From the Adirondacks to Acadia

A Wildlands Network Design for the Greater Northern Appalachians

Conrad Reining, Karen Beazley, Patrick Doran, Charlie Bettigole

WILDLANDS PROJECT ~ SPECIAL PAPER NO. 7

We are ambitious. We live for the day when grizzlies in Chihuahua have an unbroken connection to grizzlies in Alaska; when wolf populations are restored from Mexico to the Yukon to Maine; when vast forests and flowing prairies again thrive and support their full range of native plants and animals; when humans dwell on the land with respect, humility, and affection.

Toward this end, the Wildlands Project is working to restore and protect the natural heritage of North America. Through advocacy, education, scientific consultation, and cooperation with many partners, we are designing and helping create systems of interconnected wilderness areas that can sustain the diversity of life.

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CONTENTS

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EXECUTIVE SUMMARY

THIS REPORT PRESENTS A PROPOSED WILDLANDS network design for the Greater Northern Appalachian region of the northeastern United States and southeastern Canada. This region spans 388,541 km^2 (96,010,538 acres) and encompasses two ecoregions, the Northern Appalachian/Acadian and St. Lawrence/Champlain, and all or part of ten states and provinces. A network design is a conservation plan that uses the most recent research and data to identify areas of high biological value for very large regions, integrating core protected areas with wildlife linkages and economically active stewardship lands. The wildlands network design is an effective, science-based model for understanding where land and biodiversity conservation is both needed and possible.

The current study establishes the location and extent of existing core protected areas, proposed core areas, and areas of high biological significance. Core protected areas are highly-irreplaceable areas of concentrated conservation value and are therefore intended to be managed with biodiversity values as the primary objective. Areas of high biological significance (HBS) are lands that we have identified as having significant conservation value based on the analysis. In general, these areas had somewhat lower conservation value at a regional scale than either existing or proposed core areas, although they are vital to achieving overall conservation goals. Additional study will be needed to determine the precise conservation designation for these lands. Wildlife linkages have been included in the HBS category.

To establish the location and extent of the network design elements, we used three major sources of information: 1) the results of a site selection analysis that integrates information on three major "tracks" of environmental data—focal species, environmental variation, and special elements; 2) the location of The Nature Conservancy's Tier 1 matrix forest blocks in the Northern Appalachian/Acadian ecoregion; and 3) input from experts in the states and provinces.

The total proposed network would encompass 181,519 km^2 (44,835,112 acres) or about 47% of the Greater Northern Appalachian region. All existing core protected areas, currently 24,661 km^2 (6,091,267 acres; 6.4% of the region), are captured in the proposed network. An additional 42,053 km^2 (10,387,010 acres) in proposed core areas are identified (10.6 % of the region), along with an additional 114,805 km^2 (28,356,835 acres) of lands of high biological significance (29.5% of the region). Of the total proposed network, about 14% is in existing core protected areas, 23% is in proposed core areas and the remaining 63% is in high biological significance lands. About 33% (60,235 km^2 or 14,878,045 acres) of the proposed network is in status/gap 3 or Public/Crown lands, and about 53% (96,623 km^2 or 23,865,800 acres) remains privately held and subject to potential development.

When implemented over the course of many years, the wildlands network design for the Greater Northern Appalachians should contribute to the protection and restoration of ecological integrity in the region. The strength of this design is its capacity to identify the major terrestrial conservation "nodes" in this region and the potential linkages among them. From a regional perspective, 13 high-priority conservation areas are identified, including the Gaspé Peninsula, northern and western Maine, the Chignecto Isthmus of Nova Scotia and New Brunswick, the southern Lake Champlain valley, and the Green Mountains (Vermont)/Sutton Mountains (Québec) region. The current analysis demonstrates (in conjunction with other efforts) that even smaller-scale threats can have a broader regional effect. By providing a big picture overview, this study aims to help focus conservation efforts on the places and issues, at various scales, with the greatest conservation need. While this network design should be seen as a living document, to be refined as new data and resources become available, it does provide insights into the major regional patterns of high terrestrial conservation value and landscape linkages. Regardless of future adjustments, it is unlikely that concentrated areas of the most highly-irreplaceable conservation features at the regional scale identified through this analysis will vary significantly.

INTRODUCTION

THIS STUDY EXAMINES A CONSERVATION APPROACH designed to systematically identify a network of areas of high conservation priority within the Northern Appalachian/Acadian and St. Lawrence/Champlain Valley ecoregions of the northeastern United States and southeastern Canada (hereafter the Greater Northern Appalachians). More specifically, we identify existing and proposed core protected areas (areas managed with biodiversity values as the primary objective) that are linked and buffered by areas of high biological significance. Collectively, these elements should create a conservation area network—known as a wildlands network design—to protect occurrences of rare species or communities and other sites with high ecological values, represent the range of environmental variation across the study area, and conserve sufficient habitat to support viable populations of selected focal species.

Effective conservation of biological resources and ecological systems requires management strategies at multiple spatial scales, from local-level protection of individual species or unique environmental features to the management of whole landscapes or ecosystems over broad regional scales. The establishment of a system of ecologically-based conservation areas may provide an effective strategy for representing a wide range of biological diversity, as well as providing a means for persistence of individual species and the protection of biological resources (Trombulak 2003).

Systematic conservation planning (Margules and Pressey 2000) has recently emerged as a conceptually valid approach to designing a conservation area system to achieve adequate protection of biological resources. Systematic conservation planning encompasses six steps to identify, implement, monitor, and maintain a system of conservation areas (Margules and Pressey 2000). These steps are: 1) compilation of existing data on biological resources within a planning area and identification of focal species or resources as surrogates for biodiversity; 2) establishment of specific conservation features and goals; 3) evaluation of the degree to which conservation goals are currently met; 4) explicit and objective design of new conservation areas; 5) implementation of on-the-ground conservation actions; and 6) maintenance and monitoring of conservation areas.

One approach to the conservation of biological diversity and the maintenance and restoration of ecological integrity follows three broad tracks (Noss 2003). First, the environmental variation track attempts to represent the full range of environmental variation across the area of interest. This often includes representing biotic and abiotic conditions as delineated by ecological classifications. Second, the special elements track attempts to protect occurrences of rare species or communities and other sites with high ecological values. Finally, the focal species track attempts to conserve sufficient habitat to support ecologically viable populations of species that serve important ecological roles at large spatial scales and/or are sensitive to human activities (Noss and Cooperrider 1994, Lambeck 1997, Miller et al. 1999, Noss et al. 1999). While each approach can lead to the siting of a conservation area to meet specific sets of goals (Noss et al. 1999), the integration of these approaches in the field of conservation area design has only recently been applied (e.g., Noss et al. 2002, Foreman et al. 2003, Miller et al. 2003, Jones et al. 2004, Beazley et al. 2005) and should produce a conservation plan that adequately provides protection for a wide range of biological diversity (Noss 2003).

Effective conservation planning relies upon explicit, systematic and efficient methodologies to evaluate and rank myriad scenarios for a conservation area system in a given landscape (Margules and Pressey 2000). While historic methods have often relied upon manual mapping and subjective decisions regarding the location and size of conservation areas, recent advances in the field of conservation area system design have provided the tools necessary to evaluate alternative scenarios (Soulé and Terborgh 1999, Scott et al. 2001, Andelman and Willig 2003, and Rodrigues et al. 2004). From a biodiversity-conservation perspective it makes sense to maximize the area under some form of conservation, however social and economic realities rarely make such expansive conservation possible. The primary aim of the conservation area design process then is to select the minimum suite of sites that effectively meets designated conservation goals (Leslie et al. 2003). There are a variety of computer-based siting algorithms (e.g., simulated annealing, iterative, optimizing) that are designed to meet such goals (see review in Leslie et al. 2003).

This report summarizes the objectives, methods and results of our conservation area system planning process in the Greater Northern Appalachians. We first present a brief introduction to the Wildlands Project and its approach to continental-scale conservation. This is followed by an overview of the Greater Northern Appalachians and then by the specific methods used to create the wildlands network design for the region. We present the network design itself and describe its features, followed by a discussion.

THE MISSION OF THE WILDLANDS PROJECT IS TO restore and protect the natural heritage of North America. To achieve this end, the organization focuses its efforts on four continental-scale "MegaLinkages" that, when implemented, will tie North American ecosystems together to conserve and benefit native species in their natural patterns of range and abundance (Figure 1). These four areas are:

1) Pacific MegaLinkage, along the west coast from Baja California to Alaska;

2) Spine of the Continent MegaLinkage, from Mesoamerica to Alaska through the Rocky Mountains and other ranges;

3) Atlantic MegaLinkage, from Florida to New Brunswick, mostly along the Appalachians; and

4) Boreal MegaLinkage, from Alaska to The Canadian Maritimes across the roof of North America.

Each MegaLinkage is comprised of several "Wildlands Network Designs," conservation plans that use the most recent research and data to identify areas of high biological value for very large regions. A typical wildlands network design covers millions of acres or hectares, and identifies existing and proposed core protected areas that are functionally linked and buffered by multiple-use lands that are managed to promote conservation goals within the broader network. These networks often cross state, provincial, municipal and international borders. Several network designs have been completed within the subregions that comprise the *Spine of the Continent MegaLinkage* (Figure 2). The Greater Northern Appalachians network design is the beginning of the Atlantic MegaLinkage.

Why Large-Scale Conservation?

Why do we need to pursue conservation on such a large scale? In short, "global biodiversity is changing at an unprecedented rate as a complex response to several human-induced changes in the global environment. The magnitude of the change is so large and so strongly linked to ecosystem processes and society's use of natural resources that biodiversity change is now considered an important global change in its own right (Sala et al. 2000: 1770)."

Major global change is occurring in land use; climate; nitrogen deposition and acid rain; invasive and exotic species (sometimes called "biotic exchange"); and atmospheric CO_2 concentration. Over the next 100 years, land use change will have the most dramatic impacts on biodiversity in terrestrial habitats, while biotic exchange will likely be most important in freshwater ecosystems (Sala et al. 2000).

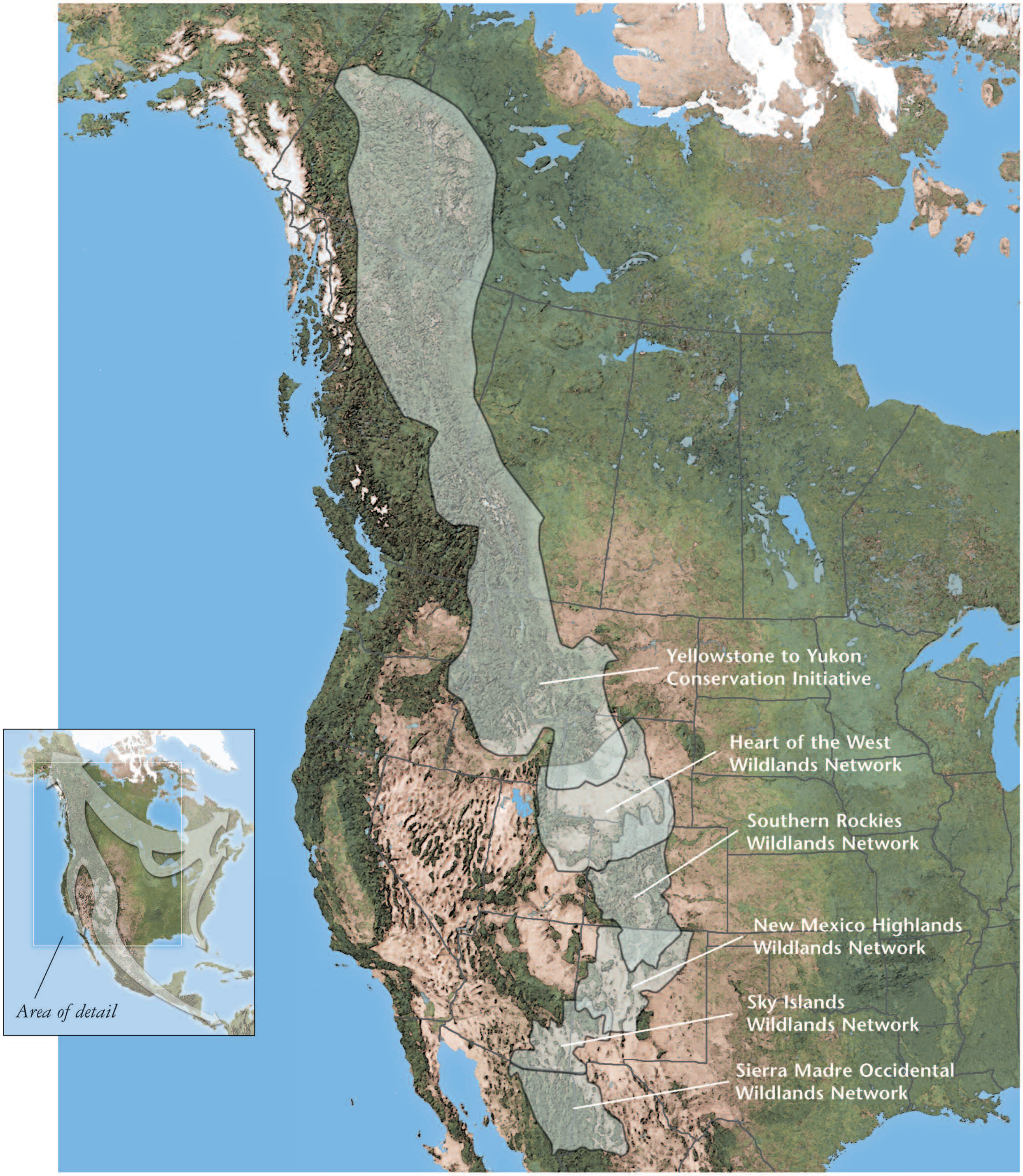
"In light of the dramatic rate at which landscapes are being changed, perhaps the most effective tool for conserving biodiversity is the establishment of reserves. These areas protect biodiversity by reducing threats to the persistence of populations (Lawler et al. 2003: 1762)." However, in North America, and worldwide, existing systems of reserves are not doing a good job of conserving the full sweep of biodiversity. Recent assessments show that less than 6% of the coterminous United States is in nature reserves and that most reserves are found at higher elevations and on less productive soils, even as the greatest number of plant and animal species are found at lower elevations. Analyses of land-cover types indicate that approximately 60% of mapped cover types have less than 10% of their area in nature reserves. Land ownership patterns show that areas of lower elevation and more productive soils are most often privately owned and already extensively converted to urban and agricultural uses (Scott et al. 2001).

Another study (Andelman and Willig 2003) illustrates the skewed geographical and size distributions of protected areas in the Western Hemisphere: 811 of 1413 reserves in the Western Hemisphere are smaller than 10 km^2, and 35% of the total area of these reserves is in Alaska. This study also compiled information on the ranges of all bats in the continental New World (such data are not available for all taxa). Bats are a crucial component of mammalian biodiversity and the spatial distribution of bat species richness parallels that of mammals in general. Almost 82% of threatened and small-range bat species are not protected adequately.

North America has also lost many of its native predators in large parts of their historic ranges. Wide-ranging carnivores like wolves and jaguars often play essential roles in regulating the numbers and behavior of prey species below them in food chains. Such food chains are woven into complex webs of interaction, and the loss of large carnivores can reverberate through these webs, causing the

FIGURE 1 Map of North American "MegaLinkages."

FIGURE 2 Spine of the continent megalinkage showing component wildlands network designs.



local disappearance of species and even entire communities (Estes et al. 1978, Power et al. 1996, Estes et al. 1998, Rogers and Caro 1998, Soulé and Noss 1998, Henke and Bryant 1999, Terborgh et al. 1999, Kullberg and Ekman 2000, Soulé et al 2003, Ray et al. 2005, Soulé et al. 2005). In much of North America, for example, white-tailed deer and raccoons have become overabundant in the absence of their predators, disrupting plant communities and eliminating some kinds of birds and small mammals (DeCalesta 1994, Waller and Alverson 1997, McShea and Rappole 1997, McGraw and Furedi 2005).

Predator restoration may indeed help reverse declines in the condition of biodiversity in a given system, but Ray (2005: 419) cautions that such opportunities will be best in "systems where the demise of predators has been clearly shown to result in adverse ecosystems impacts and where the system has not been importantly degraded by other factors." Ray (2005: 419) observes further that

> *In the terrestrial realm…where habitat conversion has brought on so many changes to biodiversity, the return of predators to many places may require lengthy periods of time, if recovery is achieved at all. However, in all such systems, restoring top predators may still be one important component of a restoration plan with many other elements, and by itself may still nudge along the healing process in some fashion.*

Much past conservation has been *ad hoc*, often driven by a region's scenic values or remoteness—as well as wildlife and natural values. But this approach to biological conservation has left "Canada, the United States, Mexico, and most other countries with highly fragmented systems of parks and reserves in which some elements of the native biota are overrepresented and others are not represented at all (Soulé and Terborgh 1999b)." This has occurred not only in North America but throughout the world (Margules and Pressey 2000).

The Promise of Wildlands Network Designs

One method of addressing gaps in protection and threats to biodiversity is to establish large, regional-scale systems of interconnected core reserves, selected and delineated in a systematic fashion. To facilitate the flow of life across the entire landscape, core areas should be linked by corridors of wild habitat that allow the unimpeded movement of wildlife and natural processes such as wildfire and spring floods. These interconnected wildlands should also be buffered from ecologically-degrading human activities by areas of compatible use—often called stewardship lands—where areas of low-impact farming and forestry complement the functions of the core areas (Noss and Cooperrider 1994; Trombulak 2001, 2003). The result is a network of core wild areas, functionally linked across the landscape and buffered by well-managed stewardship lands.

The question remains as to the most efficient means of creating networks of reserves. There is growing agreement within the conservation community that planning and action should adhere to four key principles (after Pressey and Margules 2000), addressed in detail below:

- Establish planning boundaries based on ecological features;
- Set clear biodiversity conservation goals within a given planning boundary;
- Follow a systematic conservation planning process; and
- Involve a broad array of stakeholders in design and implementation.

Establish planning boundaries based on ecological features MegaLinkages represent the first step toward establishing boundaries based on ecological features: in this case with regard to the Appalachian mountain region of North America. The network designs within this MegaLinkage should adhere to further ecological subdivisions. Since the mid-1990s there has been increasing agreement among conservation scientists as to the definitions, boundaries and utility of these ecological divisions, usually referred to as ecoregions (Bailey 1998, Olson et al. 2001, Bailey 2002). As Olson et al. (2001) observe, "conservation strategies that consider biogeographic units at the scale of ecoregions are ideal for protecting a full range of representative areas, conserving special elements, and ensuring the persistence of populations and ecological processes, particularly those that require the largest areas or are most sensitive to anthropogenic alterations (Noss et al. 1999, Soulé and Terborgh 1999a, Groves et al. 2000, Margules and Pressey 2000)." Accordingly, the planning boundary for the current network design exercise encompasses the Northern Appalachian/Acadian and St. Lawrence/Champlain Valley ecoregions.

Set clear biodiversity conservation goals within a given planning boundary There is also substantial agreement among conservation biologists as to the operational goals necessary for the protection and restoration of life (e.g., Noss and Cooperrider 1994, Trombulak 2001):

- Represent all native ecosystem types and stages;
- Maintain viable populations of all native species in natural patterns of abundance and distribution;
- Maintain ecological and evolutionary processes;
- Design and manage the system to be responsive to change.

As Trombulak (2001:107) observes, "taken together, these goals encompass all of the levels of the biological hierarchy: genes (through an emphasis on *viable* populations, since viability is associated with genetic diversity), species, and communities. Further, these goals encompass all three dimensions of biological organization: composition, function, and structure. The composition of biological communities is incorporated by the focus on all natural community types and species, structure by the focus on the full range of successional stages, and function by the focus on processes and adaptability." We have incorporated these operational goals in our network design process by using a three track approach (special elements, environmental variation and focal species), setting conservation goals for these features that reflect those established in the literature, and including key conservation system elements (core areas, connectivity and buffers).

Follow a systematic conservation process As discussed above, Margules and Pressey (2000) describe a six step systematic conservation planning approach to identify, implement, monitor, and maintain a system of conservation areas. We focus in this analysis on the first four of these steps: 1) compilation of existing data on biological resources within a planning area and identification of focal species or resources as surrogates for biodiversity; 2) establishment of specific conservation features and goals; 3) evaluation of the degree to which conservation goals are currently met; 4) explicit and objective design of new conservation areas.

Involve a broad array of stakeholders in design and implementation It is critical to involve regional stakeholders, scientific and otherwise, in the process of designing and implementing a network design. The draft network design should also undergo rigorous expert reviews before a final design is released. We convened a group of conservation scientists familiar with the Greater Northern Appalachians and with the Wildlands Project's scientific methods to help guide necessary research and analysis. We also worked closely with local partners to integrate their expert knowledge of the region into draft designs.

A Regional Overview of the Greater Northern Appalachians and Why They Need Protection and Restoration

VIEWED FROM SPACE AT NIGHT, MUCH OF EASTERN North America is a bright web of lights. But a few areas remain dark, unaffected by cities, towns, and roads. Despite a long history of population growth, development, natural resource extraction, and pollution—pressures that continue today—a surprising amount of land along the eastern edge of the North American continent is still wild. Looking at a nighttime image this way, the big, dark spaces in the northeastern United States and southeastern Canada stand out: the Adirondacks, northern Maine, the Gaspé Peninsula of Québec, interior New Brunswick and the isolated reaches of Nova Scotia. This extraordinary region, what we call the Greater Northern Appalachians (Figure 3), represents the intersection of the cold boreal areas of Canada with the warmer temperate forests of the eastern United States. The result is a "transition forest," a rich blend of species from north and south. Its rugged topography, complex river systems, and a long ocean coastline enhance the ecological diversity of the region.

The Greater Northern Appalachians encompasses all or part of ten states and provinces (Table 1) and is a combination of two ecoregions, the Northern Appalachian/Acadian Ecoregion and the St. Lawrence/Champlain Valley Ecoregion. The Northern Appalachian/Acadian Ecoregion extends from the Tug Hill plateau and Adirondack Mountains of New York, across the Green Mountains of Vermont and White Mountains of New Hampshire and into Maine. The ecoregion encompasses all the provinces of Maritime Canada (New Brunswick, Nova Scotia and Prince Edward Island) as well as the Appalachian complex of eastern Québec, extending to the Gaspé Peninsula and Îles-de-la-Madeleine (Magdalene Islands) (Anderson et al. 2006). The geographic boundaries of the ecoregion were derived and modified by an international team of scientists from standard ecological land classification frameworks in Canada and the U.S. (Omernick, 1987, Bailey et al. 1994, Keys et al., 1995, Li and Ducruc 1999, Marshall and Schut 1999, ECWG 2003, Neily et al. 2003).

Anderson et al. (2006) describe the ecoregion as a rugged, forested landscape dominated by spruce, maple, beech, birch, pine, fir, hemlock and oak.

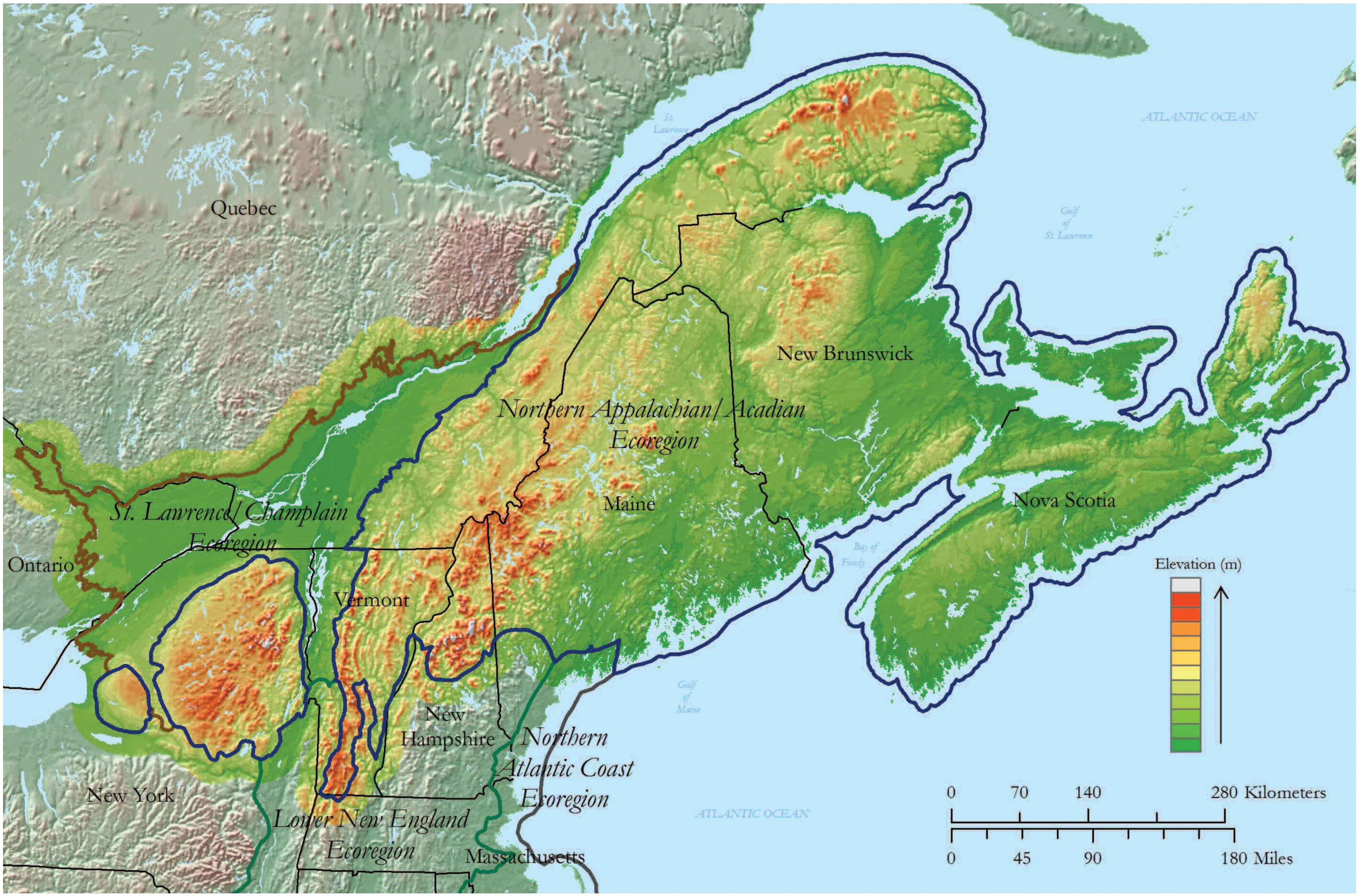
> *Eighty-two percent of the region's 82 million acres (about 332,000 km²) are covered by roughly equal amounts of conifer (28 percent), deciduous (24 percent) and mixed (24 percent) forest types. Presently, about 6 percent (4 million acres, about 16,000 km²) of the forest is in an early successional state, most of that being "working forest" harvested in the last five years. The western and more southerly parts of the ecoregion in New York and Vermont are considerably more deciduous in nature than the large northeastern provinces New Brunswick, Nova Scotia and eastern Québec, which are chiefly coniferous.*

There are substantial marine and coastal influences in the Acadian portion of the ecoregion. According to Ricketts et al. (1999) this is the second richest ecoregion for vertebrate diversity within the temperate broadleaf and mixed forest regions.

The lowlands of the Champlain and St. Lawrence valleys are different enough from the Northern Appalachian/Acadian ecoregion to constitute a separate ecoregion. Encompassing major urban centers such as Burlington, Montreal and Québec City, the St. Lawrence/Champlain ecoregion surrounds the Adirondacks and separates them from the Tug Hill plateau and the main stem of the Appalachians. Thompson et al. (2002: 3) detail that the ecoregion includes "vast stretches of fertile land, rich woodlands, vibrant wetlands, dramatic cliffs...and hosts a number of endemic species as well as more widespread species at the edges of their ranges. It provides critical habitat for migratory birds, breeding grassland birds, and wintering raptors. Because of its fertile soils, relatively mild climate, and stunning scenery, the ecoregion has been used by humans for at least 10,000 years, and very heavily for the last 300 of these." Prior to European settlement, the fauna of this region likely resembled that of the nearby mountainous areas, although this has changed dramatically over centuries of settlement, agriculture and logging. With 75% or more this area now in agricultural production, natural communities have been reduced greatly in size and are isolated from one another (Kavanagh et al. 2001).

The Greater Northern Appalachians (GNA) presents an extraordinary opportunity for conservation because the region has either retained or regained a large proportion of its historical forest cover (McKibben 1995; Cogbill et al.

FIGURE 3 Greater Northern Appalachians showing Northern Appalachian/Acadian and St. Lawrence/Champlain Valley ecoregions (Ecoregional boundary source: The Nature Conservancy/Eastern Resource Office).



2002). Despite its predominantly wooded condition, however, the habitats and species of this region suffer from a wide range of ecological impacts and face numerous ongoing threats. Today's forests, for example, are far younger and less diverse than those that used to dominate the landscape (Lorimer 1977, Charles et al. 1999, Irland 1999, Northern Forest Alliance 1999, 2002) and several species, such as the passenger pigeon, wolf, wolverine, elk, caribou and mountain lion, have vanished completely or have been reduced to small populations (Thompson 2002, Carroll 2003, 2005). Climate change and mercury and acid deposition are also major threats to the region (Carroll 2005, Evers 2005, Anderson et al. 2006). Substantial and remote portions of the region face threats from residential development (Austin 2005) and new and expanded roads, ranging from subdivision and collector roads to highways, are an ongoing concern (Baldwin et al. *In review*). Compounding these problems is the increasingly rapid turnover in ownership of massive tracts of forestland, particularly in the U.S., brought on by changes in the global forest products industry and other factors (Hagan et al. 2005, Northern Forest Lands Council 2005). In addition, this region appears to be facing a "latent extinction risk" as described by Cardillo et al. (2006). These researchers identified areas of the world where mammals have biological traits that make them particularly sensitive to future human impacts, but they are not yet threatened because such impact is currently low. Their study identified the "Eastern Canadian Forest," which encompasses much of the Greater Northern Appalachians, as one of those areas of latent extinction risk.

In many cases, quick action by conservationists has helped secure tens of thousands of acres (or hectares) from conversion to development. Despite these successes, however, vast tracts of ecologically important lands remain unsecured from development throughout the region (Figure 4).

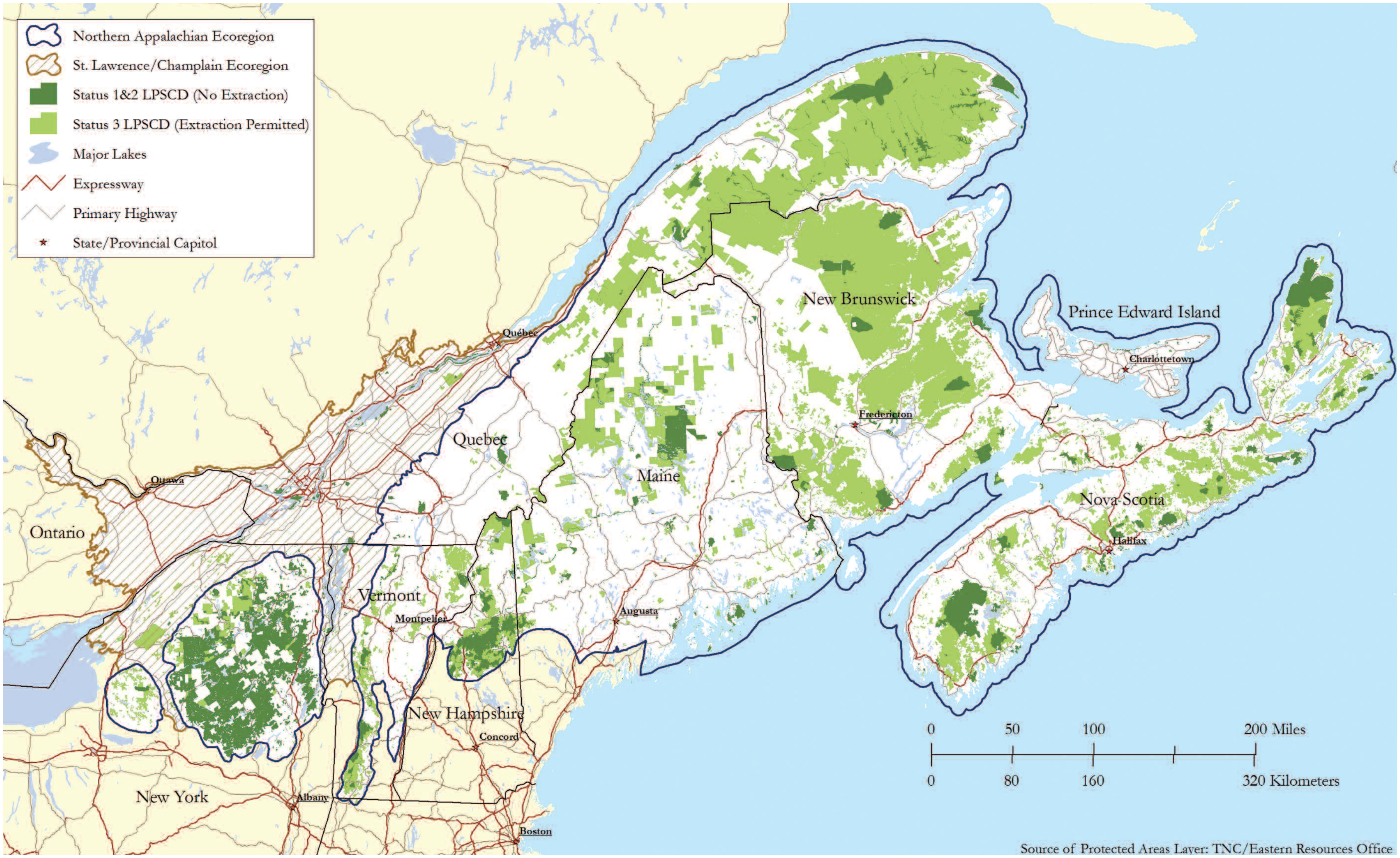
In the Greater Northern Appalachians as a whole, lands permanently secured from conversion to development (LPSCDs) (e.g., Status/Gap 1, 2 and 3 lands, such as public conservation lands, easements on private lands, Crown lands in Canada)[1] cover approximately 30% of the region (Table 2).

TABLE 1 The Greater Northern Appalachians (GNA) as distributed among ten states and provinces (in km^2 and acres, and as a percentage occupied by the state or province). Ecoregional boundary source: The Nature Conservancy/Eastern Resource Office.

State or Province	Km^2	Acres	Percent of GNA Region
Maine	76,680	18,948,122	19.7%
Massachusetts	73	18,016	0.0%
New Brunswick	73,087	18,060,252	18.8%
New Hampshire	7,984	1,972,929	2.1%
New York	38,439	9,498,511	9.9%
Nova Scotia	56,015	13,841,696	14.4%
Ontario	13,562	3,351,305	3.5%
Prince Edward Island	5,897	1,457,192	1.5%
Québec	96,785	23,916,037	24.9%
Vermont	20,018	4,946,477	5.2%
Total	**388,541**	**96,010,538**	**100%**

1. The idea of lands permanently secured from conservation to development (LPSCDs) emerged during a meeting in February 2006 of scientists associated with Two Countries, One Forest (2C1Forest), a bi-national collaborative seeking to advance conservation in the Northern Appalachian/Acadian ecoregion. These scientists realized that "protected areas" or "conservation areas" were inadequate to describe the wide range of lands that are off limits to residential development but may be subjected to a wide range of management practices, some of which, like conversion to plantations and clearcutting, may have substantial effects on biodiversity. The LPSCD term acknowledges this broad range of management regimes within this set of lands that are off-limits to residential development. See Crist (2000) for more information on mapping and categorizing land stewardship. LPSCD status levels correspond to the three main types of conservation land identified under the GAP regional species and analysis program, as follows: **Status 1**—An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events (of natural type, frequency, intensity, and legacy) are allowed to proceed without interference or are mimicked through management. **Status 2**—An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state, but which may receive uses or management practices that degrade the quality of existing natural communities, including suppression of natural disturbance. **Status 3**—An area having permanent protection from conversion of natural land cover for the majority of the area, but subject to extractive uses of either a broad, low-intensity type (e.g., logging) or localized intense type (e.g., mining). It also confers protection to federally listed endangered and threatened species throughout the area. (LPSCD data source: TNC/Eastern Resource Office).

FIGURE 4 Greater Northern Appalachians study boundary, with Status 1, 2 and 3 lands permanently secured from conversion to development (LPSCDs). LPSCD coverage is current as of early 2006, although it does not include some important areas, such as the large conservation easements recently established in Downeast Maine.



Within the GNA region there is broad variation in the extent and distribution of lands secured from development. Maine, for example, which makes up nearly 20% of the Greater Northern Appalachians (refer to Table 1), contains only about 10% of these secured lands (Table 3). Large blocks of northern Maine are in private ownership with no guarantee of protection from future development. New York, on the other hand, makes up roughly 10% of the GNA region—about half the area of Maine—but it contains about 12% of the lands secured from development, much of it in the Adirondacks.

The Wildlife Conservation Society Canada and Two Countries, One Forest are working to understand the current and future threats in the region and to map them in a

TABLE 2 Extent of Status 1, 2 and 3 lands permanently secured from conversion to development (LPSCDs) by state and province within the Greater Northern Appalachians study area (Source: TNC/Eastern Resource Office). No extraction of natural resources is permitted on status 1 and 2 lands. Extraction is permitted on status 3 lands.

	Status 1 & 2 (no extraction permitted)			**Status 3 (extraction permitted)**		
State or Province	***km²***	***Acres***	***% of study area***	***km²***	***Acres***	***% of study area***
Maine	2,199	543,421	0.6%	9,109	2,250,979	2.3%
Massachusetts	0	26	0.0%	24	5,958	0.0%
New Brunswick	2,192	541,573	0.6%	32,308	7,983,539	8.3%
New Hampshire	1,771	437,584	0.5%	2,325	574,459	0.6%
New York	10,196	2,519,392	2.6%	3,373	833,489	0.9%
Nova Scotia	4,492	1,110,104	1.2%	13,500	3,335,972	3.5%
Ontario	17	4,152	0.0%	0	0	0.0%
Prince Edward Island	69	17,118	0.0%	2	529	0.0%
Quebec	3,161	781,003	0.8%	25,377	6,270,859	6.5%
Vermont	650	160,554	0.2%	2,959	731,111	0.8%
Totals	**24,746**	**6,114,927**	**6.4%**	**88,978**	**21,986,896**	**22.9%**

TABLE 3 Status 1, 2 & 3 conservation lands in the states and provinces as a percentage of all conservation lands, and showing the ratio of the area of LPSCDs in a state or province to the amount of land the state or province occupies in the study area.

State or Province	**Status 1 & 2**	**Status 3**	**Status 1, 2 & 3**	**Ratio of LPSCDs to state/province area in study area**
Maine	8.9%	10.2%	9.9%	0.50
Massachusetts	0.0%	0.0%	0.0%	1.13
New Brunswick	8.9%	36.3%	30.3%	1.61
New Hampshire	7.2%	2.6%	3.6%	1.75
New York	41.2%	3.8%	11.9%	1.21
Nova Scotia	18.2%	15.2%	15.8%	1.10
Ontario	0.1%	0.0%	0.0%	0.00
Prince Edward Island	0.3%	0.0%	0.1%	0.04
Québec	12.8%	28.5%	25.1%	1.01
Vermont	2.6%	3.3%	3.2%	0.62
Totals	**100.0%**	**100.0%**	**100.0%**	

spatially explicit way. These mapping efforts take the form of the Current and Future Human Footprints. Building upon the global methodology developed by the Wildlife Conservation Society and Center for International Earth Science Information Network (Sanderson et al. 2002), the Current Human Footprint (CHF) analysis measures direct human influence on the land within the ecoregion based on four categories of Human Influence: Access (roads, rail), Human Habitation (population density, dwelling density, urban areas), Human Landuse (agriculture, development, forestry, mining, large dams) and Electrical Power Infrastructure (utility corridors). The resulting high resolution (90 meter) map displays a composite of Human Influence relative to the ecoregion that reveals not only the remaining wildness and potential ecological linkages within the area, but also identifies potential low-cost opportunities for conservation action, priority areas for restoration, and hotspots of human development that present barriers to regional connectivity (Woolmer et al. *In prep.*). The Future Human Footprint (FHF) aims to forecast impacts from human development into the future. The FHF is based on scenarios for the future growth of population, roads, and dwellings derived, from geographical analyses of past patterns and trends as well as modeling landuse use transitions, highlighting increasing threats from, amenity-focused development in wild areas such as around lakeshores.

The threats facing this region, combined with vast opportunities for conservation and advances in conservation science, prompted The Nature Conservancy (TNC) and its partners to begin pursuing comprehensive conservation planning for the Northern Appalachian/Acadian and St. Lawrence/Champlain Valley ecoregions in the late 1990s (Anderson et al. 1998). A key part of this planning in the Northern Appalachian/Acadian ecoregion involved identifying large representative examples of the "matrix-forming" forests (matrix blocks) that dominate the landscape (Anderson et al. 1999; 2006). Many of the datasets developed as part of their ecoregional planning process were generously shared with us and have been used to create the wildlands network design described in this document. The processes used by TNC to delineate the matrix blocks, and how we took their locations into account as we developed our network design, are described below (Methods for Creating the Wildlands Network Design) and in Appendix 1.

Study Area

Our study area consists of the intersection of two ecoregions defined by The Nature Conservancy (TNC), the Northern Appalachian/Acadian and the St. Lawrence/Champlain Valley ecoregions, and encompasses 388,541 km^2 (91,145,138 acres) (refer to Figure 3). For purposes of site selection analyses, the study area is further buffered, extending into a small portion of the Lower New England ecoregion, south of Lake Champlain and the mountains of Vermont. Despite gaps in uniform data availability for some of these ecoregions, we chose to maintain these study area and buffer boundaries because important wildlife linkages likely fall within the St Lawrence/Champlain and Lower New England ecoregions, and buffering is advantageous to take into account important contextual information just outside the study area. Data limitations are discussed below.

Three-track Approach to Conservation Planning

The conservation planning methodology that we applied in the GNA region focused on environmental variation, special elements, and focal species, and is described more fully as follows.

Environmental Variation To represent the variation in ecological conditions that exists across the region, we used a data layer of Ecological Land Units (ELUs) developed by The Nature Conservancy (TNC) (Anderson et al. 1999, 2006; Groves et al. 2003*)*. ELUs are unique combinations of three environmental factors—elevation, geology and landform—that are important to the distribution and abundance of ecological communities in the ecoregion. Analyses by TNC and its partners indicate that smaller-scale ecosystems, communities and species locations are highly correlated with the types and diversity of ELUs (Anderson et al. 2006). The original ELU layer provided by the TNC consisted of many hundreds of unique combinations of elevation, geology and landform. These were subsequently consolidated in consultation with a TNC ecologist by combining similar categories within each elevation, geology and landform class. The final layer consisted of 162 unique combinations of elevation, geology and landform (Figure 5, Appendix 2)

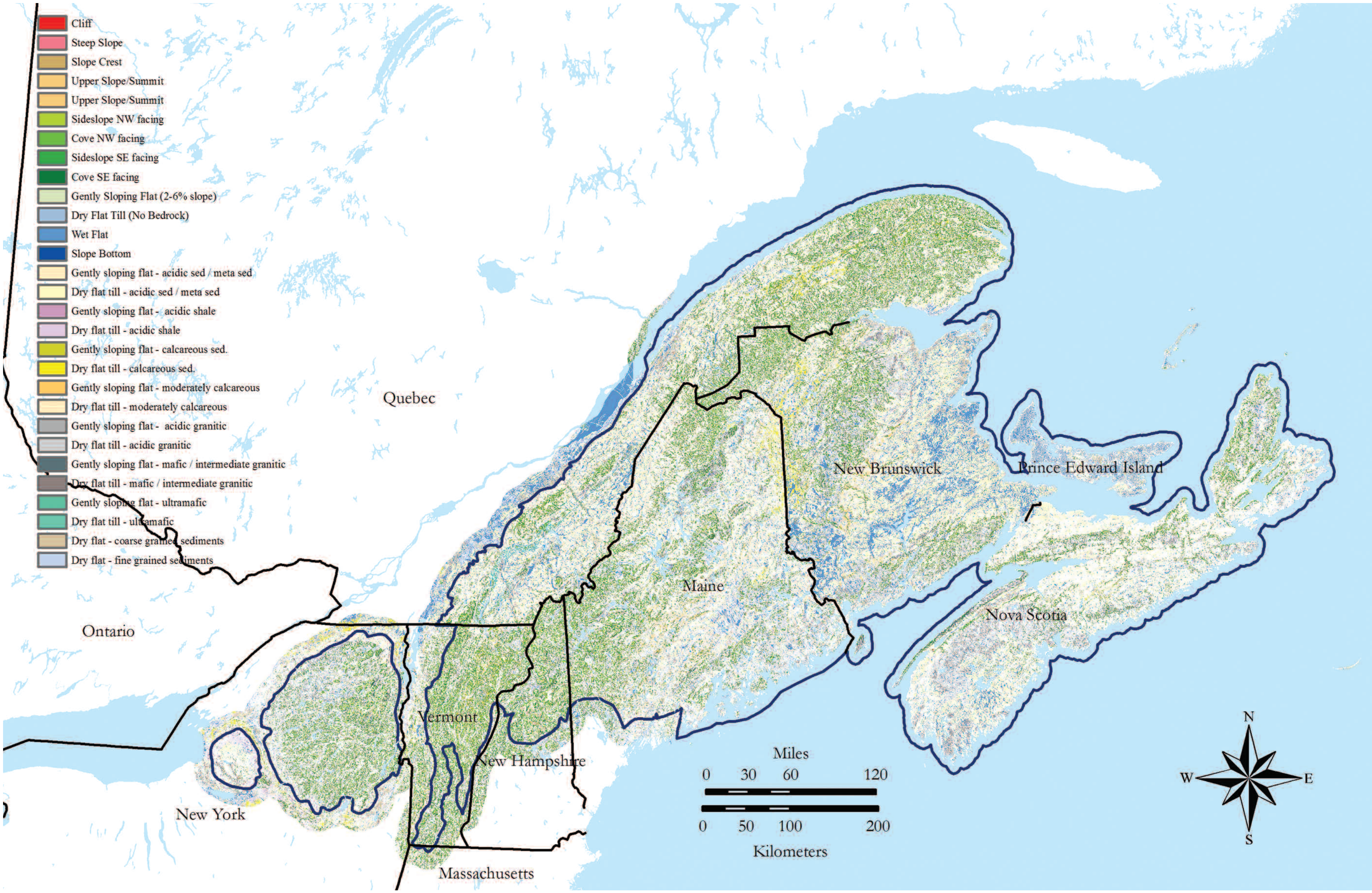
Special Elements For our special elements track we used a geographic data layer of modeled occurrences of small to moderately-sized, high-quality ecosystems developed by the Eastern Regional Office of TNC. This database consisted of nine ecosystem types: Open Wet Basins, Pine Barrens, Open Dry Flats, Beach Dune, River Systems/Coves, Floodplain, Forested Wetlands, Steep Slopes and Cliffs, and Summits. Predicted occurrences of each of the types were first modeled with existing ecological data. Modeled occurrences were then reviewed by regional experts and high-quality occurrences of each type were identified (Anderson et al. 2006). In this study we used only these high-quality occurrences as input data.

In most such analyses, rare, threatened and endangered species occurrence data (e.g., G1 {critically imperiled globally} to G3 {vulnerable globally} and S1 {extremely rare at state/province level} to S2 {very rare at state/province level}) as defined by TNC and other Natural Heritage programs) are used. However, in the case of the Greater Northern Appalachians study area, our data were of inconsistent availability and of questionable reliability. In particular, different species were monitored in each state and province, and we could not access data for Maine and the Canadian provinces. Consequently, we used ecosystem occurrences 1) as a surrogate or coarse filter for these species-based data and 2) to represent places of high conservation value (geographical clusters of diversity and rarity), as is also consistent with the definition of special elements[2] provided by Noss et al. (1999b). Ideally, if data sets are reasonably uniform, either rare species element occurrences or modeled occurrences of ecosystems, or both, could be used as special elements.

Focal Species Focal species planning complements special elements and representational (or environmental vari-

2. Special elements are species and places of high conservation value such as critical areas for species at risk and geographical clusters of diversity and rarity (Noss et al. 1999b).

FIGURE 5 Ecological land units in the Northern Appalachian/Acadian ecoregion (Data source: The Nature Conservancy/Eastern Resource Office).



ation) approaches to the wildlands network design process. Special elements and representation help identify areas to include in the network, whereas *focal species are used primarily to help address how large the network components should be and how they should be configured* (Miller et al. 1998). A carefully selected set of focal species, effectively representing a broad range of life requisites, can be seen as surrogates for the protection of many other species.

We used data from a focal-species analysis (Carroll 2003, 2005) that identified areas of high quality (source) habitat for three species of carnivores: Canada lynx (*Lynx canadensis*), American marten (*Martes americana*), and eastern gray wolf (*Canis lupus*, or *Canis lycaon* [after Wilson et al. 2000]). These three mammalian carnivores are native to the study area but are considered threatened or extirpated in some or all of the region. These three species differ in their basic habitat requirements and the factors responsible for their decline (Carroll 2005). Vertebrate carnivores are used as focal species because they are vulnerable or sensitive to human activities and human-induced landscape change (Weaver et al. 1996, Lambeck 1997, Carroll et al. 2003). Lynx and marten are especially important in the Greater Northern Appalachians because their populations represent "peninsular extensions of broader boreal ranges (Carroll 2005:3)." As such they may be particularly sensitive to climate change, such as changes in snowfall, and represent unique ecotypes of these species at the southern limit of their range (Carroll pers. comm. 2006).

In developing the focal-species analyses, Carroll, a carnivore biologist with extensive experience in model development, obtained focal species data, and derived resource-selection functions (RSFs) (Boyce and McDonald 1999) and dynamic, individual-based models (e.g. PATCH, Schumaker 1998) for these three species. Carroll built on extensive regional research on wolf (e.g., Harrison and Chapin 1998, Mladenoff and Sickley 1999, Paquet et al. 1999), lynx (e.g., Hoving 2001, Hoving et al. 2003, 2004, 2005) and marten (e.g., Hepinstall et al. *In prep*., Chapin et al. 1998, Payer and Harrison 2003) to provide analyses of habitat, population viability and conservation needs for the study area.

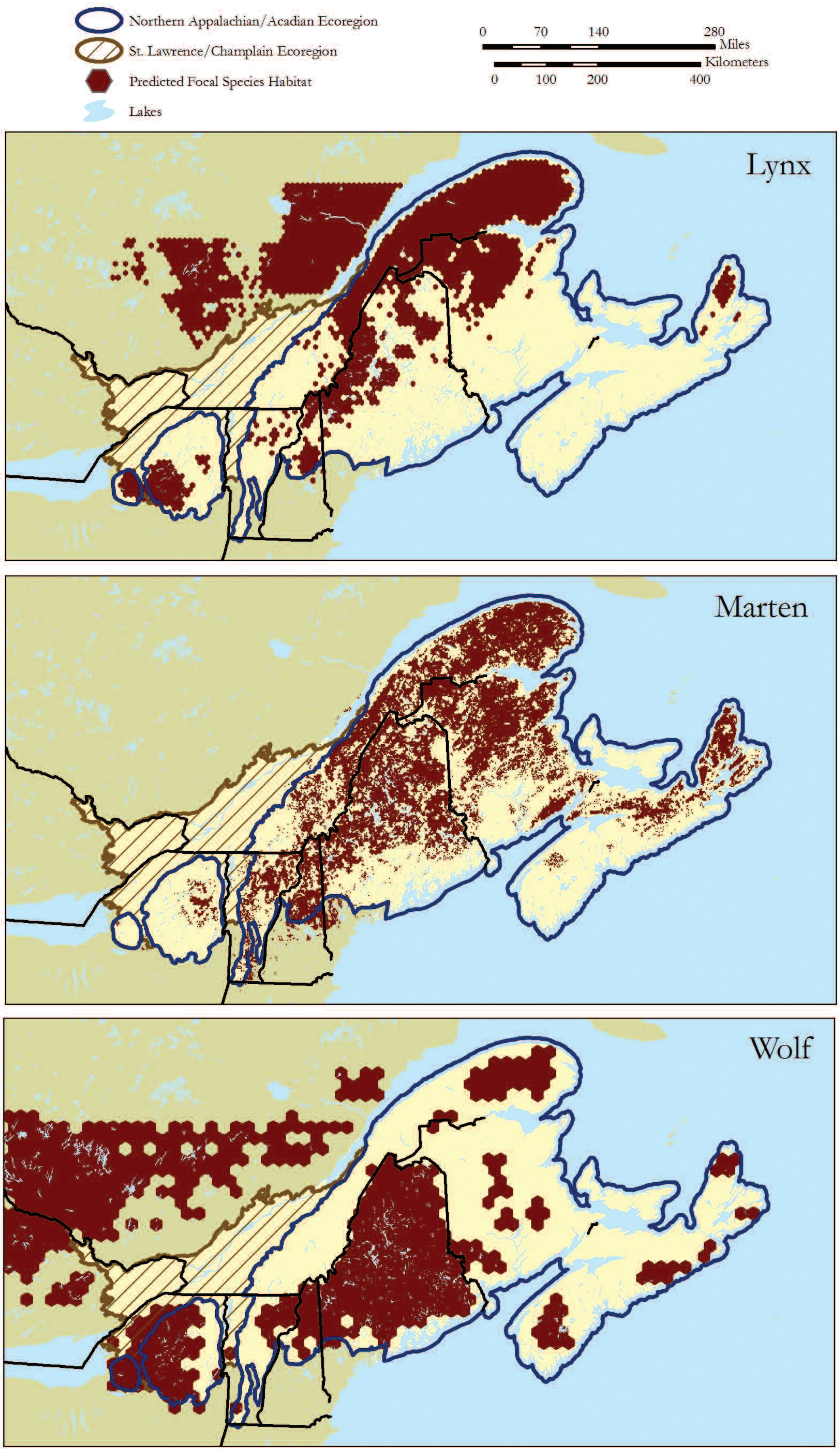
Though the input data varied for each species, they generally consisted of spatially-explicit predictions of source habitat and of source habitat threatened under varying ecological scenarios.[3] Source habitats are areas with positive predicted population growth rates. For the wolf there are two data layers: 1) predicted source habitat under current landscape conditions, and 2) predicted threatened source habitat under a condition of future landscape change due to human population growth. For the lynx there are four data layers. The first pair of data layers consists of 1a) base scenario prediction of source habitat with no population cycling, and 1b) predicted threatened source habitat under scenario with population cycling. The second pair consists of 2a) base scenario prediction of source habitat with population cycling and no trapping of lynx, and 2b) predicted threatened source habitat under scenario with population cycling and trapping. For the American marten, there are also four data layers. The first pair consists of 1a) base scenario prediction of source habitat with trapping, and 1b) predicted threatened source habitat under increased trapping pressure. The second pair of data layers consists of 2a) base scenario prediction of source habitat under a scenario of habitat restoration, and 2b) predicted threatened source habitat under a scenario of timber harvest. In total, 10 data layers were used to represent the habitat requirements for the three focal species (Figure 6). These and other scenarios are described in more detail in Carroll (2003, 2005).

Site Selection

As discussed above, effective conservation planning relies upon explicit, systematic and efficient methodologies to evaluate and rank myriad scenarios for a conservation area system in a given landscape (Margules and Pressey 2000). Recent advances in the field of conservation area system design have provided the tools necessary to evaluate alternative scenarios (Soulé and Terborgh 1999, Scott et al. 2001, Andelman and Willig 2003, and Rodrigues et al. 2004). The primary aim of the conservation area design process is to select the minimum suite of sites that effectively meets designated conservation goals (Leslie et al. 2003). While there exist a variety of computer-based siting algorithms (e.g., simulated annealing, iterative, optimizing) that are designed to meet a set of conservation goals based on a set of conservation features or targets (see

3. Threatened source habitat represents areas that occupy the upper right quadrant of irreplaceability/vulnerability graphs developed as part of the spatially explicit population modeling. Irreplaceability in this context is the relative value of an area as source habitat for a given species. Vulnerability is the likelihood that a site's conservation value will be reduced over time. Values were plotted on a graph of irreplaceabiity (y-axis) versus vulnerability (x-axis), and the graph is divided into four quadrants. The upper right quadrant includes sites with high irreplaceability and high vulnerability – threatened sources. These areas remain source habitat even under the threat scenarios. See Carroll (2005) and Carroll et al. (2003) for a detailed discussion.

FIGURE 6 Predicted source and threatened source habitats for three focal species (Data source: Carroll 2003, 2005).



review in Leslie et al. 2003), the simulated annealing algorithm has been shown to meet conservation goals more effectively than other approaches (Ball 2000, Possingham et al. 2000), so we use that algorithm in this analysis.

For each of the 181 conservation features (162 for environmental variation, 9 for special elements, and 10 for focal species), we compiled spatial data and set conservation goals (described below in Conservation Goals). Site selection software was used to generate alternative reserve design solutions, specifically MARXAN (v1.8.2), a software program for site selection (Ball and Possingham 2000; Possingham et al. 2000). MARXAN allows for the use of a spatially explicit simulated annealing optimization method to find a set of planning units that meets identified conservation goals while minimizing costs. The objective function used by MARXAN's simulated annealing algorithm (hereafter referred to as a MARXAN analysis) is as follows:

$$TotalCost = \sum_{Sites} Cost + BLM \sum_{Sites} Boundary + \sum_{ConValue} CFPF * Penalty + CostThresholdPenalty(t)$$

In this equation, TotalCost is the total cost of the reserve system used to compare alternative solutions; Cost is a measure of the cost, often the area, of each of the sites within the reserve system; Boundary is the length of the boundary of the reserve system; BLM is the user defined boundary length modifier; CFPF, or conservation feature penalty factor, is the penalty factor for not reaching a conservation goal; and CostThresholdPenalty is a penalty added if the cost is exceeded. These MARXAN parameters are discussed in more detail below. The TotalCost of a specific simulated annealing run can then be compared to other such runs within the same set of input parameters, or across different sets of input parameters.

Planning Units

The aim of the reserve design process is to select a suite of planning units that, when incorporated into a reserve system, meets a set of predetermined conservation goals. The process for setting conservation goals is described below. Planning units are the spatial areas into which the study area is divided for the purposes of analyses and with which the data are associated, typically as hexagonal or square grid cells of a consistent size. In our study, we chose a hexagonal planning unit with a size of 1000 hectares (about 2471 acres). The hexagonal shape provides a number of benefits. First, it approximates a circle and provides the benefits of relatively smooth coverage of the planning area and a low edge-to-area ratio. Second, the smaller size will maximize the amount of internal homogeneity of a given planning unit and thus help increase the efficiency of the site selection algorithm. Third, when the hexagons are relatively small, it will be easier to adapt the outputs of the site selection algorithm to political boundaries and natural features (e.g., watersheds). The 1000 hectare (ha) size was sufficient to be larger than the coarsest data input, yet small enough to be useful for on-the-ground conservation efforts. Finally, it is adequately large to result in a manageable number of planning units across the study area so as to not exceed the computational limits of the software.

An integral part of a systematic approach to the design of reserve systems is to evaluate the conservation status of planning units, specifically to identify existing protected areas as well as those areas unavailable to conservation efforts. The MARXAN software allows for individual planning units to be automatically included or excluded from the reserve design solution. One option is to "fix" or "lock" individual planning units into the initial reserve, and consequently, during the simulated annealing process, the planning units will be "fixed" into the final solution. Another option is to fix/lock individual planning units out of the initial reserve and, during the simulated annealing process, the planning units will be excluded from the final solutions.

To designate whether an individual planning unit should be fixed in the reserve design, we used existing information on the distribution of lands permanently secured from conservation to development (LPSCDs, Figure 4). We locked into the reserve design analyses all hexagons with LPSCD Status 1 or 2 comprising >= 75% of the 1000 ha hexagon. All hexagons with >= 50% of the 1000 ha hexagon in urban zones, as derived from ESRI (2002) datasets, were locked out of the reserve design analyses. This serves to exclude areas whose current state of land conversion or development offers few opportunities for conservation even though they may potentially represent conservation features.

In preliminary site selection runs we also examined a number of runs without locking in hexagons meeting the protected area cut-off. Site selection results with protected areas locked in or out did not visibly differ from one another. Given few visible differences, we chose only to examine runs with protected areas locked into the final solution.

Sensitivity Analysis

Within the conservation area design process, a number of input parameters influence the final conservation area design, such as the choice of conservation features, specific goals for those features, or the weight given to fragmentation (or spatial cohesiveness) parameters. It thus becomes vital to assess the sensitivity of the selection process to variations in certain input parameters. To investigate the sensitivity of the site selection process to variations in two primary input parameters, we examined the sensitivity of the algorithm to variations in conservation goals by setting four different combinations of conservation goals, as described below. Second, we examined the sensitivity to variations in the algorithm's boundary length modifier (BLM) a parameter that influences the spatial cohesiveness of the planning units, and thus the configuration of the network. We conducted these analyses with the goal of identifying planning units within a conservation area system that were relatively insensitive to variations in these two parameters.

MARXAN Parameters

MARXAN allows the user to customize a range of model parameters, and thereby influence kinds of outputs produced by the model. We describe below four of the key parameters that we varied in the course of this analysis: site cost, species penalty factor, boundary length modifier, and goals for various conservation features.

Site Cost The cost of including an individual planning unit into the final reserve design is considered in the calculation of the total portfolio cost. This cost can be the monetary cost of the land, but such information is not uniformly available at the scale of the study area, so we assigned each planning unit a cost = 1. Under this designation, the model total portfolio cost is driven by the conservation features and the model will seek to minimize the area of the final conservation portfolio.

Species Penalty Factor In addition to assigning a cost to individual planning units, MARXAN allows the user to assign a penalty factor to individual features for not meeting conservation goals. For all ELU and special elements features, we assigned a species penalty factor = 1. We altered this assignment, however, for the focal species where we had two features for the wolf and four features for the lynx and American marten. Here, we assigned each of the four lynx and four American marten features a penalty factor = 1, and assigned the two wolf features a penalty factor = 2, essentially weighing the wolf features equal to the lynx and American marten features.

Boundary Length Fragmentation of habitat and reserves frequently has detrimental effects on the health of such reserves and their ability to support biological diversity (Newmark 1985, 1995; Paquet and Callahan 1996, Gibeau and Heuer 1996, Forman et al. 1997). In a reserve system, one measure of fragmentation is the length of the reserve boundary relative to the area of the reserve. For a given total area of a reserve system, a longer total boundary length would be characteristic of a fragmented system, while a shorter length would characterize a relatively unfragmented reserve. MARXAN allows the user to control the degree of fragmentation or spatial cohesiveness in a reserve design by including a boundary length modifier in the objective function.

To explore the effects of the boundary length modifier (BLM) on the reserve design, we varied the value of the BLM in our analyses. After initial trial runs to determine workable values, we chose to run reserve design analyses using three boundary length modifier values: 0, 0.001, and 0.01. This range of values balances the benefits in flexibility and efficiency of using an unrestricted run (i.e., 0, which has no influence over clumping) with levels of spatial cohesion more realistic for ecological functioning such as species dispersal and migration.

Conservation Goals Conservation goal setting presents many challenges, especially with the increasing emphasis on considering conservation at multiple spatial scales (Tear et al. 2005). Ideally one would establish a single quantitative goal for a given conservation feature based on extensive understanding of the needs of a given species or ecosystem. These data are rarely available, however, especially for more than 180 individual conservation features, so we adapted a method used by researchers modeling marine protected areas off the coast of British Columbia (Ardron 2003). Accordingly, rather than use a single set of parameters, we chose a range of scenarios based on different boundary length modifiers and goals for given targets. From these, we then examined the results for trends, focusing on areas that emerge under a variety of conditions. Those areas that are selected repeatedly can be interpreted as having a high utility or usefulness for the overall design. While they may not necessarily meet all the goals, these areas of high overlap provide clear guidance as to where initial conservation efforts should be directed. The individual scenarios can also be used to provide guidance for areas that are not selected repeatedly but that may contribute to the overall network design.

We set high, medium and low goals for each feature (Table 4) based on consultations with experts in site selection analysis and on goal levels in other studies that used a simulated annealing site selection algorithm (e.g., Carroll et al. 2003, Leslie et al. 2003; Foreman et al. 2003; Jones et al. 2004). We then associated each of the goal levels with the three boundary modifier values described above (Table 5). Additional scenarios were defined combining high (focal species and special element) and low (environmental variation) goals. In total these combinations of goal levels and boundary modifiers comprise the site selection rules for 12 distinct scenarios. All goals were applied to the study area as a whole; no sub-regional goals were set.

MARXAN Runs & Summary Statistics For each of the 12 scenarios, we ran the model 100 times, each with 1,000,000 annealing iterations. Each scenario produced

TABLE 4 Percentage goals for each conservation feature.

Feature	Low goal	Medium goal	High goal
Focal species			
Wolf			
1. Source habitat under current landscape conditions	40%	50%	60%
2. Threatened source habitat under future landscape change scenario	40%	50%	60%
Lynx			
1a. Base scenario prediction of source habitat with no population cycling	40%	50%	60%
1b. Threatened source habitat under scenario with population cycling	40%	50%	60%
2a. Base scenario prediction of source habitat with population cycling and no trapping of lynx	40%	50%	60%
2b. Threatened source habitat with population cycling and trapping of lynx	40%	50%	60%
American marten			
1a. Base scenario prediction of source habitat with trapping	40%	50%	60%
1b. Threatened source habitat under increased trapping pressure	40%	50%	60%
2a. Base scenario prediction of source habitat under scenario of habitat restoration	40%	50%	60%
2b. Threatened source habitat under scenario of timber harvest	40%	50%	60%
Environmental variation (Ecological Land Units)	5–20%*	25–40%*	45–60%*
Special elements			
Open wet basins	50%	66%	75%
Barrens: Pine	50%	66%	75%
Barrens: Open Dry Flats	50%	66%	75%
Beach Dune	50%	66%	75%
River Systems/Coves	50%	66%	75%
Floodplain	50%	66%	75%
Forested Wetlands	50%	66%	75%
Steep Slopes and Cliffs	50%	66%	75%
Summits	50%	66%	75%

* Percentage goals for ELUs vary with rarity, with rarer ELU types having the highest and common types having the lowest.

two outputs. First, MARXAN selected the single run (of the 100 total runs) that best met the conservation feature goals while minimizing the cost. This is termed the "Best Run." MARXAN also tallies the number of times each individual planning unit is selected in each of the 100 runs. This summary is termed the "Summed Runs" output. The summed runs output can also be thought of as summed "irreplaceability," defined as the "extent to which the loss of the area will compromise regional conservation targets (Margules and Pressey 2000)." An area that scores highly in the summed runs output might not be included in the best solution, but could be considered an alternative site (Carroll et al. 2003).

Due to our interest in controlling for variation in the boundary length modifier and the goal levels, we calculated an additional summary variable. For all of the 12 scenarios, we summed the summed runs outputs. We call this output "summed-summed run." Therefore, each planning unit could potentially have been selected from 0–1200 runs. Those planning units selected a majority of times, as well as those selected infrequently, demonstrate a relative insensitivity to changes in the boundary length modifier and the goals. Thus, as discussed above, those areas that are selected repeatedly can be interpreted as having a high utility or usefulness for the overall design. Those planning units selected a moderate number of times are more sensitive to the input parameters, but still contribute to meeting the goals of the reserve design.

Data Limitations

With the assistance of The Nature Conservancy and its partners, we were able to assemble uniform data coverages for the tracks (representation, special elements, focal species) discussed above for the Northern Appalachian/Acadian portion of the region. We were not able, however, to obtain the following uniform datasets for incorporation into the site selection analysis:

- land-use/land-cover (these data were incorporated into the focal species analyses, so they do have some influence on the results, albeit not as a distinct conservation feature or target for which goals could be established);
- special element occurrences, such as G1/G2 or S1/S2 species at the state and provincial level;
- TNC's Tier 1 matrix forest blocks in the Northern Appalachian/Acadian ecoregion (we were able to incorporate the matrix blocks into the post site selection process of network design, as described below);
- data on most coastal shore and wetland ecosystems; and
- aquatic features.

Focal species data were available for the lowland St. Lawrence/Champlain Valley ecoregion, and for a very small portion of the Lower New England ecoregion, but uniform data sets for representation and special elements were not available for those ecoregions.

As a result of these data gaps and the regional-scale

TABLE 5 General goals for each conservation feature.

	Scenario	Goal: Focal Species	Goal: Environmental Variation	Goal: Special Elements	Boundary Length Modifier
Low	1	Low	Low	Low	0.0
	2	Low	Low	Low	0.001
	3	Low	Low	Low	0.01
Medium	4	Medium	Medium	Medium	0.0
	5	Medium	Medium	Medium	0.001
	6	Medium	Medium	Medium	0.01
High-Low	7	High	Low	High	0.0
	8	High	Low	High	0.001
	9	High	Low	High	0.01
High	10	High	High	High	0.0
	11	High	High	High	0.001
	12	High	High	High	0.01

focus of our analyses, it is likely that we have not identified important smaller-scale habitats that warrant protection. The results of other, finer scale mapping efforts will identify additional important local areas of conservation, especially in coastal areas.

Results of the Site Selection Analysis

Below we present the results for the series of best runs (Table 6, Figure 7). In each of the 12 scenarios, the relevant goal levels (low, medium, high-low and high) are met for all conservation features.[4] The 12 scenarios in Figure 7 are arranged such that the top three are those with the lowest goals, the middle two rows meet medium and high-low goals, respectively, and the bottom row meets the highest goals. Similarly, the scenarios are arranged from left to right, such that the left column contains those with no boundary modifier (no clumping rules [0.0]), those in the middle column have medium clumping rules (0.001), and those in the right-hand column have higher clumping rules (0.01).

The amount of area encompassed in a given best run varies considerably based on the combination of goal scenario and boundary length modifier. For the lowest set of goals, with no boundary length modifier (scenario 1), the best run encompasses 81,836 km^2 (20,222,080 acres), or about 21% of the study area. Increasing the boundary length modifier to 0.001, and therefore the spatial cohesiveness or "clumpiness" of the output, while maintaining the same (low) goals, increases the best run area to 97,485 km^2 (24,088,960 acres) or 25.2% of the study area (scenario 2). The highest goals, without a boundary length modifier (scenario 10), increase the area of the output to 64,472 km^2 (41,262,080 acres), more than double the area of the lowest goal/boundary length modifier combination. As would be expected, the highest goals with the highest boundary length modifier (scenario 12) requires the highest area of all the scenarios, 50.5% of the study area.

We also intersected the best run for each scenario with the corresponding summed run result for each scenario, then classified the results as to how frequently a given planning unit was selected (Figure 8). These intersected outputs provide additional insight into the relative importance or irreplaceability of a particular planning unit within a given scenario. That is, the more frequently a given planning unit is selected, the more it contributes to satisfying the goals set for the conservation features (put anoth-

TABLE 6 Best runs under each MARXAN scenario, by area (km^2, acres, and square miles) and as a percentage of the Greater Northern Appalachian study area.

Scenario	Goals	Boundary Length Modifier (BLM)	Best Run (km^2)	Best Run (sq. mi.)	Best Run (acres)	% of study area
1	Low	0	81,836	31,597	20,222,080	21.1%
2	Low	0.001	97,485	37,639	24,088,960	25.2%
3	Low	0.01	123,721	47,769	30,572,160	31.9%
4	Med	0	114,959	44,386	28,407,040	29.7%
5	Med	0.001	131,217	50,663	32,424,320	33.9%
6	Med	0.01	159,035	61,404	39,298,560	41.1%
7	High-Low-High	0	122,358	47,243	30,235,520	31.6%
8	High-Low-High	0.001	141,228	54,528	34,897,920	36.5%
9	High-Low-High	0.01	172,540	66,618	42,635,520	44.5%
10	High	0	166,980	64,472	41,262,080	43.1%
11	High	0.001	176,427	68,119	43,596,160	45.5%
12	High	0.01	195,815	75,604	48,386,560	50.5%

4. There are a total of 2172 combinations of conservation features and goals (12 goal scenarios * 181 features). Although 23 of these combinations did not meet 100% of their goals, in these instances >99.9% of the goal was met, essentially meeting the 100% goal.

FIGURE 7 Map composition showing MARXAN best run for each scenario. Green planning units are those that were locked-in because they contain status 1 and 2 LPSCDs.

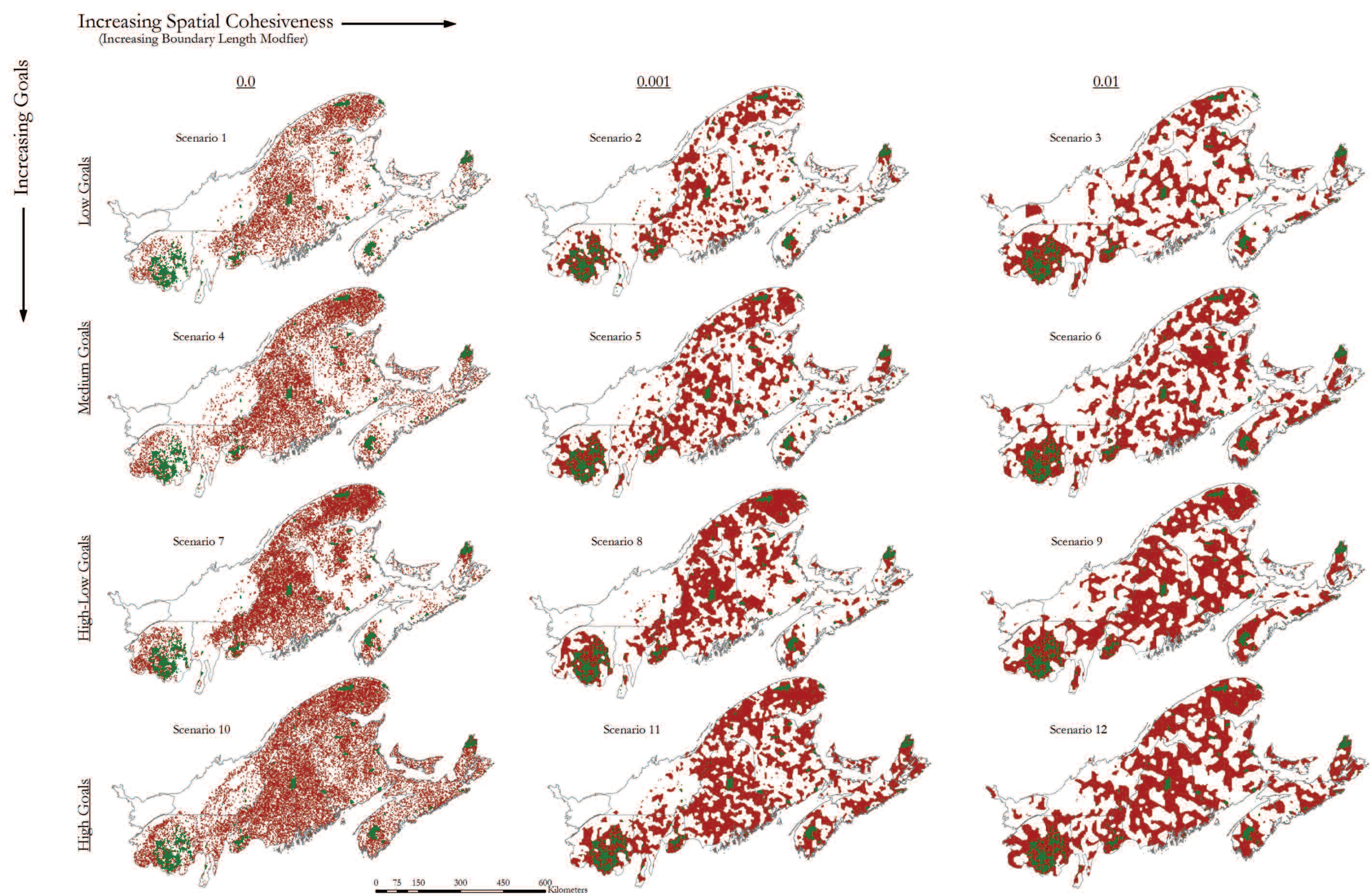


FIGURE 8 Map composition showing MARXAN best run for each scenario intersected with corresponding summed run. Orange colors indicate planning units selected greater than 50% of the time. Green planning units are those that were locked-in because they contain status 1 and 2 LPSCDs.

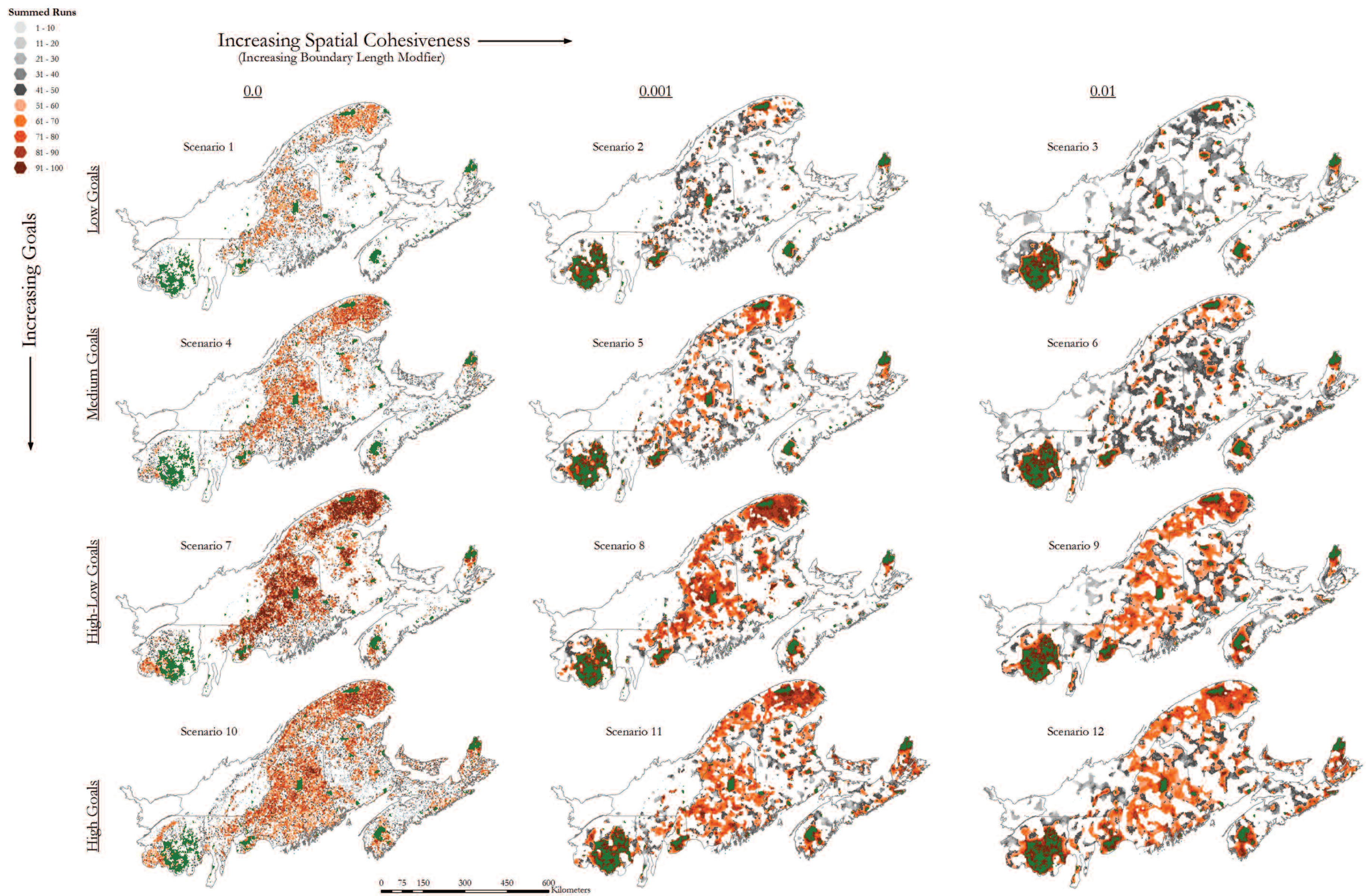
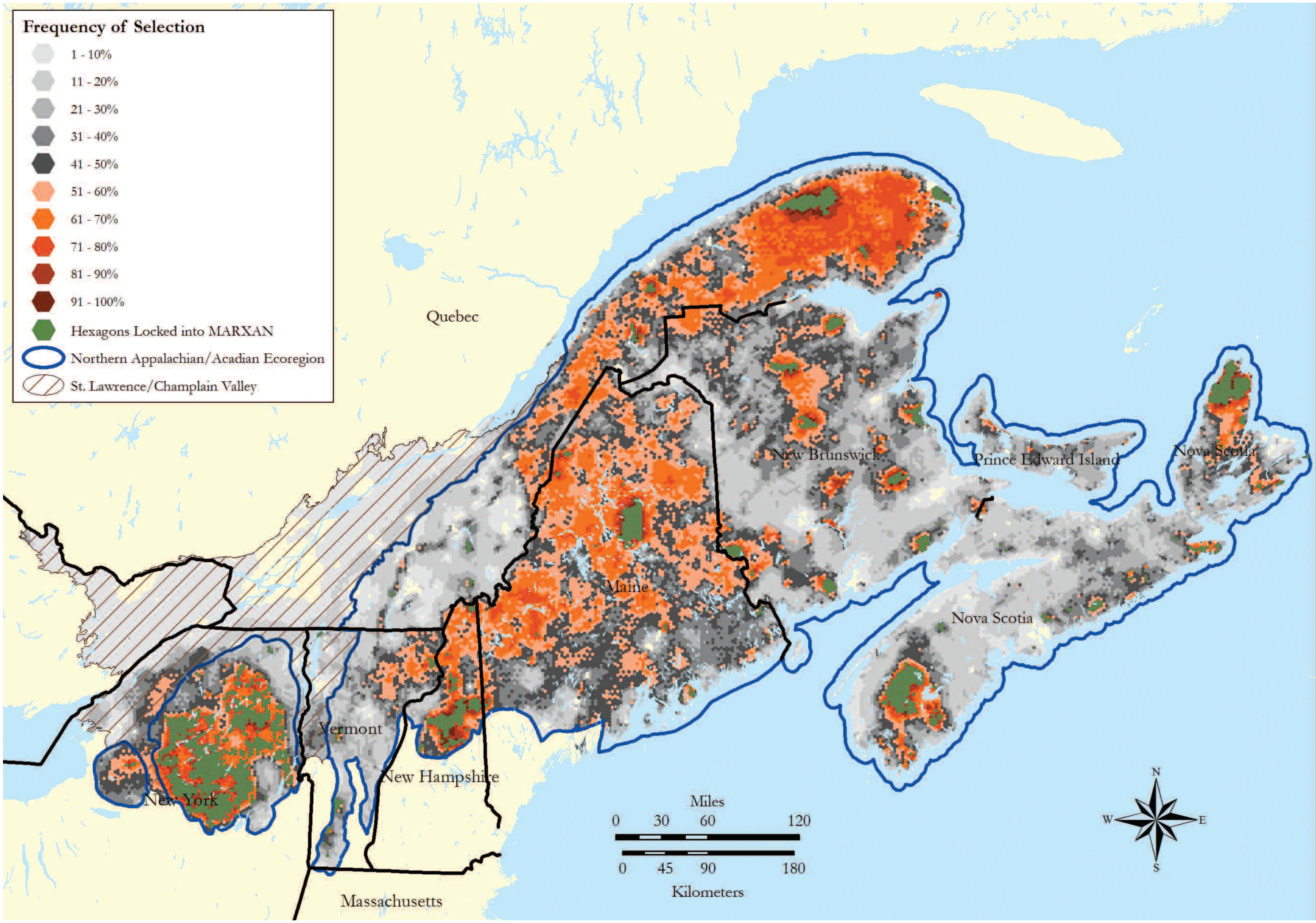


FIGURE 9 Summed-summed run output. This output sums the summed run outputs of all 12 scenarios. Orange colors show those planning units selected greater than 50% of the time in all scenarios. Green planning units are those that were locked in because they contain status 1 and 2 LPSCDs.



er way, the more frequently a planning unit is selected, the more irreplaceable it is), so we want to pay special attention to those units selected most frequently in developing our network design.

Finally, we combined the summed runs for all 12 scenarios to create the summed-summed run output (Figure 9), and similarly classified these results by frequency of planning unit selection. These results show the relative importance of each planning unit for meeting the goals regardless of the scenario displayed.

Methods for Creating the Wildlands Network Design

From Decision-support to Decision-making The output from the MARXAN analyses provides useful information to support decisions about the location and extent of the elements of a wildlands network design. However, since there are several potential solutions, additional steps need to be taken to incorporate local knowledge, and other data that may not have been captured by the site selection algorithm, to make defensible decisions regarding the network design.

Defining the Network Elements In theory, a wildlands network design should be comprised of core wild areas, wildlife linkages and stewardship (or compatible use) lands. As described below, we were able to identify numerous new potential core areas. However, as we proceeded with the design, we found it difficult to distinguish between linkages and stewardship lands. We decided, therefore, to combine these elements into a single classification: "High Biological Significance (HBS)." This term has been used in other wildlands network designs (e.g. Foreman et al. 2003). Accordingly, we use the following elements in our wildlands network design.

EXISTING CORE PROTECTED AREAS These are existing Status 1 or 2, Lands Permanently Secured from Conversion to Development (LPSCDs);

PROPOSED CORE AREAS These are areas of concentration of high conservation values that we believe warrant a high level of protection based on the analysis;

AREAS OF HIGH BIOLOGICAL SIGNIFICANCE (HBS) These are areas that we have identified as having significant conservation value at a regional scale based on the analysis. Although the HBS lands are vital to achieving the conservation goals for the network as a whole, in general they had somewhat lower conservation values than either existing or proposed core areas. Some of these lands are currently Status 3 LPSCDs. Additional study and discussion with stakeholders will be needed to determine the precise conservation designation and management objectives for these lands. Wildlife linkages have been included in the HBS category.

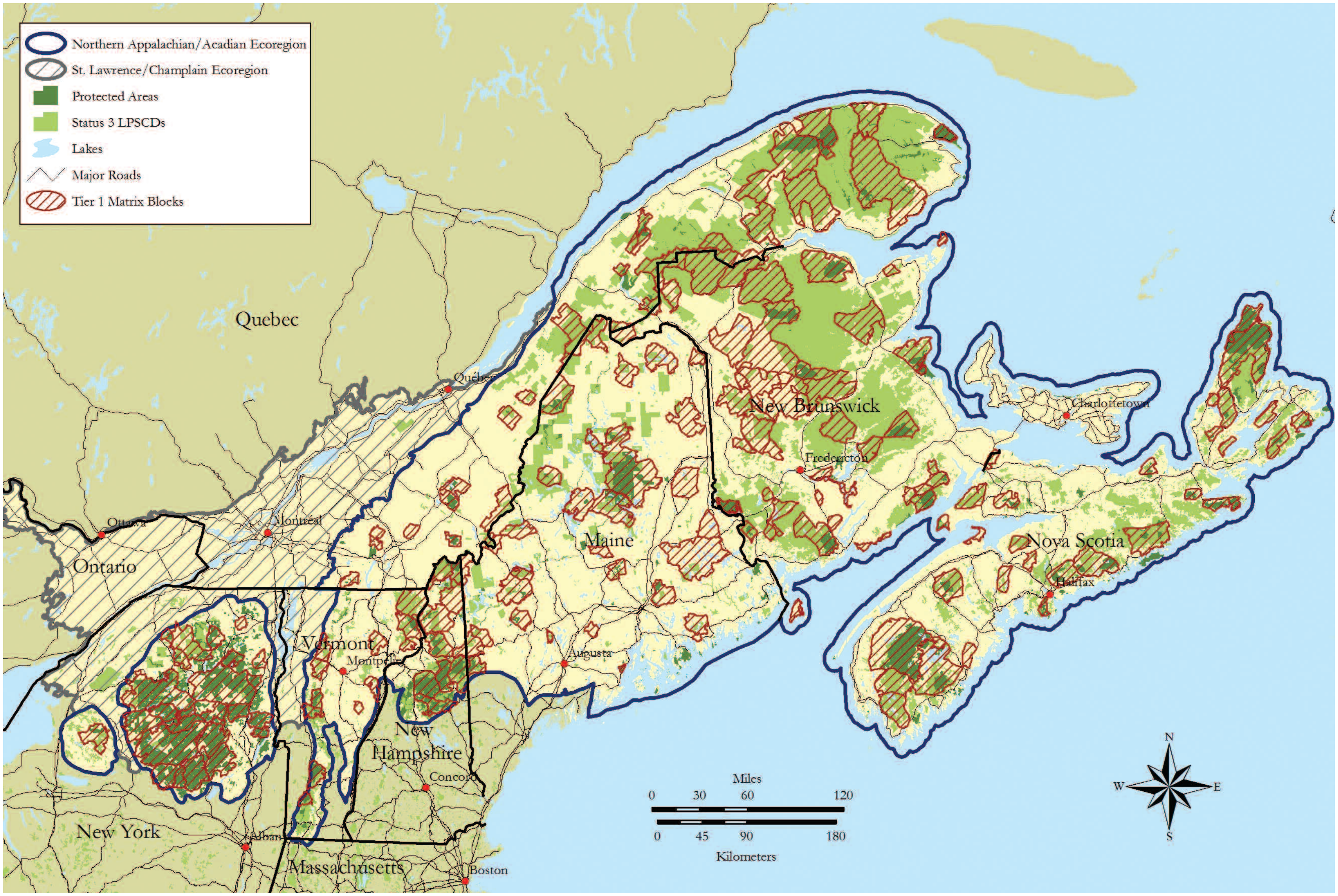
LPSCDS NOT SELECTED AS PROPOSED CORE OR HBS LANDS We have also identified a fourth category of LPSCDs that we have not included in the network, but that we have indicated on some of the maps since they can contribute to the functioning of the network and to biodiversity conservation. These are Status 3 LPSCDs, nearly all Crown Lands in Nova Scotia, New Brunswick and Québec, that we did not identify as either proposed core or area of high biological significance but that supplement the network. These lands contribute to the functioning of the overall network and should be subject to best management practices, such as certification by the Forest Stewardship Council (FSC).

To establish the location and extent of the network design elements, we used three major sources of information: 1) the results of the site selection analyses discussed above; 2) The Nature Conservancy's Tier 1 matrix forest blocks in the Northern Appalachian/Acadian ecoregion (Anderson et al. 2006); and 3) input from experts, such as local leaders in environmental non-governmental organizations, representatives from government wildlife agencies, and university scientists. To obtain expert input we conducted a series of meetings in Nova Scotia, New Brunswick, Québec, Vermont, New York and Maine from January through May 2006.[5]

The Nature Conservancy's (TNC) Tier 1 matrix forest blocks (Figure 10) were identified after we had completed our site selection analyses, so these blocks were not incorporated as distinct ecological features in the MARXAN algorithm. We were, however, able to incorporate the blocks into the expert-driven network design process that occurred after the site selection analyses were completed. Through consultations with TNC and other experts, the matrix blocks were overlain with the results of the site selection analyses and taken into account in choosing and refining the preferred scenarios. In some cases, the network boundaries were expanded or adjusted to incorporate a

5. Massachusetts was excluded from the analysis because only a very small portion of the state falls within the study area. Prince Edward Island was excluded because it is separated from the mainland by water and because its environment is so highly modified.

FIGURE 10 The 176 critical forest sites, or Tier 1 matrix forest blocks, in the Northern Appalachian/Acadian ecoregion. TNC and partners recommend a 10,000-hectare (25,000 acre) core reserve in each block devoted to the restoration of complete forest ecosystems surrounded by lands secured from conversion to development. Source: Anderson et al. (2006).



Tier 1 block that local experts considered an exceptional example of conservation values, either in addition to or instead of representing these values elsewhere in the network. Occasionally a Tier 1 block was not added or incorporated into the network design, such as when its conservation value was considered adequately captured by another area within the network design. In some of these cases, the area selected by the site selection analyses overlapped with Tier 2 blocks identified by TNC as alternatives to or of similar conservation value as Tier 1 blocks. (The multistep process utilized by TNC to delineate the Tier 1 and 2 matrix forest blocks is summarized in Appendix 1 and described in detail in Anderson et al. [2006]) As a consequence of these and other refinements, the network design includes 76% of the total area of the Tier 1 matrix blocks.

In addition to those based on TNC's matrix forest blocks, a summary of the refinements from expert input received during the series of meetings in each state or province follows (see Appendix 3 for detailed descriptions of these refinements).

NOVA SCOTIA Participants chose the best run of scenario 6 (medium goals for all features; highest BLM of 0.01) as the base scenario because it captures many of the known conservation priorities in the province. They also recommended that we add certain elements from the best run of scenario 12 (highest goals for all features; highest BLM of 0.01) to capture other known areas of high ecological value and importance for connectivity. Participants also recommended that we reduce the scope of the design from that shown in scenario 6 in certain areas, such as the west coast and southern end of Cape Breton. A number of linkages were also added based on expert knowledge. In refining the network for Nova Scotia we were able to draw on the work of Beazley et al. (2005), which delineated potential areas of core and connectivity based on analysis of representation, special elements and focal species. We also drew on the work by the Nova Scotia Public Lands Coalition/Ecology Action Center to delineate new wilderness areas in the Chignecto and Ship Harbor Long Lake regions.

NEW BRUNSWICK Participants chose the best run of scenario 12 a base scenario because it captures many of the known conservation priorities in the province, but recommended that we add elements of the best run of scenario 9 (higher focal species goals, lower representation goals, higher special element goals; highest BLM of 0.01). A number of HBS lands that did not occur in either scenario 9 or 12 were added based on expert opinion, including unfragmented sections of Gagetown military reserve. Participants also recommended that we reduce the scope of the design plan from that shown in scenario 12 in the heavily used agricultural areas on the western border of New Brunswick. We also added a five-km-wide buffer around the network design elements. The buffering is intended to provide flexibility in ensuring a portion of the area will always be managed in support of the larger network while determining how and where resources will be managed within the area. For example, functional linkages between core areas should always be maintained somewhere within these buffer areas, while allowing for shifting linkages over space and time.

QUÉBEC Local experts divided the portion of the province that falls within the study area into three smaller regions: "Eastern," "Central," and Western," and selected a preferred scenario for each subregion. These sections are similar to the sub-regions described in Québec's ecological land classification system (Anderson et al. 2006). The Eastern section is equivalent to the Gaspé Peninsula; the Central section comprises the Temiscouata Hills, with its limit somewhat offset to the west and capturing part of the Beauce area; and the Western section encompasses the two remaining Appalachian subregions: the Estrie-Beauce Plateaus and Hills and the Green and White Mountains.

For the Eastern section, planning units were included from the best run of scenario 9. Within the Eastern section, cores were delineated where the summed-run values, within the best-run outline from scenario 9, were greater than 80%. All planning units within the best-run outline with summed-run values less than 80% were included as HBS lands. For the Central section, planning units were included from the best run of scenario 9. Within this best run, core areas were identified as those with summed-run values of greater than 70%. For the Western section, planning units were included from the best runs of scenario 6 and scenario 12. Planning units with values greater than 50% for scenario 6, and 60% for scenario 12 were included as cores.

VERMONT Meeting participants identified scenario 11 (higher goals for focal species, representation, and special elements; moderate BLM of 0.01) as the preferred scenario. After reviewing the results of the analysis for the St. Lawrence/Champlain Valley portion of Vermont, local experts concluded that the results were not robust enough to support the identification of a network design in that ecoregion, since the input data consisted only of focal-species features. The Lower New England ecoregion has focal-species data only; there is, however, a probable linkage between the Adirondacks and Vermont in this ecoregion. The site selection analysis under Scenario 11 shows a large block of planning units selected with high frequency. We reviewed these results with local experts and they concurred that the planning units selected with high frequency, mostly in the Lake Bomoseen area to the east of Lake George, were indeed important and should be included in the network. Linkages between the Lake Bomoseen complex and important core and proposed core areas in southern Vermont were also identified during the review process.

NEW YORK Workshop participants recommended that we add relatively small amounts of new core protected areas to the base of existing protected areas within the "Blue Line" Adirondack Park boundary, focusing instead on ensuring that connectivity between the Park and other areas of the region be maintained or restored. Important connectivity regions identified include the linkage with Tug Hill Plateau, the Algonquin to Adirondack linkage with Algonquin Provincial Park (Quinby et al. 1999, 2000), and the linkage with Vermont, south of Lake Champlain. We excluded planning units selected within the St. Lawrence/Champlain Valley ecoregion except those within the three linkages noted above, and those in selected hamlets within the Blue Line (reflecting feedback from meeting participants).

MAINE We conducted five meetings that did not achieve consensus around a single scenario that should serve as the basis for further conservation planning, though there was somewhat more agreement around scenario 8 (higher goals for focal species, lower goals for representation, and higher goals for special elements, moderate BLM of 0.001). The best run of scenario 8 was consequently used as the basis for a first draft, along with other inputs. We returned to Maine in May 2006 to review this first draft with a set of experts in a daylong workshop. That workshop produced several changes that have been incorporated into the current network design, including the addition of lands of high biological significance in Downeast Maine (based on scenario 12), the addition of a linkage along the upper St. John River in far northern Maine (based on expert opinion), and the elimination of several gaps within and between HBS lands in northern and western Maine (based on expert opinion plus summed-summed runs and alternate scenarios.)

NEW HAMPSHIRE We did not conduct face-to-face meetings in New Hampshire because such a large portion of the state in the study area is already in some form of conservation. Instead we drafted a proposed design for the state and sent it to several external reviewers for their consideration. Two experts from New Hampshire attended face-to-face meetings in Maine. The design outline included planning units containing more than 50% of Tier 1 matrix blocks, more than 10% of Status 1 or 2 LPSCDs, and more than 25% of Status 3 LPSCDs. We delineated proposed cores by intersecting the network outline with summed runs values from scenario 11. Planning units selected 70% or more were included as cores. Planning units selected less than 70% were included as areas of high biological significance. A reviewer noted some gaps in the resulting design, which were corrected.

Methodological Limitations and Strengths

Wildlands network design is an interplay of applied science and expert judgment and as a consequence the results that are produced will vary with the assumptions made, the factors considered, and the quality of the input data. As previously described, there are several issues related to gaps in the availability of consistent data across the study area. With updated and more-detailed data, it is possible that certain planning units would be identified as of greater or lesser importance, potentially influencing network design. Nonetheless, we have made every attempt to acquire and utilize the best available data at this time.

One factor with the potential to influence the network design involves the suite of focal species used. Wolf, lynx and marten all occur or have occurred throughout the study area. However, as the results of Carroll (2003, 2005) demonstrate, source habitats for these species will likely be concentrated in the boreal and sub-boreal portions of the study area, in good part because this is where snowfall, a critical factor in marten and lynx viability, is greatest. Carroll (2005:36) observes that "decreased snowfall impacts marten and lynx through decreased prey abundance and/or vulnerability, and decreased competitive advantage over sympatric carnivores (Krohn et al. 1995, Mowat et al. 2000)." Carroll (2005: 36) further notes that "this relationship may change as competitor and prey species themselves each respond individualistically to climate change. However, the application of climate change predictions here is valuable as an initial exploration of the potential effects of decreased snowfall and the interaction of climate change with other threat factors."

In any event, another set of focal species analyses should be conducted with a suite of species that are more specific to the non-boreal and Acadian portions of the ecoregion and more prevalent in landscapes with more human influence. For example, reviewers in Maine focused on the region encompassing Skowhegan, Farmington, Augusta, and Waterville, and suggested that moose, fisher and brook trout may be better focal species for that region. These and other species have also been identified as potential focal species for Maine and Nova Scotia (Beazley and Cardinal 2004), with potentially broader applicability to the Northern Appalachian/Acadian ecoregion. In their conservation system planning for Nova Scotia, Beazley et al. (2005) used moose, marten and goshawk.

The analyses do not adequately consider aquatic systems, particularly riverine connectivity. This is at least partially as a consequence of data limitations, which led to an early decision to exclude aquatic considerations, a problem that is not uncommon to network design analyses. River corridors in particular are threatened by development and ELUs associated with rivers are not well represented in the draft network. Reviewers in Maine, for example, noted that there are no complete pathways from the coast to the rest of interior Maine and agreed that those connections are important.

It is also important to remember that goals were set at a regional versus sub-regional scale. Since goals for the conservation features could be met anywhere in the study area, site selection occurs over the region as a whole—an area in Acadian Nova Scotia is as valid as one in the Adirondacks of New York in meeting a given set of goals. This may cause the results to cluster in areas such as northern Maine and the Gaspé Peninsula of Québec where the goals may be satisfied in a more efficient manner, such as by capturing several goals in one location and by responding to boundary modifier rules. In other studies (e.g., Carroll et al. 2003) subregional-scale goals have been set within a region. This approach in the Northern Appalachian/Acadian ecoregion would likely change the distribution of the outputs, perhaps providing a more even distribution of sites throughout the study area. We recommend that future site selection analyses stratify the study area into smaller regions and establish goals for those regions, while maintaining regional goals.

During our visits to Maine, reviewers expressed concern that the focal species data set might not capture the actual lynx source habitat in the northern part of the state. We asked lynx researchers at the University of Maine about this critique and their opinion was that the dataset is accurate, though perhaps conservative in estimates of source habitat in the north. They recommended that we use scenario 8, with its high focal species goals, as a base and that we identify connectivity to important source areas in New Brunswick and Québec. The connectivity recommendations by the University of Maine researchers closely matched those of Carroll (2005). We incorporated these recommendations into our design for Maine. We also note that the inputs to the lynx PATCH scenarios were based on Hoving et al. (2005), which is the best published material on regional lynx habitat. Based on this assessment, we believe that this dataset is sound for the purposes of the conservation planning presented here, but it should be carefully reviewed and updated as necessary.

For focal species conservation features and goals, we used a combination of predicted source and threatened source data as inputs into the site selection analysis. Unlike some other analyses that have used a combination of dynamic population model results and a site selection algorithm (e.g., Carroll et al. 2003), we were not able to quantitatively evaluate the resulting network design to confirm that it provides a threshold amount of source and other habitat necessary to insure population viability. We did, however, consult with relevant wildlife experts who indicated, on the basis of their familiarity with the species and the region and their best judgment, that there appeared to be sufficient habitat area encompassed by the network in key areas such as northern Maine. Nonetheless, we recommend that there be capacity, as part of a package of future focal species studies, to evaluate the network design for its ability to provide sufficient habitat to support viable populations of a range of focal species.

The boundary length modifier function of MARXAN enables the site selection algorithms to "generate options that are well connected (Leslie et al. 2003)." Caution should be exercised, however, in using the linkages that result, since there is no guarantee that these connectivity options are appropriate for specific species. We have attempted to use the results of the PATCH analyses, and their identification of important source areas and broad linkage outlines, as guides in the network design refinement process. Researchers using similar combinations of site selection algorithms and dynamic population models (Carroll et al. 2003) have used the technique of starting with best run outputs from the site selection, then adding additional areas to serve as linkages based on information derived from PATCH. Summed-run results can be used in this context to more precisely determine the linkage locations. Although we have attempted to follow this method, linkage delineation in this region would benefit from additional field data, future analyses of least-cost paths in selected areas, additional local and expert input, and remotely-sensed data such as high-resolution satellite imagery and aerial photos.

It is critical to rerun the site selection algorithm on a regular basis to incorporate new data and changes in potential conservation areas, such as the establishment of new protected areas and the conversion of natural areas to urban land uses. The comprehensive conservation planning initiative envisioned by 2C1Forest in 2006 and 2007, described below, anticipates increasing the capacity among researchers in the region to use this software, and we strongly endorse this effort.

Despite these cautions in interpreting the results, it is important to acknowledge the strengths of this analysis. First, the analysis incorporates a comprehensive, ecoregional-scale focal species dimension to conservation planning for this region. As Carroll (2003: 2) observes, "comprehensive analysis of viability needs for the three species can result in a stronger and more efficient restoration strategy than would separate single-species recovery efforts." Second, we were able to assemble, through collaborations with generous partners, a uniform dataset for a broad, representative array of conservation features. Third, we applied a site selection algorithm at an ecoregional scale, bringing this powerful tool to bear on conservation decision-making in this region. We hope that this dataset, and the underlying grid of planning units, can serve as a springboard for refined conservation planning as well as a monitoring framework to track conservation progress. While this network design should be refined as new data and resources become available, it does provide important insights into the major regional patterns of high terrestrial conservation value and landscape linkages. Regardless of future adjustments, it is unlikely that concentrated areas of the most highly irreplaceable conservation features at the regional scale identified through this analysis will vary significantly.

Results of the Network Design

The composite wildlands network design created as a consequence of the MARXAN analyses and subsequent consultations with local experts encompasses approximately 47% of the study area (Figure 11). It consists of existing and proposed core protected areas, and other areas of high biological significance (including potential stewardship/buffer areas and linkages between core protected areas), and is supported by additional LPSCDs outside of the network.

We classify proposed core areas into primary and secondary categories based on information from the summed-summed runs output (Figure 12). We recommend that all proposed cores receive status 1 or 2 protection over time. Primary cores likely have the highest conservation value based on the analysis and thus may be higher priority. Similarly, we classify high biological significance lands into three categories (primary, secondary, and tertiary) based on summed-summed runs data. Primary HBS lands likely have higher conservation value than other HBS lands and so should be given priority both in terms of future assessments and conservation. Nonetheless all are important to achieving the percentage conservation goals for special elements, environmental variation, and source habitat for focal species. That is, the network as a whole identifies those conservation areas that are likely essential for long-term persistence of biodiversity in this region.

Due to the data gaps in the St. Lawrence/Champlain Valley ecoregion, we have restricted most of our network design elements to the Northern Appalachian/Acadian portion of the study area, with the exception of obvious linkages within the St. Lawrence/Champlain Valley region. Because of this exclusion, the statistics cited below and summarized in Tables 7 and 8 are likely conservative estimates of the amount of land that should be included in a comprehensive network design.

- The total proposed network would span 181,519 km^2 (44,835,112 acres) or about 47% of the study area.
- All existing status 1 and 2 lands, currently 24,661 km^2 (6,091,267 acres), or 6.4% of the region, are captured in the proposed network.
- An additional 42,053 km^2 (10,387,010 acres) in proposed core areas, about 11% of the region, are identified.
- About 60,235 km^2 (14,878,045 acres) of current status 3 LPSCDs, or 68% of the current total of 88,952 km^2 (21,971,035 acres) in the study area as whole, are included in the network.
- We identified 114,805 km^2 (28,356,835 acres) of lands of high biological significance, about 29.5% of the region.
- Of the total proposed network, about 14% is in existing core protected areas, about 23% is in proposed core areas and the remaining 63% is in high biological significance lands. Thirty-three percent of the proposed network is currently in status/gap 3 or Public/Crown lands.
- A total of 96,623 km^2 (23,865,800 acres) remain unsecured from development, or about 53% of the total proposed network (Figure 13).

- There are 28,717 km² (7,092,990 acres) of status 3 LPSCDs, nearly all Crown Lands in Nova Scotia, New Brunswick and Québec, that we did not identify as either proposed core or area of high biological significance but that supplement the network. These lands contribute to the functioning of the overall network and should be subject to best management practices, such as certification by the Forest Stewardship Council (FSC). When combined, the proposed network and non-selected LPSCDs total 210,235 km² (51,928,102 acres) or about 54% of the planning area.

We have identified several broad high-priority areas, based on a combination of empirical information about regional biological importance (as derived from one or more site selection scenarios and the summed-summed runs output), contribution to regional and local connectivity (as derived from Carroll [2003, 2005], site selection scenarios and consultations with local experts), and qualitative threat information gleaned from local expert input, such as planning officials and non-governmental organizations (Figure 14). We have not established conservation priority among the areas listed below, so they are numbered on a rough east-to-west basis.

1) CHIGNECTO ISTHMUS LINKAGE This linkage connects Nova Scotia with the rest of the ecoregion, preventing the functional isolation of populations of focal species: "although holding little suitable habitat currently, [the isthmus] may support occasional dispersals which may be critical over the long term for maintenance of genetic viability in the isolated lynx and marten populations of Cape Breton Island (Carroll 2005: 40)." It is also identified as critical by Beazley et al. (2005).

2) GASPÉ PENINSULA With large forest blocks, and low road and population densities, the Gaspé Peninsula represents an important source area for lynx and marten. Much of the peninsula is selected with high frequency across all site selection scenarios (refer to Figure 9). A high percentage of this area is in some form of public ownership.

3) LOWER GASPÉ/UPPER RESTIGOUCHE RIVER WATERSHED This area, with large forest blocks, is also important for lynx and marten. Portions of this area are selected with high frequency across all site selection scenarios (Figure 9) and Carroll (2003, 2005) broadly identifies habitat connectivity for one or more focal species in this area. According to local conservation groups, sizable blocks of old forest on Crown Land in this part of New Brunswick are threatened by logging operations.

4) LINKAGE FROM NORTHERN MAINE TO RESTIGOUCHE A number of researchers (Carroll [2005] and local experts) identified this linkage as important for lynx and marten.

5) CENTRAL NEW BRUNSWICK LINKAGE This area is broadly identified by Carroll (2003, 2005) as a linkage between potential reestablished wolf populations in Maine and New Brunswick. The area encompasses Canaan Bog protected area and clusters of sites to the northeast of Fredericton that that are selected with high frequency across a range of site selection scenarios.

6) NOTRE DAME MOUNTAINS OF QUÉBEC/ST. JOHN RIVER REGION OF MAINE A particularly important connection between core areas in the Gaspé and the rest of the region is provided by this area. It is selected with high frequency across all site selection scenarios (Figure 9).

7) NORTHCENTRAL MAINE This area, much of which is in private ownership, contains critical focal species habitat and retains large forest blocks with low or no human population density. The area is selected with high frequency across a range of site selection scenarios (Figure 9).

8) WESTERN/BOUNDARY MOUNTAIN REGION OF MAINE A broad diversity of habitats and terrain, including the upper Androscoggin watershed, are located in this region and this area is selected with high frequency across a range of site selection scenarios (Figure 9). This region may be coming under increasing threat from increases in residential development according to Hagen et al. (2005) and land use officials in Maine.

9) MOUNT MEGANTIC (QUÉBEC)/CONNECTICUT LAKES/NORTHEASTERN HIGHLANDS OF VERMONT As with the Boundary Mountains, this diverse terrain supports important representative landscapes and serves as an important landscape linkage. Portions of this area are under increasing threat from road and residential development according to local conservation groups. This area is selected with high frequency across a range of site selection scenarios (Figure 9).

10) GREEN MOUNTAINS (VERMONT)/SUTTON MOUNTAINS (QUÉBEC) The Green Mountain spine, which transitions into the Sutton Mountains of Québec, may provide a north-south linkage along the main stem of the Appalachians.

11) SOUTHERN LAKE CHAMPLAIN LINKAGE Three ecoregions come together in this critical link between the Adirondacks of New York and the Green Mountains of Vermont. Portions of this area are selected with high frequency in several site selection scenarios and local experts confirmed its importance.

12) ADIRONDACK-TO-TUG HILL LINKAGE Carroll (2003) suggests that long-term wolf viability in the

TABLE 7 Summary statistics for wildlands network design for the study area as a whole and by state and province.

Km²	ME	NB	NH	NY	NS	QC	VT	Total
Existing Protected Areas (Status 1 and 2 LPSCD)	2,199	2,192	1,771	10,196	4,492	3,161	650	24,661
Proposed Core	10,157	8,099	1,768	4,095	6,726	9,045	2,163	42,035
High Biological Significance (HBS) lands	31,243	18,182	2,611	8,631	13,509	33,282	7,347	114,805
Total Network	**43,599**	**28,473**	**6,150**	**22,922**	**24,727**	**45,488**	**10,160**	**181,519**
Status 3 LPSCD not in Network	767	15,244	62	594	5,490	6,398	161	28,717
Total	***44,366***	***43,717***	***6,212***	***23,428***	***30,217***	***51,886***	***10,321***	***210,235***
Acres								
Existing Protected Areas (Status 1 and 2 LPSCD)	543,153	541,424	437,437	2,518,412	1,109,524	780,767	160,550	6,091,267
Proposed Core	2,508,671	2,000,461	436,813	1,011,396	1,661,238	2,234,072	534,359	10,387,010
High Biological Significance (HBS) lands	7,717,021	4,490,954	644,917	2,131,857	3,336,723	8,220,654	1,814,709	28,356,835
Total Network	**10,768,845**	**7,032,839**	**1,519,167**	**5,661,665**	**6,107,485**	**11,235,493**	**2,509,618**	**44,835,112**
Status 3 LPSCD not in Network	189,545	3,765,327	15,253	146,721	1,356,080	1,580,372	39,693	7,092,990
Total	***10,958,391***	***10,798,165***	***1,534,420***	***5,808,386***	***7,463,565***	***12,815,865***	***2,549,311***	***51,928,102***

TABLE 8 Summary statistics, as percentages, for the wildlands network design by province/state and for the study area as a whole.

	ME	NB	NH	NY	NS	QC	VT	Study Area Total
Existing Protected Areas (Status 1 and 2 LPSCD)	2.9%	3.0%	22.2%	26.5%	8.0%	3.3%	3.2%	6.3%
Proposed Core	13.2%	11.1%	22.1%	10.7%	12.0%	9.3%	10.8%	10.8%
High Biological Significance (HBS) lands	40.7%	24.9%	32.7%	22.52%	24.1%	34.4%	36.7%	29.5%
Total Network	**56.9%**	**39.0%**	**77.0%**	**59.64%**	**44.1%**	**47.0%**	**50.8%**	**46.7%**
Status 3 LPSCD not in Network	1.0%	20.9%	0.8%	1.56%	9.8%	6.6%	0.8%	7.4%
Total of Network + Non-selected LPSCDs	***57.9%***	***59.8%***	***77.8%***	***61.2%***	***53.9%***	***53.6%***	***51.6%***	***54.1%***

FIGURE 11 Proposed Wildlands Network Design for the Greater Northern Appalachians. The area included in the network design is shown in light green. Current protected areas (status 1 & 2 LPSCDs) within the network are shown in dark green. The New Brunswick buffer (see text for description) is shown in the lightest green. Status 3 LPSCDs not included in the network are shown in brown.

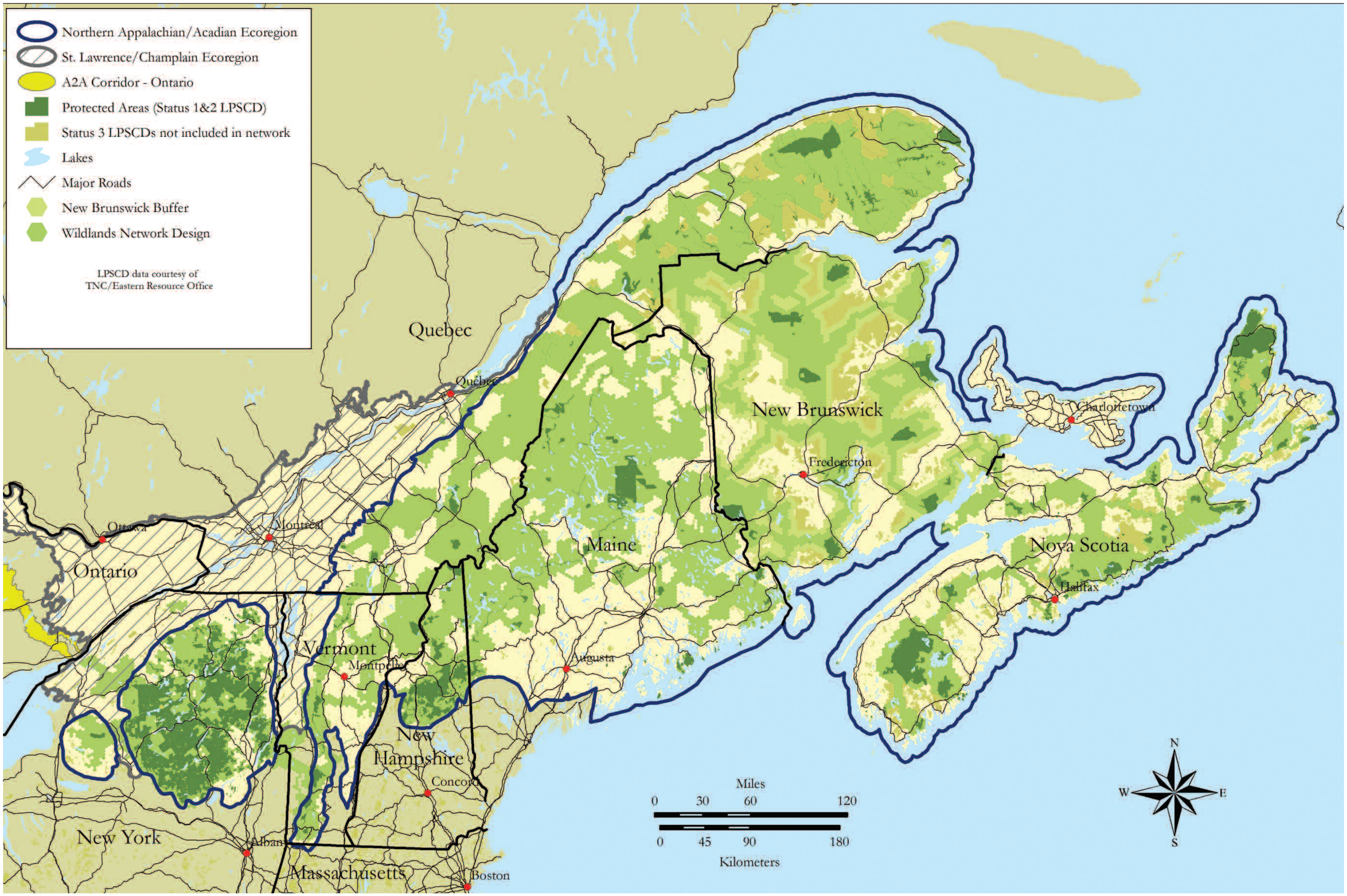


FIGURE 12 Proposed Wildlands Network Design for the Greater Northern Appalachians. Current status 1 and 2 protected areas are shown in dark green, primary and secondary proposed cores are shown in shades of maroon, and areas of high biological significance are shown in shades of brown. Status 3 LPSCDs not included in the network are in light green.

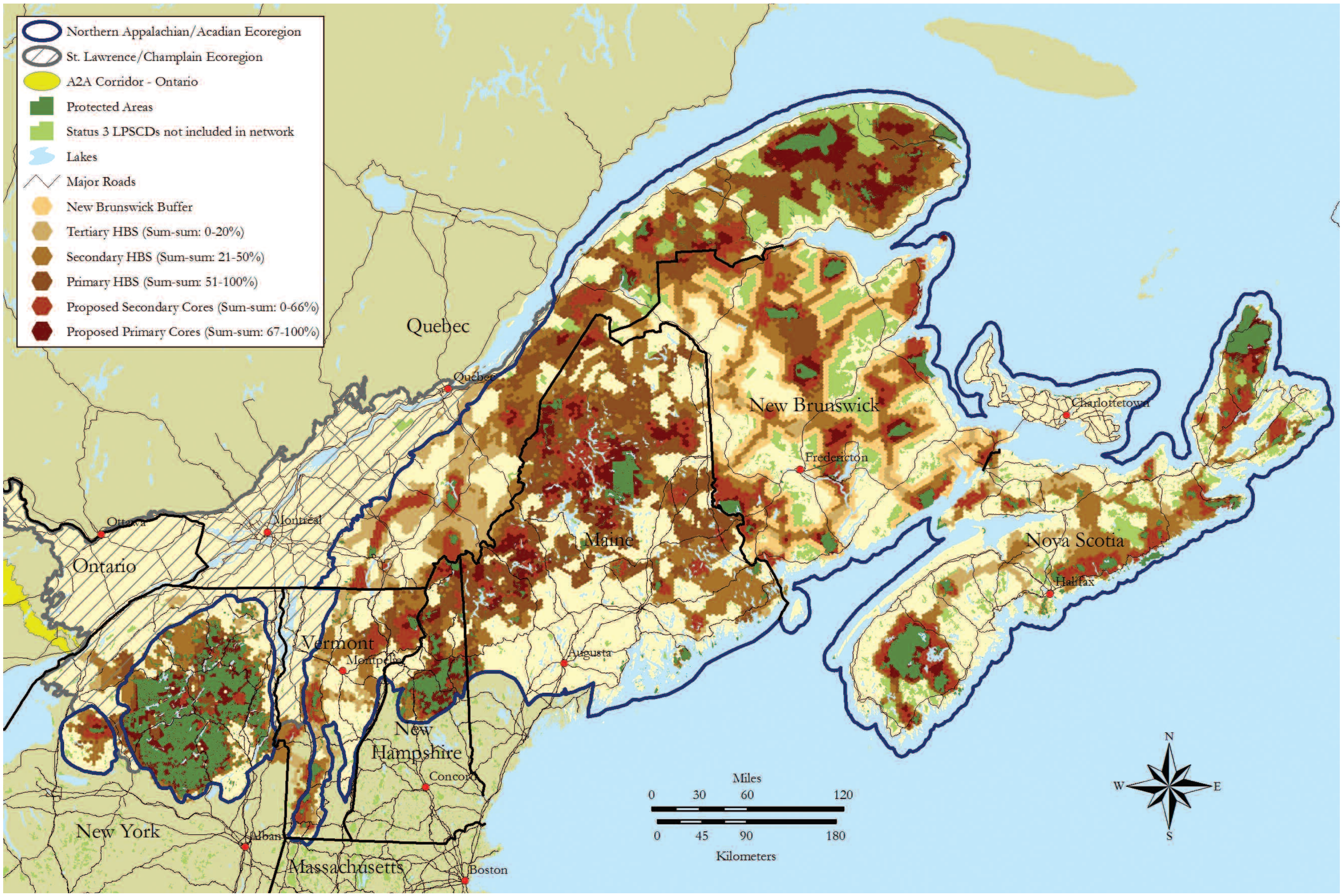


FIGURE 13 Outline of wildlands network design showing lands secured and unsecured from development. Secured lands are shown in tan, unsecured lands in brown. A large block of land in Downeast Maine with recently secured conservation easements is not shown. Status 3 LPSCDs not included in the network are in light green.

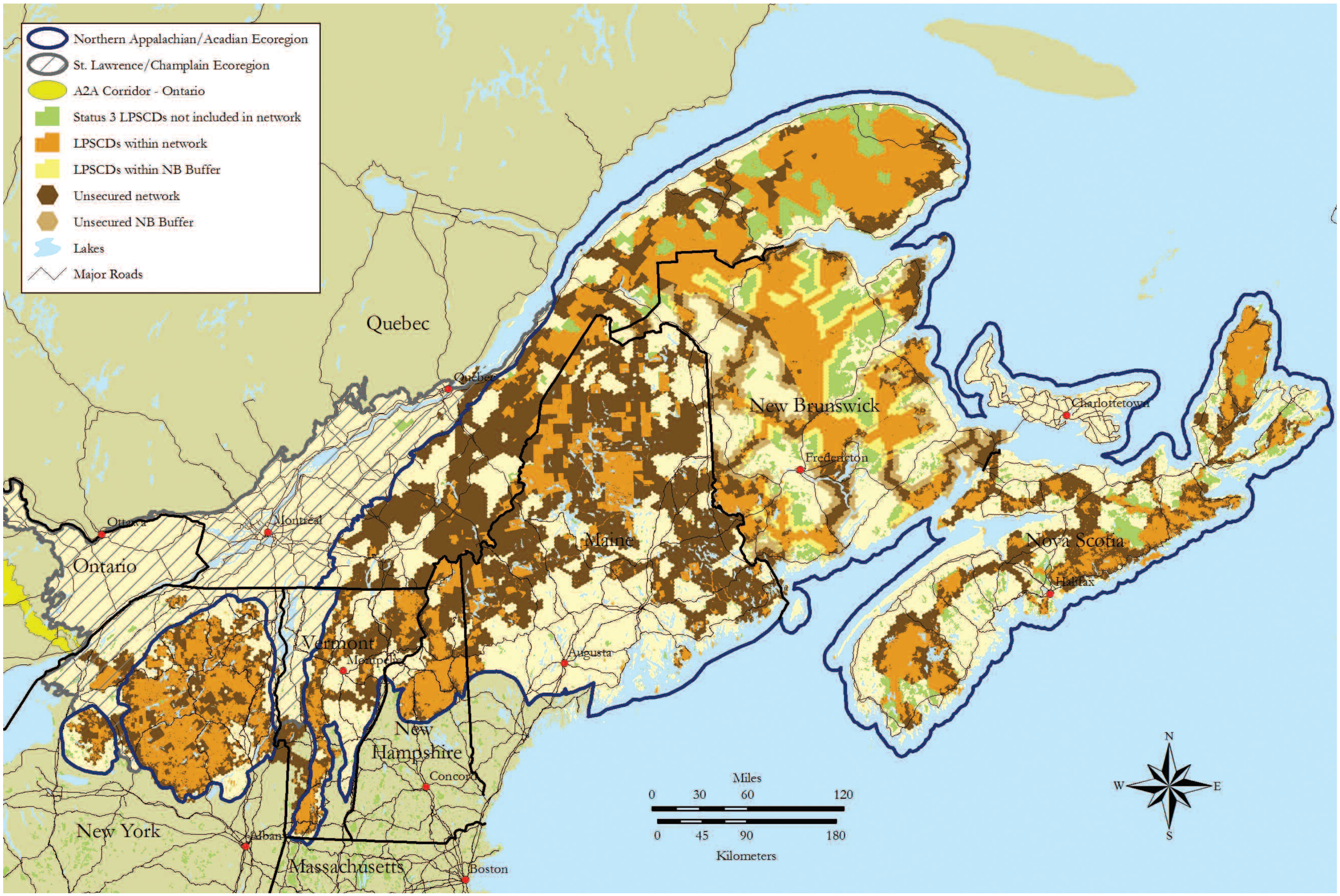
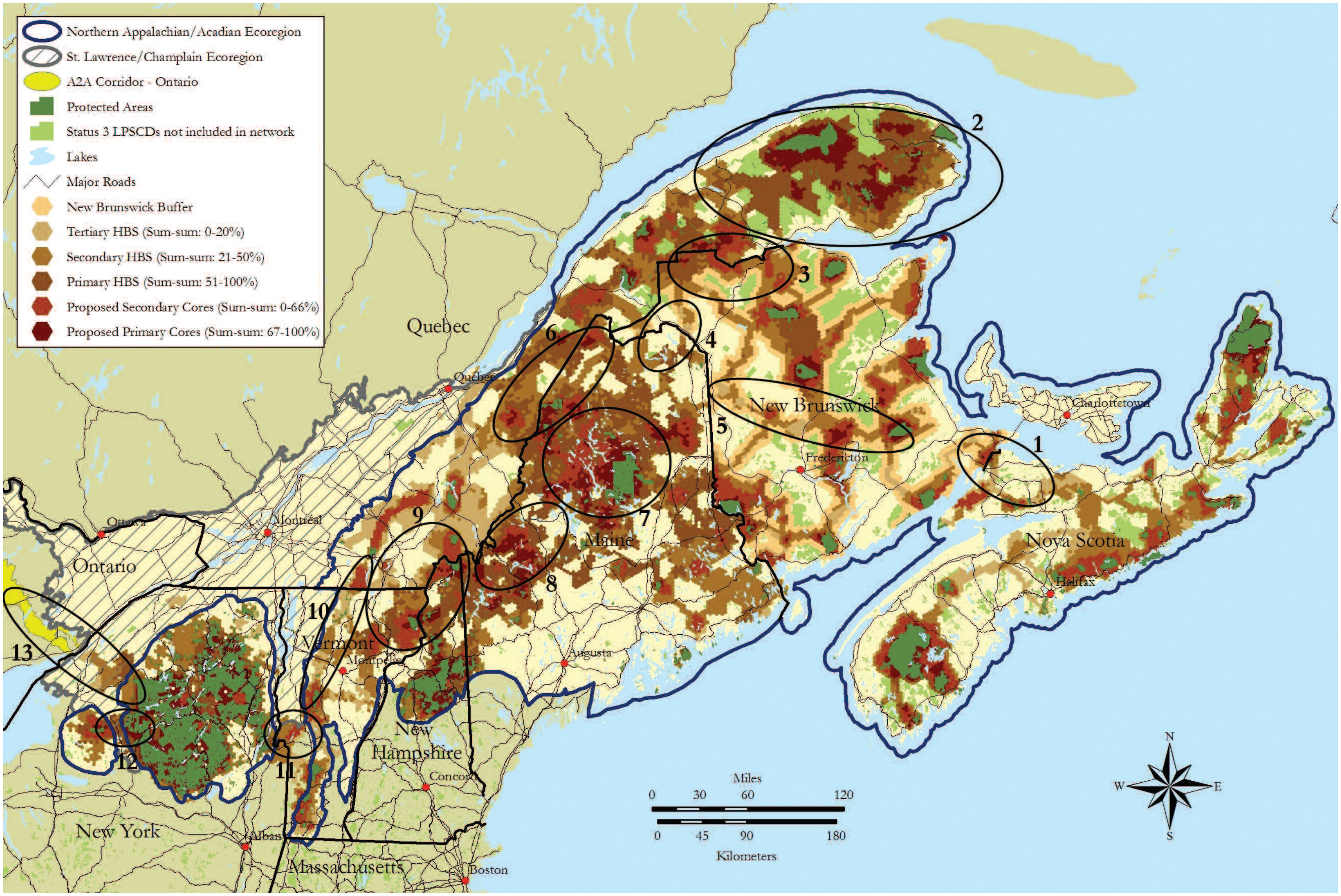


FIGURE 14 Priority conservation areas (delineated by ovals) in the Wildlands Network Design. See text for brief description of each numbered area. We have not established priority among the areas indicated below, so they are numbered on a rough east-to-west basis.



Adirondack region would be dependent on the Tug Hill habitat outside the Blue Line, to the west of the Park. The Black River Valley that separates the Adirondacks from Tug Hill is heavily settled.

13) ALGONQUIN-TO-ADIRONDACK LINKAGE Some of this linkage falls outside of the study area. It has been identified as a likely linkage between the Northern Appalachians/Acadian ecoregion and the boreal regions of the southern Canadian Shield (Quinby et al. 1999, 2000).

Goal Attainment in the Network Design

The outline of the proposed wildlands network was intersected with the three-tracks of the MARXAN inputs to evaluate how well the goals are met (Table 9). The network captures 68% or more of each of the 10 focal species features, exceeding the high-goal level (60%; refer to Table 5). High (75%) goals were met for each special element with the exception of beach dune and open wet basins. Open wet basins met low (50%) goals, with 61.8% captured, and 48% of beach dune is represented. The draft network captures an average of 79.5% of each special element. Two ELU types[6] (out of 162) are not captured in the draft network (Appendix 2). The network captures between 13% and 100% of the remaining ELUs. The network captures nine of the ELU types at the low goal (5–20%) level and 150 types at the medium goal (25–40%) level or higher. At least 118 ELU types are captured at the high goal (45–60%) level. On average the draft network captures 68.3% of each ELU type, greater than the high goal range set for ELUs.

TABLE 9 Focal species and special element features captured in network design[7]

Conservation Feature	Percent captured by draft network
Focal Species	
Wolf	
1. Source habitat under current landscape conditions	68.0%
2. Threatened source habitat under future landscape change scenario	67.9%
Lynx	
1.a. Base scenario prediction of source habitat with no population cycling	73.0%
1.b. Threatened source habitat under scenario with population cycling	71.6%
2.a. Base scenario prediction of source habitat with population cycling and no trapping of lynx	73.2%
2.b. Threatened source habitat with population cycling and trapping of lynx	71.0%
American marten	
1.a. Base scenario prediction of source habitat with trapping	69.4%
1.b. Threatened source habitat under increased trapping pressure	68.2%
2.a. Base scenario prediction of source habitat under scenario of habitat restoration	67.6%
2.b. Threatened source habitat under scenario of timber harvest	73.6%
Average	**70.4%**
Special Elements	
Beach Dune	48.1%
Barrens: Open Dry Flats	84.4%
Barrens: Pine	86.3%
River Systems/Coves	84.6%
Floodplain	75.5%
Forested Wetlands	95.6%
Steep Slopes and Cliffs	89.1%
Summits	90.5%
Open Wet Basins	61.8%
Average	**79.5%**

6. These two ELU types, very low elevation coves and flats underlain by ultramafic bedrock, are very small coastal features on islands off the coast of Maine. We do not include them in our design but they should be captured by finer scale conservation planning.
7. For goal attainment of ELUs, refer to Appendix 2.

DISCUSSION

THE WILDLANDS NETWORK DESIGN PRESENTED here is the first draft of our vision for a set of linked conservation areas that, when implemented over the course of many years, should contribute to the protection and restoration of ecological integrity in the Greater Northern Appalachians. Its implementation will depend in part on its consideration by officials, planners and other decision makers throughout the region who influence the course of development and conservation priorities. The strength of this design is its capacity to identify the major terrestrial conservation "nodes" in this region and the potential linkages among them. The network captures nearly all the conservation features included in the assessment, many of them at high goal levels.

This network design highlights the great importance of northern Maine and the Gaspé Peninsula for long-term conservation in this region, not only for species like lynx, marten and (potentially) wolf, but also as the remaining places in the region where large new wildlands could be established. These two large forested areas are the "heart" of the ecoregion in many respects. However, it is also essential to maintain the connections between these areas; several connections should be maintained from northern Maine through the base of the Gaspé, and through northern Maine into the Restigouche region of New Brunswick and Québec. The north-south linkages from the Gaspé into the heart of New Brunswick are also critical, especially with climate change.

There are currently good linkages between southeastern New Brunswick and Downeast Maine, and these should be maintained and reinforced through continuing efforts to establish new conservation areas on both sides of the border. There is still a tenuous connection between New Brunswick and Nova Scotia through the Chignecto Isthmus; this is an area warranting critical conservation attention, as is well recognized by local and regional conservation groups. Nova Scotia has two large protected "anchors" at opposite ends of the province in the form of the Cape Breton Highlands and the Tobeatic/Kejimkujik complexes, yet there remains a great need to establish permanent connections between these complexes and with the rest of North America.

Returning to northern Maine, it will be essential to ensure the long-term connections along the Appalachians in Québec and western Maine into northern New Hampshire, northern Vermont and spine of the Green Mountains. Current development patterns (Woolmer et al. *In prep.*), however, indicate potential threats to substantial portions of southern Québec and Vermont. The boundary mountains region of western Maine is important in its own right, and is a key part of the linkage from Québec and Maine to the rest of the Appalachians, yet is relatively unsecured from development.

There is a critical linkage to the Adirondacks via the southern Lake Champlain region. Within the Blue Line of the Adirondack Park, there is an extensive, relatively well-established complex of protected lands with an administrative body, the Adirondack Park Authority, that provides substantial control and oversight of development for the most part. To the west of the Adirondacks is the Tug Hill area, which should be viewed as an extension of the Adirondacks, given its importance, for example, for long-term wolf viability. Yet the valley connecting the Adirondacks and Tug Hill is heavily settled, so there is at best a tenuous ecological connection between these two areas. Conservation action to maintain or restore the linkage is warranted. The Algonquin to Adirondack (A2A) (Quinby et al. 1999, 2000) linkage that ties the Adirondacks to the rest of the southern Canadian Shield via the Frontenac Axis appears somewhat less threatened than the Adirondack-Tug Hill linkage, but also merits additional conservation assessment and action.

New Brunswick presents somewhat of a network design conundrum. As shown in Table 3, New Brunswick has the highest ratio of LPSCDS to state/province area in the study region, with the exception of New Hampshire. A substantial amount of the province appears to have a basic level of conservation in place because of the large amount of public Crown Land. Local conservationists quickly point out, however, that this is a false sense of security. There is pressure for conversion of natural forest to plantations and the amount of older forest on Crown Lands continues to decline driven by heavy demand for forest products throughout the province (Legislative Assembly of New Brunswick 2004). When we visited New Brunswick to review the site selection scenarios with local experts, they chose two of the highest goal scenarios (9 and 12) as the basis for network design, and the resulting design broadly follows the footprint of those scenarios. It is important to emphasize that while New Brunswick has numerous regionally important areas, as identified in the site selection scenarios, these same scenarios also suggest that New Brunswick may be somewhat less regionally vital than the Gaspé Peninsula and northern and western Maine (refer to Figures 7, 8 and 9). At the recommendation of local experts, we reduced the size of the proposed linkages in the agricultural areas of western New Brunswick, but also added linkages in areas, such as Gagetown, that were not initially identified. Local conservationists and ecological researchers, cognizant of the local political climate, also recommended that we incorporate a management buffer around high biological significance lands that would allow flexibility in resource management while still supporting the broader conservation goals of the network design, such as to maintain a linkage between core areas over time. Nonetheless, we assume that status 3 LPSCDs—Crown Lands—will provide at least a minimum amount of conservation over time, and, indeed, that management practices will improve on those lands. In light of the ongoing challenges to those lands, we recognize that this is a large assumption and that much effort will be required to ensure that this assumption proves true.

As currently delineated, the network as a whole would encompass nearly 47% of the study area. Adding existing lands secured from development outside of the network as supplemental elements, the total rises to more than 53%. We propose new core protected areas that encompass about 11% of the region, which would bring the total in existing and proposed core areas to more than 17%. It is possible that with further analysis the proportion of the network that should be in core protected area would rise. Moreover, as noted above, due to the data gaps in the St. Lawrence /Champlain Valley ecoregion, we have restricted most of our network design elements to the Northern Appalachian/Acadian portion of the study area, with the exception of obvious linkages within the St. Lawrence/Champlain Valley region. Because of this exclusion, these statistics are conservative estimates of the amount of land that should be included in a comprehensive network design.

It is illustrative to compare our results against those from similar studies in eastern and western North America. In a report issued in 2005, scientists in Massachusetts called for establishing 250,000 acres (just over 1,000 km^2) of large new wildlands reserves in the state, predominantly on public land. Under that plan, 50% of state-owned lands would be managed as core protected areas. In total about 5% percent of Massachusetts would be managed as core protected area. This report also called for securing from development an additional 2.25 million acres (about 9,100 km^2) as "well-managed Woodlands to support sustainable timber harvesting, extensive wildlife habitat and human recreation and enjoyment (Foster et al. 2005)." Together, these initiatives would entail securing up to 50% of the state of Massachusetts from development. To implement this bold plan, the authors advocate the formation of "Woodland Councils" throughout the state.

In Nova Scotia, Beazley et al. (2005) determined that about 60% of Nova Scotia, including 32% in core areas, should be managed for conservation objectives to maintain genes, species and ecosystems over time. These figures are strikingly consistent with those of Noss et al. (1999a) who proposed 60–65% in strict and moderate protection, and about 34% in core areas in their conservation plan for the Klamath-Siskiyou Ecoregion.

The Heart of the West Conservation Plan, which focuses on the lowlands of the Wyoming Basins Ecoregion and Utah-Wyoming Mountains Ecoregion, recommends that about 45% of the study area be managed as core protected area or landscape linkage (Jones et al. 2004). When this lowland area is connected to the Utah-Wyoming Mountains Ecoregion (Noss et al. 2002), over 53% of the larger Heart of the West region would be managed as the equivalent of core protected area (Jones et al. 2004).

Comparatively, the amount of land recommended here for inclusion in the network falls well within the ranges of these other plans. Indeed, since the goal for Massachusetts, a much more populated area than the Greater Northern Appalachians, is 50% of the state secured from development, the goal for the Greater Northern Appalachians (GNA) could be higher. Foster et al. (2005) call for placing about 5% of Massachusetts in wildlands (core protection). Again, given lower population densities and larger blocks of undeveloped land in the GNA region, our proposal for at least 17% of the GNA region in core protection is modest.

We have stressed in the limitations section that several important datasets were not included in the site selection analyses, that subregional goals were not set, and that the boundary modifier influenced the clumping of selected areas. As a result, this design is likely biased toward the central, northern and more boreal and sub-boreal portions of the study area, away from the Acadian and de-centralized sub-regions. Several reviewers noted that important areas of conservation value, particularly in central interior Maine, and along the coastal portions of the study area, are not well represented in this design. For these reasons, we do not consider that this design fully captures important localized conservation features in the more southerly and coastal sub-regions of the study area as a whole. The Nature Conservancy's assessment for the Northern Appalachian/Acadian ecoregion (Anderson et al. 2006), and other state-and province-level efforts, provide finer-scaled detail and identify important sub-regional and localized conservation priorities for this Acadian subregion. To gain more insight into the habitat needs and dispersal corridors for species in the non-boreal sub-regions, we recommend a broader suite of focal species, and a more-thorough synthesis of other significant examples of existing research. Such research and synthesis should also examine the potential for riparian corridors in the many rivers that run inland from coastal Maine.

The network design presented here is complementary to the results presented in the ecoregional assessment prepared by The Nature Conservancy and its partners for the Northern Appalachian/Acadian ecoregion (Anderson et al. 2006). Although we used some of the same datasets, our approach differs in fundamental ways. For example, we used 1000 ha planning units as our basic unit of analyses and defined boundary length modifiers to minimize fragmentation within the network design, rather than stipulating a minimum-size criterion. Second, we excluded urban areas and incorporated current habitat conditions into our focal species inputs rather than directly assessing current landuse/landcover conditions. In considering connectivity, we sought to avoid areas that were clearly dominated by human developments and settlements, or were identified populations sinks for focal species; however, we did not necessarily avoid highways and other barriers because of the potential to mitigate these if the conservation values are high. This approach provides the opportunity to create a network design that includes the future potential for restoration of the landscape. For example, areas that currently are not in good condition but that provide a combination of representation values for ELUs and future source areas for focal species are not excluded from consideration. Such areas may play important conservation roles under future change scenarios related to development patterns, resource harvesting activities and/or climate change.

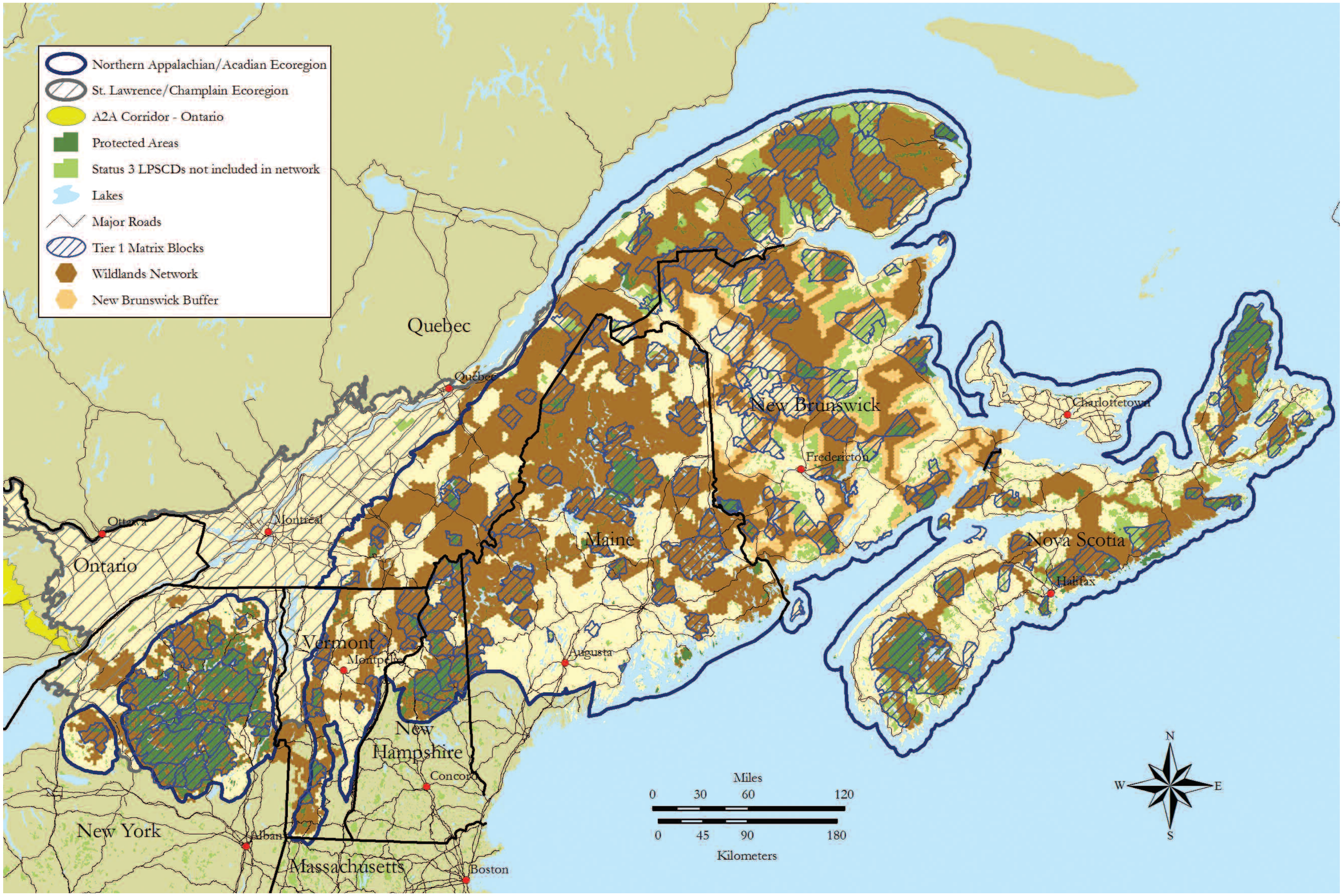
Third, we used a combination of site selection algorithms and consultations with local experts to select sites that met our conservation goals in an efficient manner. This provides a consolidated network of sites and linkages; however further assessment is required to refine the boundary delineation on the basis of ecological features rather than the hexagonal edges of the planning units.

Finally, our approach integrated focal species considerations along with special elements and ELUs, and identified linkages between core protected areas as fundamental to the goals of the network. Conversely, TNC and its partners invested considerable effort in representing ELUs and special elements, including rare species, and considering both minimum size and land-cover condition in identifying matrix blocks in their ecoregional plan, and in delineating boundaries for their matrix blocks based on many factors, including roads and other geographic features. Both approaches provide important information for conservation planning, and despite their differences they display considerable overlap. Indeed, when overlaid with the wildlands network design, 76% of the land area of the Tier 1 matrix forest blocks are captured in the network (Figure 14).

Under the broad umbrella of additional scientific work required to integrate and refine a comprehensive network design for the region, the efforts of Two Countries, One Forest (2C1Forest) are of considerable interest. Among the initiatives they envision is the opportunity to meld the approaches used by the Wildlands Project and The Nature Conservancy. 2C1Forest is leading a process that aims to integrate the hexagonal planning units and site selection algorithm used in this analysis, additional datasets, and the results of the TNC's ecoregional planning. These new results can then be linked to threat data from the Current and Future Human Footprint projects to provide greater insight into conservation priorities.

This wildlands network design and other planning and threat assessment efforts taking place in this region highlight the importance of considering conservation issues at a large spatial scale. Wide ranging species, for example, must be considered in this broader context. Species like wolf and lynx, with their demands for substantial amounts of relatively secure habitat (low road and human population density), provide a critical perspective on the placement and size of habitat. Identifying the connectivity needs for these species will not only contribute to their long-term viability but will aid countless other species, particularly in the context of climate change. Indeed, research by Carroll (2005) suggests that climate change will interact with other threats to form an "extinction vortex" that may substantially affect population viability of lynx and marten. Carroll's conclusion is reinforced by new findings by Cardillo et al. (2006) that there may be a latent extinction risk for mammals in Eastern Canadian Forests. Such a possibility highlights the need to move to

FIGURE 15 Tier 1 matrix forest blocks overlaid on the wildlands network design (Source of matrix forest block data: Anderson et al. [2006]).



"more precautionary and regionally-coordinated management of these species [...] or they may suffer range contraction in areas that are now considered the core of their regional range (Gaspé for the lynx and northern Maine for the marten) (Carroll 2005: 3)."

Carroll's recommendation for cross-border, regionally-coordinated management of high profile species such as lynx and marten extends to other large-scale conservation issues as well, such as regional-scale transportation projects and acid and mercury deposition. However, as this analysis demonstrates (in conjunction with other efforts), even smaller-scale threats can have a broad regional effect. We hope, then, that by providing a big picture overview we can help focus conservation efforts on the places and issues, at various scales, with the greatest conservation need.

We stress that this analysis is most accurate at the regional scale and conceptual level—it can help identify big picture conservation needs and opportunities. However, at the scale of implementation, finer-scale analysis, such as local conservation area planning, least-cost path analyses, and engagement of a broader set of stakeholders, will help refine where and how conservation actions should be carried out.

Although we cannot treat implementation exhaustively here, we can identify some major elements of work that will be necessary to advance conservation action in the Greater Northern Appalachians. The first broad track involves raising awareness of the ecological and cultural values/features/characteristics of the region as a whole, as well as the threats and conservation opportunities available. It is also necessary to convene scientists, advocates, land trusts, and donors with ecoregional interests who can advance a broad-scale conservation agenda. The Two Countries, One Forest collaborative was formed for precisely these purposes and is advancing this work. Entities such as the Northern Forest Alliance in the U.S., and similar alliances in Canada, will also be important in advancing these networking and communications efforts.

A second major element of work, also being advanced by 2C1Forest, involves "bringing-to-ground" focused conservation work in areas of high conservation priority. This network design identifies 13 areas that we believe warrant particular attention because of their biological importance, contribution to regional connectivity, and exposure to threat. In these areas, finer-scale conservation planning, outreach to local conservation and policy stakeholders, and locally-targeted communications efforts should be implemented, with the ultimate goal of bringing more land under some form of conservation. Implementation details will vary widely from area to area and will depend a great deal on the local capacity to implement conservation activities. Some priority areas, such as the Chignecto Isthmus, Green Mountains/Sutton Mountains, and Southern Lake Champlain, have good exisiting local capacity to move forward. Other areas, such as the Adirondack-to-Tug Hill and Lower Gaspé/Upper Restigouche River Watershed, have much less local capacity and may require organizational development to advance conservation activities.

A third major implementation element involves public policy at the federal, state and provincial levels, as well as across political boundaries. For example, much of the land in Maine included in the proposed network falls within the State's plantations and unorganized townships—areas under the jurisdiction of the Land Use Regulatory Commission (LURC). The Commission has land use regulatory jurisdiction over these areas because they have no form of local government to administer land use controls or, if they have local government, they choose not to administer land use controls at the local level (LURC 1997). This 420,800-ha area (10.4 million acres) covers over half the state and represents one of the largest contiguous undeveloped areas in the northeast U.S., and perhaps the eastern U.S. The size and regional conservation priority of the area thus highlights the critical role of the Commission in future conservation policy and action.

The results of this network design, and other scientific products at this ecoregional scale, may help to influence the decisions of this Commission and should be provided to them.

In New Brunswick, a 2002 report by the Jaakko Poyry consulting firm proposed nearly doubling softwood supply for industrial purposes during the next 50 to 60 years by increasing, among other things, the amount of land in softwood plantations and the harvest in Special Management Zones (these are areas that contain mature coniferous habitat and deer wintering areas, among other features). These changes would likely have had substantial impacts on the diversity of New Brunswick forests, and the recommendations were broadly criticized. A Select Committee of the New Brunswick legislature concluded that it did not view the Jaakko Poyry report as a "go forward" document (Legislative Assembly of New Brunswick 2004) so major changes to forest management policy in New Brunswick have been averted for the time being. Nevertheless, the pressures for increased wood supply remain and represent a substantial challenge to increased conservation on public and private land, and to more biodiversity-oriented forestry practices. As in Maine, this and other ecoregional-scale studies may help provide information about the importance of New Brunswick's forests for regional biodiversity conservation.

Conclusion

The network design presented here calls for a significant amount of new conservation land. However, this region has great conservation potential, and the amount of land identified is very much in line, or moderate, in comparison with similar analyses both within and outside of this region that identify areas necessary to the conservation of the full range of biodiversity. Indeed, the use of detailed, regionally-uniform datasets and a site selection algorithm has allowed us to identify areas that meet high conservation goals in a relatively compact network design. While we acknowledge that this network should be refined as new data and resources become available, this design provides important insights into the major regional patterns of high terrestrial conservation value and landscape linkages. Regardless of future adjustments, it is unlikely that concentrated areas of the most highly irreplaceable conservation features at the regional scale identified through this analysis will vary significantly.

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APPENDIX 1
Methods Used by TNC, NCC and their Partners to Delineate Matrix Forest Blocks

To identify representative examples of the "matrix-forming" forests that make up so much of the Northern Appalachian/Acadian ecoregion, TNC, NCC and their partners developed a multi-step strategy to assess the matrix forest system (Anderson et al. 2006):

- subdivide the entire forest into smaller semi-discrete "forest blocks" using roads and other fragmenting features;
- classify all forest blocks into representative forest landscape;
- screen each forest block, using size, condition and landcover in the surrounding landscape context as indicators of biodiversity value and resilience; and
- identify for conservation action a network of functional forest blocks representative of the diversity of forest types and landscape elements of the ecoregion.

Once forest blocks were identified and their forest–landscape types characterized, they were screened using size, condition and landscape context criteria. Blocks had to be a minimum of 10,000 hectares (25,000 acres), have little internal fragmentation, contain some elements of old-growth or mature forest, have outstanding features like high quality headwaters or examples of smaller-scale ecosystems and species, and be substantially surrounded by natural or semi-natural land cover (see Anderson et al. 2006 for details).

The planning team then stratified forest block selection across all forest-landscape types in the ecoregion to maximize the inclusion of different communities and species within the blocks. Ecological lands units and other features were used to identify 72 distinct strata or "ELU-Groups." One or more blocks were then selected within each group based on biodiversity values, forest condition, feasibility of protection, landscape context and complementarities to the other blocks. A total of 176 "Tier 1" matrix forest blocks were identified (refer to Figure 10). Tier 2 blocks were also identified; they met the criteria, but, based on current condition or feasibility or other factors were deemed lower priority or alternate candidates at this time. The Tier 1 blocks encompass 27% of the ecoregion, however, the block boundaries are not necessarily intended as conservation area boundaries. TNC recommends a 10,000-hectare (25,000 acre) core reserve devoted to the restoration of complete forest ecosystems with biological legacies and "old-growth" characteristics within each block, surrounded by lands secured from conversion to development. (Anderson et al. 2006).

APPENDIX 2
Ecological Land Unit Types Captured by Draft Wildlands Network

To represent the variation in ecological conditions that exists across the region, we used a data layer of Ecological Land Units (ELUs) developed by The Nature Conservancy (TNC) (Anderson et al. 1999, 2006; Groves et al. 2003). ELUs are unique combinations of three environmental factors—elevation, geology and landform—that are important to the distribution and abundance of ecological communities in the ecoregion (Figure 16).

Analyses by TNC and its partners indicated that smaller-scale ecosystems, communities and species locations were highly correlated with the types and diversity of ELUs (Anderson et al. 2006). The original ELU layer provided by the TNC consisted of many hundreds of unique combinations of elevation, geology and landform. These were subsequently consolidated in consultation with a TNC ecologist by combining similar categories within each elevation, geology and landform class (Table 10). The final layer consisted of 162 unique combinations of elevation, geology and landform.

The following is an example of a consolidated Wildlands Project ELU type:

> 300000 Mid + 50000 Acidic Grantic + 2000 Sideslope = 352000 Mid Elevation Acidic Granitic Sideslope

Two ELU types (out of 162), very low elevation coves and flats underlain by ultramafic bedrock, are not captured in the draft network (Table 11). These ELU types are found on islands off the coast of Maine. The network captures between 13% and 100% of the remaining ELUs. On average the draft network captures 68.3% of each ELU type, greater than the high goal range set for ELUs (45–60%).

FIGURE 16 Ecological Land Unit (ELU) key developed by TNC.

Elevation Class (in feet)			+	Bedrock Class	+	Topographic Feature
1000	very low	0–800		100 acidic sed/metased		**10's: Steep Slopes**
2000	low	800–1700		200 acidic shale		10 cliff
3000	mid	1700–2500		300 calcareous sed/metased		11 steep slope
4000	high	2500–4000		400 mod calcareous sed/metased		12 slope crest
5000	alpine	4000+		500 acidic granite		13 upper slope
				600 mafic/intermediate granitic		14 flat summit
				700 ultramafic		**20's: Side Slopes**
						20 sideslope—N/E
						21 cove—N/E
						22 sideslope—S/SW
						23 cove—S/SW
						30's: Flats
						30 dry flat till or patchy sediment
						31 dry flat fine-grained sediment
						32 wet/moist flat
						33 slope bottom
						34 dry flat coarse-grained sediment
						40's: Aquatic
						40 stream
						41 river
						42 lake

> ***Example:***
> 2000 low + 500 acidic granite + 32 wet flat = ELU2532 low acidic granite wet flat

TABLE 10 Crosswalk and consolidation of Wildlands Project and TNC ELU layers.

Ecological Land Unit Component	TNC Code	WP Code
Elevation Class		
Coastal 0-20ft (0–6m)	1000	100000
Very Low 20-800ft (6–244m)	2000	200000
Low 800-1700ft (244–518m)	3000	300000
High 1700-2500ft (518–762m)	4000	400000
Very High 2500-4000ft (762–1219m)	5000	500000
Alpine 4000+ ft (1219+ m)	6000	500000
Bedrock Class		
Acidic sedimentary/metamorphic bedrock	100	10000
Acidic shale bedrock	200	10000
Calcareous sedimentary/metamorphic bedrock	300	30000
Moderately calc sedimentary/metamorphic bedrock	400	30000
Acidic granitic bedrock	500	50000
Mafic/intermediate granitic bedrock	600	50000
Ultramafic bedrock	700	70000
Deep coarse sediments	800	80000
Deep fine sediments	900	90000
Topographic Feature		
Cliff	10	1000
Steep slope	11	1000
Slope crest	12	1200
Upper Slope	13	1300
Flat summit	14	1200
Sideslope NE aspect	20	2000
Cove NE aspect	21	2100
Sideslope SW aspect	22	2000
Cove SW aspect	23	2100
Gently sloping flat	24	2400
Dry flats	30	2400
Wet flat	32	3200
Slope bottom	33	2100

TABLE 11 Consolidated ELU types captured by Greater Northern Appalachians wildlands network.

ELU Type	Percent captured by draft network	ELU Type	Percent captured by draft network	ELU Type	Percent captured by draft network	ELU Type	Percent captured by draft network
102000	50%	231300	49%	351300	63%	471300	99%
102100	28%	232000	37%	352000	66%	472000	98%
102400	63%	232100	45%	352100	73%	472100	100%
103200	100%	232400	29%	352400	67%	472400	99%
111000	20%	233200	34%	353200	73%	473200	100%
112000	28%	251000	67%	371000	99%	482100	97%
112100	30%	251200	44%	371200	80%	482400	95%
112400	24%	251300	42%	371300	75%	483200	96%
113200	39%	252000	41%	372000	74%	511000	105%
131000	100%	252100	46%	372100	79%	511200	98%
132000	21%	252400	43%	372400	80%	511300	96%
132100	34%	253200	54%	373200	87%	512000	97%
132400	17%	271000	100%	382100	73%	512100	99%
133200	26%	271200	91%	382400	64%	512400	95%
151000	95%	271300	86%	383200	68%	513200	99%
152000	32%	272000	71%	392100	53%	531000	97%
152100	33%	272100	77%	392400	62%	531200	86%
152400	24%	272400	77%	393200	63%	531300	79%
153200	27%	273200	79%	411000	95%	532000	84%
172100	0%	282100	38%	411200	81%	532100	95%
172400	0%	282400	30%	411300	81%	532400	84%
182100	29%	283200	34%	412000	86%	533200	100%
182400	36%	292100	34%	412100	90%	551000	99%
183200	42%	292400	22%	412400	88%	551200	99%
192100	13%	293200	21%	413200	95%	551300	98%
192400	20%	311000	61%	431000	102%	552000	99%
193200	31%	311200	58%	431200	71%	552100	100%
201000	59%	311300	59%	431300	74%	552400	100%
202000	26%	312000	63%	432000	79%	553200	100%
202100	41%	312100	68%	432100	81%	571000	100%
202400	100%	312400	66%	432400	81%	571200	100%
203200	100%	313200	70%	433200	83%	571300	100%
211000	45%	331000	86%	451000	96%	572000	100%
211200	39%	331200	48%	451200	90%	572100	100%
211300	41%	331300	48%	451300	90%	572400	100%
212000	42%	332000	52%	452000	93%	573200	100%
212100	50%	332100	58%	452100	96%	582100	100%
212400	36%	332400	55%	452400	92%	582400	100%
213200	42%	333200	52%	453200	95%		
231000	74%	351000	81%	471000	100%		
231200	41%	351200	64%	471200	99%		

APPENDIX 3
Detailed Methods Used to Create the Wildlands Network Design at the State and Provincial Level

To establish the location and extent of the network design elements, we used three major sources of information: 1) the results of the site selection analyses discussed above; 2) The Nature Conservancy's Tier 1 matrix forest blocks (Anderson et al. 2006)[8] and 3) input from experts in the states and provinces.

To obtain expert input we conducted a series of meetings in Nova Scotia, New Brunswick, Québec, Vermont, New York and Maine from January through May 2006.[9] We also consulted some experts by telephone.

In those meetings we presented the results of the site selection analysis, then sought to:

- determine the preferred scenario, or combination of scenarios, for the state or province based on local conservation knowledge;
- determine overlap with known areas of conservation value;
- identify areas of known conservation value that are not captured;
- discuss problems/deficiencies in the analysis; and
- discuss how this study should be communicated with other audiences.

Nova Scotia Participants chose the best run of scenario 6 (medium goals for all features; highest BLM of 0.01)—as the base scenario. They also recommended that we add certain elements from the best run of scenario 12 (highest goals for all features; highest BLM of 0.01), to capture other known areas of high ecological value and importance for connectivity. Participants also recommended that we reduce the scope of the design from that shown in scenario 6 in certain areas, such as the west coast and southern end of Cape Breton. A number of linkages were also added based on expert knowledge. Proposed cores were based on planning units selected more than 50% of the time in scenario 6. Areas of High Biological Significance (HBS) were based on either a) planning units selected 50% or less of the time in scenario 6, b) selected planning units added from scenario 12, or c) hexagons added because they represented important linkages, and were delineated using focal species source habitat data, existing Status 3 LPSCD's, and color ortho maps from Google Earth. Where possible, all 3 types of HBS were matched to the boundaries of TNC's Tier 1 Forest Matrix Blocks. In refining the network for Nova Scotia we were able to draw on the work of Beazley et al. (2005), which delineated potential areas of core and connectivity based on a representation, special elements, and focal species approach for the province.

New Brunswick Participants chose the best run of scenario 12 as the base scenario, then recommended that we add elements of the best run of scenario 9 (higher focal species goals, lower representation goals, higher special element goals; highest BLM of 0.01). A number of linkages were added based on expert opinion that did not occur in either scenario 9 or 12. Participants also recommended that we add blocks of old forest in the Restigouche region that had been identified in separate mapping exercises. Proposed cores were delineated based on planning units selected more than 60% of the time in scenario 12. HBS lands were delineated based on either a) planning units selected 60% or less of the time in scenario 12, b) selected planning units added from scenario 9, c) unfragmented sections of Gagetown military reserve, or d) hexagons added because they represented important linkages based on expert opinion, and were delineated using focal species source habitat data, existing Status 3 LPSCD's, and color ortho maps from Google Earth. Where possible, HBS lands were matched to the boundaries of TNC's Tier 1 Forest Matrix Blocks. Participants also recommended that we reduce the scope of the design plan from that shown in scenario 12 in the heavily used agricultural areas on the western border of New Brunswick. We also added a five km buffer around the network design elements. The area of this buffer is not included in the proposed network—only the area of the core, proposed core, or HBS land is included. The buffering is designed to provide flexibility in how resources are managed within a given area, while ensuring that a portion of the area will always be managed in support of the larger network.

8. These matrix blocks were identified by TNC as part of their ecoregional assessment for the Northern Appalachian/Acadian ecoregion (Anderson et al. 2006).
9. Massachusetts was excluded from the analysis because only a very small portion of the state falls within the study area. Prince Edward Island was excluded because it is separated from the mainland by water and because its environment is so highly modified.

Québec Local experts divided the area of the province in the study area into three smaller regions: "Eastern," "Central," and Western," and selected a preferred scenario for each subregion. These sections are similar to the subregions described Quebec's ecological land classification system (Anderson et al. 2006). The Eastern section is equivalent to the Gaspé Peninsula; the Central section comprises the Temiscouata Hills with its limit somewhat offset to the west and capturing part of the Beauce area; and the Western section encompasses the two remaining Appalachian subregions: the Estrie-Beauce Plateaus and Hills and the Greens and White Mountains.

For the Eastern section, planning units were included from the best run of scenario 9. Within the Eastern section, cores were delineated where the summed runs values from scenario 9 were greater than 80%. Planning units with values less than 80% were included as areas of high biological significance (HBS). For the Central section, planning units were included from the best run of scenario 9. Within this best run, core areas were identified as those with summed-run values of greater than 70%. We chose relatively high cutoff percentages for the Eastern and Central regions, in consultation with local experts, because of the large amount of public land and core protected areas in this part of Québec. For the Western section, planning units were included from the best runs of scenario 6 and scenario 12. Planning units with summed-runs values greater than 50% for scenario 6, and 60% for scenario 12 were included as cores.

Vermont Meeting participants identified the summed runs of scenario 11 (higher goals for focal species, representation, and special elements; moderate BLM of 0.01) as the preferred scenario. In the network outline we included planning units containing more than 50% of Tier 1 or 2 matrix blocks, more than 10% of Status 1 or 2 LPSCDs, and more than 25% of Status 3 LPSCDs. We also included additional planning units using the summed runs for Scenario 11. As much as possible, these planning units were added based on focal species data, Vermont Land Cover data, and the recommendations of the Vermont meeting. Cores were delineated within the draft network based on high summed run values, wilderness, proposed wilderness and roadless areas, Tier 1 Matrix blocks, and land use/land cover. After reviewing the results of the analysis for the St. Lawrence/Champlain portion of Vermont, local experts concluded that the results were not robust enough to support the identification of a network design in most of the St. Lawrence/Champlain ecoregion since the input data consisted only of focal-species features. The Lower New England ecoregion has similar data gaps; there is however a probable linkage between the Adirondacks and Vermont in this ecoregion. The site selection analysis under Scenario 11 shows a large block of planning units selected with high frequency. We reviewed these results with local experts and they concurred that the planning units selected with high frequency, mostly in the Lake Bomoseen area to the east of Lake George, were indeed important and should be included in the network. Linkages between the Lake Bomoseen complex and important core and proposed core areas in southern Vermont were also identified by during the review process.

New York Workshop participants recommended that we add relatively small amounts of new core protected areas to the base of exiting protected areas within the "Blue Line" Adirondack Park boundary, focusing on ensuring that connectivity between the Park and other areas of the region be maintained or restored. Important connectivity regions identified include: 1) the linkage with Tug Hill Plateau, 2) the Algonquin to Adirondack linkage with Algonquin Provincial Park (Quinby et al. 1999, 2000) and 3) the linkage with Vermont south of Lake Champlain. In the network outline we included planning units containing more than 50% of Tier 1 matrix blocks, more than 10% of Status 1 or 2 LPSCDs and more than 25% of Status 3 LPSCDs. We also included planning units using the best runs for scenario 5 (medium goals for all 3 tracks; moderate BLM of 0.01) intersected with values from the summed runs of scenario 5. Those planning units included in the best run and selected more than 50% of the time in the summed runs were included in the network. We excluded planning units selected within the St. Lawrence/Champlain ecoregion unless they fall within the three linkages noted above, and planning units falling on selected hamlets within the Blue Line (reflecting feedback from meeting participants).

Maine We conducted five meetings that did not achieve consensus around a single scenario that should serve as the basis for further conservation planning, though there was somewhat more agreement around scenario 8 (higher goals for focal species, lower goals for representation, and higher goals for special elements, moderate BLM of 0.001). The best run of scenario 8 was consequently used as the basis for a first draft, with other inputs, as follows: 1) include planning units containing more than 10% of Status 1 and 2 lands; 2) include planning units containing more than 50% of Status 3 lands; 3) include planning units containing more than 50% of Tier 1 Matrix Blocks; 4) include planning units from the best run of scenario 8 that were selected more than 60% of the time when the summed runs output is overlaid on top of the best run for the scenario; include linkages that were not in any of the sources above, but that were identified by local experts in meetings on 15-17 March 2006. As much as possible, focal species data was used in the placement of these linkages. This entire outline was then intersected with values from the unclipped summed runs of scenario 8. Those planning units selected 80% or more were designated as cores. Planning units selected 80% or less were designated as areas of High Biological Significance.

We returned in May 2006 to review the first draft with a set of experts in a daylong meeting. That meeting produced several changes that have been incorporated into the current network design , including the addition of lands of high biological significance in Downeast Maine (based on scenario 12), the addition of a linkage along the upper St. John river in far northern Maine (based on expert opinion), and the elimination of several gaps within and between HBS lands in northern and western Maine (based on expert opinion plus summed-summed runs and alternate scenarios.)

During both visits, reviewers questioned the gaps in the lynx source and threatened source dataset used as an input to the MARXAN model. See the discussion of this issue in limitations

New Hampshire We did not conduct face-to-face meetings in New Hampshire because such a large portion of the state in the study area is already in some form of conservation. Instead we drafted a proposed design for the state and sent it to several local external reviewers for their consideration. In addition, two experts from New Hampshire attended face-to-face meetings in Maine. The design outline included planning units containing more than 50% of Tier 1 matrix blocks, more than 10% of Status 1 or 2 LPSCDs, and more than 25% of Status 3 LPSCDs. We delineated proposed cores by intersecting the network outline with summed runs values from scenario 11. We used scenario 11 because of its use in both Vermont and Maine. Planning units selected 70% or more were included as cores. Planning units selected less than 70% were included as areas of high biological significance. One reviewer recommended some additions to the resulting design based on local knowledge, which were incorporated.

After our initial visits or contacts with reviewers, we developed draft network designs for each state or province. These were sent to reviewers with the following questions.

- Does this draft design capture major elements of terrestrial biodiversity?
- Are there major areas lacking?
- Is the extent and placement of proposed cores correct and adequate? Too much, too little?
- Is the extent and placement of areas of High Biological Significance correct and adequate?
- Are linkages, in-state and to other states and provinces, in the right places?
- Does this reflect the input you provided during the review meeting(s)?

APPENDIX 4
Experts Who Participated in Meetings or Were Otherwise Consulted in the Development of the Network Design

The following individuals participated in meetings conducted in the states and provinces, or were otherwise consulted, during the January–May 2006 network design process. Their participation does not imply endorsement of the views or findings in this document.

Name	Affiliation
Mark Anderson, Ph.D.	The Nature Conservancy
Elizabeth Dennis Baldwin, Ph.D.	University of Maine
Robert Baldwin, Ph.D.	Two Countries, One Forest
Peter Bauer	Residents Committee to Protect the Adirondacks
Douglas Bechtel	The Nature Conservancy
Kathleen Bell, Ph.D.	University of Maine
Matthew Betts, Ph.D.	Greater Fundy Ecosystem Research Group, University of New Brunswick
Bill Brown	Adirondack Nature Conservancy and Land Trust
Robert Bryan, M.S.	Maine Audubon
Dirk Bryant	Adirondack Nature Conservancy and Land Trust
Michael Carr	Adirondack Nature Conservancy and Land Trust
Carlos Carroll, Ph.D.	Klamath Center for Conservation Research
Barbara Charry, M.S.	Maine Audubon
Diano Circo	Natural Resources Council of Maine
Roberta Clowater	Canadian Parks and Wilderness Society New Brunswick Chapter
Charles Clusen	Natural Resources Defense Council
David Coon	Conservation Council of New Brunswick
Andrew Cutko	NatureServe
Kathleen Daly	Trust for Public Land
John Davis	Adirondack Council
Kermit deGooyer	Ecology Action Centre
Bart DeWolf, Ph.D.	Elliotsville Plantation
Michael DiNunzio	Association for the Protection of the Adirondacks
Maureen Drouin	Sierra Club—Maine Office
Stéphanie Duguay	Appalachian Corridor
Kathleen Fitzgerald	Notheast Wilderness Trust
Graham Forbes, Ph.D.	University of New Brunswick
Fritz Gerhardt, Ph.D.	Northwoods Stewardship Center
David Gibson	Association for the Protection of the Adirondacks
William Ginn	The Nature Conservancy
Michale Glennon, Ph.D.	Wildlife Conservation Society
Louise Gratton	Nature Conservancy of Canada/Appalachian Corridor
John Harbison	Sierra Club
Daniel Harrison, Ph.D.	University of Maine
Francine Hone	Appalachian Corridor
Brian Houseal	Adirondack Council
Donald Katnik, Ph.D.	Maine Department of Inland Fisheries &Wildlife

Kasey Legaard	University of Maine
Robert Long, Ph.D.	University of Vermont
Alex MacDonald	Canadian Parks and Wilderness Society Nova Scotia Chapter
Josette Maillet	Nature Conservancy of Canada
Christopher Miller, Ph.D.	Ecologist
Margo Morrison	Nature Conservancy of Canada
John Nordgren	The Henry P. Kendall Foundation
James Northup	Forest Watch
Jamie Phillips	Eddy Foundation/Wildlands Project
Spencer Phillips, Ph.D.	Northwoods Stewardship Center
Agnieszka Pinette	Maine Department of Conservation, Land Use Regulation Commission
Raymond Plourde	Ecology Action Centre
Connie Prickett	Adirondack Nature Conservancy and Land Trust
David Publicover, D.F.	Appalachian Mountain Club
Kristen Puryear	Maine Department of Conservation
Peter Quinby, Ph.D.	Pymatuning Laboratory of Ecology, University of Pittsburgh
Justina Ray, Ph.D.	Wildlife Conservation Society Canada
Clément Robidoux	Appalachian Corridor
John Roe	The Nature Conservancy
Joshua Royte	The Nature Conservancy
Steven Sader, Ph.D.	University of Maine
Jim Shallow	Audubon Vermont
Margo Sheppard	Nature Trust of New Brunswick
Inuk Simard	Conservation Council of New Brunswick
Erin Simons	University of Maine
Michael Soulé, Ph.D.	UC Santa Cruz/Wildlands Project
Jym St. Pierre	RESTORE: The North Woods
Sally Stockwell, Ph.D.	Maine Audubon
James Sullivan	Two Countries, One Forest
Bonnie Sutherland	Nova Scotia Nature Trust
John Terborgh, Ph.D.	Duke University/Wildlands Project
Michael Tetreault	The Nature Conservancy
Elizabeth Thompson	University of Vermont/Vermont Land Trust/The Nature Conservancy
Stephen Trombulak, Ph.D.	Middlebury College
Barbara Vickery	The Nature Conservancy
Karen Woodsum	Sierra Club—Maine Office
Gillian Woolmer	Wildlife Conservation Society Canada

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