: Boreal Owl, Olive-sided Flycatcher, Palm Warbler, Wilson's Warbler, Rusty Blackbird. **Typical species:** Spruce Grouse, Northern Saw-whet Owl, Three-toed Woodpecker, Black-backed Woodpecker, Yellow-bellied Flycatcher, Tree Swallow, Gray Jay, Common Raven, Boreal Chickadee, Red-breasted Nuthatch, Hermit Thrush, Tennessee Warbler, Nashville Warbler, Northern Parula, Bay-breasted Warbler, Black-and-white Warbler, Northern Waterthrush, Mourning Warbler, Canada Warbler, Lincoln's Sparrow, Pine Siskin, Masked shrew, Red squirrel, Red-back vole, Southern bog lemming.

Size relationships of black spruce/dwarf shrub peatland complexes in the Northern Appalachian ecoregion.



Factors to the left of the arrow should be encompassed reserve of that size

Peatlands accumulate peat and close at the rate of 2 to 20 cm per 100 years (Mitch and Gosslink 1986)

*Based on examination of time-sequence airphotos they may close at about 0.25 acre per year during dry years, many have been stable for 3000-4000 years (Crum 1998)

Ave block size = 13,170 acres, mode = 8092, median = 2799

Northern alkaline cliff

Carex scirpoidea sparsely vegetated alkaline cliff

Concept

Sparsely vegetated calcareous cliffs of high elevations or boreal regions.

Vegetation Description

Heterogenous mixture of shrubs, scrubby trees and herbs on vertical cliff faces of alkaline rock. Vegetation is restricted to cracks and crevices where soil accumulates, thus the internal structure is patchy and varies from well-vegetated to barren. Characteristic **trees** include northern white cedar (Thuja occidentalis), mountain maple (Acer spicatum).
Shrubs: red current (Ribes triste), shrubby cinquefoil (Pentaphylloides floribunda).
Herbs: birdeye primrose (Primula mistassinica), Kalm's lobelia (Lobelia kalmia), lyre-leaved rockcress (Arabis lyrata), hairy rockcress (Arabis hirsuta), early saxifrage (Saxifraga virginiensis), ashy whitlow grass (Draba lanceolata), roseroot (Sedum rosea), scirpus-like sedge (Carex scirpoidea), ebony sedge (Carex eburnea), deershair sedge (Scirpus cespitosus), slender cliff brake (Cryptogramma stelleri), maidenhair spleenwort (Asplenium trichomanes), fragrant woodfern (Dryopteris fragrans), rock-selaginella (Selaginella rupestris).

Environmental setting

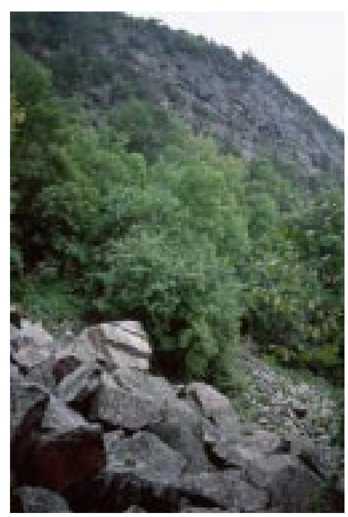
Vertical or near vertical outcrops of resistant alkaline rock (limestone or dolomite) with minimal soil development.

Maine: Circumnuetral cliff community (in part:northern and high elevation types)

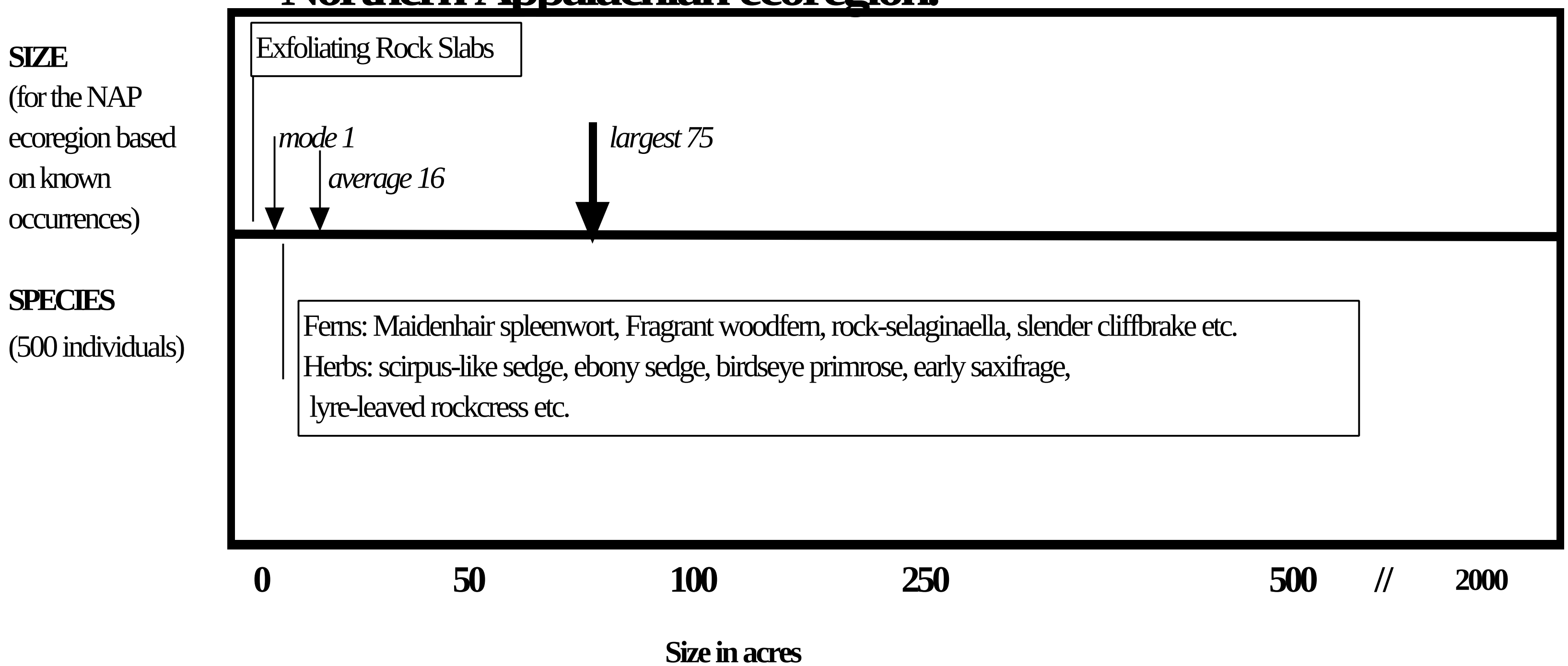
New Hampshire: NNE calcareous cliff community, NNE circumneutral cliff community

New York: Calcareous cliff community (in part: northern and high elevation regions)

Vermont: Boreal calcareous cliff community

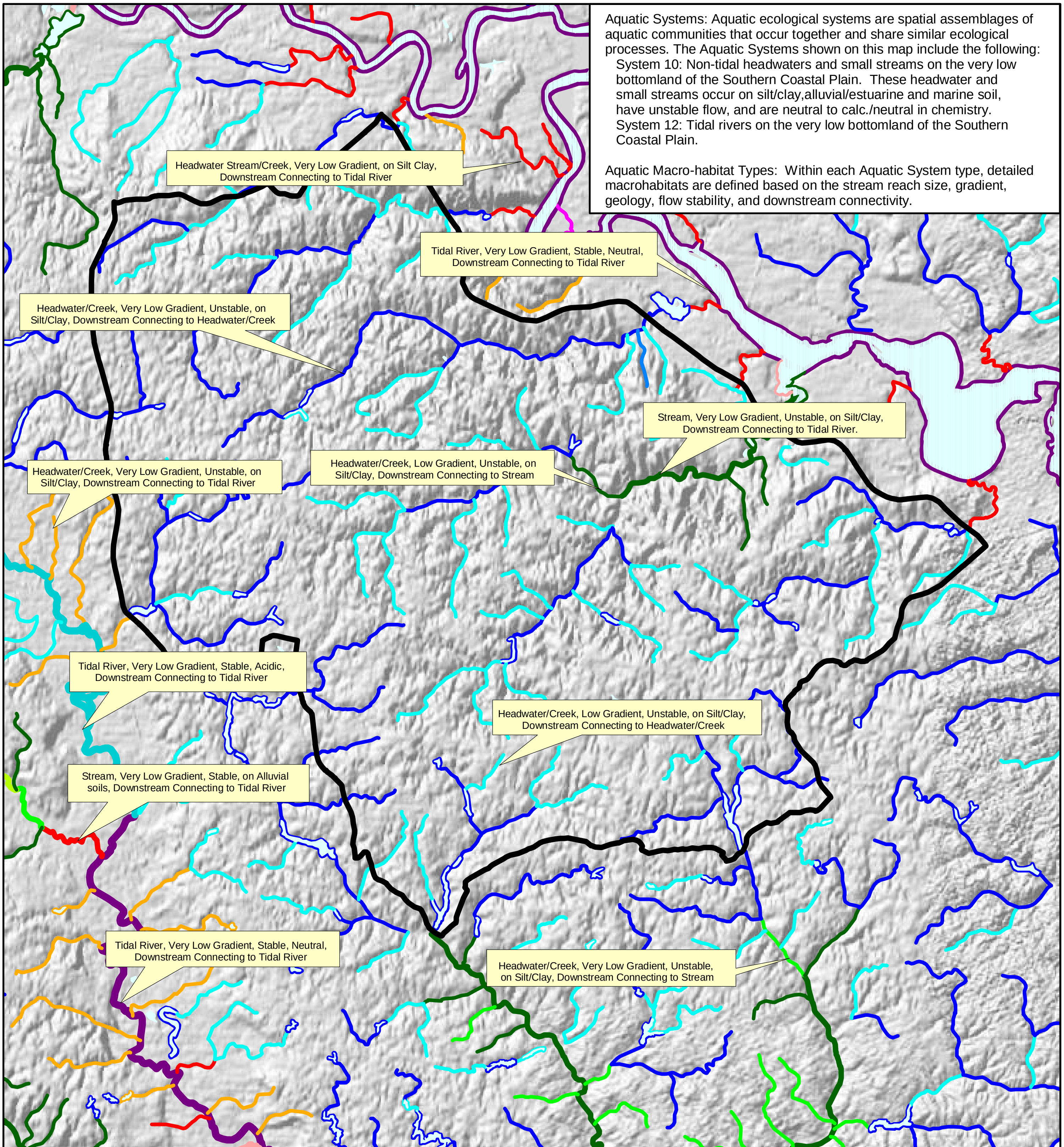


Scaling factors and size relationships of calcareous cliffs in the Northern Appalachian ecoregion.



Factors to the left of the arrow should be encompassed reserve of that size
Many known occurrences have remained for over 100 years based on historical records
Restricted invertebrates unknown

Heterogenous mix of ferns, shrubs, scrubby trees and herbs on vertical cliff faces. Vegetation is restricted to cracks and crevices where soil accumulates



Freshwater Aquatic Systems and Macrohabitats

A. P. Hill Matrix Occurrence: Chesapeake Bay Lowlands Ecoregion

A. P. Hill Matrix Occurrence

Scale 1:150,000

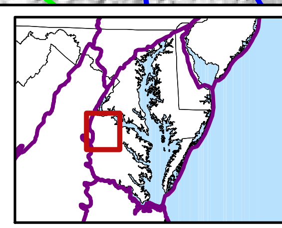
1 0 1 2 3 Miles

System 10: Macrohabitats

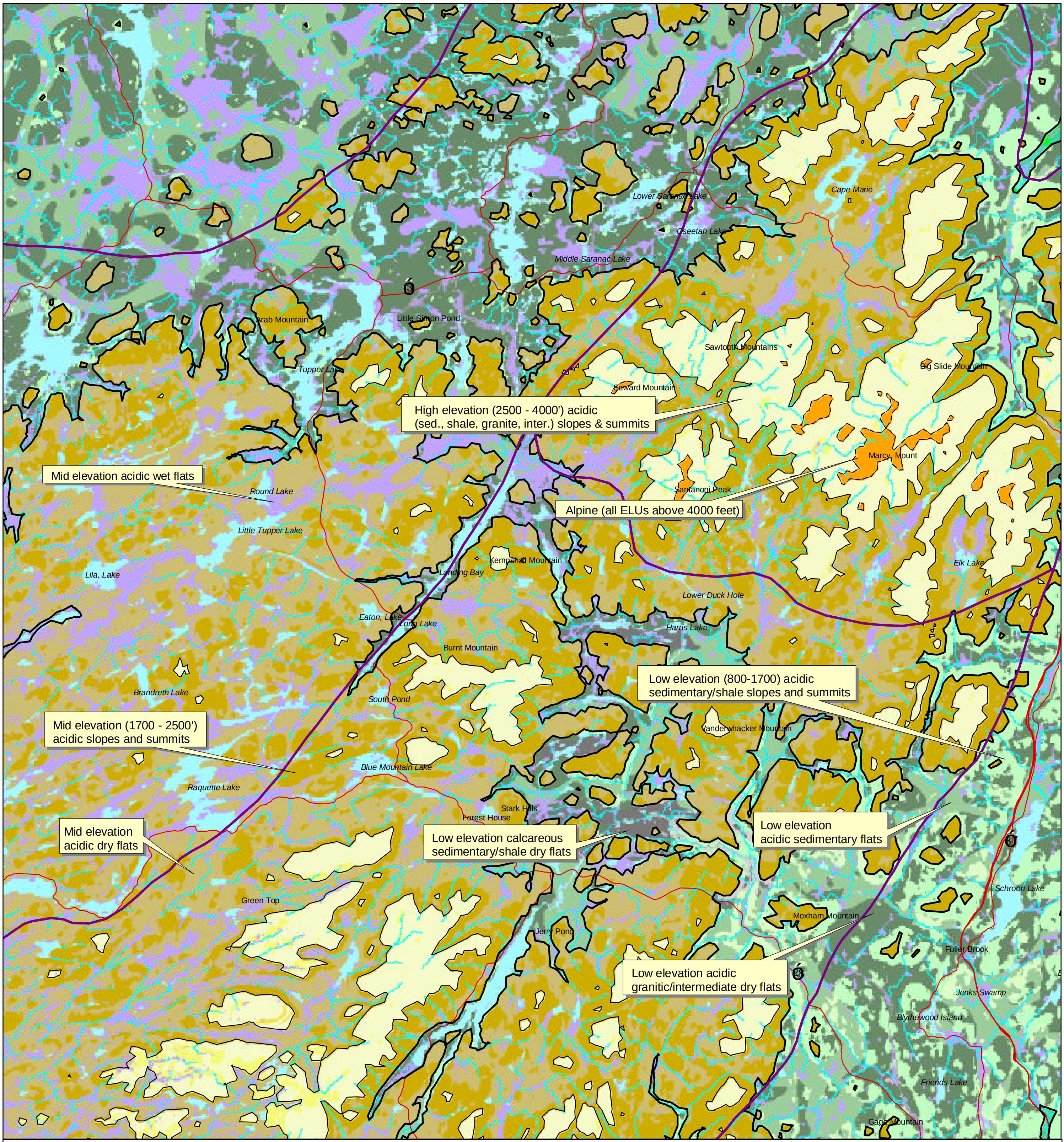
- Headwater/Creek, Very Low Gradient, Unstable, on Silt/Clay, Downstream Connecting to Headwater/Creek
- Headwater/Creek, Low Gradient, Unstable, on Silt/Clay, Downstream Connecting to Headwater/Creek
- Headwater/Creek, Moderate Gradient, Unstable, on Silt/Clay, Downstream Connecting to Headwater/Creek
- Headwater/Creek, Very Low Gradient, Unstable, on Silt/Clay, Downstream Connecting to Stream
- Headwater/Creek, Low Gradient, Unstable, on Silt/Clay, Downstream Connecting to Stream
- Headwater/Creek, Very Low Gradient, Stable, on Alluvial soil, Downstream Connecting to Tidal River
- Headwater/Creek, Very Low Gradient, Unstable, on Silt/Clay, Downstream Connecting to Tidal River
- Headwater/Creek, Low Gradient, Unstable, on Silt/Clay, Downstream Connecting to Tidal River
- Stream, Very Low Gradient, Stable, on Alluvial soil, Downstream Connecting to Stream
- Stream, Very Low Gradient, Unstable, on Silt/Clay, Downstream Connecting to Stream
- Stream, Low Gradient, Stable, on Alluvial soil, Downstream Connecting to Stream
- Stream, Very Low Gradient, Stable, on Alluvial soil, Downstream Connecting to Tidal River
- Stream, Very Low Gradient, Unstable, on Silt/Clay, Downstream Connecting to Tidal River

System 12: Macrohabitats

- Tidal River, Very Low Gradient, Stable, Neutral, Downstream Connecting to Tidal River
- Tidal River, Very Low Gradient, Stable, Acidic, Downstream Connecting to Tidal River

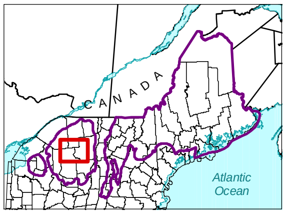


Data Sources:
Hydrology: EPA RF3 1:100k. Macrohabitats and Systems. ECS/FWI 2/01.
Ecoregion boundaries; TNC/ECS based on USFS (Keys et. al) subsections & NHP data.
Map produced by TNC/ECS GIS March/01



Coarse Scale Ecological Systems

Five Ponds & High Peaks Matrix Blocks - Long Lake Region, NY

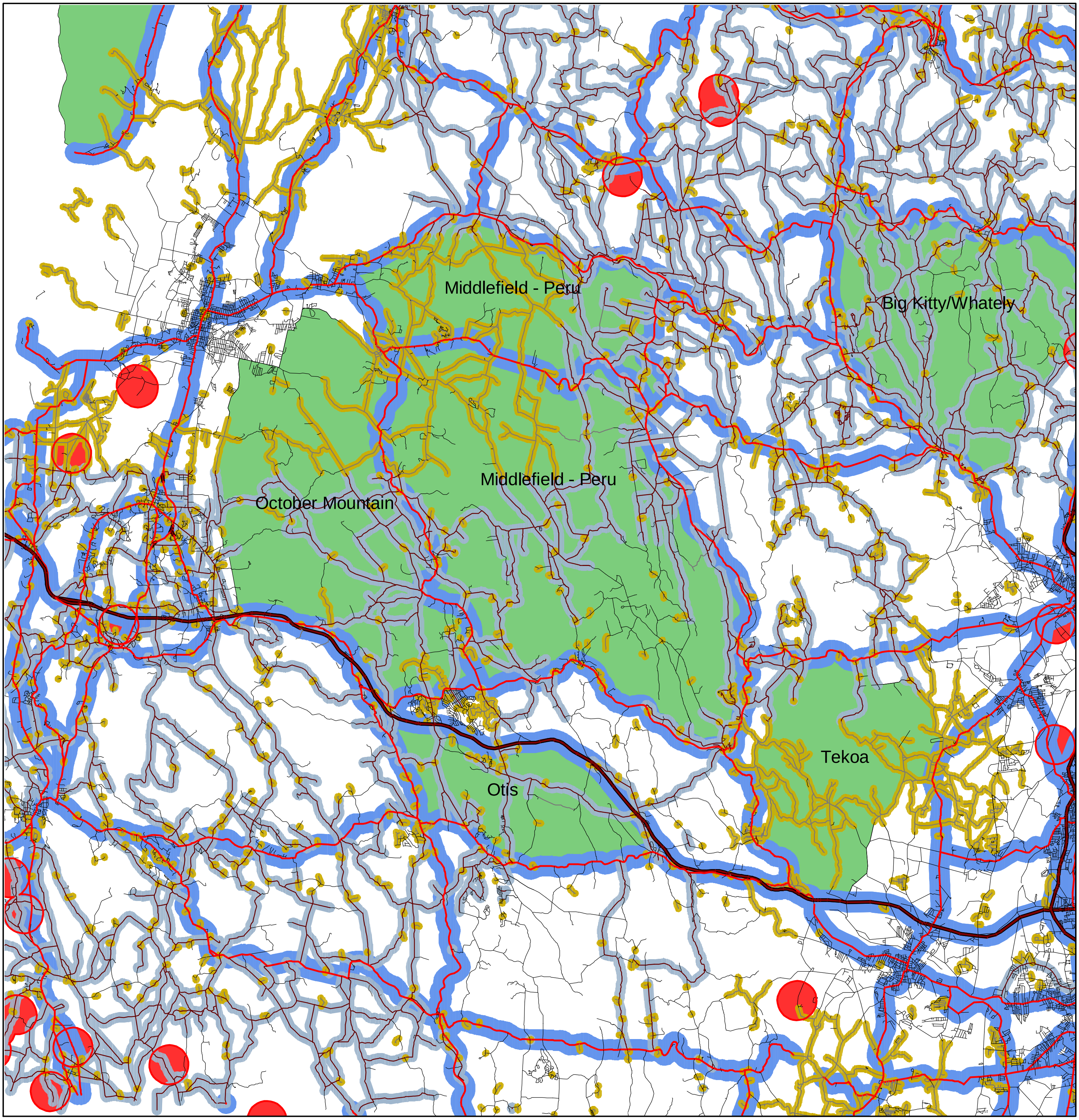


Scale 1:460,000

0 5 10 15 Miles

- 0 - 800 Ft. Very Low Elevation
- 800 - 1700 Ft. Low Elevation
- 1700 - 2500 Ft. Mid Elevation
- 2500 - 4000 Ft. High Elevation
- Primary roads
- Ecoregional subsections

Data Sources:
Systems; TNC ECS 90 m. Draft ELU groupings.
Ecoregion boundaries; TNC/ECS based on USFS (Keys et. al) subsections & NHP data.
Map produced by TNC/ECS GIS April, 2001.



Matrix Block Forest Core Analysis - Road Buffer

Berkshire Plateau - Western MA.

DRAFT Road Classes

Patch Community
Tier 1 Matrix Area
600 m. Primary Road Buffer
300 m. Secondary Road Buffer
200 m. Tertiary Road Buffer

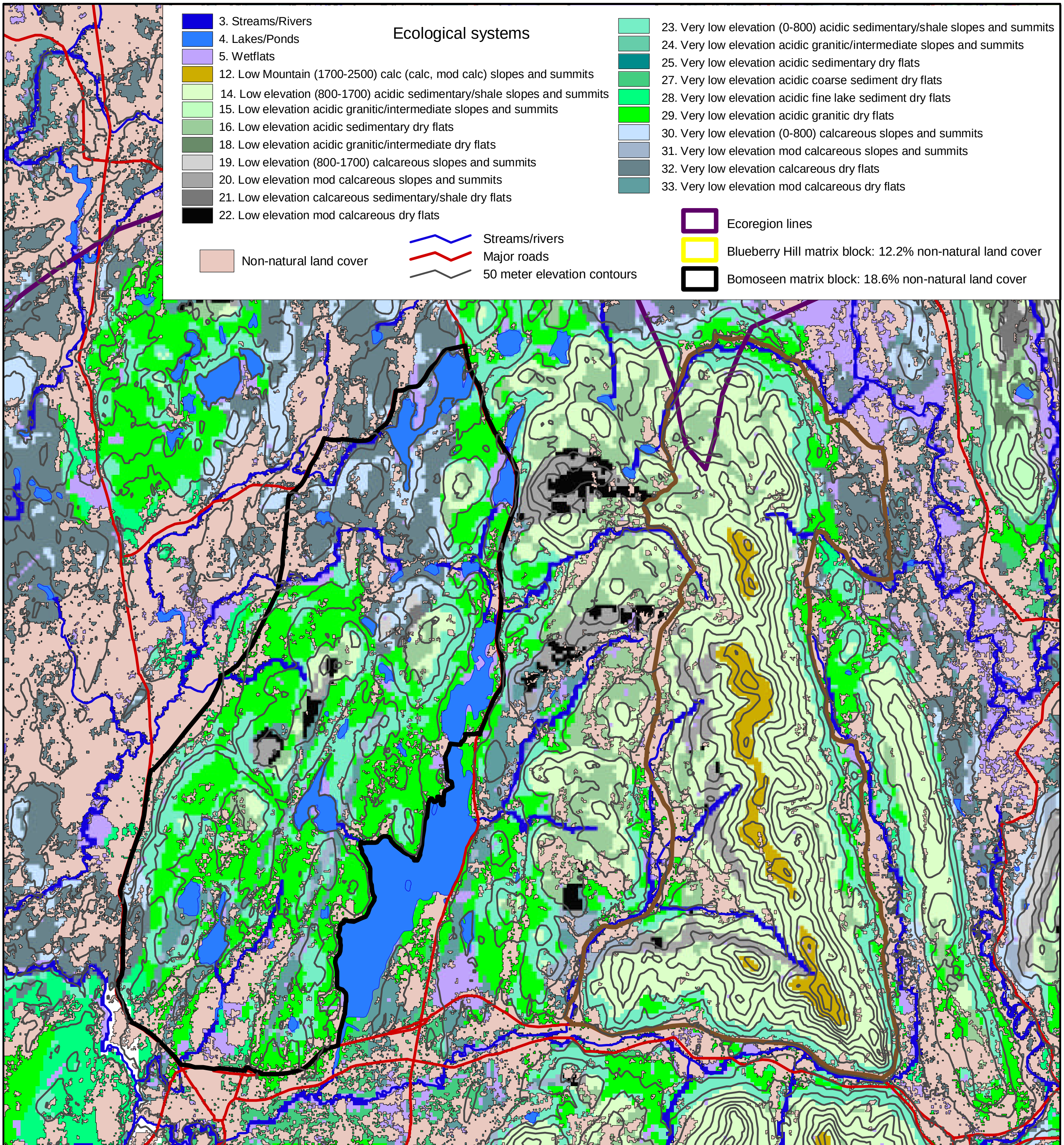
Primary road with limited access
Primary road
Secondary and connecting road
Local road
Road, major and minor unknown cat.

N

Scale 1:271,000

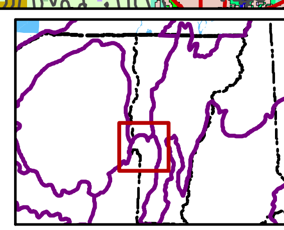
0 4 8 12 Miles

Data: Roads, GDT 1:100,000.
Map produced by TNC Eastern Conservation Science 3/01



Ecological Systems and Land Use/Land Cover Conversion

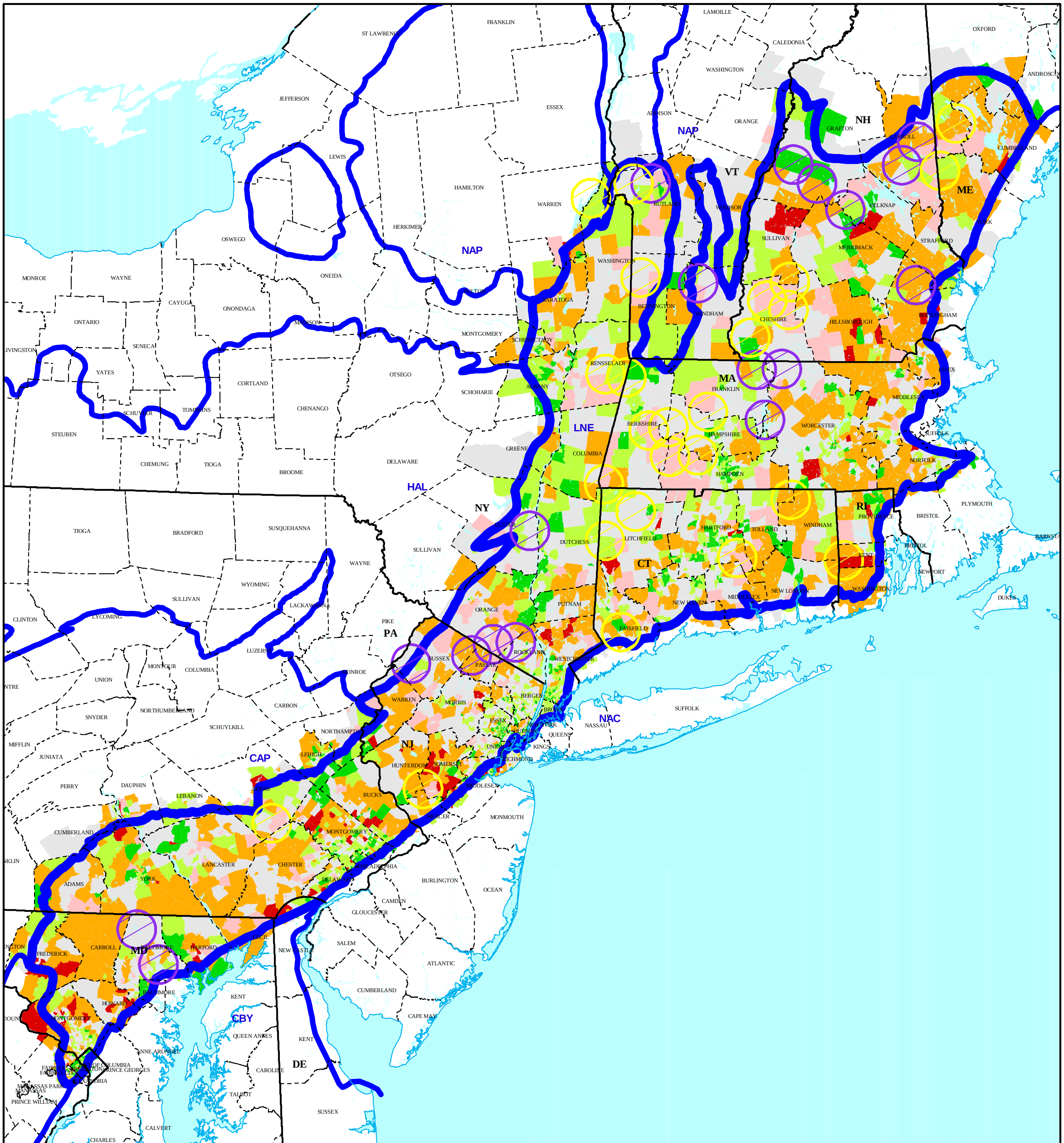
Bomoseen and Blueberry Hill Matrix Blocks:
Lower New England-Northern Piedmont Ecoregion



Scale 1:130,000

1 0 1 2 3 Miles

Data Sources:
Systems: TNC ECS 90 m. draft; August, 2000.
Ecoregion boundaries: TNC/ECS based on USFS (Keys et. al) subsections & NHP data.
Land cover: USGS/EPA National Land Cover Data, from Landsat TM data, c. 1992.
Water bodies, rivers, major roads: USGS Digital Line Graphs, 1:100k
Map produced by TNC/ECS GIS, March, 2001.



Percent Average Annual Population Change Rate 1990 - 1997

Lower New England Ecoregion

Rate of Change 1990 - 1997

- -28 - -1
- -1 - 0
- 0 - 1.1
- 1.1 - 1.4 (Average US Growth)
- 1.4 - 4
- 4 - 100 (>4% is fast growth)

- State / National
- County
- Ecoregion
- Coast
- Open Water

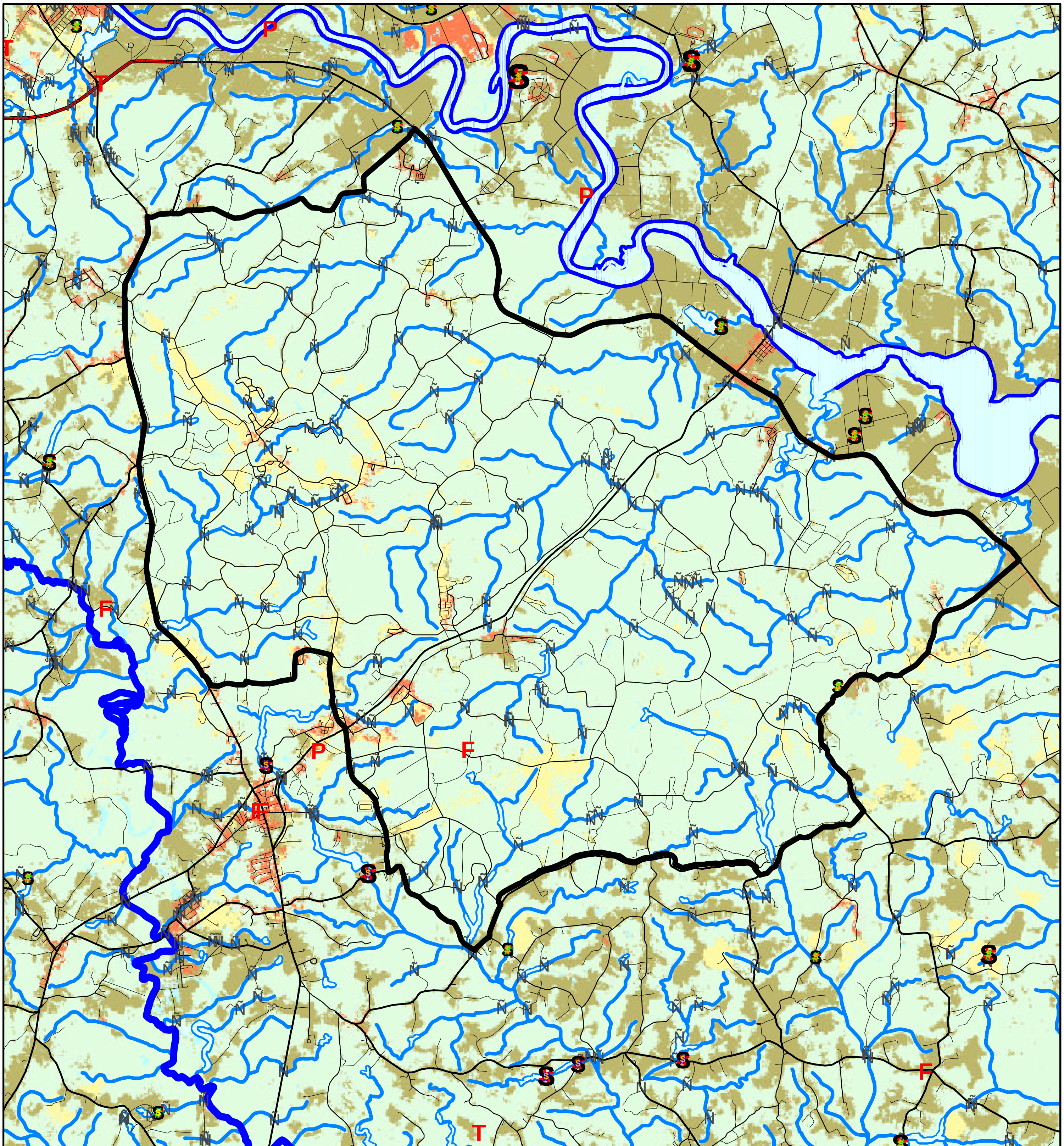
- 10yr Action Portfolio Matrix as 100,000 acre circle
- Portfolio Matrix as 100,000 acre circle

N

Scale 1:3,200,000

10 0 10 20 30 40 50 Miles

Data Sources:
U.S. Census Blocks and Political Boundareis from ESRI Maps and Data 2000.
Growth Estimates: Larry Gorenflo TNC
Ecoregion boundaries; TNC/ECS based on USFS (Keys et. al) subsections & NHP data.
Map produced by TNC/ECS GIS March/01



Freshwater Aquatic Condition

A. P. Hill Matrix Occurrence:
Chesapeake Bay Lowlands Ecoregion

Scale 1:150,000

1 0 1 2 3 Miles

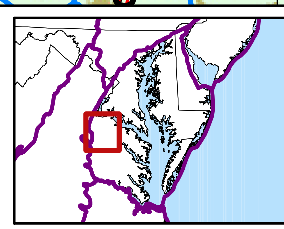
- Primary Road
- Secondary Road
- Local Road
- Ñ Road Stream Crossing
- Natural Land Cover
- Transitional Barren/Clearcut
- Agriculture
- Developed
- Open Water
- P PCS Discharge
- T TRI Discharge
- F IFW Discharge

Dam Normal Storage (acre/ft)
- 0 - 25
- 25 - 100
- 100 - 200
- 200 - 500
- 500 - 1000
- 1000 - 3000

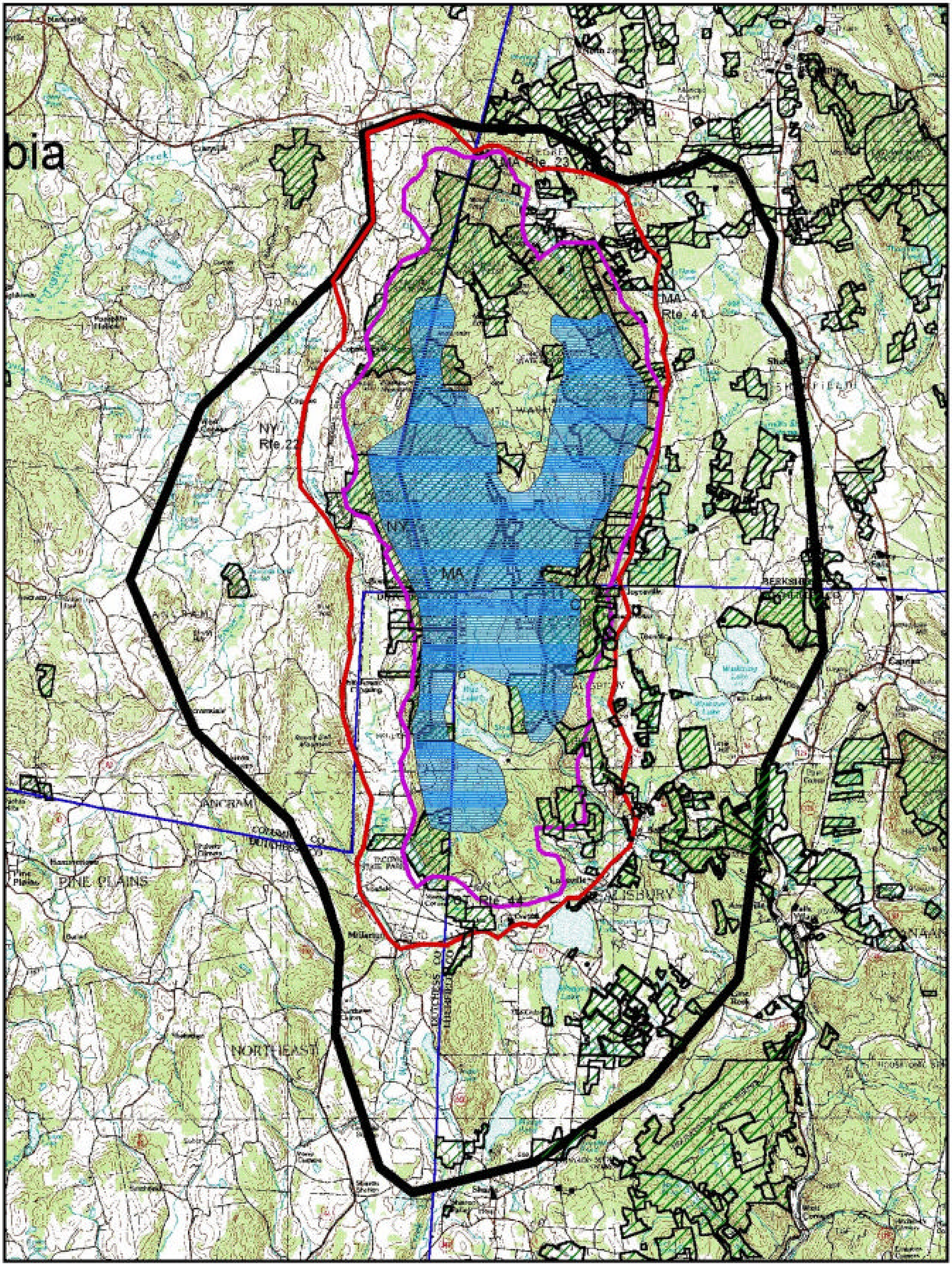
Dam Primary Purpose
- IRRIGATION
- RECREATION

Downstream Hazard Given Dam Failure
- # LOW
- # SIGNIFICANT

- System 10 Reaches
- System 12 Reaches
- A. P. Hill Matrix



Data Sources:
Hydrology: EPA RF3 1:100k. Macrohabitats and Systems. ECS/FWI 2/01.
Ecoregion boundaries; TNC/ECS based on USFS (Keys et. al) subsections & NHP data.
Map produced by TNC/ECS GIS March/01

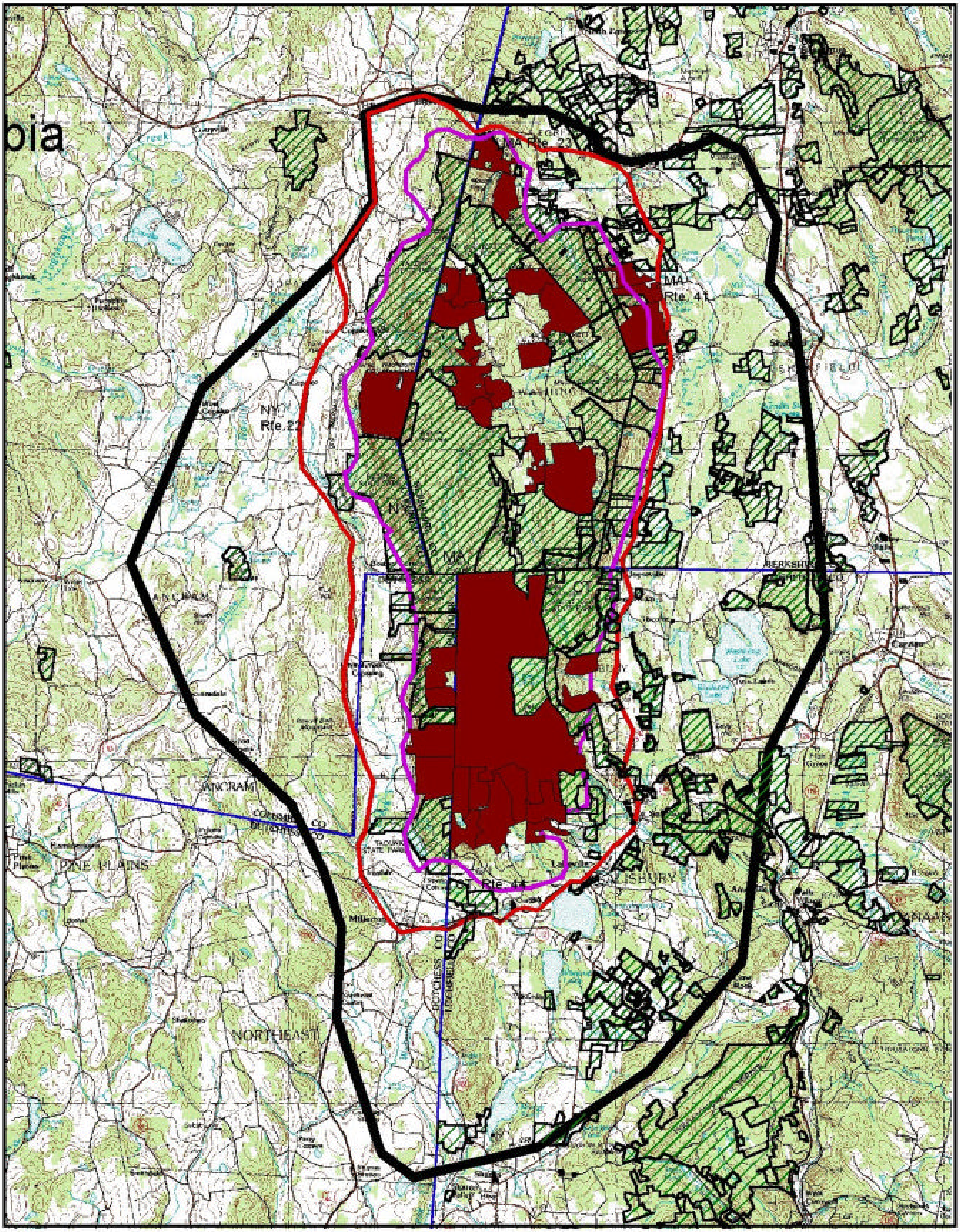


Zone Without Extensive Areas of Invasive Non-Native Plants in the Berkshire Taconic Landscape Program

Invasive-Free Areas
Protected Open Space
Berkshire Taconic Landscape Program
Forest Core Road Boundaries
Forest Core

2 0 2 4 Miles

Data sources:
USGS Topo 1:100,000
Protected Parcels:
MassGIS 1:25,000, various dates
BRPC 1997 1:25,000
Housatonic Valley Association, 2000
Map produced by Frank Lowenstein



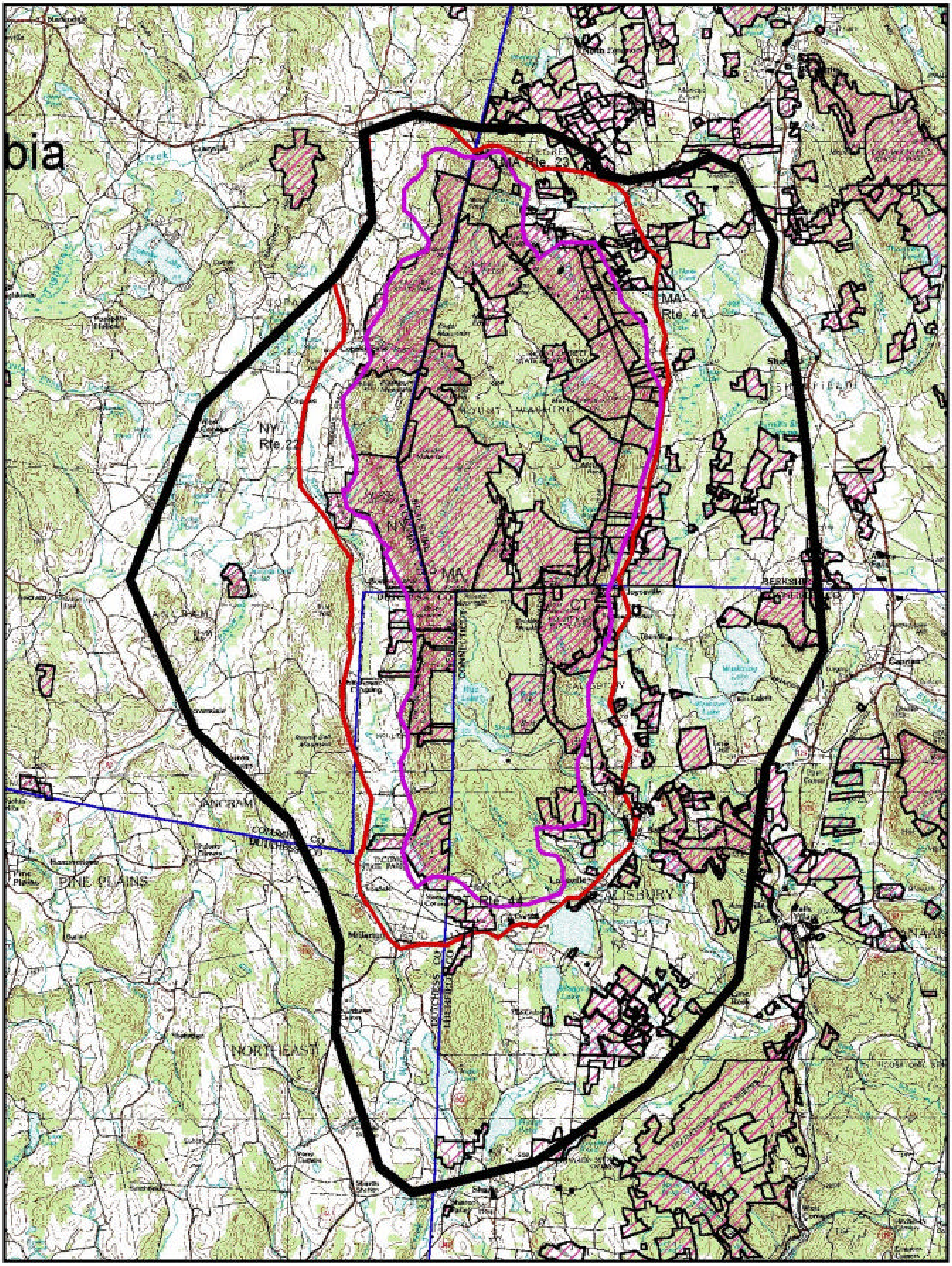
The Nature Conservancy

Large Unprotected Parcels in the Forest Core of the Berkshire Taconic Landscape Program

2 0 2 4 Miles

Large Unprotected Parcels
Protected Open Space
Berkshire Taconic Landscape Program
Forest Core Road Boundaries
Forest Core

Data sources:
USGS Topo 1:100,000
Protected Parcels:
MassGIS 1:25,000, various dates
BRPC 1997 1:25,000
Housatonic Valley Association, 2000
Map produced by Frank Lowenstein

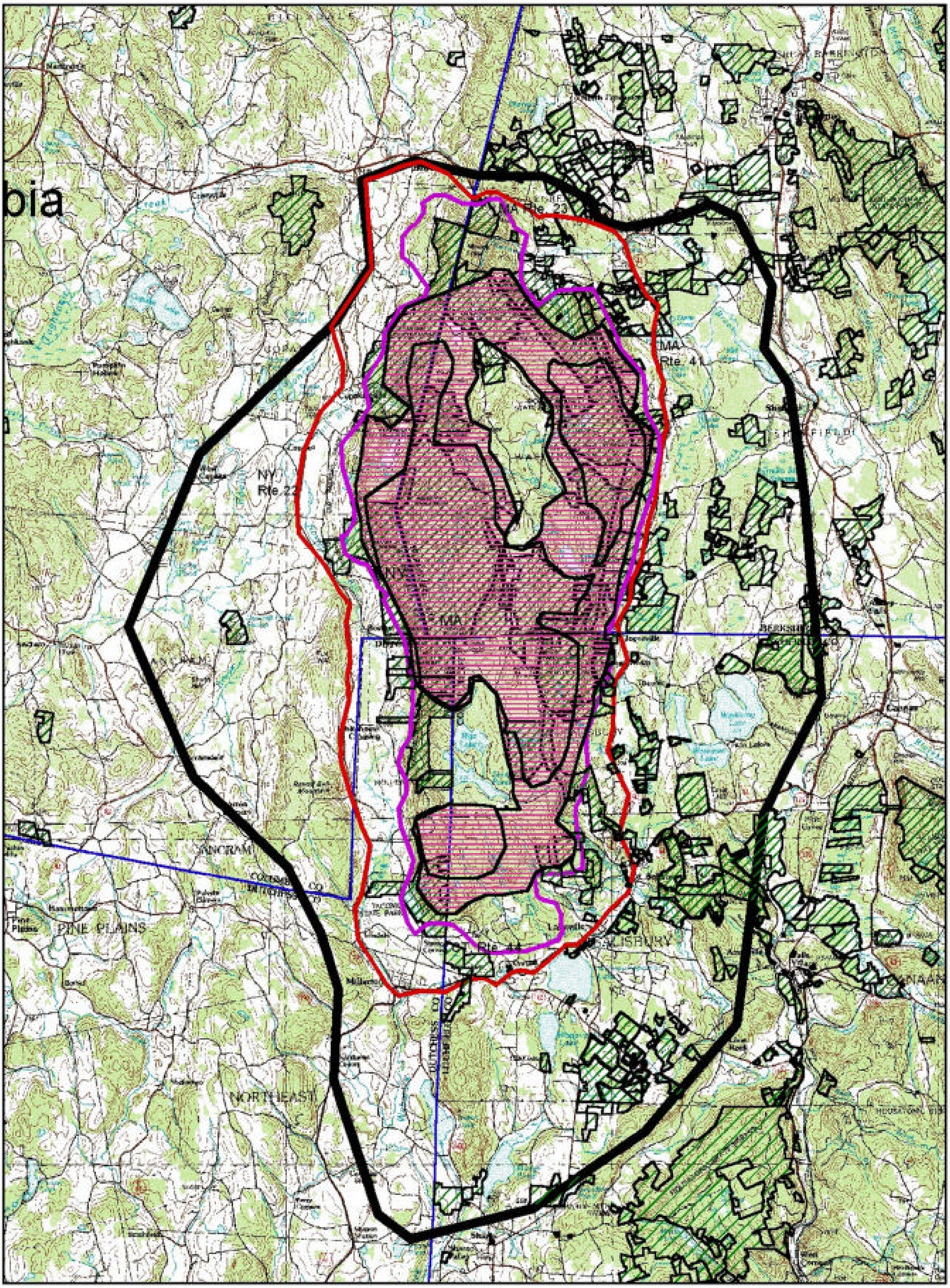


Berkshire Taconic Landscape Program

The Nature Conservancy

2 0 2 4 Miles

Data sources:
USGS Topo 1:100,000
Protected Parcels:
MassGIS 1:25,000, various dates
SRPC 1997 1:25,000
Housatonic Valley Association, 2000
Map produced by Frank Lowenstein



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Proposed Critical Forest Conservation Areas in the Berkshire Taconic Landscape Program

Proposed Critical Forest Conservation Areas
Protected Open Space
Berkshire Taconic Landscape Program
Forest Core Road Boundaries
Forest Core

2 0 2 4 Miles

Data sources:
USGS Topo 1:100,000
Protected Parcels:
Housatonic Valley Association, 2000
Map produced by Frank Lowenstein
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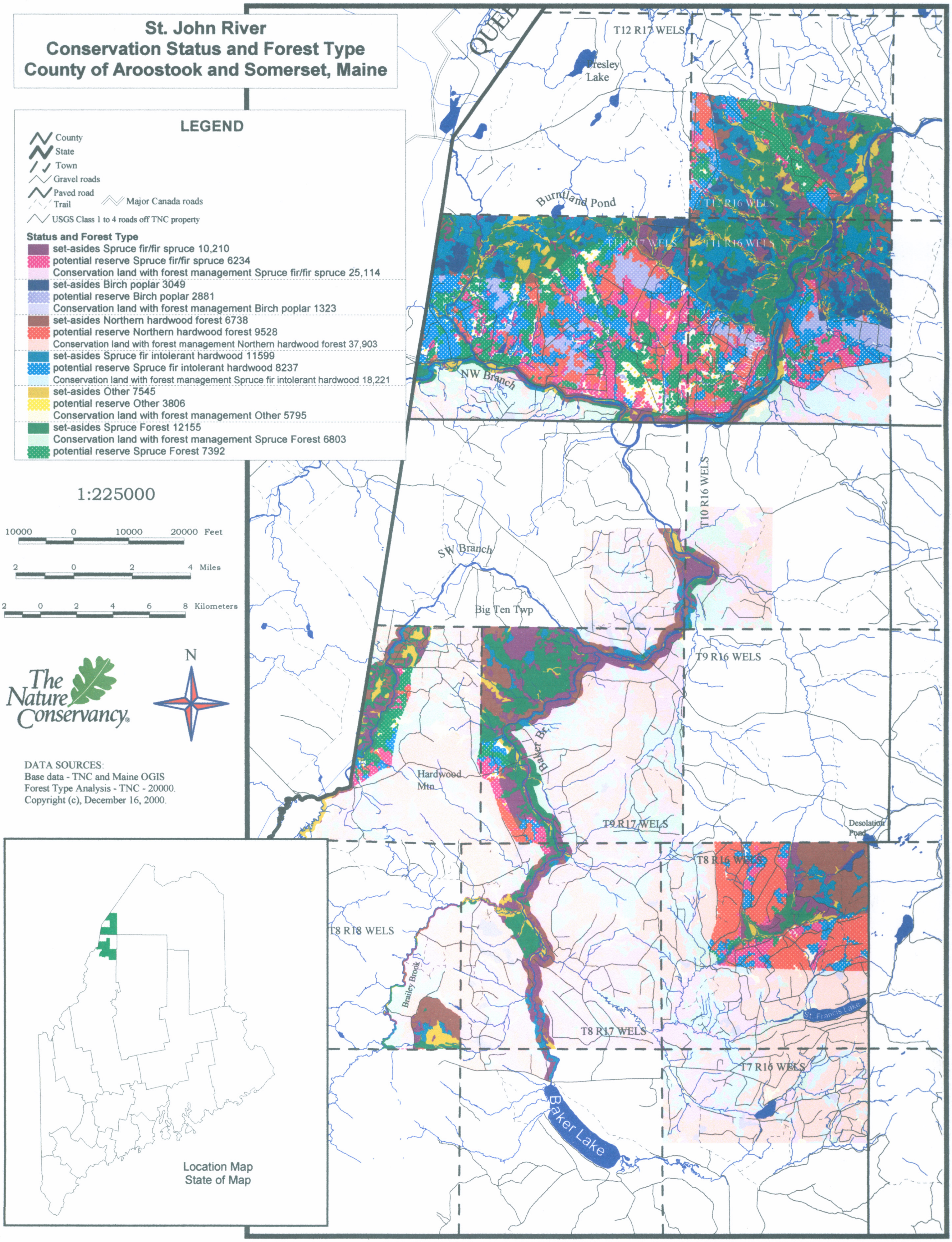
Map 3a.5

St. John River Conservation Status and Forest Type County of Aroostook and Somerset, Maine



Dwarf Pine Barrens Southern Half

Historic Fires Vegetation - 1996

Historic fires:
- 4-12-45?
- 8-13-45
- 1945?
- 1945?, 1947-69
- 1945?, 7-12-55
- 1947-69
- 7-12-55
- 7-12-55, 1969-85
- 6-29-57
- 1969, 1985

Sunrise Fire perimeter (August 24-29, 1995)

Vegetation types:
- AL - Agriculture
- DL - Developed
- DPP - Dwarf pine plain (>= 60% pine)
- DPPHW - Dwarf pitch pine-heath woodland
- DPPSOS - Dwarf pine plain (< 60% pine)
- G - Grass-landscape
- HE - Heath
- HW - Hardwood forest
- PPHW - Heath variant of pitch pine-oak-heath woodland
- PPOF - Pine-oak
- PPOHW - Pitch pine-oak-heath woodland
- S - Sand
- SO - Scrub oak
- W - Surface water
- Wt - Freshwater wetland

Pine Barrens boundary
Core/Compatible Growth Area boundary

Hydrography
Wetland boundary
Town boundary
Major road
Minor road
Trail

The Nature Conservancy

N

Scale 1 : 24,000

500 0 500 Meters

1000 0 1000 2000 3000 Feet

DATA SOURCES:

Sunrise Fire perimeter - TNC, 1:24,000, 1997.
Vegetation cover - Dept. of Forestry and Wildlife Management, UMASS Amherst. 1:24,000, 1997.
TNC site boundaries - TNC Long Island Chapter, digitized by TNC Eastern Regional Office GIS. 1:24,000, 12/94.
Roads - NYSDOT. 1:24,000. Complete as of 1983.
Hydrography - Suffolk County Water Authority, 1:24,000.
Wetlands - NYSDEC. Regulatory Wetlands Maps, 1:24,000.
Town Boundaries - NYSDEC. Source date and scale unknown.

Map produced by TNC/ERO GIS, 7/28/98.