PLANNING METHODS FOR ECOREGIONAL TARGETS: TERRESTRIAL ECOSYSTEMS AND COMMUNITIES*

Coarse-filter and fine-filter targets

The mission of the Nature Conservancy is the long-term conservation of all biodiversity (ecosystems, communities, species and sustaining processes) present in all ecoregions. This broad objective encompasses every living thing from rare salamanders or large carnivores to whole ecosystems such as montane spruce-fir forest with all its associated species diversity, structural components and ecosystem functions. The Nature Conservancy describes its comprehensive protection approach as "coarse-filter / fine-filter" strategy. "Coarse-filter" targets are the ecosystems and communities that characterize the ecoregion and define its landscapes. These targets are the subjects of this chapter. It is a significant topic, as coarse filter targets not only implicitly conserve up to 99% of the species present in the ecoregion but also help maintain the larger ecological context and processes of the region. "Fine-filter" targets are those species that we believe can not be adequately conserved by the protection of ecosystems alone but require explicit and direct conservation attention. They are the subjects of the chapter *Planning Methods for Ecoregional Targets: Species*.

It is worth considering the meaning of "conserving an ecosystem's associated species, structural components and ecosystem functions." "Associated species" include everything from breeding habitat for birds and mammals to complex vegetation layers to soil invertebrates. "Structural components" refer to vegetation structure and, more broadly, to all the accumulating organic materials that link a system historically to a place and stabilize the ecosystem. These features, collectively termed *biological legacies*, include coarse woody debris, seed banks, soil nutrient reservoirs and extensive fungal networks — essentially the by-products of previous or current residents. The third term, "important ecosystem functions," refers to processes such as water filtering and storage, nutrient transformations, solar energy capture and carbon sequestration that an ecosystem performs. Keeping these three dimensions of an ecosystem in mind can help clarify the criteria for defining ecosystem types, assessing the viability of examples and selecting places for conservation action.

Ecosystem and community targets: Introduction

Unlike focal species targets, where a small proportion of all the potential species are selected for direct conservation attention, for ecosystems and communities *all* types

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The standard methodologies sections created for this and all Northeast ecoregional assessment reports were adapted from material originally written by team leaders and other scientists and analysts who served on ecoregional planning teams in the Northeast and Mid-Atlantic regions. The sections have been reviewed by several planners and scientists within the Conservancy. Team leaders included Mark Anderson, Henry Barbour, Andrew Beers, Steve Buttrick, Sara Davison, Jarel Hilton, Doug Samson, Elizabeth Thompson, Jim Thorne, and Robert Zaremba. Arlene Olivero was the primary author of freshwater aquatic methods. Mark Anderson substantially wrote or reworked all other methodologies sections. Susan Bernstein edited and compiled all sections.

occurring in the ecoregion were automatically considered primary targets in the ecoregional plan. In Northeastern plans the number of systems under consideration is a function of the diversity of varying environmental conditions in the ecoregion and the idiosyncrasies of the system taxonomy. Across all plans the numbers of ecosystems range from 60 to 250 per ecoregion, certainly a manageable set compared to the number of species.

Ecosystems and communities

A source of confusion is the use of the terms: *ecosystem*, *ecological system*, *community*, and *natural community*. As used in the Northeast these terms are interchangeable with no hard definitions separating their meanings. All the terms refer to a repeatable and recognizable organization of biodiversity, with a typical species composition, structure, environmental setting and set of sustaining processes.

A difference of emphasis is implied in the choice of terms. The term *ecosystem* emphasizes a feature's structure, environmental setting and sustaining processes, accepting a more generalized species composition. The term *community* puts more emphasis on a feature's specific species composition. In many Northeastern states the term *natural community* refers to an inventory unit most similar in concept to an ecosystem, since these units are recognized as much by a landscape and environmental setting as by a specific composition. Many ecologists conceive of ecosystems as mosaics of one to several communities that occur together under the same environmental conditions and controlling processes. These are only conventions, however, and the terms do not imply a spatial hierarchy, which we discuss below.

Our understanding of the ecosystem and community concepts depends on how well we grasp the dynamics of natural systems and the spatial patterning that develops within them. For example, a wetland ecosystem may be composed of relatively distinct vegetation communities with their spatial configuration corresponding to water depth. Understanding the cause of the spatial zonation may add insight into the internal dynamics of the system. However, there is ample evidence that in many systems the distinctiveness and stability of vegetation communities within the ecosystem is more apparent than real. In spite of individual preferences for "lumping vs. splitting," ecologists agree that we should strive to conserve the ecosystem (or, if one prefers, the mosaic of communities) as a holistic unit.

The term ecosystem also has a variable relationship to the term *habitat*. Again, the difference is primarily one of perspective. A freshwater marsh ecosystem is "habitat" for many marsh-breeding species. Moreover, as discussed later in this section, if a specific marsh ecosystem does not provide habitat for multiple breeding populations of marsh breeding species, then in our analysis it will fail to meet the viability criteria for that ecosystem. Finally, the term habitat is most often defined relative to the needs of a particular species and may include multiple ecosystem types for breeding, foraging and dispersal.

Ecosystems and scale

The term ecosystem, as used here, does not imply any particular scale of feature. Rather, it focuses on the distinctiveness of the biota, setting and processes that define the system. Floodplain forests, freshwater marshes, peat-forming bogs, fire-adapted forests on coarse sandy outwash and forested swamps are a few examples of moderately sized ecosystems found in the Northeast that are quite distinct in biota and process. At smaller scales, we recognized cliff and talus slope ecosystems, rocky summit ecosystems, toe-slope and ravine ecosystems, lake and pond shore ecosystems, and seepage channel ecosystems. Most of these systems are associated with a particular topographic or geologic setting or a locally dominant process such as fire or flooding. Because they occur across a landscape in relatively distinct patches we referred to these as *patch-forming ecosystems*. A few ecosystem types dominate much of the natural land area in and around the patch systems. Because these ecosystems form the background matrix we referred to them as *matrix-forming ecosystems* (adopting the terms from Forman 1995). In the Northeast, all the matrix-forming ecosystems are forest types, but in other regions they may be open shrublands or herbaceous grassland.

When examining a landscape, it becomes immediately clear that patch-forming ecosystems nest within matrix-forming ecosystems. By definition, this way of grouping systems recognizes a spatial hierarchy. For example, a large area dominated by lowland conifer forest (a matrix-forming system) may, on close examination, reveal a network of bogs, fens, marshes and rolling hills (large patch systems). These may contain even smaller settings of cliffs, outcrops and shores (small patch systems). Some authors reserve the term ecosystem only for the dominant matrix-forming system and refer to the smaller ecosystems as "special habitats" or "biotic hotspots." However, the smaller ecosystems meet the criteria of being repeatable and recognizable organizations of biodiversity with a typical composition, structure, environmental setting and set of maintaining processes. Patch-forming ecosystems are often richer in species diversity than the matrix-forming ecosystems they are embedded in and are thus of great interest to conservationists. Regardless of the scale at which they occur in a landscape setting, ecosystems and communities are still "coarse-filter" targets in that they are composed of many individual species populations and conservation activity is best directed at maintaining the entire system.

In this section we will use the term *ecosystem* to refer to the coarse filter unit at any scale, supplementing it occasionally with the term *community* to emphasize certain points. Although nature is fundamentally variable and dynamic, a conscientiously applied ecosystem classification is a tool that significantly clarifies the best places and strategies for conservation work.

Ecosystems and physical setting

The physical environment is closely related to ecological processes and biotic distributions. Climate, bedrock, soils, and topography appear to be strongly linked to ecosystem patterns and processes. To incorporate the physical setting into our identification of ecosystem targets, we developed a comprehensive ecoregion-wide data layer or map of physical features that we termed *ecological land units* or ELUs.[1] The next section illustrates the use of ELUs in developing the target list of ecosystems.

[1] Development of ELUs is the subject of a separate chapter, *Ecology of the Ecoregion*, incomplete as of July 2003, but see Ferree 2003

Developing the target list

Not every landscape feature, geologic formation or natural process forms a distinct ecosystem. It was the task of the ecology technical team to highlight, name and describe those settings that do and, by default, to ignore those that do not. Thus, developing the target list for terrestrial ecosystems was synonymous with developing and applying a standard classification system to the ecoregion. The results catalog and describe an unambiguous set of ecosystem targets for each region (see Table COMM1 below).

Table COMM1. Examples of ecosystem types in the LNE/NP ecoregion selected as targets.

ECOSYSTEM/COMMUNITY GROUP	SAMPLE ECOSYSTEM TARGET
Bogs & Acidic Fens	Highbush Blueberry / Peatmoss species Shrubland
Calcareous Fen	Eastern red cedar / Shrubby cinquefoil / Yellow sedge - Rigid sedge Shrub Herbaceous Vegetation
Deciduous or Mixed Woodland	Red Oak / Eastern Rockcap Fern Woodland
Palustrine Forest & Woodland	Eastern Hemlock / Great Rhododendron / Peatmoss spp. Forest
Ridgetop/ Rocky Summit	White Pine - Red Oak / Poverty Grass Acid Bedrock Herbaceous Vegetation
Sandplains	White Pine - Grey Birch / Sweetfern / Little Bluestem Woodland
Terrestrial Conifer Forest	Red Spruce - Balsam Fir - American Mountain-Ash Forest

The ecology technical team was composed of scientists familiar with the systems of the ecoregion. For the most part, these were state-based ecologists who had developed classification systems for their respective states. Leaders of the technical teams came from a variety of organizations including state Natural Heritage programs, NatureServe and TNC.

As a starting point, a list of all potential ecosystems was compiled for the ecoregion based on the U.S. National Vegetation Classification (NVC[2]), which is a hierarchical classification based primarily on vegetation structure and water conditions. Preliminary units for ecoregional targets were identified at the hierarchical scale of the *association.* An association is defined by three characteristics: vegetation structure, full floristic composition, and environmental setting. Through a series of two to eight meetings the technical team made a significant effort to clarify and improve the NVC specific to the ecoregion.

The results were compiled into an ecosystem or community document that was adopted by the states and served as the baseline target list for the ecoregion. In the document, each ecosystem is characterized by information on its composition, structure, associated species, environmental setting and general concept (see sample page at end of chapter).

Auxiliary information on each ecosystem

By necessity, the process of developing the ecosystem classification also involved developing a number of conventions for working with the classification that helped overcome some inherent problems. These conventions included identifying a size scale

[2] Grossman et al. 1998; Anderson et al. 1998; Maybury 1999. The NVC itself was developed from the classification work of state ecologists that has been reviewed and compiled into a single overarching framework. The framework is based on a modified version of the UNESCO world vegetation classification.

and distribution pattern for each ecosystem, constructing hierarchies for aggregating similar fine-scale ecosystem types into broader types, and identifying explicit connections between ecosystems and their topographic, geologic and climatic setting.

This information, collected during the technical team meetings and in subsequent interviews, was later used extensively to set conservation goals, establish viability criteria, assess ecoregional gradients and develop accurate maps for each ecosystem type. Team members were asked to:

1. Determine the distribution for each association by **subsection** within the ecoregion
2. Evaluate the distribution of each association within the ecoregion in relation to its **global distribution**
3. Determine the patch **size** (matrix, large patch, small patch, or linear) for each association
4. Describe the topographic position, substrate type and other features of the **physical setting** for each association to facilitate making connections between associations and Ecological Land Units (ELUs)
5. Identify any **new associations** not represented in the NVC subset already linked to the ecoregion.

As part of this data-refining process, descriptions of NVC associations were adjusted to reflect the floristic composition and physical setting of the association specific to the ecoregion. Characteristic breeding species of birds, mammals, reptiles and amphibians were collected in some ecoregions from the ecologists, while in others they were assembled after the fact by a different team.

Methods for developing auxiliary information

Subsection distribution pattern: The distribution of the ecosystem within the ecoregion was characterized by an expert-opinion estimate of its occurrence within geographically defined subregions (USFS subsections, Keys et al. 1995). For each ecosystem, ecoregional subsections were marked as to the occurrence of the system using a three-part scale: 0=absent, 1=probably present, and 2= present with certainty. This allowed for a simple map showing the estimated distribution of the ecosystem across the ecoregion.

Global range and distribution pattern: To assess and highlight the importance of a particular ecosystem with respect to this ecoregion, each type was tagged with one of four rangewide distribution categories — Restricted, Limited, Widespread, Peripheral — all measured relative to the ecoregion. The ecology technical teams accomplished this by using global distribution estimates available from the state Heritage Programs, NatureServe and other sources available at the Eastern Conservation Science center. The definitions listed below were treated as approximations allowing for a certain amount of acceptable error. Determining and clarifying the true range-wide distribution of each community type is a long-term goal of the classification authors.

Restricted/Endemic: Occurs primarily in this ecoregion; it is either entirely endemic to the ecoregion or generally has more than 90% of its range within the ecoregion.

Limited: Occurs in the ecoregion of interest, but also within a few other adjacent ecoregions (i.e., its core range is in one or two ecoregions, yet it may be found in several other ecoregions).

Widespread: Is distributed widely in several to many ecoregions and is distributed relatively equally among those ecoregions in which it occurs. A ecosystem that is widespread is not necessarily "common" in the ecoregion.

Peripheral: The ecosystem is more commonly found in other ecoregions (generally less than 10% of its total distribution is in the ecoregion of interest). The distribution in the ecoregion of interest is continuous with that in adjacent ecoregions. *Disjunct* ecosystems were considered a special case, where the occurrence of the ecosystem in the ecoregion was disjunct from its core distribution outside the ecoregion.

Ecosystem scale and patch size: Ecosystems were categorized as matrix-forming, large patch-forming, or small patch-forming depending on their scale of occurrence in the ecoregion and based on the following definitions.

Matrix-forming: Dominant systems (they are all forest types in the Northeast) that form extensive and contiguous cover on the scale of 1000s to millions of acres. Matrix forests occur on the most extensive landforms and typically have wide ecological tolerances. They may be characterized by a complex mosaic of successional stages resulting from characteristic disturbance processes (e.g., New England northern hardwood-conifer forests) or they may be relatively homogeneous. Matrix-forming ecosystems are influenced by large-scale climatic processes and cross broad elevation and topographic gradients. They are important habitat for wide-ranging or large area-dependent fauna, such as large herbivores or forest interior birds. Specific examples include red spruce–balsam fir montane forest, maple-beech-birch northern hardwood forest, white pine – red oak mixed forest and a variety of successional types. In some ecoregions, the aggregate of all matrix forest types covers, or historically covered, 75-80% of the natural vegetation of the ecoregion.

Large Patch-forming: Ecosystems that form large (50–5000 acres) but discretely defined areas of cover (several orders of magnitude smaller than the matrix types). Large patch systems are associated with environmental conditions that are more specific than those of matrix forests. Thus they are subsequently less common or less extensive in the landscape. Large-scale processes influence large-patch systems, but their influence tends to be overridden by specific site features that drive the local processes (e.g. hydrology or soil erosion). Examples include red maple swamps, cattail marshes, black spruce bogs, alpine krumholtz, or pine barrens. We considered *linear* systems, which most often occur along rivers (e.g. floodplain forests or alluvial marshes), to be a special form of large patch systems

Small Patch-forming: Ecosystems that form small, discrete patches of cover. Individual occurrences of these systems range in size from 1 to 50 acres. Small patch ecosystems occur in very specific ecological settings, such as on specialized landform types or in unusual microhabitats. They are often dependent on the maintenance of ecological processes in the surrounding matrix and large patch communities. Small patch ecosystems often contain a disproportionately large percentage of the total flora, and may support a specific and restricted set of associated fauna (e.g. reptiles, amphibians, or invertebrates) dependent on specialized conditions. Examples include calcareous fens, calcareous cliffs, acidic rocky summits, enriched cove forests and rivershore grasslands.

Explicit links to ecological land units: Each system was ranked as to its degree of association with each of several bedrock types, topographic positions and elevation classes (see table below). Development of these ecological land units or ELUs[3] is the subject of a separate chapter, *Ecology of the Ecoregion*, and details may be found there.[4]

Table COMM2. Ecological Land Unit variables

ECOLOGICAL LAND UNITS: generalized example. An ELU is any combination of these three variables.		
TOPOGRAPHY	GEOLOGY	ELEVATION ZONE
Cliff	Acidic sedimentary	Very Low (0-800')
Steep Slope	Acidic shale	Low (800-1700')
Slope Crest	Calcareous	Medium (1700-2500')
Upper slope	Moderately Calcareous	High (2500-4000')
Sideslope –N facing	Acidic granitic	Alpine (4000+'}
Sideslope – S facing	Intermediate or mafic	
Cove or toeslope-N facing	Ultra mafic	
Cove or toeslope–S facing	Deep fine-grained sediments	
Low hilltop	Deep coarse-grained sediments	
Gently sloping flat		
Dry flat		
Valley bottom		
Wet flat		
Slope bottom flat		
Stream		
River		
Lake or pond		

New systems: Some associations were described in the NVC, but not formally recognized as occurring in the focal ecoregion; others were not yet described. For these "new" associations, the team created a standard name and wrote a description. The new system is intended to be combined and coordinated with other newly identified associations from other ecoregions in an update of the NVC. (Until the process has been completed the ecoregion-specific name for the new ecosystem should be considered provisional.)

[3] While the variables that we used are physical ones, the classes were based on biological considerations (e.g., tree distribution, for Elevation Zone).
[4] Incomplete as of July 2003, but see Ferree 2003.

Setting Minimum Conservation Goals for Ecosystem Targets

Goal setting, viability analysis and locating ecosystem examples followed somewhat different methods depending on whether the ecosystem was a matrix-forming type or a patch-forming type. In all ecoregions, patch-type ecosystems were the most numerous type of ecosystem and the evaluation of them followed the methods presented below. Matrix-forming ecosystems, although consisting of only a handful of types, required a separate set of analyses and some different approaches to locating and evaluation. Those methodologies are described in the chapter on Matrix-forming Ecosystem Targets.

The minimum conservation goal for an ecosystem target in an ecoregional plan was defined as the minimum number and the spatial distribution of viable examples required to insure the persistence of the ecosystem over one century. Because it was not possible to conduct full assessments of the dynamics and processes of each ecosystem during the time allotted for the planning process, generic minimum goals were established for groups of similar ecosystems.

Quantitative global minimums

Our approach to patch-forming ecosystems assumed that because these ecosystems occur in a discrete and localized way, they were amenable to treatment as “occurrences” in a form analogous to local populations. For instance, an example of a distinct freshwater marsh ecosystem can be described as to its species composition, structure and topographic setting, evaluated with respect to its size, condition and landscape context, and tracked in a spatial database relative to its occurrence at a particular place. Moreover, the set of all marsh “occurrences” can be counted, their distribution patterns examined, and each one evaluated as to the probability of its persistence. While this pragmatic way of dealing with more discrete ecosystem types proved to be workable it does not imply that there are not important connections (e.g. hydrologic or topographic) between occurrences. Whether occurrences in close proximity should be evaluated as one or many can be confusing. In most cases, state Natural Heritage programs, which struggle with these issues regularly, have developed clear guidelines for determining what defines a single occurrence. Whenever available we adopted these guidelines.

Conservation goals for patch ecosystems had two components: numeric and distribution. Patch size type and the range-wide distribution of an ecosystem were used to determine both the number of occurrences needed to preserve an association throughout the ecoregion and the spatial distribution of occurrences (i.e., stratification) necessary to represent both the range-wide rarity and environmental variability of each community type.

The numeric component of the conservation goal (the replication goal) assumed that across a small patch-forming system’s entire range, a minimum number of 20 viable occurrences was necessary to insure the persistence of at least one of those occurrences over a century.[5] Subsequently, the minimum goal of 20 was adjusted for the focal ecoregion based on the relative percentage of the systems total distribution was concentrated in the ecoregion and the scale of the system type. Thus, replication goals within an ecoregion were equal to 20 for small patch-forming systems that were restricted

[5] Cox et al. 1994 and Quinn and Hastings 1987

to that ecoregion alone. Those systems depend entirely on conservation efforts within that area for long-term protection.

For ecosystems that occurred across a few ecoregion (e.g. had a “limited” distribution), the ecoregional goal was lower (14). For species with “widespread” or “peripheral/disjunct” distributions, the goal was set even lower under the assumption that conservation of these ecosystems will be repeated across several ecoregions. In a similar way, conservation goals were highest for small patch communities that have the highest probability of extinction over the next century and lowest for large systems that are unlikely to disappear (see Table COMM3 for large- and small-patch ecosystem goals).

Table COMM3. Conservation goals for patch-forming ecosystems.
In this table a large patch ecosystem that was restricted to the ecoregion had a numeric goal of 16 viable examples distributed across the major subregions of the ecoregion.

PATCH–FORMING ECOSYSTEMS	LARGE PATCH Stratification goal in parentheses	SMALL PATCH Stratification goal in parentheses
Restricted/Endemic	16 (4)	20 (4)
Limited	8 (2)	14 (2)
Widespread	4	4
Peripheral	*	*

*****Objectives determined on a case by case basis.

Distribution goals

The distribution component of the conservation goal, sometimes referred to as the *stratification* goal, was intended to insure that independent ecosystem examples would be conserved across gradients reflecting variation in climate, soils, bedrock geology, vegetation zones and landform settings under which the system occurs. As the parenthesized values in Table COMM4 indicate, the amount of stratification necessary for each target was weighted such that Restricted ecosystem types required the most extensive within-ecoregion stratification and Widespread ecosystems required no stratification within the ecoregion. This insured that examples of each ecosystem were conserved across the ecoregion and not all concentrated in one geographic region.

To develop a stratification template for the ecoregion, US Forest Service subsections (Keys et al. 1995) were grouped into subregions based on an analysis of biophysical factors. The subregions were made up of clusters of subsections that were more related to each other in terms of ELUs than to other units. Table COMM4 shows an example for one ecoregion. Numbers in parentheses are acres.

Table COMM4. Example of stratification table for the Northern Appalachians (Anderson 1999). Acres are shown in parentheses.

Northern Appalachian / Boreal Ecoregion						
Northern Appalachian Mountains (16.8M)				Boreal Hills and Lowlands (15.4M)		
Adirondacks / Tug Hill (6.7M)		White and Green Mountains (10.2M)		Northern Boreal Hills (5.3M)	Southern Boreal Hills (10.1M)	
Tug Hill Plateau	Adirondack Mountains	White Mountains	Green Mountains Vermont Piedmont	Northern Boreal Hills	Central Maine Lowland	Southern Maine Coastal
M212F	M212D	M212A	M212C M212B	M212Aa,b 212Aa	212A,B 212C,D	212C 212D
(700K)	(5.9M)	(6.8M)	(3.4M)	(5.3M)	(6.9M)	(3.1M)

Based on the two preceding tables, examples of a Restricted ecosystem in the NAP ecoregion would be protected across four subregions: the Adirondack/Tug Hill, the White and Green Mountains, the Northern Boreal Hills and the Southern Boreal Hills (assuming it occurred in all four). Ecosystems with a Limited distribution would be protected across two subregions: the Northern Appalachian Mountains and the Boreal Hills and Lowlands.

The conservation goal was met for a ecosystem target when we were able to identify enough *viable* examples (see below) distributed across the ecoregion such that both the numerical and stratification standards were met. *For most targets we were not able to do this.* The plans not only highlight a set of places for conservation attention but also identify gaps in our knowledge in a very precise manner.

In addition to the scientific assumptions used in setting conservation goals, the goals contain institutional assumptions that will require future assessment as well. For example, the goals assume that targets in one ecoregion are targets in all ecoregions in which they occur. After the completion of the full set of first iteration ecoregional plans, target goals should be assessed, reevaluated and adjusted.

Assessing the Viability of Individual Ecosystem Examples

The conservation goals discussed above incorporate assumptions about the viability of the *ecosystem type* across the ecoregion. The goals assume that instances that are of low quality or too small have been screened out through an analysis of local viability factors. This section, concerns the evaluation of viability of each ecosystem example or "occurrence" at a given location.

Ideally, the local occurrences of each ecosystem selected for inclusion in a conservation portfolio should exhibit the ability to persist over time under present conditions. In general, this means that the observed occurrence is in good condition, has sufficient resilience to survive occasional natural and human stresses, and is of a size that is adequate to contain multiple breeding populations of the characteristic species associated with the ecosystem.

Locating examples of patch-forming communities

For most patch-forming ecosystems, the factors that define an example have been thought through and are documented in state Natural Heritage databases. Whenever Heritage program "occurrence specifications" were available we adopted them for use.

In the Northeast, a variety of mapping and predictive modeling techniques have been recently developed for locating examples of ecosystems. However, the examples of patch communities that were incorporated into the ecoregion portfolios were almost exclusively those documented by Natural Heritage element occurrence records and thus ground-verified. There are several reasons for this. First, the information needed to assess the example and determine whether an occurrence passed the viability screening criteria was readily available in the record. Second, the Heritage element occurrences databases in the East are extensive, selective and have matured to the point where the best examples of most ecosystem types are already well documented—particularly the small patch ecosystems. Third, we believe that ground verification is a wise step before any conservation action takes place.

To coordinate community occurrences across state lines, assess the viability of occurrences, and set goals, all community occurrences in the database were assigned to one of several ecological groups. Each of these occurrences was initially identified within their respective state classifications, and thus needed to be linked ("crosswalked" or "tagged") to the NVC classification developed for the ecoregion. Each occurrence, with its state name, was crosswalked to an NVC name by the state Heritage ecologist, or by staff from ECS with review by the state ecologist.

Viability screening criteria

Prior to examining ecosystem occurrences, we developed a set of qualifying criteria (a rough estimate of viability) through a succinct assessment of three attributes historically used by Natural Heritage programs to evaluate occurrences: **size**, **condition** and **landscape context**.

Size: Size of an occurrence was considered fundamental for predicting both the stability and the resilience of an ecosystem occurrence and the diversity of plant and animal species within the occurrence. Size criteria for ecosystems integrated three independent sources of information. The first was the *actual size range* of the system in the ecoregion. This measure was highly correlated with the specific landscape setting and conditions that define the ecosystem. Second was the scale and extent of the *disturbance processes* that affect the ecosystem. In particular, we used the size of severe damage patches to estimate the minimum dynamic area of an ecosystem. Third, we examined the *breeding territory* or minimum area requirements of the associated species we expected to be conserved through the protection of this ecosystem type. For example, breeding territory sizes of bitterns and rails were used to inform freshwater marsh conservation, and territory sizes for Lincoln's sparrow, palm warblers, and bog lemmings were important for dwarf shrub bogs. The chapter on Matrix-Forming Ecosystem Targets includes an extensive discussion of size.

The size of an ecosystem occurrence was a standard field in the Heritage element occurrence database; however, over the many thousand of occurrences we examined, only about two-thirds included a value for the field. When size data was included we used the information directly. When it was not we used some combination of expert interviews with ecologists, GIS analysis based on ecological land units and land cover, and airphoto analysis to confirm the size of an example. A number of cross check tests over occurrences, experts, and GIS methods confirmed that we have used accurate information on the size of ecosystem examples in the Northeast plans.

Condition: A variety of observable features affect the condition of a community occurrence. Primary among the features that we considered were *fragmentation* by roads, trails or land conversion, *invasion* by exotics, and *anthropogenic manipulation*, such as cutting, grazing, mowing, altered soils, and altered natural processes, usually reflected in changes in vegetation structure and composition. Additionally, *positive features* such as the development of biological legacies or evidence of historical continuity were considered evidence of good condition.

With the exception of roads and other fragmenting features, current condition is presently very difficult to evaluate without actual site visits. The standard field form for occurrence and site evaluation used by the ecologists in the state Heritage programs (Sneddon 1993) addresses much of this information in a standardized way. However, evaluation of over a thousand completed forms suggested that there has been a wide range in how consistently and thoroughly this form had been used across states. A good approximation of condition can be found in the Heritage database field for Element Occurrence Rank if, indeed, the occurrence has been identified. Descriptive notes on the occurrence in Heritage databases were very useful when they existed. We supplemented this information by asking the state ecologists to rank the occurrence using a simple three-part scale:

1 = **high**, no signs of anthropogenic disturbance, no exotics, no obvious fragmenting features, system well developed, biological legacies present and abundant.

2 = **moderate**, some signs of anthropogenic disturbance, some exotics present, some fragmenting features, system moderately well developed, biological legacies present but not abundant.

3 = **poor**, obvious signs of anthropogenic disturbance, many exotics present, obvious fragmenting features, system poorly developed, critical biological legacies absent or present in very low quantities.

We also flagged certain ecosystems occurrence with an “old-growth” designator, defined as having trees 180 years old or greater, or containing other evidence of historical continuity such as peat build up of several meters.

Landscape quality or context: For patch-forming ecosystems, the surrounding landscape is important in the evaluation of viability. This concept is well understood by ecologists who have observed the degradation and disappearance of ecosystem occurrences once believed to be protected. Patch-forming ecosystems have degraded when fire regimes were altered (e.g. pine barrens), the surrounding hydrology was interrupted (e.g. fens and pond shores), water chemistry was altered (e.g. freshwater wetlands and ponds), or seasonal disturbance regimes were altered (e.g. rivershore grasslands and ice-scour communities). Wetland, floodplain and other lowland communities are particularly susceptible to alterations in landscape processes, as lowland features tend to accumulate, concentrate and depend on materials from outside their own systems. Conversely, high elevation or upper slope systems on poor substrate types may be more biologically isolated and thus more tolerant of degradation or changes in the surrounding landscape.

A precise estimate of the landscape area relevant to the processes that sustain each ecosystem should take into account the features discussed above. However, assessing and quantifying how intact the specific critical landscape processes were surrounding each occurrence of a patch system was beyond the scope of possibility for the ecoregion assessment. As an alternative we examined a 1000 acre buffer area surrounding each patch-forming ecosystem occurrence, using the occurrence location as the center point of the buffer. For each occurrence, we collected expert opinion and also performed a standardized GIS analysis of landcover and roads. In both cases we condensed the data to a four-part ranking system.

1 = Area surrounding the occurrence is composed of intact matrix forest or a mosaic of natural systems.

2 = Area surrounding the occurrence is mostly forest or undisturbed lands but there may be a small proportion of developed land, agriculture or clearcutting within the buffer.

3 = Area surrounding the occurrence is characterized by fragmented forest, agricultural land or rural development.

4 = Area surrounding the occurrence is mostly developed.

The numerical ranges and cutoffs that defined each rank operationally varied somewhat among ecoregions. The GIS landscape context landcover values for the LNE/NP ecoregion, for example, are shown in Table COMM5.

Table COMM5. Landscape Context Landcover Criteria for Natural Terrestrial Communities in the Lower New England/Northern Piedmont Ecoregion

1	Surrounded by > 90% natural land with < 5% (50 acres) of low and high density residential development and industrial development and < 5000 meters of any type of fragmenting features.
2	Surrounded by > 80% natural lands with < 5% (50 acres) of low and high density residential development and industrial development and < 5000 meters of any type of fragmenting features.
3	Surrounded by > 60% natural lands with < 5% (50 acres) of low and high density residential development and industrial development and < 10000 meters of any type of fragmenting features.
4	Surrounding area < 60% natural land or > 50 acres of more intensely developed than in class or > 10000 meters of any type of fragmenting feature.

State ecologists reviewed the GIS assessment of the 1000-acre landscape context for each occurrence. Generally, there was high agreement between the expert opinion, auxiliary information and the GIS estimate.

We arrived at the 1000 acre buffer area using the assumption that the landscape scale is an order of magnitude larger than the occurrence scale and therefore the size of the assessment area should be an order of magnitude larger than the mean size of the patch communities. Based on an sample of 1300 patch-forming ecosystem occurrences we calculated *10 time the mean size* (101 acres x 10) or two orders larger than the modal size (which was 10 acres) and rounded this to 1000 acres. This value was subsequently used to approximate the landscape scale for all occurrences. However, in a few cases, particularly for small patch, globally rare systems, 1000 acres was considered to be too large to assess context. These occurrences were evaluated more critically using the judgment of the ecologists.

Combining the viability criteria

An algorithm was used to assess viability for patch-forming ecosystems based on the possible combinations of size, condition, and landscape context (see Table COMM6). Different size standards were used for large patch systems of various types (generally >100 acres), and small patch systems(generally > 25 acres, but variable). The combinations were intended to maximize the probability that an occurrence was viable, functional as a coarse filter, and associated with a reasonably intact site. Occurrences that ranked low for one criterion had to be ranked high for one or both of the other criteria in order to be considered viable. Where there was uncertainty about the classification of a community to patch type (e.g., large vs. small), generally the more conservative criteria (in parentheses) were applied.

Table COMM6. Generalized table of qualifying criteria combinations for patch-forming ecosystems.

Current Condition (1-3)	Landscape Context (1-4)	Size: Large Patch (acres)		Size: Small Patch (acres)				Viability Estimate
		Forest/ Woodland	Shrub/ Herb	Forest	Wood-land	Shrub	Herb	
1	1	100	50	20	10	5	5 (1)	Yes
2	1	100	50	20	10	5	5 (1)	Yes
3	1	100	50	20	10	5	5(1)	Maybe
1	2	100	50	20	10	5	5 (1)	Yes
2	2	100	50	20	10	5	5 (1)	Maybe
3	2	100	50	20	10	5	5 (1)	Maybe
1	3	200	100	50	50	10	10	Yes
2	3	200	100	50	50	10	10	Maybe
3	3	200	100	50	50	10	10	No
4	Any	Any						No
any	4	Any						No

Addressing Gaps in the Data

Future field inventories and analyses of existing data sets will supply additional detail on subregion distribution of ecosystems. These components can be added to future versions of the classification and will further our understanding of how many of the ecosystems occur across the entire region. Our assumption is that the large matrix forests will encompass many of the associations within the ecoregion even where ground-verified inventory, which would confirm their presence, is lacking. Other sites will be added in future revisions of the plans where significant gaps in representation have been identified.

The minimum goals based on generic ecosystem types were intended to provide guidance for conservation activity over the next few decades. They should serve as benchmarks of conservation progress until more accurate goals can be developed for each target. The generic goals were not intended to replace more comprehensive restoration plans. On the contrary, ecosystems that do not meet the ecoregional minimum goals should be prioritized for receiving a restoration plan including an exhaustive inventory if such does not already exist.

Quercus rubra / Polypodium virginianum Woodland (CEGL006320 ECS) — G3G5
LNP SUGGESTED NAME: Quercus rubra – Betula alleghaniensis / Polypodium virginianum Woodland

Red Oak / Eastern Rockcap Fern Woodland
[Red Oak Talus Slope Woodland]
Description: Open, bouldery, acidic talus slope woodlands in the Northern Appalachian and Lower New England / Northern Piedmont ecoregions. Habitat (large talus and boulders) rather than geography differentiates this association from *Quercus rubra / Vaccinium spp. / Deschampsia flexuosa* Woodland (CEGL006134). Ericads generally lacking, vines and ferns more characteristic. Common associates are species of *Corydalis, Woodsia, Dryopteris* as well as *Parthenocissus quinquefolia, Polypodium virginianum, Tsuga canadensis, Pinus strobus*. 6/98 NAP Very open to moderately closed canopy, heterogeneous composition of *Quercus rubra, Acer saccharum, Betula nigra, Betula alleghaniensis, Betula papyrifera, Betula populifolia, Fagus grandifolia, Acer rubrum*. Scattered and clumped tall shrubs/small trees include *Acer spicatum, Acer pensylvanicum, Rubus spp., Viburnum acerifolium* (occasional), *Ribes* spp. Prevalent component of vines are *Parthenocissus quinquefolia, Parthenocissus vitacea, Toxicodendron radicans, Celastrus scandens, Polygonum cilinode*. Scattered ferns and herbs are *Dryopteris marginalis, Polypodium virginianum, Pteridium aquilinum, Carex pensylvanica, Corydalis sempervirens (*localized*), Solidago bicolor, Solidago caesia*, and others. Acidic talus slopes of low-elevation valleys. Substrate is bouldery talus derived form acidic bedrock. Elevation range is roughly 500-2000 feet. Groundcover is exposed talus, moss-covered boulders and deciduous litter.

LNP Scale: Small to large patch **Distribution**: Limited
TNC Ecoregions: 61:C, 62:C, 63:C
References:

State	SRank	State Name
CT		S?
MA	S4	Acidic Talus Forest / Woodland+
ME	S3	Acidic Talus+
NH	S?	Red oak-black birch/marginal woodfern talus forest/woodland
NJ?	SP	
NY	S?	Acidic talus slope woodland
VT		S3 Transition Hardwood Talus Woodland+

Quercus rubra / Vaccinium spp. / Deschampsia flexuosa Woodland (CEGL006134 ECS) — G3G5
LNP SUGGESTED NAME: Quercus rubra – Quercus prinus / Vaccinium spp. / Deschampsia flexuosa Woodland

Red Oak / Blueberry species / Wavy Hairgrass Woodland
[Central Appalachian High Elevation Red Oak Woodland]
Description: Dry, open, rocky slope or summit woodlands in the Northern Appalachian, Lower New England / Northern Piedmont and Central Appalachians ecoregions. Open, stunted to somewhat closed canopy of *Quercus rubra*. *Quercus prinus* may be codominant. Common associates are *Quercus alba, Betula lenta* and *Acer rubrum* with minor component of *Quercus velutina, Betula populifolia, Betula papyrifera* and *Pinus rigida*. Tall-shrub layer is often lacking but may include *Acer spicatum, Sambucus racemosa, Rhus typhina, Kalmia latifolia, Hamamelis virginiana, Viburnum nudum var. cassinoides, Rhododendron* spp. Ericaceous shrubs and graminoids are characteristic. Well-developed low-shrub cover of *Vaccinium angustifolium, Vaccinium pallidum, Gaylussacia baccata, Kalmia angustifolia*. Scattered grasses include *Deschampsia flexuosa, Danthonia spicata, Carex pensylvanica*, and herbs *include Gaultheria procumbens, Aralia nudicaulis*. Herbs: *Pteridium aquilinum, Aralia nudicaulis, Maianthemum canadense, Aster acuminatus, Corydalis sempervirens, Deschampsia flexuosa, Carex pensylvanica, Polypodium virginianum*. Environmental setting: Talus slopes, rocky slopes and summits of low, moderate or high elevations. Soils are shallow, well-drained, nutrient-poor acidic gravels and coarse sands. Exposed bedrock prominent. Grades into *Quercus prinus* Forest, *Pinus rigida* woodlands or sparsely vegetated rocky summits (*Pinus strobus, Quercus rubra) / Danthonia spicata* Sparsely Wooded Herbaceous Vegetation CEGL005101.

LNP Scale: Small patch or large patch? **Distribution:** Widespread
TNC Ecoregions: 59:C, 61:?, 62:C, 63:C
References: Thompson and Sorenson 2000

State	SRank	State Name
CT		S?
DE	S?	
MA	S4	Ridgetop Chestnut oak Forest / Woodland
ME	S1	chestnut oak woodland=
NH	S?	Appalachian oak – pine Forest+ and Red oak – pine / heath rocky ridge woodland+
NY	S?	pitch pine oak heath rocky summit+
PA	S?	Dry oak-heath woodland
VA?	SP	
VT		S2 Dry oak woodland
WV	S?	