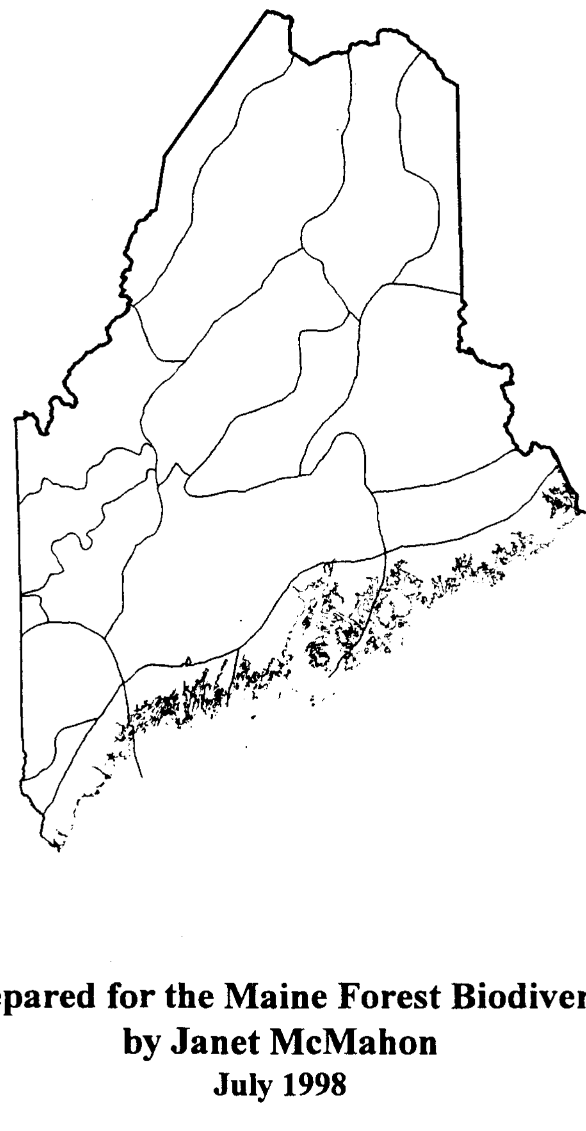
AN ECOLOGICAL RESERVES SYSTEM INVENTORY:

POTENTIAL ECOLOGICAL RESERVES ON MAINE'S EXISTING PUBLIC AND PRIVATE CONSERVATION LANDS



A Report Prepared for the Maine Forest Biodiversity Project
by Janet McMahon
July 1998

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AN ECOLOGICAL RESERVES SYSTEM INVENTORY:

POTENTIAL ECOLOGICAL RESERVES ON MAINE'S EXISTING PUBLIC LANDS AND PRIVATE CONSERVATION LANDS

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PROLOGUE

In May of 1994, nearly 100 people came together to discuss the issue of biodiversity in Maine's forests. Representing landowners and managers (large and small, federal and private, non-profit and commercial), advocates (environmental, sportsmen, property-rights, land conservation, and others), the scientific community, state agencies and educators, we learned from outside experts and discussed this complex topic among ourselves. At the end of this two-day meeting the group agreed to constitute itself as the Maine Forest Biodiversity Project (MFBP), to meet again for further mutual education about biodiversity, and to begin work on three tasks: 1) an assessment of the status and trends of biodiversity in Maine; 2) identification of forest practices that help to maintain biodiversity, and 3) completion of an effort begun by the State Planning Office to define and assess the potential for an ecological reserve system on Maine's public land and private conservation lands.

Over the following four years, the group has met ten times to continue discussions on the conservation of biodiversity, to stay apprised of various protection and research efforts currently underway, and to keep up with the developing science of this emerging field. Along the way, we have commissioned several reports[1], of which this is one, to further explore the status of Maine's biodiversity and steps that could be taken to help maintain it. Our mission has been to explore and develop strategies that help maintain viable populations of existing native species and viable representatives of existing ecosystems in Maine. MFBP participants believe that this goal can be achieved through a combination of baseline reserve lands and managed forests. The group also agrees that ecological reserves can help us understand characteristic features and interactions of native ecosystems, and maintain rare species and ecosystems unlikely to be maintained elsewhere.

Project participants are keenly aware that ecological reserves may take land out of timber production, providing conservation benefits but incurring other costs. MFBP participants believe that any policy deliberations about reserves should be informed by a full discussion of the costs and benefits involved. Of course, before costs and benefits can be considered productively, an understanding of the potential scope of an ecological reserve system is necessary.

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[1]MFBP initiatives include:

-An assessment of Maine's biodiversity (available through the Department of Conservation): *Biological Diversity in Maine: An Assessment of Status and Trends in the Terrestrial and Freshwater Landscape* (Gawler, Albright, Vickery, Smith 1996).
-A study of a potential collection of ecological reserves on public and private non-profit lands (this report).
-A landowner's and forester's manual on "Biodiversity in the Working Forest" (forthcoming Fall 1998).
-An examination of U.S. Forest Service Inventory data as a tool for statewide measurement and assessment of forest biodiversity.
-A public outreach program about the Biodiversity Project and biodiversity in Maine.

Accordingly, we commissioned this report to help flesh out what a system of ecological reserves in Maine might look like. First, a scientific panel, convened by the MFBP, reviewed the State Planning Office's 1993 report, *An Ecological Reserves System for Maine: Benchmarks in a Changing Landscape.* They reported back to Project participants, endorsing the report's precepts and general approach. Then, in 1995, the MFBP contracted with the report's author under the guidance of the MFBP's Scientific Advisory Panel to complete the inventory initiated by the State Planning Office, and to outline areas that have potential as ecological reserve sites on Maine's public and private conservation lands. At the same time, Project participants began discussions on the nature and purposes of reserves, the assumptions on which the original report and current inventory were based, appropriate reserve uses, and guidelines for the inventory and reserve design itself. This report is the result of a responsive, adaptive process. As the work progressed and stages of the project were brought before MFBP participants and the Scientific Advisory Panel, new guidelines for the inventory and design work were developed, and the study and this report were adapted accordingly.

The goal of the inventory was to better identify 1) a possible range of reserve sizes, 2) which of Maine's ecosystem types (meeting reserve criteria) occur on existing public and private conservation lands, and 3) the acreage potentially required to adequately represent the range of ecosystem types in Maine.

A key assumption among MFBP participants is that both reserve lands and managed forest lands contribute to the maintenance of biological diversity in Maine. For that reason, the potential reserves identified in this report are generally smaller than reserves that might be designed within a highly developed or fragmented landscape. The areas described as potential reserves in this report incorporate representative examples of Maine's ecosystems. These potential reserves were designed to work in concert with the surrounding managed forest to help maintain the state's current biodiversity. However, this system of reserves by itself would not ensure the maintenance of viable populations of all plant and animal species found in Maine, nor would it restore the biodiversity of Maine's past.

Because a system of ecological reserves would serve a public function it seemed logical to initially test the potential for such a system on existing public lands. The MFBP therefore limited this study to state and federal public lands and non-profit conservation land ownerships (about 5% of the state). In addition, it was stipulated that, where possible, potential reserve boundaries should be drawn to include necessary "internal buffers" (avoiding *de facto* expectations for special management of private lands adjoining potential reserves). More information related to the scope and limitations of the report can be found beginning on page 5.

We are grateful to the participating agencies and organizations (see list page *xi*) for underwriting the costs of field surveys, and the Scientific Advisory Panel (page *ix)* for their time and guidance.

While more information is always desirable, we believe that this report succeeds by 1) fulfilling the intention of the 1989 State Planning Office effort to fully apply its theoretical approach for designing ecological reserves on Maine's public lands and private conservation lands, 2) generating a much clearer idea of the potential size and extent of a reserve system that is capable of representing all of Maine's terrestrial and wetland ecosystems, and 3) providing a well-reasoned foundation for others to calculate the costs and benefits of such reserves to the people of Maine.

As MFBP participants evaluated how best to understand and conserve biodiversity in Maine we:

- conclude that it is desirable to maintain viable populations of existing native species and viable representatives of existing native ecosystems
- assume that both reserve lands and managed forest lands contribute to the maintenance of biodiversity

This report is a product of the Maine Forest Biodiversity Project. It should be understood, however, that:

- this report does not constitute a proposal by Project participants
- this report is simply an inventory of those existing public lands and private conservation lands that could serve as ecological reserves
- participants intend that the information in this report will be useful as a basis for preliminary economic analyses as part of any public policy discussions on the creation of ecological reserves in Maine

Having gathered this information, we now offer it to those who are charged with making decisions about the future of these sites, and the future of an ecological reserve system for Maine: the public and non-profit land managers, and ultimately, the people of Maine.

— Maine Forest Biodiversity Project Steering Committee and
Philip Gerard, Project Director

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The first and most important acknowledgment goes to the Scientific Advisory Panel of the Maine Forest Biodiversity Project for its oversight, ideas, criticism, and varied perspectives on the ecological reserves inventory and the importance of reserves. In nineteen meetings held over the course of three years, the panel provided input on sampling protocol, interpretation of field data, reserve selection and design guidelines, and recommended uses of reserves. Panel members include: Linda Alverson, Aram Calhoun, Tom Charles, Charlie Cogbill, Dave Courtemanch, Ron Davis, Ivan Fernandez, Susan Gawler, Mac Hunter, George Jacobson, Steve Kahl, Don Kidder, Sharon Kinsman, Bill Krohn, Mark McCollough, John Moring, Dave Publicover, Bob Seymour, Barbara Vickery, and Alan White.

This report synthesizes an enormous amount of information and field data. Field data were collected over the course of two and a half summers by sixteen field ecologists and assistants, who endured—in turn—one of the driest and one of the wettest summers on record. They are: Michelle Buonopane, Becky Chalmers, Philip deMaynadier, Norman Famous, Arthur Haines, Georgia Hall, Bruce Hammond, Chris Hoffman, John Lortie, Eugenie Moore, Tony Owens, Sally Rooney, Josh Royte, Tonie Simmons, Marcia Spencer-Famous, and Jill Weber.

Field data collected for each site inventoried were supplemented with the first-hand knowledge of land managers and agency foresters and biologists. We wish we had more time to tap the depths of this knowledge, but greatly appreciate their timely response to our many requests for information on the lay of the land, current condition of forests and wetlands, recreational use, and land use history. Our thanks go to the Bureau of Parks and Lands regional foresters: Marc Albert, Tom Charles, Jim Ecker, Jay Hall, Don Kidder, Vernon Labbe, Del Ramey, Peter Smith, Robin Smith and Steve Swatling; Bureau of Parks and Lands state park managers: Dan Bell, Gordon Bell, Steve Curtis, Bruce Farnum, Phil Farr, Leland Griffin, Tim Hall, Ben Kreiton, John Smith and Doug Tyler; Maine Department of Inland Fisheries and Wildlife biologists: Philip Bozenhard, Sandy Eldridge, Gene Dumont, Keel Kemper, Mark McCollough, Tom Schaeffer, Mark Stadler and Kevin Stevens; U.S. Fish and Wildlife Service biologists and refuge managers: Deborah Anderson, Ward Feurt, Stephanie Koch, Jennifer Megyesi, Maury Mills and Mark Sweeny; Wayne Millen and Steve Fay of the White Mountain National Forest; David Manski and Linda Gregory of Acadia National Park; Caroline Norden and Jane Arbuckle of Maine Coast Heritage Trust; Buzz Caverly, Jean Hoekwater and Jensen Bissell of Baxter State Park; Kyle Stockwell, Nancy Sferra, Tom Rumpf and Barbara Vickery of The Nature Conservancy; Joe Spaulding of the National Audubon Society; Kari Schank and Steve Hubner of the U.S. Department of Defense; Paul Johnson and John Neff of the Maine Appalachian Trail; Bob Chute of Bates/Morse Mountain Conservation Area; Mary Ellen Boelhower of the Forest Society of Maine; Les Hyde of the Knox-Lincoln County Cooperative Extension Service; and Bill Hancock of the Maine Audubon Society.

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Susan Gawler of the Maine Natural Areas Program contributed to this effort in more ways than can be counted. I am particularly grateful for her analysis of the field data collected during the inventory and for drafting portions of the methods and results section of this report. The data set was enormous and "messy," requiring many weeks to standardize. Sue's patience, objectivity, and diligence enabled us to use the data to help evaluate the quality of individual potential reserve sites. Her work breaks new ground by shedding light on geographic variation among certain ecosystem types in Maine. Credit is also due to Michelle Buonopane, Sara Cairns, Diana Stahl, and Brian Carlson for helping with data entry and organization. In addition, the Maine Natural Areas Program, along with the Maine Department of Inland Fisheries and Wildlife, provided valuable information on the status and location of rare plant and animal populations. Thanks to Sarah Holbrook for making this information available.

The reserve design phase of the inventory involved the preparation of reserve design base maps and a database to organize site information for each potential reserve. Dan Coker and Nick Becker of The Nature Conservancy deserve special thanks for the hundreds of hours they spent drafting maps, calculating acreages, and preparing figures for this report. Anna Marie Thron and Chris Hoffman designed the database, Cliff Alton entered the data, and Anna Marie and Cliff helped extract the summary data that form the basis for the inventory results. All with amazing grace under pressure.

The Maine Forest Biodiversity Project Steering Committee skillfully wove the inventory into the agendas of each of the project's conference meetings and helped tap the collective wisdom of the group. Past and present Steering Committee members include: Barrie Brusila, Doug Denico, Cathy Johnson, Ted Johnston, Roger Milliken, Tom Morrison, Jym St. Pierre, Jim Tobin, Bill Vail, Barbara Vickery, Bruce Wiersma, and Kent Wommack.

The Nature Conservancy provided logistical support – much of it in kind – and expertise through the duration of the inventory. The endless details that are part of an effort like this one were taken care of by Susan Caldwell and then by Kristin Foord. Kristin prepared tables and graphs and typed this report. To both, I owe many thanks. I am particularly grateful to Barbara Vickery for the wisdom she brought to the project and for being a sounding board throughout.

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Marie Thron and Debbie Cameron, who amassed and organized data on lakes and soils. And thanks to the rest of the staff for allowing me to disassociate myself from the day-to-day goings-on at The Nature Conservancy so I could focus on this inventory.

Maine Forest Biodiversity Project director Phil Gerard, assistant Sarah Aley, and former director, Leslie Hudson, lent logistical and moral support from start to finish. Grady McGonagill and Maggie Herzig, the Maine Forest Biodiversity Project's lead facilitators, were indispensable to this effort. They created an environment in which project participants could constructively guide and contribute to the ecological reserves inventory. Our understanding of ecological reserves is, as a result, far broader and deeper than it was when our discussions began in 1994. Grady and Maggie were assisted by a dedicated team of facilitators, including: Powell Woodward, Ed Landreth, Jim Davidson, Mary Jane Ferrier, John Goodrich, Nancy Hammett, Pat Jennings, Mary Lou Michael, Trish Perry, Julie Towne, and Seth Tuler.

Barrie Brusila, Aram Calhoun, Tom Charles, Sue Gawler, Mac Hunter, Cathy Johnson, Sharon Kinsman, Bill Krohn, Roger Milliken, David Publicover, Barbara Vickery, and Peter Vickery reviewed the report in its entirety and provided thoughtful comments on the content and tone of the final draft. In addition, Ken Elowe reviewed Appendix B and offered valuable insights on potential uses and management of reserves.

Other people contributed to the project in a variety of ways. Tony Owens and Chris Davis made core boards for the field teams – Chris also prepared several of the graphics in the report; Jim Dunham, of Tanglewood 4-H Camp, generously hosted two training sessions for the field teams; Owen Fenderson made the Department of Inland Fisheries and Wildlife's MIDAS Lakes Database available; Bob Johnston of the Maine Geological Survey generously loaned air photos to us whenever we needed them; and Henry Trial of the Maine Forest Service lent us data from the Service's spruce budworm spray program.

Much of the financial support for this project came from the many landowners and government agencies whose land was inventoried, including the Maine Department of Conservation, Maine Department of Inland Fisheries and Wildlife, Acadia National Park, U.S. Fish and Wildlife Service, U.S. Forest Service, Maine Coast Heritage Trust and The Nature Conservancy. We would also like to acknowledge the generous support of the Kendall Foundation, the Cabot Foundation, the Davis Conservation Foundation, the Ben and Jerry's Foundation, the Kenduskeag Foundation, the Maine Community Foundation, the National Fish and Wildlife Foundation, the Surdna Foundation, and the USGS Biological Resources Division.

Finally I would like to thank the participants of the Maine Forest Biodiversity Project for their creative energy, different viewpoints, thoughtfulness, and good humor.

—Janet McMahon

EXECUTIVE SUMMARY

More than 98% of Maine's lands are managed for forestry, or agriculture, or are developed for housing, commerce and industry. Because these managed lands are, by definition, subject to human activities, the opportunity for understanding the effects of environmental changes caused, for example, by pollution, climate change or land management practices, is limited. It is often too difficult to unravel and isolate the consequence of any single environmental impact when so many activities are taking place.

As a result, unmanaged areas (where changes occur with no direct human influence) take on particularly valuable roles. They function as controls, allowing comparison with managed landscapes (helping scientists and land managers clarify the impact of environmental changes) as well as protecting important natural areas. Unmanaged lands are valuable as ecological baselines or benchmarks and as areas that help maintain a complete array of native habitats. In Maine, relatively few such areas exist, even on public lands. One means of assuring that these unmanaged, ecological benchmark areas are available is to systematically select, for just those purposes, a collection of lands representing all of Maine's natural areas, or **ecosystems**. This is often referred to as an ***ecological reserves system***. In Maine approximately 100 discrete types of ecosystems have been classified by the Maine Natural Areas Program of the Maine Department of Conservation. Some more familiar examples among them include: northern hardwood forests, salt marshes, white cedar swamps, and spruce-fir forests.

This report was commissioned to provide information on the potential for an ecological reserve system on Maine's existing public lands and on nature preserves owned by conservation organizations. Numerous questions were addressed during the preparation of this report (and are outlined in this report's *Introduction*). However, the report's principal focus was :

- to examine the extent of variation that may occur in Maine's ecosystem types in different locations across the state;
- to see how well Maine's varied ecosystems are represented on the state's public lands and on private nature preserves;
- and to evaluate whether some of these lands could potentially function as ecological reserves.

History

In the mid-1980's a group of scientists, conservationists, and natural resource managers recommended the establishment of an ecological reserves system for Maine. Ecological reserves, they suggested, would have three important functions: 1) they would contribute to the conservation of Maine's biological diversity; 2) they would serve as unmanaged benchmarks or controls against which changes in the state's environment could be measured; and 3) they would serve as outdoor laboratories and classrooms for comparative and baseline research and environmental education.

In 1989 the recommendations of this group led the Maine State Legislature to pass a resolve (L.D. 1241) providing funds for a study on an ecological reserves system for Maine. The State Planning Office published the results of that study in a report titled, *An Ecological Reserves System for Maine: Benchmarks in a Changing Landscape* (McMahon 1993). That report contains important background material on the ecological reserves concept. However, due to funding constraints, the 1989 inventory was only partially completed.

The report in your hands, *An Ecological Reserves System Inventory: Potential Ecological Reserves on Maine's Existing Public Lands and Private Conservation Lands*, provides a comprehensive follow-up for the earlier report. It is a product of the Maine Forest Biodiversity Project, formed in 1994 to explore and develop strategies to help maintain Maine's existing native species and the ecosystems that contain them. The Biodiversity Project is a consensus-based collaborative effort involving approximately one hundred individuals representing a wide and diverse spectrum of interests and opinions: landowners; sportsmen; educators; advocates for property-rights; forestry, wildlife and land conservation professionals; and representatives of the scientific community, state and federal agencies, and the business community.

This report does not constitute a proposal by Project participants. Participants do expect that the information in this report, in addition to its scientific value, will be useful as a basis for preliminary economic analyses as the public evaluates the merits of creating ecological reserves in Maine.

Scope

The inventory focused on terrestrial and wetland ecosystems. It was confined to the approximately 1.1 million acres in public lands and on nature preserves owned by conservation organizations. These constitute about 5% of Maine's total land area.

Key assumptions that underlie the inventory approach include the following:

- The components of biological diversity can be maintained effectively in the long term by protecting examples of the physical environments in which they occur.

- Maine's plant community diversity represents the diversity of physical environments found in the state because vegetation reflects underlying environmental variables (climate, geology, soils, etc.).

- The assemblage of species that make up many of Maine's ecosystem types (such as spruce-fir forests, shrub swamps, northern hardwood forests) varies from region to region across the state.

- A majority of plant and animal species can be protected by conserving examples of the ecosystems they occupy without having to identify, inventory, and manage each species individually.

- Managed forest lands surrounding potential reserves can connect rather than isolate reserves over time. If this surrounding landscape were highly altered by development or other land uses, larger reserves would likely be needed to ensure the viability of the ecosystems they contain.

Ecosystem Inventory and Reserve Design

Between January 1995 and September 1997, a total of 99 areas (screened out of 796 possible sites) were inventoried on Maine's public land holdings, and on privately held nature preserves. The purpose of this phase was to collect field data to determine whether the areas inventoried were adequately intact and representative enough to serve as ecological reserves, to allow comparisons of sites across the state, and to provide enough information to develop preliminary reserve boundaries.

Each potential ecological reserve site received a landscape analysis involving interpretation of aerial photography; a review of current and historical information (including consultations with land managers) on topography, geology/soils, forest cover types, rare and endangered species, and surface water. Protocol for collecting environmental and vegetation data in the field were established with the assistance of a Scientific Advisory Panel (please see the frontispiece of this report for a listing of panel members). Field surveys were then carried out by several teams of professional field biologists. Following field surveys, data were interpreted and sites were identified for potential reserve design.

Before this study, data were limited on how much Maine's ecosystem types vary across the state. In other words, how much does a northern white cedar swamp ecosystem in Lubec resembles a northern white cedar swamp ecosystem in Bethel? To test this question, field inventory information was recorded and analyzed by site, and by 19 distinct state *biophysical* regions established by the U.S. Forest Service based on differences in climate, landform, soils, and vegetation (these biophysical regions, called *subsections* in this report, are depicted in *Figure 4*).

In the selection and design phase of this initiative, ecosystem boundaries were drawn on topographic maps. Reserve design guidelines, recommended by a Scientific Advisory Panel, directed the drawing of preliminary potential reserve boundaries. Once a potential reserve boundary was outlined, reserve selection criteria (also established with the assistance of the Scientific Advisory Panel) were applied, to determine whether the site qualified as a potential reserve.

Results

Sixty-nine potential reserve sites were identified. These sites encompass 498,700 acres, representing approximately 45% of the state's public and private conservation land and approximately 2% of the state's total land area. Of Maine's 115 ecosystem types, eight are not known to be found on the inventoried lands.

Sixteen of the 69 potential reserve sites are self-contained in the sense that the ecosystems that are represented at the site are well within the potential reserve boundaries. Forty-two sites are not self-contained and 11 more do not have the potential to be self-contained and may not be viable because the surrounding landscape is intensively developed. Size of potential reserve areas ranges from 83 acres to 181,360 acres (Baxter State Park). Thirty-four of the potential reserves identified are smaller than 1,893 acres, and 34 are larger.

Of the 69 potential reserve sites, 18 are in mountainous terrain and 29 are designed around wetlands. Potential reserves in mountainous areas tend to be much larger (average size of mountainous potential reserves ~ 20,300 acres) than the overall average. Potential reserves centered around wetlands tend to be relatively small (average size of wetland potential reserves ~ 2,000 acres). No potential wetland reserve boundaries are large enough to encompass the entire watershed of the wetland ecosystem of interest.

Preliminary work indicates that a number of Maine's ecosystems differ significantly in composition from one biophysical region to another (Maine contains 19 biophysical regions or *subsections*). Therefore, in order to have a collection of ecological reserves that effectively represent the variation of ecosystems across the state, it may be necessary to establish reserves in <u>each</u> of Maine's bioregions. This variation causes the study's key question – **how well are Maine's ecosystems represented on the state's public lands and on private nature preserves?** – to have at least a two-part answer:

1. When variation <u>is not</u> acknowledged and the question is evaluated <u>state-wide</u>, 92% of Maine's 115 terrestrial and wetland ecosystems are represented at least once on the inventoried lands.
2. When variation <u>is</u> acknowledged and the question is evaluated <u>biophysical region by biophysical region</u>, 46% of Maine's ecosystems are represented at least once in each of the 19 biophysical regions (in which they occur).

Thirty-seven of the 69 potential sites have half, or more, of their acreage currently under a form of management recommended by the Scientific Advisory Panel as being appropriate for ecological reserves. Thirty-seven percent of the acreage outlined as potential reserve sites in this report is presently considered operable timberland: forests that can and will be harvested under current Maine State statutes, public agency mandates, or management plans. Some parts of the state, although they contain public lands, have no qualifying reserves, while other parts, such as northwest Aroostook County and large swaths of central Maine have no public lands or private nature preserves to inventory for potential reserves. In southern Maine potential reserve sites are generally much smaller and their reserve values are often diminished as a result of surrounding, non-compatible land use.

Conclusions

This ecological reserves inventory and reserve design process was carried out to see how well Maine's ecosystems are represented on the state's public lands and on private nature preserves, and to evaluate the ecological reserve potential of these lands.

The results of this study imply that a system of many reserves, rather than one or a few, would be required to collectively encompass the full range of ecosystem types that comprise the Maine landscape. Existing public lands and private conservation lands are not adequate to accomplish this objective. The report indicates that approximately half the state's ecosystem types are effectively (though not necessarily optimally) represented on the 69 potential reserve sites located on public holdings and private conservation lands. However, in most cases, the reserve potential of these areas cannot be fully realized unless 1) these areas can be managed in a way that is compatible with ecological reserve objectives and 2) boundaries can be extended so that reserve areas can fully contain and adequately buffer the features they are designed to protect over the long run.

The inventory results are fundamentally affected by the exclusive focus on Maine's public and private conservation lands. These are typically small, unevenly distributed, and comprise only 5% of the state's area. We know relatively little about the remaining 95% of Maine's area. Therefore it is difficult to determine how effectively inventoried lands represent Maine's ecosystems overall.

The distribution and sizes of potential reserve sites are based on the locations and sizes of existing public and private conservation land holdings and, as a result, may not reflect an ecological ideal. In addition, existing boundaries of most of Maine's public and private conservation land units do not follow the boundaries of ecosystems. As a result, many potential reserves outlined in this report are not ecologically complete (i.e., they do not entirely contain the ecosystems of interest and/or include an adequate internal buffer) within the confines of existing public or private conservation land boundaries. Therefore, were the prototype reserves outlined in this report established as designed, there would remain significant gaps in the representation of Maine's ecosystem diversity.

While ecological reserves, as defined here, can – along with functioning as ecological benchmarks – contribute to the maintenance of biological diversity, they cannot do it alone, and have not been designed for this purpose. To conserve biological diversity in Maine, ecological reserves will need to be woven into a larger framework that integrates reserves with managed landscapes and with single rare species protection efforts. The key functions of the unmanaged reserves outlined in this report would be to increase our understanding of nature and help us become better managers of working land, while maintaining rare species and ecosystems unlikely to be maintained elsewhere.

Finally, in presenting this report, Maine Forest Biodiversity Project participants have agreed that any policy deliberations about reserves should be informed by a full discussion of the costs and benefits involved. For costs and benefits to be considered productively, an understanding of the potential scope of an ecological reserve system is necessary. A principal purpose of this report is to begin to provide that understanding. Having gathered this information, the Biodiversity Project makes it available to the general public and others responsible for making decisions about the future of ecological reserves in Maine.

INTRODUCTION

The Ecological Reserves Concept

Maine is a state with enormous natural variety. Found at the interface of two major forest regions – the boreal spruce-fir forest to the north and the temperate deciduous forest to the south, the state's flora and fauna are inherently diverse. There are as many types of peatlands squeezed into four degrees of latitude in Maine as Europe has in twenty. Vast forests, rugged mountains, thousands of lakes, miles of free-flowing rivers, island archipelagoes, broad bays, and bold coasts are all Maine landscapes. Although Maine's environment is changing, it is one of the few states in the lower 48 with the majority of its ecosystems still largely intact. From a scientific and educational standpoint, these ecosystems are an extremely valuable resource, but also a vulnerable one. The demands of tourism, recreation, residential development, intensive forestry, and other land uses on a finite supply of land and water are creating a landscape that is increasingly fragmented. Perhaps even more pervasive is the habitat degradation caused by global pollutants such as ozone and carbon dioxide.

To assess the impacts of these and other factors, we need to understand how ecosystems function and change naturally, without human intervention. The ecological reserves concept has been developed to provide a framework for identifying and protecting a network of sites that represents the full range of Maine's natural diversity. In essence, such a system would serve as a "reference library" of the best examples of Maine's natural ecosystems, with each reserve functioning as an indispensable volume in a statewide collection. A well-designed, adequately protected system of ecological reserves would provide an invaluable and irreplaceable resource for science, teaching, and natural resource planning today and in the future.

The purpose of an ecological reserves system, as envisioned by the Maine Forest Biodiversity Project, is to represent all native ecosystem types across their natural range of variation in Maine in a permanently protected system of reserves. Individual reserves would serve as 1) benchmarks against which biological and environmental change in both managed and unmanaged ecosystems could be measured; 2) habitats adequate to maintain viable populations of species whose habitat needs are unlikely to be met on managed lands; and 3) sites for scientific research, long-term environmental monitoring, and education.

The value of having a representative set of protected areas as ecological benchmarks or controls has been recognized in Maine for more than a decade. Such reserves are critical to our ability to answer questions about the maintenance of biological diversity, the natural state of species populations and ecosystems, and the range of variation that will be observed in them in the absence of direct human intervention (Arcese and Sinclair 1997). Studying areas that are relatively unmanaged by humans will enhance our ability to manage natural resources for a wide range of goals (Arcese and

Sinclair 1997). For example, studies in Baxter State Park conclusively demonstrated that spruce suffered less damage than fir from an uncontrolled spruce budworm outbreak, and helped researchers and managers understand which factors predispose a stand to budworm damage (McMahon 1993).

In addition to their value as benchmarks, ecological reserves would make a significant contribution to the protection of Maine's biological diversity. Biological diversity, or "biodiversity," is simply the diversity of life—in all its forms and all its levels of organization. Ecologists tend to focus on biological diversity at three levels: the gene, the species, and the ecosystem. The most familiar level, species diversity, is the variety of species in a given area. A less obvious level of biological diversity is the genetic variation among members of the same species. Genetic diversity is considered essential to the health and long-term survival of a species. The more genetic variability in a herd of deer, for example, the healthier the population tends to be. A third level of biological diversity reflects regional variations in climate, topography, soils, and bedrock type. Different physical settings have more or less distinctive communities of species. The variety of biological communities in a given area is referred to as ecosystem diversity. It is this third level of diversity that is the primary focus of ecological reserves and this report.

Biodiversity and ecological reserve defined

For our purposes, an ecological reserve can be defined as an area established to maintain one or more natural ecosystems that are representative of a region. These areas are relatively undisturbed or are well along in the process of recovery from human disturbance. They are large enough to maintain the functions and processes naturally present in each ecosystem type. Ideally, they are also large enough to include the minimum conditions necessary for long-term survival and adaptation of constituent species and populations. From a biodiversity conservation standpoint, a complete system of Maine's characteristic ecosystems would complement existing programs that focus primarily on rare and endangered species.

What is different about this approach?

The ecological reserves approach described in this report differs from many other conservation strategies in two respects. First, it focuses on *representative* natural ecosystems and landscapes rather than rare and endangered species. Ecosystem is defined here as an assemblage of interacting plants and animals and their common environment (Gawler at el. 1996)[1]. Some common types of ecosystems in Maine are northern hardwood forests, northern white cedar swamps, and dwarf shrub bogs. By

[1] The Maine Natural Areas program (MNAP) uses dominant vegetation and plant communities to distinguish upland and wetland ecosystem types. This is based on the assumption that vegetation integrates underlying environmental variables and can be used as a surrogate for physical and faunal diversity. In this report, ecosystem is used synonymously with the MNAP definition of natural community.

focusing on ecosystems, a network of reserves can be designed to include not only most of the species native to a region, but a variety of physical environments as well. This reflects the view that, in the long term, biological diversity may be maintained most effectively by protecting a diversity of physical environments. The assumption is that general vegetation patterns and patterns of diversity will follow physiographic patterns through time, even if actual assemblages of species change. Potential reserve areas are chosen systematically, using classifications of both regional landscapes (biophysical regions) and ecosystems, to ensure that a full range of biological and physical diversity is included in the system.

Second, ecological reserve systems are typically designed to provide a framework for baseline monitoring and long-term research. In order to maximize the value of a reserve system for monitoring and research, reserves are intended to be permanently protected and are designed to reflect ecological rather than property boundaries. Because a purpose of this system is to provide insights into how ecosystems respond to natural disturbance, the intent is to allow ecosystems to develop and evolve without human interference (for example, no timber harvesting, introduction of exotic species, or impoundments) rather than to manage in favor of a given species or successional stage.

The Purpose of the Maine Forest Biodiversity Project Ecological Reserves Inventory and this Report

The concept of an ecological reserves system was first promoted in Maine through a legislative resolve mandating a study to see if the state needed such a system and, if so, what it should look like. The study was undertaken in 1989-1990 by the Maine State Planning office with input and oversight from a ten-member steering committee. The State Planning Office study, *An Ecological Reserves System for Maine: Benchmarks in a Changing Landscape* (McMahon 1993a), included a description of the rationale for establishing ecological reserves and a preliminary inventory of existing public lands and private conservation lands to determine which ecosystem types were already represented and adequately protected. Other topics addressed in the study included a review of similar programs in other states and countries, reserve design criteria, appropriate uses of reserves, protection strategies for reserves, and ways to integrate an ecological reserves system with other natural areas programs in Maine. The State Planning Office inventory of potential ecological reserve sites was partially completed. Funding was not available to conduct a thorough ground-based survey or develop reserve designs for potential reserve areas.

At its first meeting in 1994, the Maine Forest Biodiversity Project (MFBP) decided that one of its first key objectives should be to complete the State Planning Office inventory. The Ecological Reserves Inventory conducted by the Maine Forest Biodiversity Project took place between January 1995 and October 1997, with guidance from twenty scientific advisory panel members as well as the group decisions of nearly one hundred MFBP participants. The purpose of this inventory report is to give project participants and others a much better idea of what is on existing public and private conservation lands and a concrete picture of what a reserve system serving the above purposes might look like.

Specific questions addressed include:

1. What ecosystem types are represented within the inventoried areas and what are their relative levels of quality? Conversely, what ecosystem types are not represented?

2. How are these ecosystem types distributed across the state and its biophysical regions?

3. How many of the sites evaluated qualify as reserve candidates and why? How many acres do these sites represent, individually and collectively?

4. To what degree do ecosystem types vary geographically across the state?

5. If regional variation exists, how many examples are needed, and, in what geographic distribution, to capture this variation?

6. How many acres of productive timberland are included in areas that qualify as reserves?

7. How many of the areas that qualify as potential reserves are currently being managed in a way that is compatible with ecological reserve objectives?

This report summarizes the results of the Maine Forest Biodiversity Project Ecological Reserves Inventory. It is not a proposal for an ecological reserves system. However, it is our hope that the inventory results will inform efforts to establish ecological reserves in Maine and help others evaluate what the potential benefits and costs of an ecological reserve system might be.

SCOPE OF THE INVENTORY

(What it does and doesn't do)

What Was Inventoried

The purposes of the ecological reserves inventory were: 1) to see how well the different ecosystems in Maine are represented on the state's public lands and private conservation lands, and, 2) to evaluate the ecological reserve potential of these lands. The legislative resolve that authorized the original State Planning Office study required that the inventory be confined to the approximately 1.1 million acres that are in public or private conservation ownership in Maine[1]. Maine Forest Biodiversity Project participants stipulated that they wanted to determine how well these lands met the objectives of an ecological reserve system before considering how any gaps might be filled on private land holdings.

Because the inventory was restricted to public and private conservation lands, which constitute only 5% of the state's land area, several caveats need to be kept in mind. First, because many public and private conservation units were originally acquired largely for their recreational and aesthetic values, this 5% is unlikely to include a representative sample of the state's ecosystems and landscapes. As is true of many protected areas, much of the acreage inventoried occurs in mountainous or wet terrain—areas with relatively low soil productivity that are less suitable for forestry or agriculture. As a result, except for montane and many wetland ecosystems, it is difficult to determine with any precision how representative the ecosystems inventoried are, since we know relatively little about the remaining 95% of Maine's land base. There is also a bias toward rare ecosystem types, since land protection efforts by several agencies and organizations have historically focused largely on rare rather than common ecosystem types and habitats.

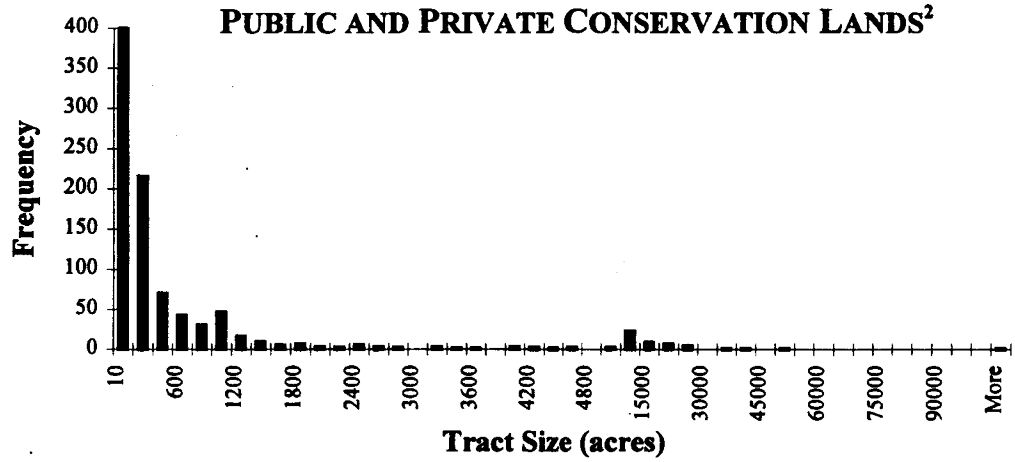
A second caveat is that distribution and sizes of potential reserve sites mirror the locations and sizes of existing public and private land units and, as a result, may not reflect an ecological ideal. For example, northwestern, northeastern, southern, and south-central Maine have the fewest public and private conservation lands and subsequently, the fewest potential reserve sites. Moreover, these are typically small (most are less than ~1,500 acres). In contrast, most of the largest units and potential reserves are in mountainous areas.

A third caveat – existing boundaries of most of Maine's public and private conservation land units do not follow ecological boundaries. The 1.1 million acres evaluated are divided into approximately 820 units and, thus, unit size is typically small; most are less than 500 acres (see Figure 1). In many cases, key features of interest, such

[1] Privately-held lands that are under conservation easement or other forms of less than fee conservation were not considered.

as peatlands, floodplains, ridges, or pond watersheds extend off the unit and onto adjacent private land. As a result, it was not always possible to design an ecologically complete reserve (including both the ecosystems of interest and an adequate internal buffer) within the existing public or private conservation unit boundary.

FIGURE 1. SIZE FREQUENCY HISTOGRAM OF MAINE'S PUBLIC AND PRIVATE CONSERVATION LANDS[2]



A Vegetation-Based Inventory and its Influence on Reserve Scale

Three assumptions underlie the inventory approach. First, in the long term, biological diversity can be maintained most effectively by protecting a diversity of physical environments, since the latter will remain relatively constant in the face of climate and other environmental changes (McMahon 1993). Second, because vegetation integrates underlying environmental variables, plant community diversity can be used as a surrogate for environmental diversity. Finally, a large majority of plant and animal species can be protected by conserving examples of the ecosystems they occupy without having to identify, inventory, and manage each species individually.

Our decision to use plant ecosystems as focal points for reserves ultimately influenced the scale of the potential reserves. The "grain-size" of an assemblage of ecosystems that recurs across a landscape may be relatively small, perhaps a few thousand acres. In contrast, designing reserves to encompass viable populations of species with large spatial requirements would require much larger areas. The needs of wide-ranging carnivores and other species with large spatial requirements were not used as a basis for reserve selection and design because Maine currently has no documented wide-ranging animal species (e.g., wolves and lynx) that are known to require completely unmanaged landscapes to survive. Hunting, trapping, and other pressures associated with

[2] Information derived from Kelly 1993. Note that the Tract Size scale (x-axis) changes from 200-acre to 5,000-acre increments after a tract size of 5,000 acres.

the presence of humans, rather than the lack of unmanaged habitat *per se*, is the likely limiting factor for these species. Consideration of strategies to conserve these species was beyond the scope of this inventory and design process as specified by the original legislative resolve and the Maine Forest Biodiversity Project.

What Was Not Inventoried

The ecological reserves inventory focused primarily on terrestrial and wetland ecosystem types. The Maine Forest Biodiversity Project stipulated that marine ecosystems be excluded from the inventory because it was beyond the purview of the project and we simply did not have the expertise to do so. Coastal islands were generally not inventoried for two reasons. First, a relatively intensive history of land use has resulted in a fairly homogenous vegetation in terms of both plant species composition and successional stage. Second, on islands, colonial seabird and wading bird populations, marine habitats, and other features may be better measures of overall biological diversity than ecosystems defined primarily by terrestrial vegetation.

Although the Scientific Advisory Panel recognized the key importance of streams and lakes in reserves because of the diversity of species they contain, their influence on adjacent ecosystems, and their value for long-term environmental monitoring, we evaluated aquatic ecosystems in only a cursory way. This reflects our poor understanding of aquatic biodiversity in Maine. Watersheds of undammed lakes and streams, and lakes that contain native, unstocked fish populations, were incorporated into potential reserve designs wherever possible. However, these were not used as the basis for the initial selection of potential public and private conservation land units included in this inventory.

A Rapid-Analysis Field Survey Approach

The field survey approach could best be characterized as a rapid assessment, rather than a complete census of all ecosystems on public and private conservation lands. If—based on aerial photos and other information—portions of a unit were determined to contain relatively intact examples of ecosystems, then a cross-section of these ecosystems was selected for sampling and characterization on the ground. On average, a team of two people spent three to four days on a given unit, collecting data from between 10 and 20 ecosystems. Typically, one quantitative sample plot was measured in each ecosystem. Along with a qualitative evaluation, this approach provided a basis for comparison with similar ecosystems on other units. We did not use a systematic, random sampling design. Rather, we consciously tried to target the best examples of natural ecosystems for field survey (mature, unfragmented, little direct human disturbance, etc.). A complete survey involving strict random sampling techniques would have involved more time and money than was available through the Maine Forest Biodiversity Project and would likely have overlooked many high quality ecosystems.

The focus of this inventory was on ecosystems and landscapes that are currently in a relatively undisturbed condition. The distinction between human-modified and undisturbed environments assumes that nature has functional, historic, and evolutionary limits and that extreme and rapid fluctuations (e.g., forest to cultivated field, draining of wetlands) are abnormal in most ecosystems. In addition, there is some evidence that areas with little or no human disturbance are more complex, more diverse, and consequently more resilient to natural disturbances than human-modified areas. In short, the less an ecosystem is disturbed by human activities, the greater its value as a benchmark or reference point.

While we recognize that there probably are no completely undisturbed ecosystems in Maine, we relied on several pre-screening criteria to set minimum standards for degree of human disturbance. For instance, we excluded sites from further analysis if they were created and maintained by artificial impoundments or were centered around reclaimed lakes and ponds, because species composition and abundance are likely to be dramatically altered by these types of management. Sites composed primarily of forested ecosystems were excluded from the inventory if they had undergone widespread harvesting in the last 40-50 years. The primary reason for this is that in heavily cut or high-graded stands it is difficult, if not impossible, to determine forest ecosystem type and composition. This criterion is likely to have skewed the inventory results because certain forest types (e.g., low elevation conifer stands) are more likely to have been harvested than other types. Many public land units, such as Round Pond, Telos, and Scraggly Lake, were eliminated from the analysis because of this criterion.

The Reserve Design Approach

Ideally, reserve design would be based solely on ecological factors, with the major criteria for reserve delineation being that it be of a size and shape and within a landscape context that can maintain the integrity of the ecosystems of interest over the long term.

The scale of individual potential reserves, and the Scientific Advisory Panel's estimates of viable reserve size, hinge on the assumption that a landscape context of managed forest land will serve to connect rather than isolate reserves over time. However, if this surrounding landscape were highly altered by development or other land uses, larger reserves would likely be needed to ensure long term viability – this may already be the case in much of southern Maine.

As a general approach to designing specific reserves, the Scientific Advisory Panel recommended starting with high quality examples of ecosystems, then incorporating additional landscape diversity by including lakes and their watersheds, topographic and geologic variability, and other features. It is important to note that the actual acreage of the ecosystems of interest is generally considerably smaller than the total reserve area required to buffer them from negative impacts of surrounding land uses and to incorporate small- to medium-scale natural disturbances. For example, to adequately buffer a key wetland, its entire watershed might be included in a potential reserve design even if it contains some land that has been recently harvested, as well as roads, borrow pits, and other disturbed areas.

The panel recommended that, ideally, reserves should be large enough to incorporate the types and scales of disturbance (wind, insects, fires, floods) that make up the natural disturbance regime of an area, and that at least some reserves should be large enough to accommodate species that may need larger tracts of unmanaged land. Different size reserves have the potential to accomplish different conservation objectives, as generalized below:

- Hundreds of acres may protect ecosystems that occur as small patches[3] on the landscape, typically in very localized geologic, edaphic, or hydrologic settings, such as cliff faces and circumneutral fens.

- Thousands of acres may protect ecosystems that occur as large patches[3] on the landscape, such as raised bogs and salt marshes.

- Tens of thousands of acres may be large enough to maintain examples of matrix-forming ecosystems[3], encompass major wind disturbances and hurricane tracks, and would probably be large enough to support populations of most birds and mammals, assuming populations of hundreds of individuals requiring on the order of hundreds of acres per individual.

- Hundreds of thousands of acres may be required to maintain populations of 100 individuals (minimum viable population size) of species, such as some raptors or carnivores, that require on the order of 5 mi^2 per individual, and may be large enough to incorporate less frequent and broader-scale disturbances such as major fires.

- Millions of acres may be required to meet the habitat requirements of even wider-ranging species, which are usually habitat generalists. Although reserves encompassing entire home ranges may not be required for species of this type, the overall distribution of reserves within a region and the condition of the land surrounding reserves could be important.

The panel estimated that on average, 5,000 to 12,000 acres should be large enough to: 1) sustain the suite of ecosystems and landscapes that characterize a given region, and, 2) be scaled to the majority of disturbances likely to affect the reserve. However, they acknowledged that this scale could not incorporate larger but less frequent catastrophic disturbances.

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[3] Small patch, large patch, and matrix-forming ecosystems are defined in Table 2 on page 27.

It is important to note that the panel viewed this size range as the minimum threshold that is defensible according to scientific literature (see for example, Lorimer and Frelich 1994 and Cogbill 1996). It is not the ideal – the ideal system would include a much larger range of reserve sizes, with at least some reserves in the 50,000+ acre size range. The large number of smaller potential reserves (1,000 - 5,000 acres) described in this report mainly reflects the Maine Forest Biodiversity Project stipulation that the inventory be confined to existing tracts of public and private conservation land.

Inventory Methods

By Janet McMahon and Susan C. Gawler

The purposes of the Ecological Reserves Inventory were to:

- collect field data on selected public lands and private conservation lands in Maine to determine if they are intact, diverse, and representative enough to serve well as ecological reserves;

- collect data allowing comparisons of sites so that a list of potential ecological reserve sites on public and private conservation lands could be developed; and

- provide enough information to develop preliminary reserve boundaries for each potential reserve site.

Evaluation was organized around natural ecosystems as an indicator of biological diversity. The inventory sought to catalog the ecosystems present on each unit surveyed and to assess the quality and viability of as many as possible. This information was used to evaluate their potential as ecological reserves.

A total of 820 areas, comprising approximately 1.1 million acres (~5% of the state) were evaluated between the State Planning Office inventory and this one. These included public lots, wildlife management areas, state and national parks, national forests and wildlife refuges, and private nature preserves and sanctuaries. Major landowners and managing agencies included the Maine Bureau of Parks and Lands, Maine Department of Inland Fisheries and Wildlife, Baxter State Park, U.S. Forest Service, U.S. Fish and Wildlife Service, National Park Service, the U.S. Department of Defense and The Nature Conservancy. Lands held by local municipalities, local land trusts, local water districts, and land protected through conservation easements were not surveyed.

The field inventory involved the following steps:

1. Revision of the list of ecosystems to be evaluated and refinement of the biophysical region classification.

2. Development of a list of sites to evaluate.

3. Landscape analysis of each site.

4. Development of field survey protocol.

5. Field surveys.

6. Summarizing and interpreting field data.

7. Analysis of the ecological reserves inventory data to determine geographic variation of ecosystem types across biophysical regions.

8. Selection of sites for reserve design.

Each of these steps is discussed in detail below:

Step 1. Revision of the list of ecosystems to be evaluated and refinement of the biophysical region classification.

A key purpose of a reserve system is to represent all native ecosystem types across their natural range of variation in Maine. In the State Planning Office Study, a two-tiered approach was used to assess representativeness. First, an ecosystem classification was developed for Maine that lists and describes the kinds of ecosystems (typical and unusual) that occur in the state. In this classification, an ecosystem was defined as a group of plant and animal populations and their common environment. Some familiar examples are northern hardwood forests, alpine meadows, and dwarf shrub bogs.

Because no two ecosystems have exactly the same species composition or environment, it is impossible to select a truly representative example of a given ecosystem type. For example, a spruce-fir forest in Fort Kent will have a somewhat different set of species than one in southern Maine, where this ecosystem type reaches its southern limit. To capture this regional variation, a biophysical classification was developed for Maine that divides the state into 15 regions based on climate, landform, soils, and vegetation (McMahon 1990). The distinctive landscape and climate of each region produce characteristic soil and vegetation patterns. Within each region, similar ecosystems can be expected in similar positions on the landscape. For example, in Maine's Eastern Coastal Region, which is characterized by a cool, wet climate, maritime spruce-fir forests are typical of upland areas and coastal plateau bogs are often found in lowlands. The species composition of these two ecosystem types differs from that of inland spruce-fir forests and bogs.

Using the ecosystem and biophysical classifications simultaneously provides a mechanism for identifying the range of ecological diversity in Maine. If a reserve system contains examples of each ecosystem type identified in the Maine ecosystem classification, it should include most of the species native to the state. A biophysical classification can then be used to determine how many of each ecosystem type should be included in a reserve system and in what parts of the state these reserves should be located. For example, a complete ecological reserves system might include an example of each ecosystem type in each of the biophysical regions in which it occurs.

The result would be a network of reserves that not only represents each ecosystem, but also the range of variation in species composition within each ecosystem type.

The two-tiered approach used to classify diversity and assess representativeness in the State Planning Office study was also used here, but both the ecosystem classification and biophysical region classification have been refined somewhat. Our understanding and depiction of the different ecosystems in Maine are changing as we gather more information on composition, environmental settings, and distribution. The list of ecosystems described in the State Planning Office study was used as a foundation for the Maine Natural Areas Program's original classification of natural communities[1] (Maine Natural Heritage Program 1991). Since 1991, minor revisions to the list have been made to reflect new information collected in the interim. For example, review of data indicated that the "river beach" ecosystem described in MNHP (1991) actually consisted of two very distinct types, the "Hudsonia river beach" characteristic of the Saco River and the "Laurentian river beach" found in extreme northern Maine along the St. John and Aroostook Rivers. The most recently-published version of the list is in the Biodiversity Assessment prepared by the Maine Forest Biodiversity Project (Gawler et al. 1996).

An updated list of ecosystems is maintained in the Maine Natural Areas Program's Biological Conservation Database. Differences between the current list and the version used in the biodiversity assessment report (Gawler et al. 1996) largely reflect the results of this inventory, in which several ecosystems were sampled that were previously undocumented in the state.

The study of ecosystems in Maine has been based primarily on vegetation. The delineation and description of aquatic non-vegetated ecosystems is very general and differs little from that used in the 1993 State Planning Office study. River, stream, and lake ecosystems were catalogued where possible; non-vegetated estuarine and marine ecosystems were not considered in this inventory.

The current list of ecosystems that occur in Maine includes 54 upland types, 32 wetland types, 12 lake types, 9 river types, 1 subterranean type, and 7 vegetated estuarine types, a total of 115. These are listed in Table 6.

The biophysical region classification (McMahon 1990) has also been revised. It is now part of a hierarchical classification being developed by the USDA Forest Service for the eastern United States (Keys et al. 1995). In this classification, Maine is divided into 3 provinces, 7 sections, and 19 subsections. The subsections are generally equivalent to the 15 biophysical regions in McMahon (1990). These are shown in Figure 4.

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[1] In the Maine Natural Areas Program classification, the term "natural community" is synonymous with the definition of ecosystem used in this report.

Step 2. Development of a list of sites to evaluate.

In all, 99 areas were evaluated during the MFBP Ecological Reserves Inventory. These included:

- the 66 areas identified in the 1993 State Planning Office study,
- 22 new acquisitions,
- 6 areas that had been overlooked, and
- 5 areas of marginal quality that were reconsidered because of their rarity.

During the State Planning Office inventory which took place in 1989 and 1990, pre-screening criteria were applied to the 796 tracts of public and private conservation land that existed at that time. Sites were excluded from further analysis if: (1) they were smaller than 20-30 acres (unless they represented a rare or geographically restricted ecosystem type), (2) they were largely developed for other uses (e.g., picnic areas and campsites), (3) they were composed primarily of forested ecosystems that had been harvested within the last 40-50 years, or (4) they had been created and were maintained by artificial impoundments. These same pre-screening criteria were applied to the 35 new sites identified through the MFBP inventory.

Step 3. Landscape analysis.

Landscape analysis is a method of synthesizing existing information on the vegetation, physical environment, and land use history of a tract of land. This helps to target areas for field work that have the greatest potential for the feature(s) of interest (e.g., examples of different ecosystem types in relatively natural condition). The depth and scope of each analysis depends on ecosystem complexity and scale. For example, a search for a rare ecosystem type associated with a specific soil or bedrock type will be less involved than an evaluation of the variety and condition of ecosystem types that occur on a tract of land. In this case, the goal was to identify, on each unit, a cross-section of ecosystem types for field survey. If a particular unit contained three northern white cedar swamps, four acidic summits and three spruce flats, we typically identified one or two examples of each ecosystem type for field survey. The following is a list of the kinds of information typically considered during the landscape analysis phase of the ecological reserves inventory.

Site boundaries. Site boundaries were drawn onto a USGS 7.5' topographic map. Our sources of information included landowners and managing agencies and the conservation and public lands database (Krohn and Kelly 1997; MOGIS 1996).

Topography. USGS 7.5' topographic maps were used to evaluate physiographic diversity, access, and to some extent land use (roads, dams, clearings, etc.). For certain ecosystem types, aspect and slope were good indicators of potential occurrences.

Geology and soils. Certain bedrock and soil types are useful for locating unusual ecosystems such as maple-basswood-ash forests and circumneutral fens. Detailed bedrock geology maps (1:24,000 scale) exist for about half the state. A generalized map of Maine (1:500,000) (Osberg et al. 1985) was used when detailed maps were not available. Soils information was taken from Natural Resources Conservation Service county surveys and Ferwerda et al. (1997). Unfortunately, much of northern and eastern Maine has not yet been surveyed, or the information is not yet available to the public.

Cover type maps. Current forest type maps were useful for identifying mature forests and the context for these stands. Some maps also showed boundaries of old burns and the best access roads into areas targeted for field checking. Old type maps were useful for evaluating cut histories. Stand prescriptions were reviewed when available. Type maps showing wetland and other ecosystem types were particularly useful.

Biological Conservation Database. Already documented records of rare plant and animal habitats and ecosystems were plotted on 7.5' topographic maps. These records were obtained from the Maine Natural Areas Program.

Aerial photo interpretation. Stereo pairs of recent small-scale color photography (when available) were interpreted using a stereoscope. Ecosystem boundaries, cutting history and adjacent land use, site conditions, and access were determined from air photos. In some cases, looking at older photos (Maine Geologic Survey statewide coverage in black and white for 1966 and 1981) was helpful when evaluating site history, particularly for forest and wetland ecosystems.

MIDAS Lake Inventory. The Maine Department of Inland Fisheries and Wildlife maintains a database for approximately 2,000 Maine lakes and ponds. Information on lake type, fisheries, stocking history, and in many cases, water quality, was reviewed.

Spruce budworm spray history. Generalized spray maps by year are available from the Maine Forest Service. These were used to evaluate the benchmark value of certain ponds, lakes, streams, and watersheds. We assumed that ponds and streams in unsprayed watersheds are likely to have more intact flora and fauna than those that were sprayed.

Existing inventories and management plans. These sometimes provided descriptions of the features being inventoried, or the land use history of a tract. For example, the Maine Bureau of Parks and Lands and the Maine Department of Inland Fisheries and Wildlife often have management plans for their units that describe access, special features, site history, and so on.

Consultation with agency biologists, foresters, and land managers. Much of the information evaluated during the landscape analysis phase was obtained from the agency or organization most familiar with the unit being inventoried. Agency foresters, biologists, and land managers provided expertise on specific tracts of land and assisted with several phases of the inventory.

Step 4. Development of field survey protocol.

The field protocol was based on natural ecosystem survey methods used by the Maine Natural Areas Program and other ecosystem sampling methods, which were then modified by the Scientific Advisory Panel to fit the needs of this particular inventory (see sample ecological reserves inventory field form in Appendix F). Because of the wide array of ecological conditions to be sampled, the protocol included several approaches. The core information, ideally obtained for all ecosystems (observation points) encountered, was contained in the Site Summary, and used to cross-reference the sampling data from the individual observation points.

For observation points where more detailed information was collected, field crews used different sampling techniques depending on the vegetation type and the time available. For vegetated ecosystems, the following were used:

- A summary of environmental data (soils, landscape position, etc.), to be filled out for each observation point sampled;
- A vegetative structure summary with total vegetation cover and dominant species by stratum;
- Tenth-hectare plots (10 m x 100 m, which is approximately 1/4 acre) for forest ecosystems, with all trees tallied for dbh (diameter at breast height) and with subsamples for other vegetation layers;
- Prism plots as an alternative for forested ecosystems, with the addition of a species list for non-canopy vegetation;
- For non-forested vegetation, 10 m x 10 m plots;
- For aquatic features, information on hydrology and dominant plant species was collected. Water samples were collected for water chemistry analysis by the Maine Department of Environmental Protection. Aquatic features were not sampled in any detail, and the information collected was cursory.

The field survey protocol sought to obtain as much useful data as possible given the limited time available at each site. Thus, the protocol allowed different sampling methods. In a statistical analysis, this could cause concern as data collected with different methods cannot necessarily be combined in one analysis. However, the uses of the Ecological Reserves Inventory data are primarily **descriptive** rather than

statistical. This type of field survey is not like a timber cruise in that no attempt was made to estimate board-foot volumes nor to statistically compare basal area estimates, for example. These field surveys were designed to provide information on the structure, composition, and environmental setting of different ecosystems within the land units considered so that those lands could be evaluated as potential ecological reserves. Careful interpretation of these data, though collected by varying methods, can therefore yield valid results and serve the task for which they were designed.

Step 5. Field Surveys.

Of the 99 sites included in the MFBP Ecological Reserves Inventory, 14 were eliminated after application of the pre-screening criteria or landscape analysis. Seventy-nine sites were surveyed in the field. The remaining six sites were not surveyed during this inventory because comparable field data for these sites already existed.

Field surveys were conducted during the 1995, 1996, and 1997 field seasons by one of four field teams, each consisting of a trained field ecologist and one or two assistants. On average, three to four days were spent at each site. Field teams focused on areas identified during the landscape analysis—in general one or two examples of each ecosystem type present in a given unit were sampled following the protocol outlined in Step 4. This was not a systematic approach involving transects over entire units, but rather a rapid analysis approach that tried to target high quality examples of ecosystems.

Step 6. Summarizing and interpreting field data.

The 79 sites inventoried yielded 1,149 observation points. These include:

- 212 tenth-hectare plots (some as 0.05 ha or 0.025 ha plots);
- 198 prism plots;
- 326 10 m x 10 m plots;
- 128 pond/stream lists; and
- 285 reconnaissance-only points.

The samples included 8,000+ dbh measurements, 2,000+ subplots for ground-layer vegetation in the forest plots, and 2,000+ subplots in the non-forested samples, incorporating over 888 plant species.

The Maine Natural Areas Program (MNAP) provided data summaries for use in selecting and designing potential reserves. MNAP built a database in MS-Access for data entry, quality control, and summarization of the vegetation data from all vegetated observation points. Data on aquatic features were not quantitatively evaluated.

For each observation point, ecosystem type was determined (or confirmed, based on the field team's provisional name). For upland and wetland ecosystem types, this was based on the composition and structure of the vegetation. Next, MNAP staff determined which observation points represented rare or exemplary ecosystems. **Rare ecosystems** are those ranked S1, S2, or S3[2] by the Natural Areas Program. All known occurrences of rare ecosystem types were entered into the Biological Conservation Database. **Exemplary ecosystems** are occurrences of common ecosystems that are of high quality, i.e., ranked as "A" or "B" under the MNAP ranking system. Where data were sufficient, each occurrence of common ecosystem types was evaluated to determine if it could be considered "exemplary."

The A - D ranks used by MNAP and in the ecological reserves selection criteria are intended to reflect the quality and predicted viability of a particular occurrence. An A - D rank is assigned to each of three attributes—Size, Condition, and Landscape Context—and then synthesized into an overall rank.

"Size" is used as an indicator of both quality and viability. It is scaled to the occurrence pattern of the ecosystem. A 20-acre hemlock ravine that is completely intact would rate higher than a 20-acre remnant of a matrix-forming ecosystem (e.g., a beech-birch-maple forest). Along with size, composition sometimes influences a quality rank.

"Condition" indicates the relative degree of human disturbance. For forests, for example, we may ask the following questions: has there been recent cutting (of more than the occasional tree)? Are there visible signs of older cutting, or has the ecosystem outgrown past disturbance? Are there stone fences indicating former pasture or a plow layer in the soil indicating cultivation?

"Landscape context" rates whether the area immediately surrounding that particular ecosystem is intact, fragmented, or developed. For instance, a 50-acre patch of pine-oak forest is going to rank higher if it is surrounded by forested land than if it is isolated by agriculture and development.

Pending a more complete analysis of the ecological reserves inventory data, MNAP used an initial screening for common ecosystem types to separate the A-B

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[2] S1= Critically imperiled in Maine because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because some aspects of its biology makes it especially vulnerable to extirpation from the state.
S2= Imperiled in Maine because of rarity (6-20 occurrences or few remaining acres) or because of other factors making it vulnerable to further decline.
S3= Rare in Maine (on the order of 20 to 100 occurrences).

occurrences from the C-D occurrences. This screening, to judge if an occurrence of a common ecosystem was at least a "B", primarily revolved around acreage and history.

Landscape context was a secondary concern for the ecological reserves inventory since all of these occurrences are on public lands or private conservation lands to begin with, and since very small parcels and holdings with recent timber operations were generally excluded. Landscape context was considered good to excellent ("at least B") for most occurrences. Specific criteria follow:

- The minimum size criteria for B rank were at least 50 acres for a matrix-forming ecosystem and at least 20 acres for a large-patch ecosystem. For example, a 60-acre stand of mature northern hardwood forest may be ranked as an exemplary occurrence by the Maine Natural Areas Program, but it would only be considered a conservation target for a potential ecological reserve if it is part of a more extensive forested landscape (containing ecosystems with various grades of quality).

- The condition/history criteria were core ring counts of over 100 years (for forests) and/or noted as lacking obvious signs of recent human disturbance (other than localized disturbance).

- Landscape context was considered excellent ("A") if the ecosystem and its surroundings comprised at least 1,000 acres of largely undisturbed landscape, and good ("B") if the surrounding landscape showed some alteration (e.g. working forest) but not large-scale fragmentation or development.

The list of ecosystem types present at each site and their ranking as rare, exemplary, neither, or unknown (for some non-forested ecosystems for which ranking criteria are not yet developed) were then used to evaluate each site's potential as an ecological reserve.

Step 7. Analysis of the ecological reserves inventory data to determine geographic variation of ecosystem types across biophysical regions.

One of the goals in designing a system of potential ecological reserves is to assure adequate representation across the landscape, i.e., to represent the geographic range of variability in ecosystems. In the original ecological reserves report (McMahon 1993a), the goal was to include each ecosystem type in each of Maine's 15 biophysical regions in which it occurs.

The 1995-1997 inventory data, and a recent USDA Forest Service map putting Maine's biophysical regions into a regional context (Keyes et al. 1995), allow us to examine more closely the degree to which certain ecosystem types vary geographically. The USDA Forest Service mapping system uses a hierarchy of biogeographical regions from province (broadest), to section, to subsection (narrowest) (see Figure 4). Maine spans 19 subsections, which are grouped into 7 sections and 3 provinces.

The general question of interest is: would a potential ecological reserves system adequately represent Maine's biota (again, using ecosystems as the "coarse filter" for plant, animal, and other species) if one example of each ecosystem were included statewide; if one example of each ecosystem were included in each province (of occurrence); if one example of each ecosystem were included in each section; or if one example of each ecosystem were included in each subsection? Or, to put it another way, are ecosystems of the same type in different parts of the state so similar that they can be considered equivalent, potentially redundant, examples of the type, or are there substantial differences between them in terms of the species they are likely to include?

The question can best be answered by looking at the set of ecosystem types that have a relatively large number of samples from the 1995-1997 inventory. Even with over 750 plot samples, dividing them into the various ecosystem types leaves most types with fewer than 10 samples. For this analysis, 4 forested types and 3 non-forested wetland types were chosen, each of which had at least 25 samples. These included northern hardwood forests, spruce-fir forests, mixed hardwood-conifer forests, northern white cedar swamps, acidic fens, sedge meadows/graminoid swales, and dwarf shrub bogs. Geographic variation within each type was examined using a combination of a visual analysis technique (Detrended Correspondence Analysis) and a statistical analysis technique (Multi-Response Permutation Procedures). The combination provides more complete information than either technique alone. Because of the differences in data collection methods, only plant species presence/absence data were used, as these could be reliably standardized across the various types of samples. All vascular plants, herbaceous and woody, were included; bryophytes and lichens were excluded due to uneven quality of sampling. Results are summarized on page 56 and methods and results are given in detail in Appendix C and in Gawler (in preparation). The statistical tests are summarized in Table 9.

Step 8. Selection of sites for reserve design.

Of the 79 sites surveyed in the field, plus six sites for which information already existed, nine were disqualified from further analysis because they did not have high quality communities. Each of the remaining 76 sites contained one or more examples of high quality or rare ecosystem types. Six pairs and one triplet of sites were adjacent to one another or in close proximity and were evaluated as single potential reserve areas. In all, 69 sites were identified for reserve design. These are listed in Table 1 on page 22 and shown in Figure 2 on page 21.

FIGURE 2. MAP OF ALL SITES EVALUATED DURING THE ECOLOGICAL RESERVES INVENTORY

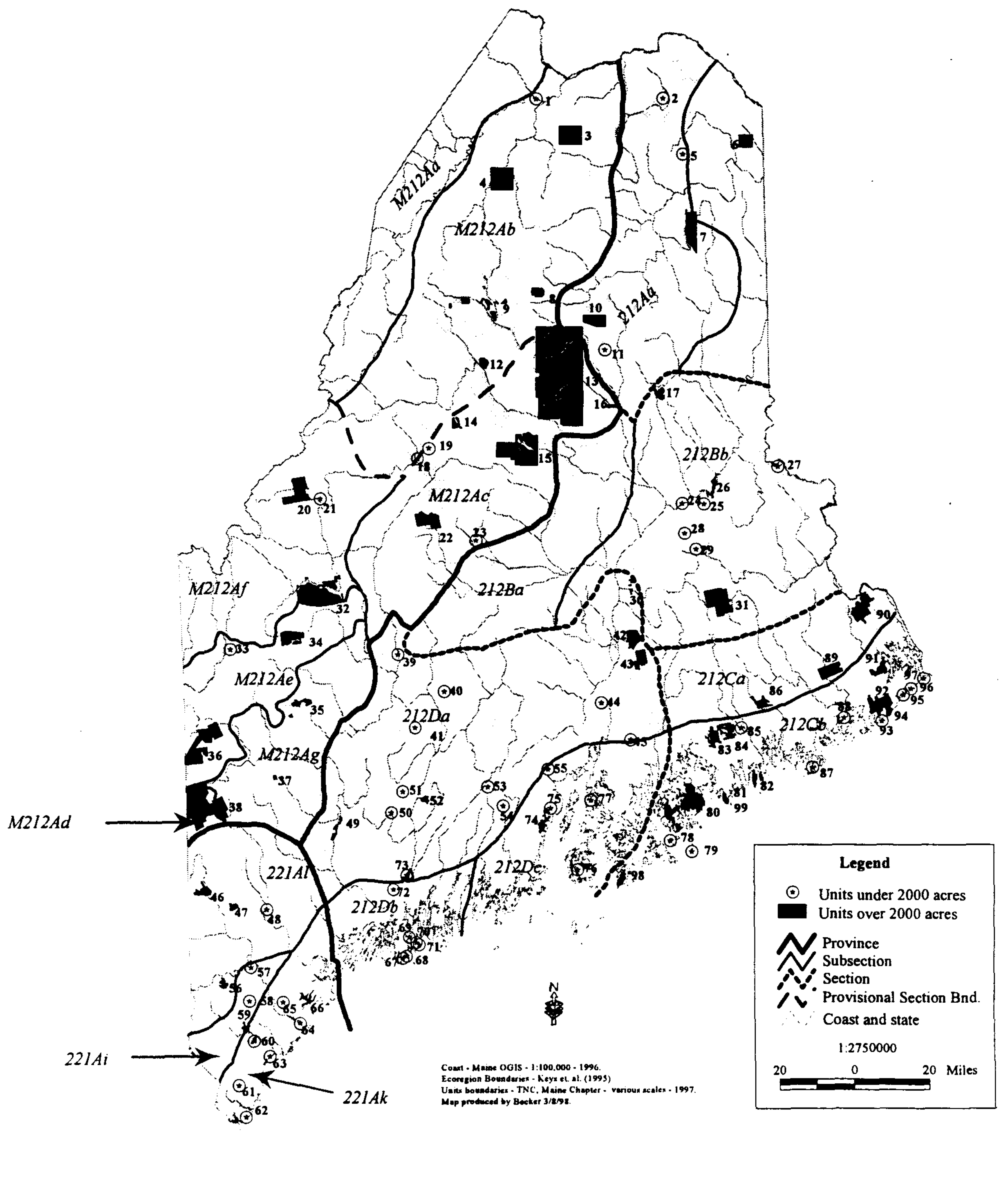


TABLE 1. SITES EVALUATED DURING THE ECOLOGICAL RESERVES INVENTORY

Map #	Site Name (Owner/Manager)[1]	Disqualified After Pre-Screening or Landscape Analysis	Disqualified After Field Check	Sites Selected for Reserve Design
1	Allagash (BPL)			X
2	Cross Lake Fen (BPL)			X
3	Deboullie (BPL)			X
4	Round Pond (BPL)	X		
5	Salmon Brook Lake Bog (BPL)			X
6	Loring (USDOD)	X		
7	Squa Pan (BPL)			X
8	Big Reed Forest Reserve (TNC)			X
9	Chamberlain (BPL)			X
10	Scraggly Lake (BPL)	X		
11	Marble Fen (TNC)			X
12	Gero Island (BPL)			X
13	Baxter State Park (BSP)			X
14	Lobster Lake (BPL)	X		
15	Nahmakanta (BPL)			X
16	Wassataquoik (BPL)			X
17	Crystal Bog (TNC)			X
18	Kineo/Farm Island (BPL)			X
19	Moosehead Unit/Days Academy (BPL)		X	
20	Holeb (BPL)			X
21	No. 5 Bog/Jack Pine (FSM)			X
22	Little Squaw (BPL)			X
23	Borestone Sanctuary (NAS)			X
24	Mattawamkeag Wilderness Park (town)		X	
25	Mattagodus Stream (IFW)			X
26	Mattawamkeag (IFW)			X
27	Forest City (IFW)			X
28	Dwinal Flowage (IFW)		X	
29	McGoon Lot (BPL)			X
30	Ayers Brook (TNC)			X
31	Duck Lake (BPL)			X
32	Bigelow (BPL)			X
33	Bald Mountain (BPL)	X		
34	Redington Twp (USDOD/BPL/NPS)			X
35	Mt. Blue (BPL)			X
36	Mahoosucs (BPL)			X
37	Little Concord Pond (BPL)			X
38	White Mountain National Forest (USFS)			X

Map #	Site Name (Owner/Manager)[1]	Disqualified After Pre-Screening or Landscape Analysis	Disqualified After Field Check	Sites Selected for Reserve Design
39	Indian/Fowl Meadow Island (TNC)	X		
40	Lake George (BPL)	X		
41	Martin Stream (IFW)	X		
42	Sunkhaze National Wildlife Refuge (USFWS)			X
43	Bradley (BPL)			X
44	Fields Pond (MAS)	X		
45	Branch Lake (BPL)			X
46	Brownfield Bog (IFW)			X
47	Middle Pond (BPL)			X
48	Sebago Lake State Park (BPL)			X
49	Turner/Leeds (BPL)	X		
50	Jamies Pond (IFW)		X	
51	Tyler Pond (IFW)		X	
52	Alonzo Garcelon (IFW)			X
53	Lake St. George (BPL)		X	
54	Appleton Bog (TNC)			X
55	Hurds Pond (IFW)		X	
56	Waterboro Barrens (TNC)			X
57	Little Ossipee/Killick (BPL/IFW)			X
58	Massabesic - Lyman (USFS)			X
59	Massabesic - Alfred (USFS)			X
60	Kennebunk Plains (IFW/TNC)			X
61	Mt. Agamenticus (IFW)			X
62	Rachel Carson NWR-Braveboat Harbor (USFWS)			X
63	Rachel Carson NWR-Upper Wells (USFWS/BPL)			X
64	Ferry Beach (BPL)			X
65	Saco Heath (TNC)			X
66	Scarborough Marsh (IFW)			X
67	Morse Mountain (Bates/TNC)			X
68	Popham Beach (BPL)			X
69	Swett Marsh/Back River (IFW/TNC)			X
70	Josephine Newman Sanctuary (MAS)			X
71	Reid State Park (BPL)			X
72	Merrymeeting/Muddy River (BPL/IFW)			X
73	Swan Island (IFW)	X		
74	Camden Hills (BPL)			X
75	Knights Pond (TNC)			X
76	The Basin (MCHT)	X		
77	Holbrook Sanctuary (BPL)		X	
78	Placentia Island (TNC)		X	

Map #	Site Name (Owner/Manager)[1]	Disqualified After Pre-Screening or Landscape Analysis	Disqualified After Field Check	Sites Selected for Reserve Design
79	Great Duck Island (TNC)	X		
80	Acadia National Park - Mt. Desert Island (NPS)			X
81	Winter Harbor (USDOD)			X
82	Petit Manan National Wildlife Refuge (USFWS)			X
83	Donnell Pond (BPL)			X
84	Spring River Lake (BPL)			X
85	Narraguagus Junction (IFW)			X
86	Great Heath (BPL)			X
87	Great Wass (TNC)			X
88	Larrabee Heath (TNC)			X
89	Rocky Lake (BPL)			X
90	Moosehorn - Baring (USFWS)			X
91	Moosehorn - Edmunds (USFWS)			X
92	Cutler Grasslands (BPL)			X
93	Western Head (MCHT)			X
94	Cutler Coast (BPL)			X
95	Eastern Head (BPL)	X		
96	Boot Head (MCHT)			X
97	Quoddy Head State Park (BPL)			X
98	Acadia National Park - Isle au Haut (NPS)			X
99	Acadia Nat. Park - Schoodic/Turtle I. (NPS/TNC)			X

Note: The following sites were combined for reserve design purposes:

* Morse Mountain and Popham Beach
* Camden Hills and Knights Pond
* Schoodic Point and Winter Harbor
* Cutler Coast, Cutler Grasslands, and Western Head
* Reid State Park and Josephine Newman Sanctuary
* Donnell Pond and Spring River Lake

[1] Key to abbreviations: BPL=Maine Bureau of Parks and Lands; BSP=Baxter State Park; TNC=The Nature Conservancy; FSM=Forest Society of Maine; NAS=National Audubon Society; IFW=Maine Department of Inland Fisheries and Wildlife; USFS=United States Forest Service; USFWS=United States Fish and Wildlife Service; MAS=Maine Audubon Society; MCHT=Maine Coast Heritage Trust; NPS=National Park Service; USDOD=United States Department of Defense.

RESERVE SELECTION AND DESIGN METHODS

Ecological reserves can be viewed as dynamic landscapes selected and designed to allow their constituent species and ecosystems to evolve over time. Because their value as benchmarks is so fundamental to the ecological reserves concept, designing reserves to be viable over the long term is essential. The reserve design phase of the ecological reserves inventory involved three steps. First, boundaries of high quality and rare ecosystems identified during field surveys were drawn on 7.5' USGS topographic maps. These ecosystems were generally the primary conservation targets. Second, the landscape context and integrity of the conservation targets were evaluated, the reserve design guidelines in Table 3 were applied, and a preliminary reserve boundary was drawn. Draft site descriptions and maps (see Appendix E for example) were sent to land managers/owners for review and comment. Third, once a potential reserve boundary was drawn, the compatibility of the surrounding landscape was evaluated and selection criteria were applied to determine whether the potential reserve qualified for inclusion on a final list of candidate sites. These were then reviewed by the Scientific Advisory Panel. The Maine Forest Biodiversity Project's stipulations that the inventory and analysis not include adjacent private land (other than to describe in most general terms the condition of the surrounding landscape) and that every attempt be made to provide internal buffers were observed throughout.

Reserve Design Guidelines

Designing ecological reserves is neither a simple nor an exact science. Because every tract of land is unique, different design guidelines apply. The design guidelines in Table 3 were developed by the Scientific Advisory Panel to provide a conscious link between conservation theory and practice, and to bring a higher degree of standardization to the reserve design process. The goal was to develop guidelines that are specific to Maine and the greater Acadian-Appalachian region. Because the type of criteria that can be applied varies with the scale of the conservation target, the guidelines are organized according to how ecosystems occur across the landscape (see Table 2 for a detailed description of different ecosystem occurrence patterns). A few ecosystem types (matrix-forming upland forests) are dominant, forming 75-90% of the land cover, while most ecosystem types (large and small patch types) cover only a small part of the land surface and are nested within the dominant types. The handful of dominant ecosystems play a disproportionately large role in defining the structure and function of the landscape as a whole. Conversely, the small and large patch ecosystems harbor a disproportionately large amount of the biodiversity. Thus, to conserve biodiversity and the biological integrity of the state, reserves were designed at a variety of scales appropriate to their targets (Anderson 1997).

In practice, reserves are typically centered around one or more key features. For example, at a given site, conservation targets might include a chain of ponds (small and large patches) that support native blueback trout populations, a talus slope (small patch) and calcareous cliff (small patch) bordering one of the ponds, and a cedar swamp (large patch) surrounding one of the ponds. These small and large patch ecosystems might be embedded within a matrix of spruce-fir and mixed forest. In most situations, reserve designs are based on a combination of the guidelines presented in Table 3.

Criteria for Selecting Potential Reserve Sites

Sites were included on the enclosed list of potential ecological reserves if they met the selection criteria developed by the Scientific Advisory Panel (Table 4). Although these criteria may more appropriately be thought of as guidelines, they were used to set minimum standards for determining whether a site qualified as a reserve, did not qualify, or whether more information is needed to make a judgment. Fundamentally, the criteria are based on standards of high quality examples of ecosystems, high landscape diversity and representativeness, and integrity/long term viability.

In developing and applying both the Reserve Design Guidelines and the Reserve Selection Criteria we were guided both by the proposed purposes of reserves and by the "underlying assumptions" developed by the Scientific Advisory Panel which are based on broadly held tenets of current conservation biology. These assumptions are listed in Appendix A.

TABLE 2. ECOSYSTEM OCCURRENCE PATTERNS

	MATRIX	*LARGE PATCH*	*SMALL PATCH*
DEFINITION	Mosaic of ecosystems forming the dominant character of the area. While individual ecosystems (e.g. northern hardwood stands) are generally in the 100's of acres, mosaics of matrix forest ecosystems generally cover 1,000's to 1,000,000 acres.	Ecosystems that occur as large patches covering generally 50-1,000 acres.	Ecosystems that typically occur as very small, 1-50 acre patches. They are often an inextricable part of a larger ecosystem mosaic.
GENERAL EXAMPLES	terrestrial forests on till, lake sediment, outwash	talus slope and cove forests summit woodlands basin swamps seepage forest floodplain herbaceous marshes bogs shrub swamps	cliff faces fens alpine ecosystems outcrops basin marshes tidal marsh ecosystems rivershore ecosystems
SPECIFIC MAINE EXAMPLES	spruce-fir flats beech-birch-maple forest mixed hardwood-conifer forest	northern white cedar swamp forested bog krummholz oak-pine woodland maple-basswood-ash forest hemlock slope forest pine barrens	circumneutral fen alpine ridge acidic rocky summits circumneutral or acidic cliffs riverside seep
APPROXIMATE SIZE (ACRES)	1,000s-1,000,000 estimate 80% of total landscape	50-1000 estimate 20% of total landscape	1-50 estimate <2% of total landscape
CONTIGUOUS-NESS	May remain functional in relatively manipulated landscapes. Inclusions of small and large patch ecosystems are typical.	Should be as large and unfragmented as possible. Will typically have inclusions of both matrix fragments and other large and small patch ecosystems.	Viability is dependent on surrounding landscape mosaic; low tolerance for any internal fragmentation.
HABITAT SPECIFICITY	general, reflects larger-scale climatic conditions as those affect dominant species	specific, typically reflects a dominant physical factor such as topographic position, hydrology or disturbance	very specific, often dependent on a variety of environmental factors interacting in a very specific way
COMPOSITION VARIABILITY	Composition is structured by competition, dominance is high and variability is relatively low. These types may be quite similar over wide areas.	Intermediate between matrix and small patch types.	Composition is structured by environmental stress which limits the dominant competitors; may serve as refugia for rare species or be highly variable in composition.
CONSERVATION VALUE	May be common but often degraded by logging, fragmentation, etc. Important as a buffer for small and large patch types. Important cover and structure for wide ranging fauna. Outstanding examples probably buffer themselves.	Important centers of biodiversity within the matrix ecosystems. Important "matrices" for the small patch types. Important sources of habitat diversity and resource patches for faunal use.	Important for biodiversity protection often with many locally rare species. Need to be imbedded in an appropriate intact landscape to be viable. May have a very specific set of associated small fauna.

M. Anderson 6/96; edited for Maine by McMahon and Gawler 12/96

TABLE 3. ECOLOGICAL RESERVE DESIGN GUIDELINES

GENERAL PRINCIPLES	DESIGN GUIDELINES	
	MATRIX-FORMING ECOSYSTEMS	SMALL/LARGE PATCH ECOSYSTEMS[1]
A) Size: Large reserves will, on average, contain a wider range of environmental conditions, and thus more different types of ecosystems, and thus more species than smaller reserves (Diamond 1975, Hunter 1996). Large reserves are more secure than small reserves because (1) they have relatively large populations that are less likely to go extinct; (2) they have proportionately less area subject to negative edge effects; (3) they are less vulnerable to catastrophic events such as fire and hurricanes and human-induced disturbances such as toxic waste spills because most catastrophes can't disturb an entire reserve if it is large enough; and (4) they have greater resilience to climate change (Hunter 1996). Large reserves will have greater research value than small reserves because they are more likely to have redundancy of natural ecosystem types (e.g. there is the potential for greater sample sizes and more replication).	- Identify and design reserve around representative landscape unit (one that displays repeatable patterns of soils, plant communities, and stream, lake and wetland types). (This is roughly equivalent to the USFS land type association. In Maine, the scale is typically in the 1,000's of acres) (USFS 1983, USFS 1985, Forman 1997).	- Include small/large patch ecosystems in their entirety or, if they are part of a larger mosaic (e.g. floodplains, pitch pine barrens) include the entire ecosystem complex and an appropriate buffer.
B) Natural disturbance regime: Ecosystem composition and structure is determined by the interaction of natural disturbance regime, topography and soils and climate (Runkle 1985, White 1987). The effects of disturbances such as spruce budworm, fire and hurricanes are typically patchy. For example, fire intensity may be greater in some vegetation types and soils than in others and the size and distribution of burned areas will be affected by topography, the location of fire breaks, etc.[5] Ecosystems characterized by large stand replacing disturbances will require more area in reserves than ecosystems characterized by small patch disturbances (Baker 1992). Reserves that are designed to include some redundancy in ecosystem types are more likely to contain the cross-section of successional stages associated with a given disturbance regime.	- Reserves should be large enough not to be profoundly changed by a single disturbance event. In Maine, 2 to 3 times the size of the local landscape unit should generally be large enough to encompass major wind disturbances and hurricane tracks as well as the vast majority of fires (MFBP Scientific Panel 1995, Foster 1992, Foster 1988).[2] A *minimum* of 5,000 acres is considered marginally effective to sustain the present landscape mosaic in Appalachian-Acadian forest ecosystems (Lorimer and Frelich 1994, Cogbill 1996). - Draw reserve boundaries to encompass natural boundaries such as shorelines of islands, lakes or large streams, and ridge-lines (these can serve as barriers to disturbances such as fire).	- See above. - Draw reserve boundaries to encompass natural boundaries such as shorelines of islands, lakes or large streams, and ridgelines (these can serve as barriers to disturbances such as fire). - Where ecosystems dependent on seasonal and/or episodic flooding are focal points of a reserve, the reserve boundary should incorporate as much of the floodplain watershed as possible and have a natural flooding regime (e.g. no major dams or flood control structures).
C) Physiographic diversity: The best way to represent biodiversity at the ecosystem level is to maintain the full array of physical habitats and environmental gradients in reserves, from the highest to the lowest elevations, the driest to the wettest sites, and across all types of substrates and topoclimates. This will result in greater species and ecosystem diversity, more resilience to disturbance, and room for species to migrate in response to climate and other environmental changes (Hunter et al. 1988, McMahon 1990, Noss and Cooperrider 1994).	- Where possible, include a cross-section of landforms (e.g., surficial deposits, gorges, cliffs, talus slopes), soil types and rock types within reserve boundary. - In areas of high relief, incorporate all aspects and elevations of one or more ridges into reserve designs.	

[1] See Table 2.

[2] MFBP Scientific Advisory Panel (1995) considered 5,000 to 25,000 acres generally large enough to encompass the most common and frequent disturbances that contribute to the natural disturbance regime of a site. This may not be large enough to encompass less frequent, large scale catastrophic disturbances.

GENERAL PRINCIPLES	DESIGN GUIDELINES	
	MATRIX-FORMING ECOSYSTEMS	SMALL/LARGE PATCH ECOSYSTEMS[1]
D) Water/Watersheds: Reserves that incorporate water bodies and, ideally, intact watersheds will incorporate aquatic species diversity and maintain functioning aquatic ecosystems and riparian habitat. In addition, including lakes and streams increases a reserve's landscape diversity and overall research potential. Reserves that fully contain one or more watersheds will be better insulated from human-induced changes in water quality and quantity and will be a cohesive unit of habitat for many aquatic species. Buffers reduce the adverse impacts of adjacent land uses on streams, ponds and wetlands. The more intensive the land use in a stream, lake or wetland watershed, the wider the buffer zone needs to be to ensure no change in the quality of aquatic or wetland habitats (Castelle et al. 1992, Brinson et al. 1981). Riparian habitats generally contain the highest species diversity of any part of the landscape (Brinson et al. 1981, Gregory et al. 1991).	- Where feasible, use watersheds of headwater streams (first, second and third order) to define outer edges of reserves. - Buffer zones around streams, lakes and wetlands should be wide enough to a) encompass all vegetation types subject to flooding, as well as steep slopes and easily erodable soils, b) reduce potential negative edge effects associated with adjacent land uses, and c) incorporate associated riparian habitats. In areas of low relief (<15% slope on adjacent upland) buffer width should be *a minimum of* 330-500 feet from the floodplain boundary (Vander Haigen and DeGraaf 1996). In areas of moderate to high relief, buffer width should extend to height of land if possible. *(Ideally, these strips should be wide enough to function as stands, with both interior and shoreline habitats.)* - Draw boundaries to include diversity of lake and stream types present (e.g., acidic and alkaline, different trophic types, different sizes, depths, hydrogeologic settings).	- Include as focal points within reserves: lakes and streams that aren't dammed, haven't been reclaimed or sprayed with pesticides, are unstocked, have few (or no) introduced/naturalized species. - Where lakes (e.g., those supporting native fish populations) and/or wetlands (e.g., circumneutral fens) are the focal point of a reserve, draw boundaries to correspond to watershed boundaries of those ponds and/or wetlands. - Buffer zones around streams, lakes and wetlands should be wide enough to a) encompass all vegetation types subject to flooding, as well as steep slopes and easily erodable soils, b) reduce potential negative edge effects associated with adjacent land uses, and c) incorporate associated riparian habitats. In areas of low relief (<15% slope on adjacent upland) buffer width should be *a minimum* of 330-500 feet from the floodplain boundary (Vander Haigen and DeGraaf 1996). In areas of moderate to high relief, buffer width should extend to height of land if possible.
E) Ecological diversity: Assumption: An estimated 85-90% of species can be protected by conserving examples of ecosystems without having to inventory, identify, and manage each species individually. Assumption: Vegetation-based reserve designs are workable because vegetation integrates underlying physical habitat variables.	- Design reserves to include assemblages of different ecosystem types that are representative of the regional landscape and/or that have a functional connection. - Incorporate rare ecosystems or those of unusually high quality, such as old growth stands, into reserve design (can justify extending boundary over greater distance to include these features than for more typical features). - Draw boundaries to include habitats for rare, peripheral or area-sensitive species, if these are known to occur at a site.	- Design reserves to include assemblages of different ecosystem types that are representative of the regional landscape and/or that have a functional connection. - Draw boundaries to include habitats for rare, peripheral or area-sensitive species, if these are known to occur at a site.
F) Degree of human impact (naturalness): The less human disturbance, the greater a site's value as a benchmark.	- Draw boundary to include areas with little or no direct human disturbance, e.g., older stands, forests that haven't been planted, converted or highgraded, primary vs. secondary forests, unditched wetlands, sparsely roaded areas, etc.	- For a small or large patch ecosystem to be a focal point of a reserve, it should have a MNAP rank of A or B (i.e., it must be high quality example of ecosystem type to be considered represented on the conservation land base).

GENERAL PRINCIPLES	DESIGN GUIDELINES	
	MATRIX-FORMING ECOSYSTEMS	SMALL/LARGE PATCH ECOSYSTEMS[1]
G) Fragmentation: Large fragments have more species and will retain more species over time than small fragments (Diamond 1975). Fragments that are isolated from other patches of similar habitats by great distances or by terrain that is inhospitable (major roads and areas modified by intensive land use such as farmland, developed areas, forest plantations) are likely to have fewer species than less isolated fragments.	- Incorporate large patches of natural vegetation types that are unfragmented by major roads, monocultures or developed areas. - Draw reserve boundaries to encompass natural boundaries of vegetation types of interest (i.e., do not truncate communities and ecosystems). - Where boundaries are drawn to correspond with ridges and mountain summits, extend line over divide to encompass natural vegetation boundaries (e.g., subalpine forests). - Incorporate physical gradients that are unfragmented by roads or areas of development so that species can shift distributions in response to environmental change without encountering barriers to movement.	- Draw reserve boundaries to encompass natural boundaries of vegetation types of interest (i.e., do not truncate ecosystems). - Where boundaries are drawn to correspond with ridges and mountain summits, extend line over divide to encompass natural vegetation boundaries (e.g., subalpine forests). - When an ownership boundary includes only a fragment of an ecosystem type of interest, incorporate into reserve boundary (or consider as focal point of reserve) only if it is likely to persist in fragmented condition, it is part of a functioning landscape, and land use on adjacent land is compatible. - Include fragments of *rare* small patch ecosystems as focal points if they are the only examples that remain -- even if they may not be naturally functioning ecosystems.
H) Connectivity: Most natural landscapes tend to grade into one another, allowing functional flows. In Maine, ecotones tend to be gradual, except for ecosystem types that are closely tied to specific substrate conditions, e.g. pitch pine barrens. Species often require more than one type of ecosystem to exist. Some major functions of landscape linkages are to: (a) provide dwelling habitat for plants and animals, (b) permit daily and seasonal movements of animals, (c) facilitate dispersal, consequent gene flow between populations, and rescue of small populations from extinctions, and (d) allow long-distance range shifts of species, such as in response to climate change (Noss and Cooperrider 1994).	- Include areas of intensive land use (e.g. plantations, old farms) if they connect key patches or fall within watershed boundary of a water body of interest. In addition to their value as connectors, they can serve as benchmarks for recovery. - Design reserves to maintain the connection between ecosystems to incorporate the multiple habitat needs of some species. - Design reserves to allow functional flows and movement of species through the landscape.	- Include areas of intensive land use (e.g. plantations, old farms) if they connect key patches or fall within watershed boundary of a water body of interest. In addition to their value as connectors, they can serve as benchmarks for recovery. - Design reserves to allow functional flows and movement of species through the landscape (e.g., environmental gradients, riparian zones, movement from breeding to nesting habitat).
I) Shape: The edge of an ecosystem typically has different microclimates, structures, species composition, and predator-prey-parasite interactions than the interior. Compact or rounded reserves have a greater proportion of interior to edge per unit area and therefore offer greater protection to those species and processes that are vulnerable to edge effects (Diamond 1975, Harris 1984). For example, a 200 acre circular old growth stand would consist of nearly 35% edge-impacted area, assuming edge effects associated with clearing extend 330' into the stand, while a 200 acre rectangular stand (4:1 length to width ratio) would consist of about 51% edge-impacted area.	- When not constrained by ownership boundaries or the natural shape of ecosystems of interest (e.g., riverine or alpine systems), draw compact or rounded reserve boundaries to minimize amount of edge.	- When not constrained by ownership boundaries or the natural shape of ecosystems of interest (e.g., riverine or alpine systems), draw compact or rounded reserve boundaries to minimize amount of edge.

TABLE 4. CRITERIA FOR SELECTING POTENTIAL ECOLOGICAL RESERVE SITES

	CONSERVATION TARGET		
	MATRIX-FORMING ECOSYSTEMS	***LARGE PATCH/ECOSYSTEM COMPLEX***	***SMALL PATCH***
QUALIFIES	A-B ranked matrix-forming ecosystems present *and* ~5,000 to 6,000 acre minimum size *and* -for mountainous areas, all aspects and elevations included **OR** A-B ranked matrix-forming ecosystems present *and* 1,000 to ~5,000 acres, but surrounding landscape is in a compatible land use **OR** includes entire watershed of third order or higher stream system	A-B ranked large patch ecosystem/ecosystem complex present ***and*** 100% of conservation target is within unit - for lakes and wetlands, entire watershed is included **OR** A-B ranked large patch ecosystem/ecosystem complex present ***and*** ≥50% of conservation target is within unit *and* surrounding landscape is in a compatible land use **OR** A-B ranked matrix-forming ecosystems on geographically isolated land masses (such as islands and peninsulas)	A-B ranked small patch ecosystem(s) present *and* 100% of conservation target is within unit - for lakes and wetlands, entire watershed is included OR A-B ranked small patch ecosystems present *and* ≥50% of conservation target is within unit, but surrounding landscape is in a compatible land use
CONDITIONAL	A-B ranked matrix-forming ecosystems present *and* 1,000 to ~5,000 acres in size but surrounding landscape is in an incompatible land use *Qualifies if:* it is the best example in subsection on public/private conservation land	A-B ranked large patch ecosystem(s)/ecosystem complex present *and* <50% within unit, but remainder is apparently intact *and* surrounding landscape is in a compatible land use *Qualifies if:* it is the only documented example of rare or restricted large patch ecosystem in subsection (including old growth remnants that include ≥50% forest interior based on an edge effect width of 150 - 330 feet)	A-B ranked small patch ecosystem(s) present *and* <50% of conservation target is within unit, but remainder is apparently intact *and* surrounding landscape is in a compatible land use *Qualifies if:* it is the only documented example of rare or restricted small patch ecosystem in subsection
DOES NOT QUALIFY	No A-B ranked matrix-forming ecosystems present **OR** <1,000 acres in size **OR** 1,000 to ~5,000 acres in size, but surrounding landscape is in an incompatible land use	<50% A-B ranked large patch ecosystem is within unit *and* surrounding landscape is in an incompatible land use **OR** No A-B ranked large patch ecosystem(s) present **OR** No rare or restricted C-D ranked large patch ecosystem(s) present	<50% A-B ranked small patch ecosystem is within unit *and* surrounding landscape is in an incompatible land use **OR** No A-B ranked small patch ecosystem(s) present **OR** No rare or restricted C-D ranked small patch ecosystem(s) present

Note:

Maine Natural Areas Program A, B, C, or D ranks for ecosystems are a summary of the following criteria:

Size/Quality: (i.e., How representative is this occurrence? Consider size, species composition, structure, landscape position, etc.) (A= Excellent; B=Good; C=Marginal; D=Poor)
Condition: (i.e., Is the ecosystem occurrence pristine or degraded? To what extent has it recovered from past human disturbance?) (A= Excellent; B=Good; C=Marginal; D=Poor)
Landscape Context: (i.e., Can this occurrence be protected from extrinsic human factors?) (A= Excellent; B=Good; C=Marginal; D=Poor)

RESULTS

The inventory results are presented in two major tables. Table 5 is an annotated list of areas that meet ecological reserves criteria. Areas are grouped by subsection, and conservation targets are summarized. Table 6, a matrix of ecosystem types by biophysical province, section, and subsection, provides a quick assessment of the degree of representation of documented high quality ecosystems on public and private conservation ownerships and how these are distributed across biophysical regions. The section entitled *Interpretation of the Results*, which begins on page 51, presents information distilled from these two tables.

<u>ANNOTATED LIST OF PUBLIC LANDS AND PRIVATE CONSERVATION LANDS WITH POTENTIAL AS ECOLOGICAL RESERVES</u>

This preliminary list describes sites that have potential to be ecological reserves. It is a synthesis and distillation of landscape analysis and field survey data, potential reserve design results, and existing information. Sixty-nine sites are listed. It is a preliminary list for three reasons. First, in several cases, the quality of key ecosystems needs to be verified by the Maine Natural Areas Program. These areas are sites with either C's (for conditional) or question marks in the three columns under Conservation Target Scale. If, after further evaluation by MNAP, these sites no longer meet the selection criteria in Table 4, they will be taken off the list. In other cases, potential reserve boundaries may need to be modified to include or exclude ecosystems after their quality is verified. Second, the distribution of public and private conservation lands sites across subsections is very uneven and there may be more than one qualified site for a ecosystem or assemblage of ecosystems in a subsection. For example, the Maine Eastern Coastal Subsection (212 Cb) has 12 potential reserve sites. There is a lot of overlap in ecosystems among some of these sites. Boot Head and Quoddy Head might be lower priorities since they contain only a subset of ecosystems present on other nearby sites. Third, the number of sites to be included in a hypothetical reserve system would depend on the level of geographic representation desired in a statewide system. For example, a goal of representing each ecosystem type in each subsection in which it naturally occurs is likely to require a larger number of reserves than representing each ecosystem type in each section or province.

The annotated list is organized as follows:

Site name, owner/manager, map number:

Sites are grouped by subsection and then listed in alphabetical order. A key to abbreviations of landowner or managing agency is given at the end of the table. Each site has a <u>map number</u> which is keyed to the location map, Figure 3 on page 36.

Conservation target(s):

Potential reserves are designed around one or more <u>key features</u> (e.g., a wetland, ridge, or pond complex). These features are in turn typically composed of assemblages of ecosystems.

For example, an alpine ecosystem may include three or four different ecosystem types (krummholz, alpine ridge, alpine snowbank, and alpine bog-meadow).

Ecosystems present in each potential reserve site are listed by ecosystem code, with terrestrial (T) ecosystems listed first, palustrine ecosystems (P) listed second, and so on. Codes and ecosystem names are given in the Key to Ecosystem Types at the end of Table 5. High quality ecosystems (those with a Maine Natural Areas Program rank of A or B, undammed lakes with native fish populations, and rare ecosystem types) are shown in bold. Underlined ecosystems are likely to have an A-B rank, but more field data is needed to assess quality. The number of ecosystems present provides a rough indication of landscape diversity, since vegetation integrates underlying physical habitat variables. Areas with steep elevational gradients or that contain wet and dry areas typically have more ecosystems than potential reserves in more homogeneous landscapes.

Ecosystem occurrence pattern (SP= small patch, LP= large patch, MF= matrix-forming) is given under scale to provide an indication of the scale of protection warranted.

The Qs and Cs under Conservation Target Scale indicate whether a given unit qualifies (Q) as a potential reserve or is currently placed in a conditional (C) category (as defined in Table 4 on page 31), pending further analysis of ecosystem quality and distribution.

Unit size:

Unit size is the size of the public land unit or private conservation ownership.

Potential reserve size:

Potential reserve size is the portion of the unit with reserve potential. This is an approximate acreage, calculated using a geographic information system from Maine Office of Geographic Information Systems maps (MOGIS 1996). The margin of error is ±100-300 acres for the larger sites. This number is useful as an indication of order of magnitude for individual sites and a potential reserve system as a whole.

Context:

Context is summarized in a three point scale that integrates: 1) the extent that the key feature(s) present can be protected within current public/private conservation unit boundaries, 2) the condition of the surrounding landscape, and 3) the rarity of the key feature(s). Context categories include:

1 = key feature(s) can be adequately protected within the current public/private conservation unit boundary.

2a = 50% or more of the key feature(s) can be protected within the current public/private conservation unit boundary; remainder extends onto compatible landscape.

2b = less than 50% of the key feature(s) can be protected within the current public/private conservation unit boundary; remainder extends onto compatible landscape.

3a = high quality ecosystems that extend beyond unit boundary onto incompatible landscape (e.g., developed, highly fragmented).

3b = rare ecosystems of low quality (C-D ranked) or old growth fragments that are the only examples known on public/private conservation land within subsection.

Figure 3.
Maine Forest Biodiversity Project
Ecological Reserves Inventory

Units with Potential Reserves

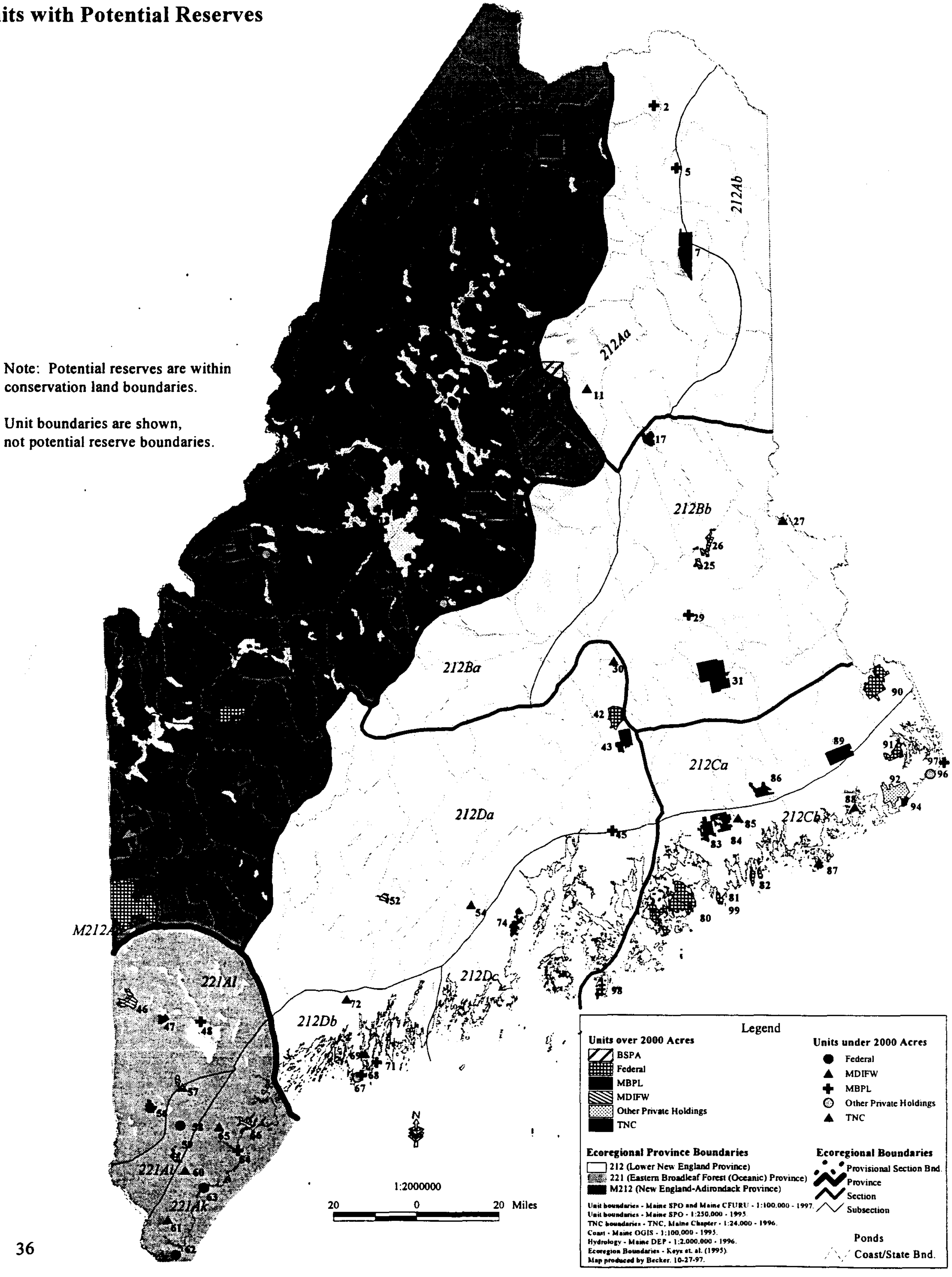


TABLE 5. ANNOTATED LIST OF PUBLIC AND PRIVATE CONSERVATION LANDS WITH POTENTIAL AS ECOLOGICAL RESERVES

(see key and notes at end of table)

1) 212Aa AROOSTOOK HILLS *1,631,827 acres (8% of state)*

Site Name (Owner/Manager)[1]	Map #	Conservation Targets: Key Features	Ecosystems Present[2]	Scale[3] SP	LP	MF	Unit Sz. (ac)	Pot. Reserve Size (ac)	Pot. Reserve Context[4]	Comments/Questions
Cross Lake Fen (BPL)	2	patterned fen ecosystem	P08, P13, P14, P16, P19, R05		C		83	83	2b	~15% of peatland is in potential reserve area
Marble Fen (TNC)	11	patterned fen ecosystem	T17, P07, P08, P09, P14, P16, P17	Q	Q		265	265	2b	~80% of peatland is in unit but most of it is not buffered
Salmon Brook Lake Bog (BPL)	5	fen/bog wetland complex	T05, P06, P08, P09, P16, P17, L03, R02	Q	Q		1,857	~1,320	2a	irregular boundaries
Squa Pan (BPL)	7	ridge and associated matrix-forming ecosystems	T02, T05, T08, T11, T12, P06, P08, P19, P23, L04, L06	Q	Q	Q	16,731	~11,770	2a	Alder Lake has unusually high pH; calcium enrichment in soils

2) 212Ab AROOSTOOK LOWLANDS - No Sites *821,817 acres (4%)*

3) 212Ba CENTRAL MAINE FOOTHILLS - No Sites *1,076,554 acres (5%)*

4) 212Bb MAINE-NEW BRUNSWICK LOWLANDS *2,191,536 acres (10%)*

Site Name (Owner/Manager)[1]	Map #	Conservation Targets: Key Features	Ecosystems Present[2]	Scale[3] SP	LP	MF	Unit Sz. (ac)	Pot. Reserve Size (ac)	Pot. Reserve Context[4]	Comments/Questions
Crystal Bog (TNC)	17	coalesced domed peatland	P04, P06, P08, P09, P13, P14, P16, P17, L03	Q	Q		4,102	4,102	2a	~80% of peatland is in TNC ownership
Duck Lake (BPL)	31	burn-origin matrix-forming communities that connect key ecosystems	T01, T02, T08, T09, T18, T21, P04, P07, P08, P13, P16, P18, P19, P21, L02, L06, L08, L09, L10	Q	Q	Q	25,200	~7,160	2b	should Gassabias Lake and watershed be included to increase aquatic diversity?
Forest City (IFW)	27	matrix-forming ecosystems are geographically confined	T02, T04, T08, T12, T18, R07	Q		?	650	~480	1	peninsula
McGoon Lot (BPL)	29	old growth remnant	T08, T12, P06, P12, P19		C		265	265	3b	undocumented old growth remnant; 4:1 length:width; ~50% of unit impacted by edge effects
Mattagodus Stream (IFW)	25	coalesced domed peatland; circumneutral fen	T08, P04, P06, P07, P08, P13, P16, P17, P19, P21, L03	Q	Q		1,425	1,425	2a	evaluated with Mattawamkeag (IFW)
Mattawamkeag (IFW)	26	Mattawamkeag River floodplain	T08, P06, P07, P08, P13, P16, P19, P21, L02, L03	Q	Q		4,119	4,119	2b	evaluated with Mattagodus (IFW). ~40% of wetland is in unit. Pot. rare mussel habitat; signif. of Mud Pond?

5) 212Ca MAINE EASTERN INTERIOR *810,980 acres (4%)*

Site Name (Owner/Manager)[1]	Map #	Conservation Targets: Key Features	Ecosystems Present[2]	Scale[3] SP	LP	MF	Unit Sz. (ac)	Pot. Reserve Size (ac)	Pot. Reserve Context[4]	Comments/Questions
Great Heath (BPL)	86	coalesced domed peatland	T08, T09, P06, P08, P09, P13, P14, P16, P18, P21, P22, P24, L03, R02, R04,	Q	Q		6,067	6,067	2a	~60% of peatland in unit. Functional rel. to Pleasant R.?; S. portion surrounded by managed blueberry land
Moosehorn - Baring (USFWS)	90	Bearce Lake watershed	T01, T04, T12, P06, P13, P16, P19, P22, L08, L09, R05	Q	Q	Q	17,594	~6,160	1	
Rocky Lake (BPL)	89	East Machias River floodplain	T02, T04, T09, P01, P06, P13, P19, P21, P22, R04, R05, R09	Q	Q	?	10,250	~5,280	2a	ecosystem quality needs verification. P01 on levee only

6) 212Cb MAINE EASTERN COASTAL 730,711 acres (3%)

Site Name (Owner/Manager)[1]	Map #	Conservation Targets: Key Features	Ecosystems Present[2]	Scale[3] SP	LP	MF	Unit Sz. (ac)	Pot. Reserve Size (ac)	Pot. Reserve Context[4]	Comments/Questions
Acadia National Park (NPS) (Isle au Haut)	98	ridges; coastal matrix-forming ecosystems	T03, T08, T19, P04, P06, P16, P19, P22, E03	Q	Q		2,728	~2,700	2a	potential reserve encompasses ~40% of island
Acadia National Park (NPS) (MDI)	80	intact lake and headwater stream watersheds, peatlands	T02, T03, T05, T08, T09, T17, T18, T19, T20, T39, T47, T52, P08, P13, P15, P16, P18, P19, P21, P22, L01, L02, L06, L08, L09, R01, R02, R03, R05, R09, E01, E02, E03, E04, E06, E07	Q	Q	Q	30,241	~21,160	1, 2a	2 separate areas (14,217 and 6945a); separated by roads and carriage trails; Fresh Meadow/NE Creek need to be eval. - their acreages are not incl. in pot. res. size given; highest diversity of ecosys. types of all units inventoried
Acadia NP (NPS) (Schoodic) /Winter Harbor (USDOD) /Turtle Island (TNC)	99, 81	jack pine forest/woodland; open headlands; offshore islands	T03, T08, T09, T17, T20, T39, T48, P08, P14, E01, E03	Q	Q		2,896	~2,530	2a	perimeter road cuts off shoreline on Schoodic tract
Boot Head (South Unit) (MCHT)	96	coastal plateau bog/open headlands	T03, T39, P06, P11, P13, P19, P21, R02	Q	Q		377	~300	2a	1 of 2 tracts has potential; evaluated w/ Eastern Head (BPL), which was disqualified
Cutler Coast/ Cutler Grasslands (BPL)	94, 92	grassland/wetland complex/coastal headlands	T03, T04, T09, T27, T34, T39, P09, P13, P14, P15, P16, P18, P19, P21, P22	Q	Q	Q	12,674	~6,570	2a	matrix-forming ecosystems dominated by spruce-fir
Donnell Pond/Spring River Lake (BPL)	83, 84	intact lake and headwater stream watersheds; ridges; matrix-forming ecosystems	T01, T02, T05, T08, T09, T12, T15, T16, T17, T18, T47, T49, T54, P13, P16, P18, P21, L05, L06, L08, L09	Q	Q	Q	14,221	~9,143	2a	long-term research study area (Mud, Salmon, Long and Tilden Ponds)
Great Wass (TNC)	87	coastal peatlands and jack pine woodlands	T03, T20, T39, P06, P11, P13, P14, P15, P16, P18, P22, E03	Q	Q		1,579	1,579	1	peninsula; small islands not included in acreage figure
Larrabee Heath (TNC)	88	coastal plateau peatland	T05, P09, P13, P14, P18, P22	Q	Q		427	427	2a	
Moosehorn-Edmunds (USFWS) /Cobscook S. P. (BPL)	91	Hobart Bog complex? matrix-forming ecosystems	T04, T05, T08, P19, P20, P22, L06, R03, R04, R05	C	C	?	7,191	~2,782	2a	quality of many ecosystems needs verification; shoreline ecosystems not evaluated
Narraguagus Junction (IFW)	85	floodplain ecosystem	T04, T08, T09, T12, P07, P18, P19, P21, P22, R05, R07, R08, R09	Q	C		1,450	1,450	2a	peninsula between rivers; burn-origin matrix-forming ecosystems -- quality needs verification
Petit Manan NWR (USFWS)	82	stream and peatland watersheds	T03, T04, T05, T17, T20, T27, T39, T51, P06, P08, P11, P13, P14, P15, P16, L09, R02, E01, E04	Q	Q		3,335	~2,310	1	peninsula, island; flats dominated by larch
Quoddy Head State Park (BPL)	97	peatland watershed; open headlands	T03, T39, P13, P15	Q	Q		532	532	2a,3a	portion of a peninsula; Carrying Place Bog can't be adequately buffered

7) 212Da CENTRAL MAINE INTERIOR 2,897,225 acres (14%)

Site Name (Owner/Manager)[1]	Map #	Conservation Targets: Key Features	Ecosystems Present[2]	Scale[3] SP	LP	MF	Unit Sz. (ac)	Pot. Reserve Size (ac)	Pot. Reserve Context[4]	Comments/Questions
Alonzo Garcelon (IFW) (North)	52	wetland complex	T01, T02, T08, T12, T49, T50, P16, P20, P22, L02, L09, R02	C	C		1,276	1,276	2a	quality of wetland ecosystems needs verification
Appleton Bog (TNC)	54	peatland complex; bog pond	T01, T02, T08, P04, P05, P07, L03, R02		Q		987	987	2a	northernmost and largest Atlantic white cedar peatland in Maine
Ayers Brook (TNC)	30	large eccentric bog complex	T04, P01, P08, P13, P14, P16, P21, P22, R05, R07	Q	Q		2,075	2,075	2a	3 noncontiguous tracts include ~40% of peatland is within unit
Bradley (BPL)	43	coalesced domed peatlands	P06, P08, P09, P13, P16	Q	Q		8,843	~7,840	2a	evaluated with Sunkhaze (USFWS); headwaters of Sunkhaze Stream
Branch Lake (BPL)	45	matrix-forming ecosystems	T01, T02, T05, T12, T32, P04, P19, L08	C		C	1,273	1,273	3a?	subsection-wide comparison needed; unit is unfragmented; ecosystem quality needs verification
Sunkhaze NWR (USFWS)	42	coalesced dome peatland/wetland complex	T01, T04, T05, T09, T12, P01, P04, P06, P08, P09, P13, P16, P18, P19, P21, P23	Q	Q		9,337	9,337	2a	evaluated with Bradley (BPL); ~80% of peatland is in unit

8) 212Dc PENOBSCOT BAY COAST 577,463 acres (3%)

Site Name (Owner/Manager)[1]	Map #	Conservation Targets: Key Features	Conservation Targets: Ecosystems Present[2]	Scale[3]: SP	Scale[3]: LP	Scale[3]: MF	Unit Sz. (ac)	Pot. Reserve Size (ac)	Pot. Reserve Context[4]	Comments/Questions
Camden Hills (BPL)/ Knights Pond (TNC)	74, 75	extensive oak-dominated forests and woodlands; ridges	T01, T05, T08, T12, T16, T17, T47, T49, P07, P08, P13, P27, R07	Q	Q	Q	5,904	~5,070	2a	includes 2 noncontiguous tracts; quality of wetland ecosystems needs verification

9) 212Db CASCO BAY COAST 343,509 acres (2%)

Site Name (Owner/Manager)[1]	Map #	Conservation Targets: Key Features	Conservation Targets: Ecosystems Present[2]	Scale[3]: SP	Scale[3]: LP	Scale[3]: MF	Unit Sz. (ac)	Pot. Reserve Size (ac)	Pot. Reserve Context[4]	Comments/Questions
Swett Marsh/Back River (IFW/TNC)	69	salt marsh ecosystem	T02, T05, T07, T19, P20, P27, E02, E03, E04, E07	Q	Q		1,233	1,233	2b	peninsulas, 2 noncontiguous tracts separated by estuarine ecosystems
Merrymeeting/ Muddy River (IFW)	72	freshwater and brackish tidal marshes	T02, T08, T49, P04, P06, P19, P21, E06, E07	C	C		~664	~380	3a	ownership of intertidal ecosystems unclear; land protection may be irrelevant
Morse Mtn. (Bates/TNC)/ Popham Beach (BPL)	67, 68	salt marsh/barrier beach ecosystems	T05, T08, T19, T22, T29, T34, T35, T38, P04, P16, P27, L05, R02, E03, E04, E07	Q	Q		1,265	~1,160	2a?	2 units on opposite sides of Morse River; largest undeveloped barrier beach system in the state
Reid State Park (BPL)	71	salt marsh/barrier beach ecosystems	T02, T04, T07, T17, T19, T34, T35, T38, T49, P04, P07, P16, P18, P21, L06, R03 E03, E04, E07	Q	Q		770	~650	2b?	no evidence of human disturbance on Little River Marsh

10) M212Aa INTERNATIONAL BOUNDARY PLATEAU - No Sites 1,020,497 acres (5%)

11) M212Ab ST. JOHN UPLAND 2,689,719 acres (13%)

Site Name (Owner/Manager)[1]	Map #	Conservation Targets: Key Features	Conservation Targets: Ecosystems Present[2]	Scale[3]: SP	Scale[3]: LP	Scale[3]: MF	Unit Sz. (ac)	Pot. Reserve Size (ac)	Pot. Reserve Context[4]	Comments/Questions
Allagash/Wesley Brook (BPL)	1	riverside seep ecosystem and associated rare plants	T02, T05, P25, R07	Q			1,000	~250	3b	riverine ecosystem; only documented example on public/private conservation land
Big Reed Forest Reserve (TNC)	8	old growth matr.-form. ecosys.; intact lake watersheds; native fish populations	T04, T05, T08, T11, T12, P06, P23, L02, L08	Q	Q	Q	4,853	4,853	1	
Chamberlain (BPL)	9	matrix-forming ecosystems; Allagash Lake? Smith Brook Fen?	T04, T05, T08, T12, T26, T47, P06, (P16, P17,) P21, P23, L02, L08, R03, R04, R05	Q	Q	Q	9,557	~5,910 8650 (w/ All. L.)	1/2a	connect Smith Brook Fen, Allagash L. and portions of watershed (comm's in parens)? peninsulas/islands/isthmus
Deboullie (BPL)	3	intact 2nd ord. stream watersheds; native fish pops; old gr. remnants; mont. gradients	T05, T12, T13, T14, T46, P06, P07, P16, P18, P23, L02, L06, L08, L09	Q		Q	21,871	~14,400	1	watersheds would incorporate matrix forest ecosystems; include P06, P23 in potential reserve?
Gero Island (BPL)	12	entire island	T04, T05, T08, T09, T12, P06, P07, P22		Q		3,185	3,185	1	island; lake dam controlled

12) M212Ac MAINE CENTRAL MOUNTAINS 1,674,614 acres (8%)

Site Name (Owner/Manager)[1]	Map #	Conservation Targets: Key Features	Conservation Targets: Ecosystems Present[2]	Scale[3]: SP	Scale[3]: LP	Scale[3]: MF	Unit Sz. (ac)	Pot. Reserve Size (ac)	Pot. Reserve Context[4]	Comments/Questions
Baxter State Park (BSP)	13	alpine and subalpine ecosystems; intact 3rd order stream watersheds; native fish pops; old growth; large forested bog	T01, T05, T06, T08, T12, T14, T15, T18, T40, T41, T42, T43, T46, P01, P06, P08, P10, P13, P16, P18, P21, P30, L01, L02, L06, L08, L09	Q	Q	Q	204,733	~181,360	1	most low-elevation upland forests have been recently harvested (only one documented A-B stand)
Borestone Sanctuary (NAS)	23	matrix-forming ecosystems; intact pond watersheds; montane gradients	T01, T05, T08, T12, T15, T47, P04, P16, L05, L08	Q	Q	Q	1,639	1,639	2a	meromictic lake? potential old growth stands
Kineo (BPL)	18 19	circumneutral cliffs; talus, outcrop	T12, T14, T46, L08	Q			800	800	1?	pot. res. ac. incl. Kineo peninsula only (4,200 ac); Sugar I. in conditional category due to cutting hist.
Little Squaw (BPL)	22	mont. grad's; intact lake and headwat. stream watersh's; native fish pops; domed bog	T05, T06, T08, T09, T12, P08, P13, P14, P16, P19, P21, L06, L08, L09, R02	Q	Q	Q	15,074	~10,360	1/2a	peatland not adequately buffered
Nahmakanta (BPL)	15	intact third order stream watersh's; native fish pops, rare mussels; montane gradients	T05, T08, T09, T12, T18, T47, P06, P13, P16, P18, P19, P21, P23, L02, L08, L09, L10	Q	Q	Q	44,586	~29,060	1	high quality matrix-forming ecosystems; includes Appalachian Trail corridor acreage
Wassataquoik (BPL)	16	floodplain of the East Branch of the Penobscot River	T01, T02, T05, T08, T09, T12, P01, P07, P16	Q	Q		2,162	2,162	2a	southern end of large floodplain ecosystem

13) M212Ad WHITE MOUNTAINS	*69,225 acres (0.3%)*									
Site Name (Owner/Manager)[1]	Map #	Conservation Targets: Key Features	Ecosystems Present[2]	Scale[3]: SP	LP	MF	Unit Sz. (ac)	Pot. Reserve Size (ac)	Pot. Reserve Context[4]	Comments/Questions
White Mtn. Nat. Forest (USFS)	38	mature n. hardwood forests; mont. gradients; headwater stream watersheds	T05, T06, T08, T11, T12, T15, T16, T17, T18, T40, T41, T47, T48, T49, P04, P06, P12, P16, P18, L02, L06	Q	Q	M	49,166	~30,710	1/2a	NH portion of WMNF may have better examples of some ecosystem types

14) M212Ae MAHOOSUC RANGELY LAKES	*710,543 acres (3%)*									
Site Name (Owner/Manager)[1]	Map #	Conservation Targets: Key Features	Ecosystems Present[2]	Scale[3]: SP	LP	MF	Unit Sz. (ac)	Pot. Reserve Size (ac)	Pot. Reserve Context[4]	Comments/Questions
Bigelow (BPL)	32	montane gradients; tarn watershed	T01, T02, T04, T05, T06, T08, T12, T41, T47 P16, P19, P21, P22, P30, L01, L02, L06, R03	Q	Q	Q	35,027	~22,040	1	extends into M212Ab; ATC
Mahoosucs (BPL)	36	montane gradients; tarn watershed	T02, T05, T06, T12, T13, T17, T40, T41, P10, P19, P30, L01	Q	Q	Q	27,253	~14,200	2a	irregular unit boundary
Redington Twp (USDOD/BPL/NPS)	34	montane gradients	T05, T06, T08, T09, T12, T40, T47, P18, P19, P21, L03, L09, R03		Q	?	14,180	~12,580	1/2a	military training area; ATC; burn origin -- quality of low-elevation ecosystems needs further verific.

15) M212Af CONNECTICUT LAKES	*1,245,395 acres (6%)*									
Site Name (Owner/Manager)[1]	Map #	Conservation Targets: Key Features	Ecosystems Present[2]	Scale[3]: SP	LP	MF	Unit Sz. (ac)	Pot. Reserve Size (ac)	Pot. Reserve Context[4]	Comments/Questions
Holeb (BPL)	20	native fish population; wetland complex; matrix-forming ecosystems	T01, T04, T05, T08, T09, T12, T18, T54, P01, P06, P07, P08, P18, P19, L02, L03, L09	Q	Q	C	19,231	~6,750	2a	evaluated with No. 5 Bog (FSM); spruce slope and burn origin matrix - qual. needs verification
No. 5 Bog/Jack Pine (FSM)	21	ribbed fen ecosystem; jack pine remnants	T18, T20, P06, P09, P08, P13, P14, P16, L03, R07	Q	Q		973	973	2a	evaluated with Holeb (BPL); quality of jack pine stand needs verification

16) M212Ag WESTERN MAINE FOOTHILLS	*786,222 acres (4%)*									
Site Name (Owner/Manager)[1]	Map #	Conservation Targets: Key Features	Ecosystems Present[2]	Scale[3]: SP	LP	MF	Unit Sz. (ac)	Pot. Reserve Size (ac)	Pot. Reserve Context[4]	Comments/Questions
Little Concord Pond State Park (BPL)	37	pond watershed	T02, T05, T07, T08, T12, T15, T47, P04, P19, R01, R03, L02	Q			622	622	2b	quality of matrix-forming ecosystems needs verification
Mt. Blue State Park (BPL)	35	montane gradients	T05, T06, T08, T12, R03		C	C	5,012	~3,200	2b	qual. of matrix-forming ecosystems needs verification. A lot of edge, but a relatively large tract for S. ME

17) 221Al GULF OF MAINE COASTAL PLAIN	*202,528 acres (1%)*									
Site Name (Owner/Manager)[1]	Map #	Conservation Targets: Key Features	Ecosystems Present[2]	Scale[3]: SP	LP	MF	Unit Sz. (ac)	Pot. Reserve Size (ac)	Pot. Reserve Context[4]	Comments/Questions
Little Ossipee/Killick (BPL/IFW)	57	floodplain of Lake Ossipee; pitch pine ecosystem	T08, T09, T23, P01, P12, P16, P20, P22, P24, P26, L03, L11, R04	C	C		1,893	1,893	2a/3a	2 tracts; also in subsection 221Al. Quality of many ecosystems needs verification
Massabesic - Alfred (USFS)	59	vernal pool/matrix forest mosaic, prime turtle habitat	T08, T09, T16, P04, P05, P12, P13, P16, P27	Q	Q		1,784	~1,650	2a	Atlantic white cedar wetlands
Massabesic - Lyman (USFS)	58	peatland complex, vernal pools, prime turtle habitat	T07, T09, P04, P09, P13, P16, P20, P27, L03, L06, L11	Q	Q		1,900	~1,460	2b	~15% of peatland is in unit

18) 221Ak GULF OF MAINE COASTAL LOWLANDS 387,718 acres (2%)										
Site Name (Owner/Manager)[1]	Map #	Conservation Targets					Unit Sz. (ac)	Pot. Reserve Size (ac)	Pot. Reserve Context[4]	Comments/Questions
		Key Features	Ecosystems Present[2]	Scale[3]						
				SP	LP	MF				
Rachel Carson NWR - Braveboat Harbor (USFWS)	62	saltmarsh ecosystem	T07, T50, P02, P16, P19, P27, E02, E03, E04, E07	Q	Q		644	644	3a?	surrounding upland developed
Ferry Beach State Park (BPL)	64	only tupelo-red maple swamp documented in Maine	T07, T16, P32	Q			117	117	3b	rare ecosystem type - only documented example in state; adjacent beach developed
Kennebunk Plains (IFW/TNC)	60	sandplain grassland	T02, T07, T09, T23, T37, P19, P24, R01	Q	C		1,177 (136=TNC)	1,177	3a	conditional because actively managed to maintain grassl.; only example on pub/priv. conserv. land; T23 low qual. ex.
Mt. Agamenticus (IFW/TNC)	61	oak-pine matrix/vernal pool wetlands; prime turtle habitat	T02, T07, T10, T12, T16, T47, T49, T53, P02, P04, P05, P16, P18, P19, P27	Q	Q	Q	1,662 (18=TNC)	1,662	2a	part of one of the largest areas of relatively unfragmented open space in southern Maine
Saco Heath (TNC)	65	domed peatland ecosystem	T01, T08, P04, P05, P08, P09, P13, P14, P16, P21, P31, L03,	Q	Q		839	839	3a	bounded by roads
Scarborough Marsh (IFW)	66	saltmarsh ecosystem	T07, T38, P31, E02, E03, E04, E07	Q	Q		3,100	3,100	3a	~75% in unit; largest example in Maine; upland is developed
RCNWR - Upper Wells/ Mousam River (USFWS)/ Laudholm Farm (BPL)	63	saltmarsh ecosystem	T22, T35, T38, P04, P19, P32, E02, E03, E04,	Q	Q		1,088	~648	3a?	~50% in unit if Mousam Division included. Surrounding upland partially developed

19) 221Al SEBAGO-OSSIPEE HILLS AND PLAIN 868,920 acres (4%)										
Site Name (Owner/Manager)[1]	Map #	Conservation Targets					Unit Sz. (ac)	Pot. Reserve Size (ac)	Pot. Reserve Context[4]	Comments/Questions
		Key Features	Ecosystems Present[2]	Scale[3]						
				SP	LP	MF				
Brownfield Bog (IFW)	46	pitch pine ecosystem; Saco River floodplain ecosystem	T07, T09, T23, P01, P02, P04, P16, P18, P21, P31, L02, L03, L06, R02, R05, R07, R08	Q	Q		5,700	~4,100	2a/3a	wetlands are managed; tract is bounded by roads
Middle Pond State Park (BPL)	47	large wetland/pond complex	T01, T02, T08, T12, T19, T47, P04, P13, P14, P21, P22, P27, R01, R05, R09	Q	Q	C	1,853	~1,605	2a	quality of forest ecosystems needs verification
Sebago Lake State Park (BPL)	48	Songo River floodplain system	T01, T07, T08, T11, T16, T49, T50, P01, P04, P07, P16, P19, P21, P27, L08, L11, L12, R07, R08, R09	C	C		1,342	~1,120	3a	conditional because qual. of hardwood floodpl. forest needs verification; adjacent land is fragmented
Waterboro Barrens (TNC)	56	pitch pine ecosystem; wetland complexes	T02, T07, T08, T09, T16, T23, T24, P03, P04, P08, P13, P16, P18, P19, P21, P26, R01, R04, R05	Q	Q		2,369	2,369	2a	largest pitch pine barren in Maine

Notes:

[1] Key to abbreviations: BPL=Maine Bureau of Parks and Lands; BSP=Baxter State Park; TNC=The Nature Conservancy; FSM=Forest Society of Maine; NAS=National Audubon Society; IFW=Maine Department of Inland Fisheries and Wildlife; USFS=United States Forest Service; USFWS=United States Fish and Wildlife Service; MAS=Maine Audubon Society; MCHT=Maine Coast Heritage Trust; NPS=National Park Service; USDOD=United States Department of Defense.

[2] **Bold** = A-B ranked and/or rare ecosystem types; underlined = verification of ecosystem quality is needed.

[3] SP = Small Patch Ecosystem; LP = Large Patch Ecosystem; MF = Matrix-Forming Ecosystem.

[4] 1 = Conservation target(s) can be adequately protected within current public/private conservation unit boundary.
2a = 50% or more of the conservation target(s) can be protected within current public/private conservation unit boundary; remainder extends onto compatible landscape.
2b = Less than 50% of the conservation target(s) can be protected within current public/private conservation unit boundary; remainder extends onto compatible landscape.
3a = High quality ecosystems that extend beyond unit boundary onto incompatible landscape (e.g., developed, altered).
3b = Rare ecosystems of low quality (C-D ranked) or old growth fragments that are only examples known on public/private conservation land within subsection.

KEY TO ECOSYSTEM TYPES

CODE	ECOSYSTEM TYPE[1]	PATTERN[2]
	Terrestrial Ecosystems	
T01	PINE - HEMLOCK/SPRUCE FOREST	matrix
T02	HEMLOCK SLOPE FOREST	small
T03	MARITIME SPRUCE-FIR FOREST	large
T04	SPRUCE-FIR FLATS FOREST	matrix
T05	SPRUCE SLOPE FOREST	large
T06	SUBALPINE SPRUCE-FIR FOREST*	matrix (l)
T07	OAK-PINE FOREST	large (m)
T08	MIXED HARDWOOD-CONIFER FOREST	matrix
T09	EARLY SUCCESSIONAL FOREST	large
T10	OAK-HICKORY FOREST*	small
T11	MAPLE - BASSWOOD - ASH FOREST*	small
T12	BEECH - BIRCH - MAPLE FOREST	matrix
T13	COLD-AIR TALUS WOODLAND*	small
T14	CIRCUMNEUTRAL TALUS COMMUNITY*	small
T15	ACIDIC TALUS COMMUNITY*	small
T16	OAK-PINE WOODLAND	small
T17	SPRUCE WOODLAND	small
T18	RED PINE WOODLAND*	small
T19	PITCH PINE WOODLAND*	small
T20	JACK PINE WOODLAND*	small
T21	RED/WHITE PINE BARRENS	large
T22	PITCH-PINE DUNE SEMI-FOREST*	small
T23	PITCH PINE - SCRUB OAK BARRENS*	large
T24	PITCH PINE - HEATH BARRENS*	large
T25	ACIDIC SHORELINE OUTCROP	small
T26	CIRCUMNEUTRAL SHORELINE OUTCROP*	small
T27	TALL MEADOW*	large (s)
T28	CIRCUMNEUTRAL SHORELINE SHRUB THICKET*	small
T29	ACIDIC SHORELINE SHRUB THICKET	small
T30	HUDSONIA RIVER BEACH*	small
T31	LAURENTIAN RIVER BEACH*	small
T32	LAKESHORE SAND BEACH	small
T33	LAKESHORE COBBLE BEACH	small
T34	BEACH STRAND	small
T35	SAND DUNE*	small
T36	INLAND SAND BARREN*	small
T37	SANDPLAIN GRASSLAND*	small
T38	MARITIME SHRUBLAND	small
T39	OPEN HEADLAND	small
T40	KRUMMHOLZ*	large

CODE	ECOSYSTEM TYPE[1]	PATTERN[2]
	Terrestrial Ecosystems (continued)	
T41	ALPINE RIDGE*	small (l)
T42	ALPINE CLIFF*	small
T43	ALPINE SNOWBANK*	small
T44	SERPENTINE OUTCROP*	small
T45	TEMPERATE CIRCUMNEUTRAL OUTCROP*	small
T46	BOREAL CIRCUMNEUTRAL OUTCROP*	small
T47	ACIDIC ROCKY SUMMIT	small
T48	ACIDIC CLIFF	small
T49	OAK-BEECH FOREST	large (s)
T50	WHITE OAK - RED OAK FOREST*	large
T51	LARCH FOREST	small
T52	NORTHERN WHITE CEDAR WOODLAND*	small
T53	CHESTNUT OAK WOODLAND	large (s)
T54	RED PINE FOREST	small
	Palustrine Ecosystems	
P01	HARDWOOD FLOODPLAIN FOREST*	large
P02	PERCHED HEMLOCK-HARDWOOD SWAMP*	small
P03	BLACK WILLOW - ALDER SWAMP	small
P04	RED MAPLE SWAMP	small (l)
P05	ATLANTIC WHITE CEDAR SWAMP*	large
P06	NORTHERN WHITE CEDAR SWAMP	large
P07	SPRUCE-FIR SWAMP	large (s)
P08	FORESTED BOG	large
P09	PEATLAND LAGG	small
P10	ALPINE BOG-MEADOW*	small
P11	MARITIME SLOPE BOG*	small
P12	FLOATING KETTLEHOLE BOG	small
P13	DWARF SHRUB BOG	large
P14	MOSS LAWN BOG	small (l)
P15	PLATEAU BOG LAWN*	small (l)
P16	ACIDIC FEN	large (s)
P17	CIRCUMNEUTRAL FEN*	small
P18	BEAVER FLOWAGE	small
P19	SHRUB SWAMP	small
P20	CATTAIL MARSH	small
P21	SEDGE MEADOW*	large
P22	GRAMINOID SWALE	small
P23	NORTHERN WHITE CEDAR SEEPAGE FOREST*	large (s)
P24	OUTWASH SEEPAGE FOREST*	small
P25	RIVERSIDE SEEP*	small

CODE	ECOSYSTEM TYPE[1]	PATTERN[2]
	Palustrine Ecosystems (continued)	
P26	OUTWASH PLAIN PONDSHORE*	small
P27	VERNAL POOL	small
P29	HARDWOOD SEEPAGE FOREST (new)	small
P30	ALPINE PONDSHORE*	small
P31	PITCH PINE BOG*	small
P32	TUPELO-RED MAPLE SWAMP*	small
	Lacustrine Ecosystems	
L01	TARN*	++
L02	EUTROPHIC POND	++
L03	BOG POND	++
L04	ALKALINE POND*	++
L05	MONOMICTIC OLIGOTROPHIC LAKE	++
L06	MONOMICTIC MESOTROPHIC LAKE	++
L07	MEROMICTIC LAKE*	++
L08	DIMICTIC OLIGOTROPHIC LAKE	++
L09	DIMICTIC MESOTROPHIC LAKE	++
L10	RUSH BED	++
L11	LACUSTRINE EMERGENT COMMUNITY	++
L12	LACUSTRINE SHALLOW BOTTOM	++
	Riverine Ecosystems	
R01	INTERMITTENT STREAM	++
R02	PEATLAND OUTLET STREAM	++
R03	ROCKY HEADWATER STREAM	++
R04	MIDREACH STREAM	++
R05	MARSH HEADWATER STREAM	++
R06	DEADWATER	++
R07	MAIN CHANNEL RIVER	++
R08	BACKWATER SLOUGH	++
R09	RIVERINE EMERGENT COMMUNITY	++
	Subterranean Ecosystems	
S01	CAVE COMMUNITY*	++
	Estuarine Ecosystems	
E01	BRACKISH POND	small
E02	TIDAL CREEK	small
E03	CORDGRASS SALTMARSH	small
E04	SALT HAY SALTMARSH	large
E05	SUBTIDAL ESTUARY	small
E06	FRESHWATER TIDAL MARSH*	large (s)
E07	BRACKISH TIDAL MARSH	large (s)

Notes for Key:

[1] Maine Natural Areas Program Biological Conservation Database.

[2] Anderson, Mark. 1996. Comparison of attributes for the three types of natural community occurrence patterns (unpublished). The Nature Conservancy, Boston, Massachusetts.

*=ecosystems with a MNAP rank of S1, S2, or S3.

++ "Pattern" has been applied only to vegetated ecosystems so far.

THE ECOSYSTEM MATRIX

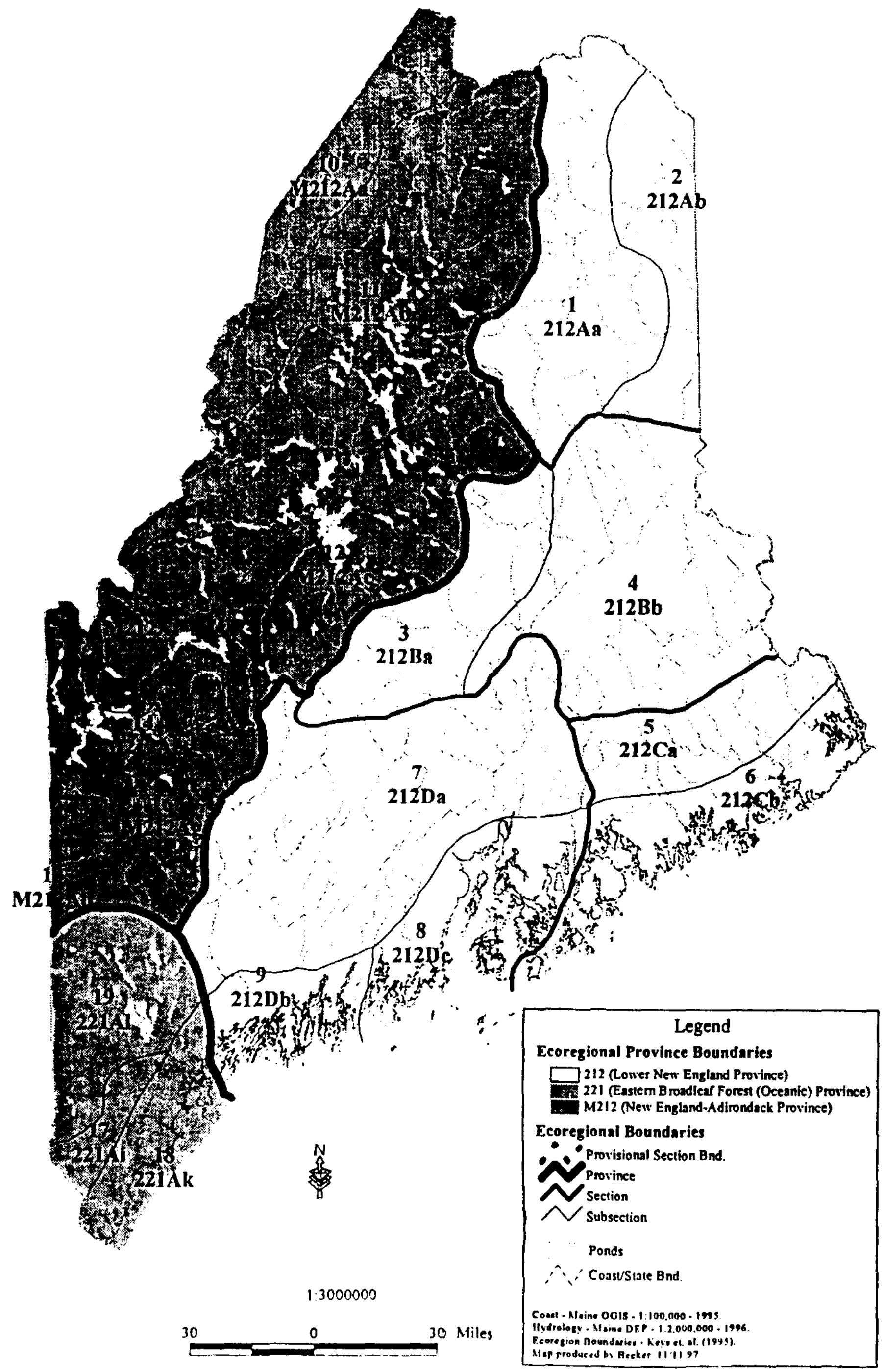
Using the Maine Natural Areas Program ecosystem classification and the biophysical region classification simultaneously provides a mechanism for identifying the range of ecological diversity in Maine. If a reserve system contains examples of each ecosystem type identified in the ecosystem classification, it should include most of the species native to the state. A biophysical classification can then be used to determine how many of each ecosystem type should be included in the reserve system and in what part of the state these reserves should be located. As proposed in the 1993 ecological reserves study, a complete ecological reserves system would include an example of each ecosystem type in each of the subsections in which it occurs. The Maine Natural Areas Program's analysis of ecosystem data indicates that the degree of geographic variation (in species composition) varies within ecosystem type and that the subsection level of classification may be necessary to capture regional variation for at least some ecosystem types. For this reason, the matrices are designed to show how well Maine's ecosystems are represented at three levels of the USDA Forest Service classification (Keys et al. 1995): province, section, and subsection. The ultimate goal is to develop a network of reserves that not only represents each ecosystem, but also the range of variation in species composition within each ecosystem type.

The matrices on the next five pages provide several pieces of information. The ecosystem types documented in the Maine Natural Areas Program's Biological Conservation Database are listed on the left. Those marked with asterisks are considered rare at the state level (they have an S-rank of S1, S2, or S3). "Pattern" is shorthand for occurrence pattern. This indicates whether an ecosystem typically occurs as a small patch (<50 acres), large patch (50 to 1,000s of acres), or as one of the mosaic of ecosystem types which form the dominant matrix of an area. See Table 2 for a more detailed description.

The province, section and subsection numbers shown at the top of each matrix are keyed to Figure 4. Sections are separated by dashed lines and provinces are separated by bold lines. **White** indicates that the ecosystem is known to occur in that subsection. **Light gray** indicates that the ecosystem type probably occurs in that subsection, but no documentation exists. **Dark gray** indicates that the ecosystem type is not known to occur in that subsection. The numbers in the boxes indicate the number of potential reserves with representative examples (either high quality (A-B ranked) or rare) of a given ecosystem type in a particular subsection. If the number is bold (and larger), it indicates that landscape integrity for one or more reserves in that subsection is high (context = 1, 2a or 2b). A "√" indicates that the ecosystem occurs on public/private conservation land, but not enough is known to characterize and evaluate that ecosystem type in general. For example, beaver flowages and vernal pools have not been described well enough to rank. A "**?**" indicates an ecosystem type occurs in a potential reserve area but requires more documentation to determine its quality.

As an example, pitch pine bogs (ecosystem P31) are known to occur in Subsections 18 and 19. Topographic and wetland maps suggest that this ecosystem type may occur in Subsection 17 as well. Two representative examples of the pitch pine bog ecosystem were found on public and private conservation ownerships (in Subsection 18) during the ecological reserves inventory.

FIGURE 4. MAP AND KEY TO ECOREGIONAL PROVINCES, SECTIONS, AND SUBECTIONS



KEY

Province	Section	Subsection			
Laurentian Mixed Forest Province (212)	A	a	1	212Aa	Aroostook Hills
		b	2	212Ab	Aroostook Lowlands
	B	a	3	212Ba	Central Maine Foothills
		b	4	212Bb	Maine/New Brunswick Lowlands
	C	a	5	212Ca	Maine Eastern Interior
		b	6	212Cb	Maine Eastern Coastal
	D	a	7	212Da	Central Maine Interior
		c	8	212Dc	Penobscot Coast
		b	9	212Db	Casco Bay Coast
New England-Adirondack Province (M212)	A'	a		M212Aa	International Boundary Plateau
		b		M212Ab	St. John Upland
	A	c		M212Ac	Maine Central Mountains
		d		M212Ad	White Mountains
		e		M212Ae	Mahoosuc Rangely Lakes
		f		M212Af	Connecticut Lakes
		g		M212Ag	Western Maine Foothills
Eastern Broadleaf Forest Province (221)	A	i	17	221Ai	Gulf of Maine Coastal Plain
		k	18	221Ak	Gulf of Maine Coastal Lowland
		l	19	221Al	Sebago/Ossipee Hills and Plain

TABLE 6. ECOSYSTEM MATRIX

CODE	ECOSYSTEM TYPE[1]	Pattern[†2]	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
			PROVINCE/SECTION/SUBSECTION[3]																		
			Laurentian Mixed Forest (212)									New England-Adirondack (M212)							EBF (221)		
			A		B		C		D			A[4]		A					A		
	Terrestrial Ecosystems																				
T01	PINE - HEMLOCK/SPRUCE FOREST	matrix				1	1							1							
T02	HEMLOCK SLOPE FOREST	small	1			1														1	
T03	MARITIME SPRUCE-FIR FOREST	large						8													
T04	SPRUCE-FIR FLATS FOREST	matrix											2			1					
T05	SPRUCE SLOPE FOREST	large	1					2					2	4	1			?			
T06	SUBALPINE SPRUCE-FIR FOREST*	matrix (l)												2	1	3		1			
T07	OAK-PINE FOREST	large (m)																1			
T08	MIXED HARDWOOD-CONIFER FOREST	matrix						3	1	1			3	4	1		1				
T09	EARLY SUCCESSIONAL FOREST	large					1	2						?			?		?		1
T10	OAK-HICKORY FOREST*	small																		1	
T11	MAPLE - BASSWOOD - ASH FOREST*	small	1										1		1						1
T12	BEECH - BIRCH - MAPLE FOREST	matrix	1				?						4	5	1	2				1	
T13	COLD-AIR TALUS WOODLAND*	small											1			1					
T14	CIRCUMNEUTRAL TALUS COMMUNITY*	small											1	2							
T15	ACIDIC TALUS COMMUNITY*	small						1						1							
T16	OAK-PINE WOODLAND	small						1		1					1						1
T17	SPRUCE WOODLAND	small	1					3		1	1				1	1					
T18	RED PINE WOODLAND*	small				1		2							1		2				
T19	PITCH PINE WOODLAND*	small						2			3										1
T20	JACK PINE WOODLAND*	small						3									1				
T21	RED/WHITE PINE BARRENS	large				?															
T22	PITCH-PINE DUNE SEMI-FOREST*	small									1									?	
T23	PITCH PINE - SCRUB OAK BARRENS*	large																	1	1	2

White = ecosystem is known to occur in subsection; light gray = ecosystem type may occur in that region but no documentation exists; dark gray = ecosystem type is not known to occur in that part of state. Numbers indicate the number of A-B ranked examples that have been documented on public and private conservation lands. If the number is small, the context code for the potential reserve area in which the occurrence is found is 3a or 3b. A "?" indicates that an ecosystem type occurs in a potential reserve area but it requires more documentation to determine quality. A "√" indicates that the ecosystem type has not been fully characterized by MNAP.
*=ecosystems with a MNAP rank of S1, S2, or S3.
†small = < 50 acre patch; large = 50 - 1,000's of acres patch; matrix = mosaic-forming ecosystems that occupy most of the landscape.

			PROVINCE/SECTION/SUBSECTION[3]																		
			Laurentian Mixed Forest (212)									New England-Adirondack (M212)							EBF (221)		
			A		B		C		D			A"[4]		A					A		
CODE	ECOSYSTEM TYPE[1]	Pattern[†2]	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
T24	PITCH PINE - HEATH BARRENS*	large																			1
T25	ACIDIC SHORELINE OUTCROP	small				√	√	√	√	√			√	√	√		√	√	√		√
T26	CIRCUMNEUTRAL SHORELINE OUTCROP*	small											1								
T27	TALL MEADOW*	large (s)						2													
T28	CIRCUMNEUTRAL SHORELINE SHRUB THICKET*	small																			
T29	ACIDIC SHORELINE SHRUB THICKET	small				√	√	√	√	√			√	√	√		√	√			√
T30	HUDSONIA RIVER BEACH*	small																			
T31	LAURENTIAN RIVER BEACH*	small																			
T32	LAKESHORE SAND BEACH	small							?												
T33	LAKESHORE COBBLE BEACH	small																			
T34	BEACH STRAND	small						?			2										
T35	SAND DUNE*	small									2									1	
T36	INLAND SAND BARREN*	small																			
T37	SANDPLAIN GRASSLAND*	small																		1	
T38	MARITIME SHRUBLAND	small									2										
T39	OPEN HEADLAND	small						6													
T40	KRUMMHOLZ*	large												1	1	1					
T41	ALPINE RIDGE*	small (l)												1	1	2					
T42	ALPINE CLIFF*	small												1							
T43	ALPINE SNOWBANK*	small												1							
T44	SERPENTINE OUTCROP*	small																			
T45	TEMPERATE CIRCUMNEUTRAL OUTCROP*	small																			
T46	BOREAL CIRCUMNEUTRAL OUTCROP*	small											1	2							
T47	ACIDIC ROCKY SUMMIT	small						2					1	1	1	1		1		1	
T48	ACIDIC CLIFF	small						2		1			1	1	1	1					
T49	OAK-BEECH FOREST	large (s)						1	1	1					1						
T50	WHITE OAK - RED OAK FOREST*	large																		1	1
T51	LARCH FOREST	small						1													

White = ecosystem is known to occur in subsection; light gray = ecosystem type may occur in that region but no documentation exists; dark gray = ecosystem type is not known to occur in that part of state. Numbers indicate the number of A-B ranked examples that have been documented on public and private conservation lands. If the number is small, the context code for the potential reserve area in which the occurrence is found is 3a or 3b. A "?" indicates that an ecosystem type occurs in a potential reserve area but it requires more documentation to determine quality. A "√" indicates that the ecosystem type has not been fully characterized by MNAP.
*=ecosystems with a MNAP rank of S1, S2, or S3.
†small = < 50 acre patch; large = 50 - 1,000's of acres patch; matrix = mosaic-forming ecosystems that occupy most of the landscape.

			PROVINCE/SECTION/SUBSECTION[3]																		
			Laurentian Mixed Forest (212)									New England-Adirondack (M212)							EBF (221)		
			A		B		C		D			A"[4]		A					A		
CODE	ECOSYSTEM TYPE[1]	Pattern†[2]	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
T52	NORTHERN WHITE CEDAR WOODLAND*	small						1													
T53	CHESTNUT OAK WOODLAND	large (s)																		1	
T54	RED PINE FOREST	small				1		?									1				
	Palustrine Ecosystems																				
P01	HARDWOOD FLOODPLAIN FOREST*	large					?		?					2			1		1		1
P02	PERCHED HEMLOCK-HARDWOOD SWAMP*	small																		1	
P03	BLACK WILLOW - ALDER SWAMP	small																			?
P04	RED MAPLE SWAMP	small (l)				?		1	2		?			1					1	1	2
P05	ATLANTIC WHITE CEDAR SWAMP*	small (l)							1										1	1	
P06	NORTHERN WHITE CEDAR SWAMP	large				3	1	2	1	1			3	1			1				
P07	SPRUCE-FIR SWAMP	large (s)	1			?				?											
P08	FORESTED BOG	large	3			2	1		3	1				1			2			1	?
P09	PEATLAND LAGG	small	1			1	1	2	1								1		1	1	
P10	ALPINE BOG-MEADOW*	small												1		1					
P11	MARITIME SLOPE BOG*	small						3													
P12	FLOATING KETTLEHOLE BOG	small				1									1				1		1
P13	DWARF SHRUB BOG	large	1			4	2	8	3	?				1			1		1	1	1
P14	MOSS LAWN BOG	small (l)	2			1	1	3	1					1			1			1	1
P15	PLATEAU BOG LAWN*	small (l)						4													
P16	ACIDIC FEN	large (s)	3			2	1	3	3		1		1	1		1	1		2	1	1
P17	CIRCUMNEUTRAL FEN*	small	2			2							1								
P18	BEAVER FLOWAGE	small	√			√	√	√	√		√		√	√	√	√	√			√	√
P19	SHRUB SWAMP	small				?	1	1	1											?	
P20	CATTAIL MARSH	small							?												
P21	SEDGE MEADOW*	large (s)				2	2	3	1		?										1
P22	GRAMINOID SWALE	small					2	2	1							1			?		?
P23	NORTHERN WHITE CEDAR SEEPAGE FOREST*	large (s)	1						1				2	1							
P24	OUTWASH SEEPAGE FOREST*	small					1												?	1	

White = ecosystem is known to occur in subsection; light gray = ecosystem type may occur in that region but no documentation exists; dark gray = ecosystem type is not known to occur in that part of state. Numbers indicate the number of A-B ranked examples that have been documented on public and private conservation lands. If the number is small, the context code for the potential reserve area in which the occurrence is found is 3a or 3b. A "?" indicates that an ecosystem type occurs in a potential reserve area but it requires more documentation to determine quality. A "√" indicates that the ecosystem type has not been fully characterized by MNAP.

*=ecosystems with a MNAP rank of S1, S2, or S3.

†small = < 50 acre patch; large = 50 - 1,000's of acres patch; matrix = mosaic-forming ecosystems that occupy most of the landscape.

++ "Pattern" has been applied only to vegetated ecosystems so far.

CODE	ECOSYSTEM TYPE[1]	Pattern†[2]	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	PROVINCE/SECTION/SUBSECTION[3]		Laurentian Mixed Forest (212)									New England-Adirondack (M212)							EBF (221)		
			A		B		C		D			A[4]		A					A		
P25	RIVERSIDE SEEP*	small											1								
P26	OUTWASH PLAIN PONDSHORE*	small																	1		1
P27	VERNAL POOL	small																	2	2	
P29	HARDWOOD SEEPAGE FOREST (new type)	small																			
P30	ALPINE PONDSHORE*	small												1		?					
P31	PITCH PINE BOG*	small																		2	
P32	TUPELO-RED MAPLE SWAMP*	small																		2	
Lacustrine Ecosystems																					
L01	TARN*	++						1						1		2					
L02	EUTROPHIC POND	++		√	√	√		√	√		√		2	2	√	1	1	√			√
L03	BOG POND	++	?			2	1		1							?	1		?	1	?
L04	ALKALINE POND*	++	?																		
L05	MONOMICTIC OLIGOTROPHIC LAKE	++						√	√		√			√							
L06	MONOMICTIC MESOTROPHIC LAKE	++		√		√	√	√	√				1	1	√						√
L07	MEROMICTIC LAKE*	++																			
L08	DIMICTIC OLIGOTROPHIC LAKE	++				√	√	1	√		√		3	3			√				
L09	DIMICTIC MESOTROPHIC LAKE	++			√	√	√	√					1	3		√	√				
L10	RUSH BED	++				?								?							
L11	LACUSTRINE EMERGENT COMMUNITY	++																	1		
L12	LACUSTRINE SHALLOW BOTTOM	++																			?
Riverine Ecosystems																					
R01	INTERMITTENT STREAM	++	√					√		√								√		√	√
R02	PEATLAND OUTLET STREAM	++	√				√	√	√		√										√
R03	ROCKY HEADWATER STREAM	++						√			√		√			√		√			
R04	MIDREACH STREAM	++					√	√					√								√

White = ecosystem is known to occur in subsection; light gray = ecosystem type may occur in that region but no documentation exists; dark gray = ecosystem type is not known to occur in that part of state. Numbers indicate the number of A-B ranked examples that have been documented on public and private conservation lands. If the number is small, the context code for the potential reserve area in which the occurrence is found is 3a or 3b. A "?" indicates that an ecosystem type occurs in a potential reserve area but it requires more documentation to determine quality. A "√" indicates that the ecosystem type has not been fully characterized by MNAP.

*=ecosystems with a MNAP rank of S1, S2, or S3.

†small = < 50 acre patch; large = 50 - 1,000's of acres patch; matrix = mosaic-forming ecosystems that occupy most of the landscape.

++ "Pattern" has been applied only to vegetated ecosystems so far.

			PROVINCE/SECTION/SUBSECTION[3]																		
			Laurentian Mixed Forest (212)									New England-Adirondack (M212)							EBF (221)		
			A		B		C		D			A[4]		A					A		
CODE	ECOSYSTEM TYPE[1]	Pattern†[2]	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
R05	MARSH HEADWATER STREAM	++	√				√	√	√				√								√
R06	DEADWATER	++																			
R07	MAIN CHANNEL RIVER	++						√	√	√			√				√				√
R08	BACKWATER SLOUGH	++		?			?	√							?						1
R09	RIVERINE EMERGENT COMMUNITY	++						√													1
Subterranean Ecosystems																					
S01	CAVE COMMUNITY*	++																			
Estuarine Ecosystems																					
E01	BRACKISH POND	small						?													
E02	TIDAL CREEK	small						1												3	
E03	CORDGRASS SALTMARSH	small						1			2									3	
E04	SALT HAY SALTMARSH	large						1			3									3	
E05	SUBTIDAL ESTUARY	small						√													
E06	FRESHWATER TIDAL MARSH*	large (s)									1										
E07	BRACKISH TIDAL MARSH	large (s)						1			4									2	

White = ecosystem is known to occur in subsection; light gray = ecosystem type may occur in that region but no documentation exists; dark gray = ecosystem type is not known to occur in that part of state. Numbers indicate the number of A-B ranked examples that have been documented on public and private conservation lands. If the number is small, the context code for the potential reserve area in which the occurrence is found is 3a or 3b. A "?" indicates that an ecosystem type occurs in a potential reserve area but it requires more documentation to determine quality. A "√" indicates that the ecosystem type has not been fully characterized by MNAP.
*=ecosystems with a MNAP rank of S1, S2, or S3.
†small = < 50 acre patch; large = 50 - 1,000's of acres patch; matrix = mosaic-forming ecosystems that occupy most of the landscape.
++ "Pattern" has been applied only to vegetated ecosystems so far.

Information Sources:

[1] From Gawler et al. 1996.
[2] See Anderson, M. 1996 and Table 2.
[3] Keys, J. Jr. et al. 1995. Ecological Units of the Eastern United States. USDA Forest Service, Atlanta, Georgia.
[4] Provisional section (based on Scientific Advisory Panel discussion and TNC classification).

INTERPRETATION OF THE RESULTS

The following generalizations can be made from the information contained in the ecosystem matrix and the annotated list of potential ecological reserve sites:

Ecosystem Representation

1. For terrestrial and palustrine (wetland) ecosystems, approximately 45% are represented on existing public lands and private conservation lands at the subsection level. At the section level, 66% of terrestrial and palustrine ecosystems are represented. At the province level, 82% of terrestrial and palustrine ecosystems are represented. Ninety-two percent are represented at least once at the state-wide level.

TABLE 7. APPROXIMATE DEGREE OF ECOSYSTEM REPRESENTATION AT THE PROVINCE, SECTION, AND SUBSECTION LEVEL

	Province	*Section*	*Subsection*
Terrestrial Ecosystems	77%	60%	40%
Wetland Ecosystems	86%	72%	50%
Average	82%	66%	45%

These percentages reflect the regional distribution of each ecosystem type and are derived from the ecosystem matrix (Table 6). For example, the alpine bog-meadow ecosystem is represented in both of the subsections in which it occurs, so it has 100% representation. The jack pine woodland ecosystem type, on the other hand, is represented in only two of the four subsections in which it is likely to occur – a representation of 50%. The numbers in Table 7 are an average of the percentages derived for each ecosystem, giving equal weight to widespread and regionally restricted ecosystems.

2. Eight terrestrial and wetland ecosystem types, six of which are rare in Maine (noted by asterisks) are not known to be represented on public and private conservation lands. These include:

T28 Circumneutral shoreline shrub thicket*
T30 Hudsonia riverbeach*
T31 Laurentian riverbeach*
T36 Inland sand barren*
T44 Serpentine outcrop*
T45 Temperate circumneutral outcrop*
P03 Black willow - alder swamp
P29 Hardwood seepage forest

3. Representation by biophysical subsection is uneven (see Figure 3). Three subsections (2, 3, and 10) have no known examples of their characteristic ecosystems on public or private conservation lands. In contrast, coastal regions have relatively high representation. For example, characteristic examples of more than 70% of the ecosystem types known to occur in Subsection 6 are represented on public and private conservation ownerships.

4. The average site inventoried has six different ecosystem types represented.

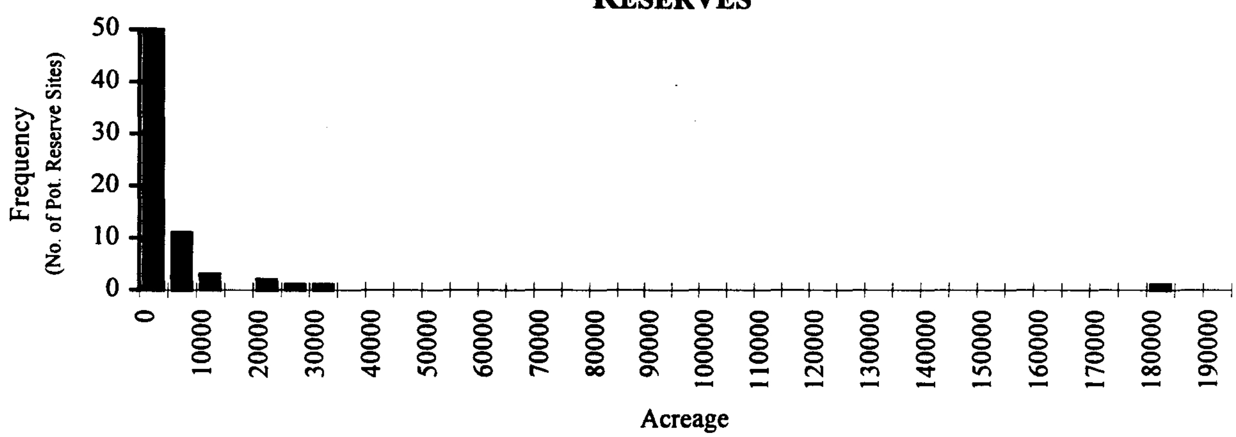
Size of Potential Reserves and Potential Reserve Acreage on Public and Private Conservation Lands

1. Sixty-nine potential reserve sites were identified through the MFBP Ecological Reserves Inventory.

2. Median potential reserve size is 2,075 acres[1]. Average potential reserve size is 7,228 acres. This average is misleading because of Baxter State Park, which has a size one to three orders of magnitude larger than the other potential reserve sites. Average reserve size excluding Baxter State Park is approximately 4,670 acres.

   The majority of potential reserve sites (51) are smaller than the average reserve size of 5,000 - 12,000 acres recommended by the Scientific Advisory Panel (Figure 5).

FIGURE 5. SIZE FREQUENCY HISTOGRAM OF POTENTIAL RESERVES



3. Total acreage of all potential reserve sites including Baxter State Park is approximately 498,700 acres. Total acreage excluding Baxter is 317,340 acres. This total does not account for redundancy within subsections. For example, the Eastern Coastal Subsection has several potential reserve sites with the same suite of ecosystems represented. When the distribution question is fully addressed, a number of sites may be removed from the current list. A rough acreage tally for these potentially "redundant" sites is 60,000 to 80,000 acres.

[1] In this case, the median is the size of the potential reserve that has 34 sites greater in acreage and 34 sites smaller in acreage. Median potential reserve size is a better indicator of reserve size than the mean when the distribution is skewed, as is the case here.

4. Average reserve size varies considerably from province to province, and from north to south (see Figure 3). Average size by province is as follows:

   New England Adirondack Province ≈ 17,800 acres
   Laurentian Mixed Forest Province ≈ 3,600 acres
   Eastern Broadleaf Forest Province ≈ 1,600 acres.

5. Eight percent of Maine's approximately 820 public and private conservation ownerships have potential as ecological reserves, according to the criteria outlined in this inventory. Their total acreage of 498,700 acres represents approximately 45% of the state's public and private conservation land and approximately 2% of the state's total land area.

Potential Reserve Scale and Context

1. Of the 69 potential reserve sites, 17 include matrix-forming ecosystems as conservation targets, 36 are focused primarily around large patch ecosystems, 8 around small patch ecosystems, and 8 are in the conditional category (see Table 5). Reserves large enough (~5,000 acres or greater) to qualify as representing matrix-forming ecosystems occur in 8 out of 19 subsections—primarily in northern and western Maine (Camden Hills State Park and Acadia National Park are notable exceptions).

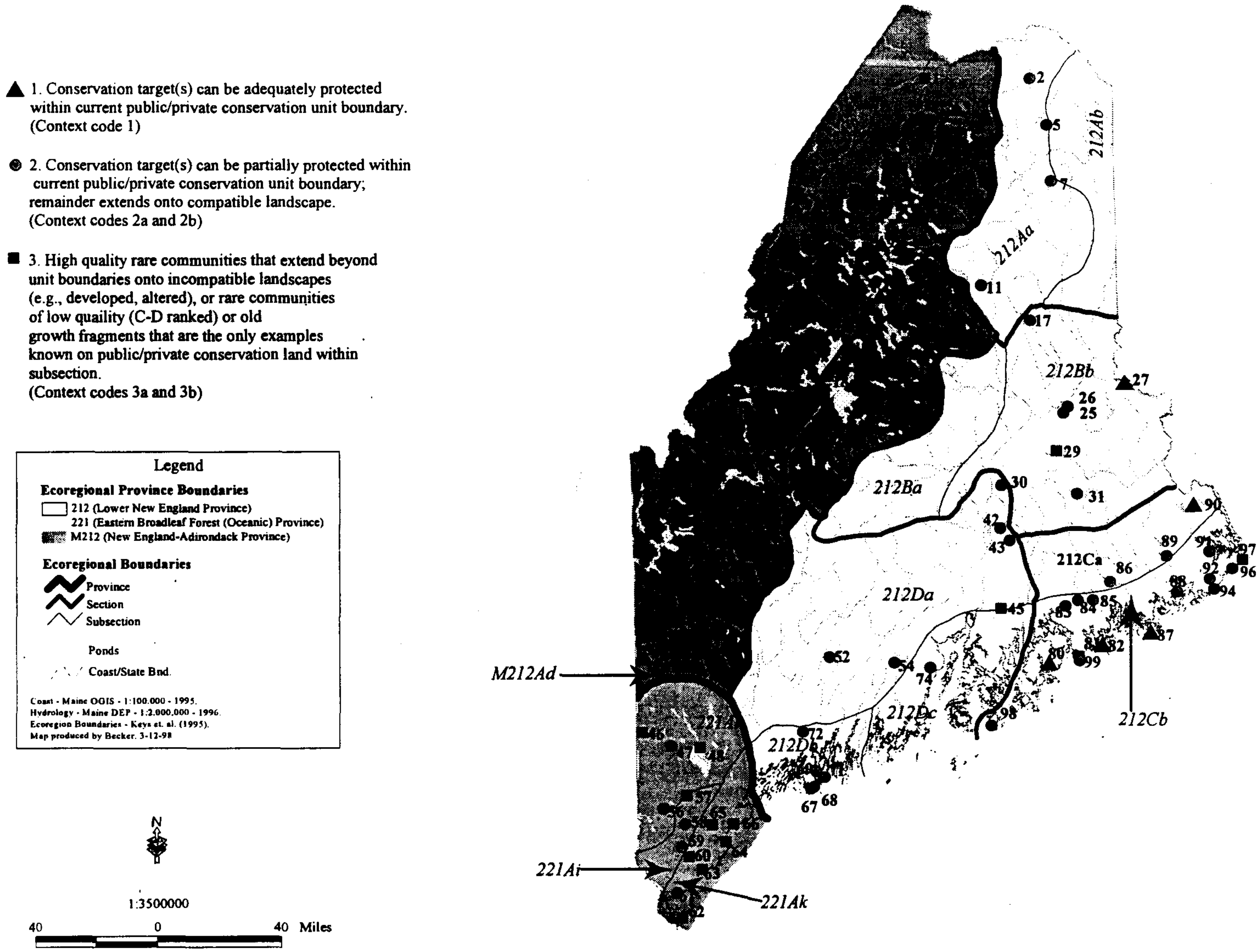
2. The context codes provide an indication of how well the conservation target(s) identified can be protected within existing public/private conservation boundaries. The 69 potential reserve sites can be grouped as follows:

Context Code[2]	Number of Sites
1	16
2a	33
2b	9
3a	8
3b	3

   Another way to interpret this information is: 16 potential reserve sites are self-contained (context code 1), 42 are not (context codes 2a and 2b), and 11 do not have the potential to be self-contained and may not be viable because the surrounding landscape is intensively developed (context codes 3a and 3b). Figure 6 shows the locations and context codes of potential reserve sites. None of the 16 self-contained potential reserve sites are in southern Maine.

[2] 1 = Conservation target(s) can be adequately protected within current public/private conservation unit boundary; 2a = 50% or more of the conservation target(s) can be protected within current public/private conservation unit boundary; remainder extends onto compatible landscape; 2b = Less than 50% of the conservation target(s) can be protected within current public/private conservation unit boundary; remainder extends onto compatible landscape; 3a = High quality ecosystems extend beyond unit boundary onto incompatible landscape (e.g., developed, altered); 3b = Rare ecosystems of low quality (C-D ranked) or old growth fragments are only examples known on public/private conservation land within a subsection.

FIGURE 6. PRIVATE/PUBLIC CONSERVATION LANDS WITH POTENTIAL RESERVES - SHOWING CONTEXT



3. Of the 69 potential reserve sites, 18 are located in mountainous terrain and 29 are designed around wetlands. Ecosystems associated with these environments are relatively well-represented on public and private conservation lands. Potential reserves in mountainous areas tend to be much larger than the overall average (average size of mountainous potential reserves ≅ 20,300 acres). Potential reserves centered around wetlands tend to be relatively small (average size of wetland potential reserves ≅ 2,000 acres), and in no case is a unit boundary large enough to encompass the entire watershed of the wetland ecosystem of interest.

4. This inventory emphasized upland and wetland ecosystem types and was not designed to represent aquatic ecosystems. More information is needed on the state's lakes and streams before their representation in a potential reserve system can be evaluated. Reserves that contain entire watersheds or watersheds of lakes with native populations of cold water fish species are listed in Table 8. No exclusively native fish populations exist in lakes or ponds of potential reserves evaluated in the Laurentian Mixed Forest or Eastern Broadleaf Forest Provinces.

TABLE 8. POTENTIAL RESERVE SITES THAT INCLUDE INTACT LAKE WATERSHEDS

Map No.	Name	Map No.	Name
90	Moosehorn-Baring	3	Deboullie*
80	Acadia National Park - MDI	13	Baxter*
83	Donnell P./Spring River L.*	22	Little Squaw*
8	Big Reed*	15	Nahmakanta*
9	Chamberlain*	20	Holeb*

*Site includes lake(s) with native cold water fish population.

Geographic Variation and Representation

by Susan C. Gawler, Maine Natural Areas Program

The results (see Appendix C, and generalized results in Table 9) indicate that almost all of the ecosystem types analyzed differ at least at the province level of the USDA Forest Service classification. At the section and subsection levels, results are more dependent on the ecosystem type. Those that form extensive mosaics over the landscape ("matrix" types), such as northern hardwood forests and spruce-fir forests, showed consistent differences at the section level and many, though less consistent, differences among subsections. Ecosystems that are constrained to small patches on the landscape by factors such as topography and hydrology showed various levels of geographic distinction. All ecosystems analyzed except for northern white cedar swamps showed some degree of variation even at the finest level—that of subsection.

These results indicate that geographic variants of ecosystem types are real, although the degree and scale vary according to the ecosystem type. The use of presence/absence data rather than abundance data means that the differences found are due to actual differences in plant species composition, not to differences in relative amounts of the same species. It must be remembered, however, that the numbers of samples used in many of the comparisons, in particular among subsections, were very small, and that many subsections or sections where the ecosystems occur could not be analyzed because of insufficient samples. These results are therefore appropriate for general guidance at this point. Specific decisions about levels of representation for a particular ecosystem type would best be based on an analysis that incorporates additional data to broaden the geographic coverage and to assure adequate samples within each subsection for that ecosystem type.

TABLE 9. SUMMARY OF THE CONSISTENCY OF VARIATION IN SEVEN DIFFERENT ECOSYSTEM TYPES AT DIFFERENT GEOGRAPHIC SCALES

Letters reflect the preponderance of statistically significant comparisons between Provinces/Sections/Subsections. C = consistent; P/I = present but inconsistent; L = little[3]. **N** = number of provinces, sections, and subsections compared. See Appendix C for detailed results.

Ecosystem type	Province		Section		Subsection	
		N		N		N
Northern Hardwood Forest	C	2	C*	3	P/I*	6
Spruce-Fir Forests	C	2	C	4	P/I*	5
Mixed Hardwood-Conifer Forests	C	3	P/I	6	P/I*	10
Mixed C-H: Oak subtype	P/I	3	P/I	4	P/I*	5
Mixed C-H: Yellow Birch subtype	L	2	(C)	2	(C)*	3
Northern White Cedar Swamp	L	2	L	5	L*	5
Acidic Fens	C	3	C	6	P/I*	7
Acidic Fen: Sweetgale subtype	(C)	2	C*	4	(C)*	3
Sedge Meadows	(C)	2	L*	3	(P/I)*	3
Dwarf Shrub Bog	C	3	C	4	C*	5
Significant comparisons (% of total), all types combined	*78%*		*61%*		*60%*	

Current Use of Potential Reserve Sites

The overriding management guideline recommended for ecological reserves is that natural ecosystems be allowed to evolve without human interference (e.g., no commercial timber harvesting, no introduction of exotic species, no impoundments). Twenty-eight of the 69 potential reserve sites currently have at least 50% of their acreage in a form of management that is compatible with this guideline. A summary of potential reserve acreage currently in comparable management by landowner or managing agency is presented in Table 10. Recreational uses were not considered in this analysis. 59% percent (292,585 acres) of total potential reserve area is in a comparable form of management. Excluding Baxter State Park, which accounts for 171,412 of this acreage, 38% of total potential reserve acres are currently in a form of management comparable to that recommended for ecological reserves. However, of the 28 sites that contain significant portions in comparable management, 16 are dominated by

[3] **Consistent**: provinces/sections/subsections differed significantly (using $p < .05$) in more than 2/3 of the pairwise comparisons; **Present/Inconsistent**: provinces/sections/subsections differed significantly in more than 1/3 but less than 2/3 of the comparisons, i.e., differences were apparent, but not consistent across the entire level; **Little or no difference**: provinces/sections/subsections differed significantly in less than 1/3 of the comparisons; **Entries in parentheses** reflect especially low sample sizes, i.e., less confidence in generalizing; **Entries with asterisks** indicate three or more additional section/subsections that could not be included in the comparisons (only one or two samples); N under each level gives the number of provinces/sections/subsections that were compared (those that had at least 3 samples). The number of pairwise comparisons for any N equals $[N*(N-1)]/2$.

wetland ecosystems, and 5 are in mountainous areas. See Appendix G for unit-by-unit information.

TABLE 10. ACREAGE OF POTENTIAL RESERVE SITES THAT ARE CURRENTLY IN A COMPARABLE FORM OF MANAGEMENT (BY LANDOWNER/MANAGER)

Owner/Manager	Total Number of Sites	Number of Sites with ≥50% Acreage in Comparable Management	Total Potential Reserve Acreage	Total Acreage in Compar. Mgmt. as % of Potential Reserve Acreage	Total Acreage in Comparable Form of Management
Baxter State Park	1	1	181,360	95%	171,412
Maine Bureau of Parks and Lands	34	6	179,520	22%	39,654
US Forest Service	3	1	33,820	49%	16,410
National Park Service	3	3	26,054	100%	26,054
US Fish and Wildlife Service	6	4	21,711	58%	12,564
ME Dept. of Inland Fisheries and Wildlife	12	3	21,556	17%	3,569
The Nature Conservancy	15	14	18,712	99%	18,576
US Department of Defense	2	1	12,380	10%	1,200
National Audubon Society	1	1	1,639	73%	1,200
Forest Society of Maine	1	1	973	100%	973
Bates College	1	1	673	100%	673
Maine Coast Heritage Trust	1	1	300	100%	300
Totals	**80[4]**	**37**	**498,698**	**59%**	**292,585**
Totals Excluding Baxter State Park	**79**	**36**	**317,338**	**38%**	**121,173**

Ownership/Operable Timberland

A summary of potential reserve acreage by landowner or managing agency and the portion of this that is operable timberland is presented in Table 11. Note that for these purposes, "operable acres" were defined as any acres that can or could be harvested under Maine state statutes, agency mandates, or management plans now in effect. For example, special protection zones, agency-determined no-cut zones and land within the Allagash Wilderness Waterway and Appalachian Trail Corridor were not counted. For a more detailed, unit-by-unit explanation of how these acreages were derived, see Appendix H.

[4] Abutting tracts in different ownerships or jurisdictions were evaluated as single potential reserve areas. The actual number of potential reserves is 69.

TABLE 11. OPERABLE TIMBERLAND ACREAGE BY LANDOWNER/MANAGER

Owner/Manager	Number of Sites	Total Potential Reserve Acreage	Total Operable Acreage as % of Potential Reserve Acreage	Total Acreage of Operable Timberland
Baxter State Park	1	181,360	5%	9,948
Maine Bureau of Parks and Lands	34	179,520	69%	123,101
US Forest Service	3	33,820	51%	17,110
National Park Service	3	26,054	0%	0
US Fish and Wildlife Service	6	21,711	34%	7,480
Maine Department of Inland Fisheries and Wildlife	12	21,556	58%	12,516
The Nature Conservancy	15	18,712	0%	0
US Department of Defense	2	12,380	92%	11,380
National Audubon Society	1	1,639	24%	400
Forest Society of Maine	1	973	10%	100
Bates College	1	673	0%	0
Maine Coast Heritage Trust	1	300	0%	0
Totals	**80[5]**	**498,698**	**37%**	**182,035**

The total acreage of operable timberland (182,035 acres) ≅ 37% of the total potential reserve acreage and ≅ 0.8% of the state's total acreage.

[5] Abutting tracts in different ownerships or jurisdictions were evaluated as single potential reserve areas. The actual number of potential reserves is 69.

KEY FINDINGS AND CONCLUSIONS

Key Findings

1. Maine currently has ~820 tracts of public land and private conservation land encompassing 1.1 million acres or ~5% of the state. Relatively few of these tracts qualify as ecological reserves, either because of their small size, level of development, or their current or past uses. Areas that have potential as ecological reserves were identified on 69 of the 820 tracts. These include most of Baxter State Park and approximately 317,338 acres (36%) of the remaining public and private conservation land. In all, these potential reserves encompass just over 2% of Maine's land area.

2. Notwithstanding the very small proportion of Maine's land area they include, these potential reserve sites would include approximately half of the variety of ecosystem types native to Maine at the subsection level and about two thirds at the section level. Almost all sites include multiple noteworthy features and could protect several different ecosystem types.

3. These potential reserve sites represent Maine's mountainous terrain and wetland types better than they do other classes of ecosystems. Despite the fact that Maine is approximately 90% forested, good examples (in a relatively natural condition and large enough to be viable over the long term) of the state's most common forest ecosystems are the least represented. In addition, although Maine is well known for an abundance of lakes, ponds, rivers and streams, these are relatively poorly represented on public and private conservation land, especially in southern Maine.

4. Areas on public or private conservation lands with good reserve potential are not evenly distributed across the state. This reflects the relative lack of public land and the small size of most public land units in central and southern Maine, eastern Aroostook County, and extreme northwest Maine. These gaps are particularly significant because these three areas represent some of Maine's most biologically distinctive landscapes.

5. Potential reserve areas range in size from 83 to 181,360 acres. Median potential reserve size is 2,075 acres. This is considerably smaller than the average range of 5,000 to 12,000 acres recommended by the Science Advisory Panel, largely because of the constraints of existing ownership boundaries.

6. Only 25% of the potential reserves contain the minimum acreage (5,000) recommended to adequately represent matrix-forming ecosystems[1]. Potential reserves of 12,000 acres or greater are found in only two of 7 sections and 4 of 19 subsections. Potential reserve areas were designed to include the natural boundaries of the key

[1] The ecosystem types which form the dominant vegetation of an area (spruce-fir forest and mixed hardwood-conifer forests, for example).

feature(s) or ecosystem types for which the site qualified and an adequate internal buffer where possible, while staying within current tract boundaries. However, for most (79%) of the potential reserve areas, existing tract boundaries do not fully contain or adequately buffer the features that the potential reserves are designed to protect. For some in this latter group, the current unit boundary contains so little of the key features of interest that these areas would not have qualified as potential reserves if they were not the only examples known on public or private conservation land of their respective ecosystem types. This is particularly true in southern Maine where the need to buffer potential reserve areas from impacts associated with adjacent land uses is greatest.

7. The purpose of an ecological reserve system, as defined here, is to represent all native ecosystem types across their natural range of variation in Maine. The Maine Natural Areas Program analysis of ecosystem data collected during the ecological reserves inventory indicates that ecosystem types do vary by region. Six of the 7 ecosystem types tested show some degree of variation in species composition even at the finest level of the biophysical region classification—that of the subsection. For example, a northern hardwood forest in the Mahoosucs Mountains Subsection shows significant differences in species composition from a northern hardwood forest in the central interior portion of Maine. This implies that to fully represent Maine's ecosystem types, examples in different parts of the state—and in most cases at least one in each subsection in which that type occurs—would be needed.

8. A key purpose of reserves is to serve as benchmarks against which biological and environmental change in both managed and unmanaged ecosystems can be measured. Most of Maine's public lands, and subsequently, most potential reserve sites, currently allow timber harvesting, gravel mining, and other uses that are likely to conflict with the objectives of ecological reserves. However, significant portions of 28 of the 69 potential reserve sites are already in forms of management (as stipulated in management plans or by statute) that are compatible with ecological reserve purposes. Sixteen of these areas are predominated by wetlands and 5 areas are in mountainous terrain.

9. Most potential reserve sites include areas of operable timberland, which is defined here as land that can be harvested under current Maine state statutes, agency mandates, or management plans. The total acreage of operable timberland within potential reserves (182,035 acres) is approximately 37% of the total potential reserve acreage and encompasses less than 1% of the state's land area. Approximately 68% of the operable acres on potential reserves are on lands managed by the Maine Bureau of Parks and Lands.

Conclusions

How well do our public and private conservation lands represent the diversity of native ecosystem types that occur in Maine? The ecological reserves inventory shows that approximately half of the state's ecosystem types are currently represented at the subsection level on the 69 public and private conservation lands identified. This is the level of representation recommended by the Scientific Advisory Panel. However, in most cases, this potential cannot be fully realized unless (1) these areas can be managed in a way that is compatible with ecological reserve objectives and (2) if boundaries can be extended so that potential reserve areas can fully contain and adequately buffer the features they are designed to protect over the long run.

The inventory results largely reflect the stipulation that the inventory be confined to Maine's public and private conservation lands, which comprise only 5% of the state and are typically small and unevenly distributed. As a result, even if these potential reserves were established as designed, there would remain significant gaps in the representation of Maine's ecosystem diversity. Further, a reserve system based on existing public and private conservation lands will fall short of meeting even the minimally adequate size distribution envisioned by the Scientific Advisory Panel.

It is clear from the inventory that a system of many reserves, rather than one or a few, would be required to collectively represent and encompass the full range of ecosystems, physical conditions, and environmental gradients that comprise the Maine landscape. In many respects, such a system, if established, should be viewed as an experiment, with three assumptions being put to the test over time[2]. The first is that the size of individual reserves will be adequate to maintain their current levels of biological diversity over time. The second is that the matrix of managed forest land in which most reserves would be located will serve to connect rather than isolate reserves. The third is that the way reserves are distributed across the landscape will capture the range of variation in ecosystem composition and gene pools (i.e., the biophysical classification is at the right scale). Ultimately, the only way to understand the degree to which this experiment is succeeding is to monitor species composition and abundance and the unfolding of natural processes in individual reserves over time.

While ecological reserves, as defined here, can contribute to the maintenance of biodiversity, they cannot do it alone, and have not been designed for this purpose. To conserve biological diversity in Maine, ecological reserves will need to be woven into a larger framework that integrates reserves with managed landscapes and with rare species protection efforts. In both cases, a key function of reserves would be to serve as reference points that would shed light on how various levels and types of management affect the native plants and animals of Maine.

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[2] Adapted from McMahon 1993b.

GLOSSARY

biodiversity — The variety of forms of life at various levels of organization, including organisms, populations, species, and ecosystems. Also known as biological diversity.

anthropogenic — Relating to or resulting from the influence of humans.

benchmark areas — Areas of natural or minimally-disturbed habitats that can serve as control or comparison areas to measure the effects of human activity and management on similar habitats in the same region.

biophysical region — Area of similar climate, physiography, and vegetation (used as a planning unit). See also **ecoregion**.

bog — A type of wetland with a peat substrate and with little groundwater influence; its water is supplied mostly through precipitation. A low-nutrient, acidic habitat.

circumneutral — At or near neutral acidity (pH 7.0); in Maine this typically refers to environments in the pH 5.5 to 7.0 range.

community — An assemblage of organisms living together in a particular habitat.

cryic — Refers to a soil temperature regime where summer temperatures at a depth of 50 cm are between 0° C (32° F) and 8° C.

ecoregion — Area of similar climate, physiography, and vegetation (used as a planning unit). See also **biophysical region**.

ecosystem — A community of organisms together with the physical and chemical environment with which it interacts. While the term ecosystem encompasses many scales, for our purposes we define upland and wetland ecosystem types primarily by the dominant plant community(ies) present.

edaphic — Related to or caused by a particular soil condition.

edge effects — The ecological changes that occur at the boundaries of ecosystems; these include changes in species composition, gradients of moisture, sunlight, soil and air temperatures, wind speed, and other factors.

environmental gradients — The change in ecological or environmental features across space, such as changes in elevation, moisture, temperature, or soil chemistry.

exotic species — A non-native species that arrived in an area as a result of human activities (transport, habitat modification, etc.). See also **introduced species**.

fen — A type of wetland with a peat substrate, influenced by groundwater flow and surface water input. Fens generally have higher nutrient levels than do bogs.

fragmentation — Subdivision of a forest (or other habitat) into smaller units, resulting in their increased isolation as well as losses of total habitat area.

introduced species — A non-native species that arrived in an area as a result of human activities (transport, habitat modification, etc.). See also **exotic species**.

lacustrine — Formed, growing, or found in lakes.

landscape — A heterogeneous land area composed of a mosaic of interacting ecosystems that is repeated in similar form throughout.

landscape analysis — Method of synthesizing existing information on the vegetation, physical environment and land use history of a tract of land, with the goal of targeting areas for fieldwork that have greatest potential for the features being inventoried.

large patch ecosystems — Ecosystems which occur as large patches, generally covering 50-1000 acres. Some Maine examples include black spruce bogs and northern hardwood forests.

lithology — The rock substrate of an area.

managed forest — Any forest that is treated with silvicultural practices or harvested.

matrix — The most extensive and most connected habitat type in a landscape, which often plays the dominant role in landscape processes.

matrix-forming ecosystems — Mosaic of ecosystem types which form the dominant vegetation of an area (spruce-fir, northern hardwood, and mixed hardwood-conifer forests, for example).

native — A species that has not been introduced from somewhere else by humans.

natural disturbance — Any relatively discrete event in time that disrupts ecosystem, community, or population structure and changes resource or substrate availability or the physical environment.

natural disturbance regime — The suite of disturbance types and scales that influence the ecosystems and landscapes of a given region.

palustrine — Of or associated with wetlands that have persistent herbaceous or woody vegetation.

peripheral species — A species at the edge of its geographical range in a particular area.

provinces — Large areas differentiated primarily by the effects of continental weather patterns interacting with broad landforms, that correspond to broad vegetation regions (USDA Forest Service National Hierarchical Classification definition).

reclamation — Removal of existing fish populations through chemical or physical means, followed by restocking with preferred fish species.

sections — Broad regions of similar geomorphology, stratigraphy, topography, regional climate, and dominant associations of potential natural vegetation (USDA Forest Service National Hierarchical Classification definition).

small patch ecosystems — Ecosystems which typically occur as very small, 1 to 50 acre patches. Some Maine examples include alpine meadows, calcareous cliffs, and riverwash barrens.

species richness — A measure of biodiversity defined as the number of species in an area; ignores relative abundance.

subsections — Divisions of a section which contain common landforms and are differentiated by subregional climate zones which influence plant community composition or species dominance (USDA Forest Service National Hierarchical Classification definition).

succession — The natural change in species composition of a particular habitat over time, typically following some major disturbance.

talus — Rock fragment slope.

terrestrial — Of the land; ecologically, usually means upland as opposed to wetland.

vascular plants — Plants with specialized tissue for conducting water and dissolved substances; includes all flowering plants, conifers, and ferns.

vernal pool — Seasonally occurring body of fresh water, usually less than two acres and self-contained.

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APPENDICES

UNDERLYING ASSUMPTIONS BEHIND THIS ECOLOGICAL RESERVE SYSTEM APPROACH

Purpose of a Reserve System

To represent all native ecosystem types across their natural range of variation within Maine in a permanently protected system of reserves. Individual reserves would serve as (1) benchmarks against which biological and environmental changes in both managed and unmanaged ecosystems could be measured, (2) habitats adequate to maintain viable populations of species whose habitat needs are unlikely to be met on managed lands, and (3) sites for scientific research, long-term environmental monitoring and education.

<u>Assumptions</u>:

1. A reserve system by itself will contribute to the maintenance of Maine's biodiversity, but it cannot do it alone. Reserves embedded in a matrix of sustainably managed land should protect a region's biodiversity over time.

2. The scale of the proposed reserve system hinges on what is probably the least certain assumption in this document, at least in some parts of the state: that a forested matrix will continue to serve to connect rather than isolate protected areas.

3. Representation of all native ecosystem types across their natural range of variation will include the greatest amount of diversity at all levels (i.e., genetic, species, environmental).

4. Maintaining viable ecosystems is generally more efficient, economical and effective than a species by species approach, especially in light of the fact that we know virtually nothing about the life histories of more than 90% of the species in the state.

5. Why Maine? This was purely a pragmatic decision, based on the assumption that timely political and public support and action is most likely at this scale.

6. Why permanent? Continuity of biological and environmental processes (e.g., soil formation, adaptation and evolution of species, development of microhabitats) is critical if reserves are to serve as baselines. One objective of reserves is to preserve the opportunity for research. A permanent reserve is very different than a temporary and managed "rolling reserve".

7. Why natural? Naturalness is best viewed as a continuum from least modified by humans to most modified by humans. The more natural an ecosystem (less human modification) the greater its value as a benchmark. This assumes that natural areas are more complex, more diverse and more resilient than human-modified areas (it is much easier to take an ecosystem apart than to put it together again). The distinction between human-modified and natural environments assumes that nature has functional, historic and evolutionary limits and that

extreme and rapid fluctuations (e.g., forest to field, global warming) are abnormal in most ecosystems.

8. Ecological reserves are an important and valid land use. They have a particularly critical role to play as benchmarks or control areas for management experiments.

Number of Reserves

The estimated number of reserves needed to represent all native ecosystem types across their natural range of variation in Maine is estimated at between 100 and 150. This assumes that each of the approximately 100 nonmarine ecosystem types documented in Maine will be represented in each of the biophysical regions in which they occur and that, on average, each reserve will contain an average of 6 ecosystem types (100 ecosystem types x 7 biophysical regions divided by 6 ecosystem types per reserve = 116 reserves). The total number will ultimately depend on how well these ecosystem types are represented on public and private conservation lands.

<u>Assumptions</u>:

1. Multiple examples of different ecosystem types are needed because:

   a. There is no such thing as <u>a</u> representative ecosystem. For example, although tree species composition may be similar, hardwood floodplain forests in northern, eastern and southern Maine contain conspicuously different suites of species in their shrub and herbaceous layers.

   b. Species well distributed across their native range are less susceptible to extinction than species confined to small portions of their range.

   c. Maine has steep environmental gradients and many peripheral species (species at the edge of their range). Peripheral populations are often genetically different from more central populations of the same species and are often more vulnerable.

2. Because there is so much variation in species richness and composition of natural ecosystems from north to south and from the coast inland, in Maine, a system of many smaller reserves (some in each biophysical region) will contain more species and ecosystem diversity than one or a very few large reserves.

3. The physical environment is more stable than vegetation and other biological elements, especially in the long term. By representing all environments in a reserve system, a significant portion of the biological elements and their evolutionary potential will be maintained.

4. The more ecosystem types (or biophysical regions) in a classification system, the more area is likely to be required to represent them all in a reserve network. For hierarchical biophysical region classifications such as Bailey's (Keyes et al. 1995), moving down the

hierarchy to discriminate ecosystems more finely captures more diversity, but with a greater investment of area and dollars.

5. The scale of Maine's biophysical region classification is equivalent to the subsection scale of Bailey's Ecoregions of the United States. Reliance on this level of resolution is based on the assumption that there is a significant difference in the species composition (and possibly structure) of ecosystems as you move from subsection to subsection.

6. A greater degree of replication (multiple examples of ecosystem types) is ecologically advantageous in that it will capture more within-type variation, guard against catastrophic loss, and foster metapopulation (groups of interacting populations of a species) stability, but it will require more area. The scientific panel agreed that for rare ecosystem types with several good examples (e.g., circumneutral fens, old growth forests) we should protect as many as feasible, even if they occur within the same subsection.

How Large Should Reserves Be? (Is there a minimum viable size?)

The scientific panel recommended that reserves be large enough to allow natural disturbance regimes (e.g., wind, insects, fires, floods) to function, and at least some reserves be large enough to accommodate the requirements of large area requiring habitat specialists. Based on these and other reserve design factors, the panel expected the size of reserves to vary greatly, but suggested an average reserve size of 5,000 to 12,000 acres.

Assumptions:

1. Although the ecological reserves system as a whole is not designed to permanently protect Maine's biodiversity, an individual reserve should be designed to maintain its diversity over time and sustain the processes that shape its constituent ecosystems. (Not really an assumption, but want to make explicit.)

2. Higher latitude regions typically have more homogeneous landscapes and more broadly distributed species. The relatively small average reserve size above assumes that Maine has very few habitat specialists that require completely unmanaged landscapes to survive.

3. The integrity of a protected area becomes more difficult to maintain as the area surrounding it becomes less natural (effective size/need for buffer).

4. Representing a species or ecosystem type in a reserve does little to guarantee its persistence there. Long term viability depends on the reserve design, which in turn may be constrained by the current unit/reserve boundaries.

5. Large blocks of habitat containing large populations of target species are superior to small blocks containing small populations.

6. The number of species represented/protected increases with reserve size.

7. Habitat in contiguous blocks is better than habitat in fragmented blocks.

8. Ecosystem health and integrity depends on maintenance of ecological processes.

9. The more complex and diverse an ecosystem, the greater its resilience to disturbance.

10. Designing reserves to take into account the long term viability of constituent ecosystems will be less expensive than the cost of intervention on reserves of inadequate size.

11. The opportunities for land protection (availability, quality, and affordability of sites) are unlikely to increase from generation to generation.

Appendix B

GUIDELINES FOR USE AND MANAGEMENT OF ECOLOGICAL RESERVES

Recommendations of the Maine Forest Biodiversity Project Scientific Advisory Panel

At the original May 1994 meeting of the Maine Forest Biodiversity Project, one of the activities agreed on by consensus was a scientific and technical review of the assumptions, process, and findings of the State Planning Office report (McMahon 1993) on ecological reserves entitled: *An Ecological Reserves System for Maine: Benchmarks in a Changing Landscape.* Following that meeting, the Steering Committee convened a Scientific Advisory Panel and charged it with this task.

As a foundation for their discussions, panel members used this description of the purpose of a Maine ecological reserves system:

> *The purpose of an ecological reserves system is to represent all native ecosystem types across their natural range of variation within Maine in a permanently protected system of reserves. Individual reserves would serve as 1) benchmarks against which environmental changes in both managed and unmanaged ecosystems could be measured, 2) habitats adequate to maintain viable populations of species whose habitat needs are unlikely to be met on managed lands, and 3) sites for scientific research, long term environmental monitoring, and education.*

The following table (Table 12) represents the consensus of the panel on the appropriateness of different activities on ecological reserves. It is an expansion of the appropriate uses section in the State Planning Office report. The information in the table represents our best thinking as scientists concerned with protecting valuable benchmark ecosystems. Discussions of the political tradeoffs involved is beyond the scope of our expertise and are best handled elsewhere.

Preamble

Establishment of an ecological reserve system is a fundamental part of any strategy aimed at protecting biodiversity. There are two fundamental and complementary objectives of an ecological reserves system. The first is to develop a comprehensive and permanent system of reserves that would represent all native ecosystem types across their natural range of variation in Maine. The goal is to maintain the natural evolutionary and ecological processes of these ecosystem types. A second objective would be to encourage the use of reserves for learning about the ecology of natural systems through research and study. Reserves would serve as environmental benchmarks and provide opportunities for descriptive and comparative studies, long term monitoring, and baseline research. Other objectives could include maintenance of recreation opportunities and aesthetic values. However, maintenance of biological diversity should take precedence over other uses of reserves.

Reserve ecosystems are dynamic and will change. Because their value as benchmarks is paramount, two overriding management guidelines for reserves are: 1) to allow natural processes to proceed with minimal human interference (e.g., no timber harvesting, no introduction of exotic species, no permanent development); and 2) to minimize disturbances associated with research, education, recreation, and other appropriate uses. In general, succession and natural disturbances would be allowed to occur. However, there may be situations where human intervention would be required to maintain an ecosystem that provides habitat for rare species (e.g., replacement of natural processes such as wildfire) or to protect abutting lands.

Implicit in the reserve concept is the idea that human uses should not alter the ecosystems in a reserve or interfere with their dynamic properties. Establishment of a reserve system would require development of a general policy that outlines uses consistent with the objectives described above. We expect that management of individual reserves would remain the responsibility of landowners or managing agencies. Ideally, land managers would be guided by a reserve system-wide advisory panel, composed of scientists and land managers, that would coordinate research and monitoring efforts, and advise on reserve management. It is also our expectation that guidelines for management and use would be tailored to each reserve and that land managers and the advisory panel would work closely with those agencies that have jurisdiction over boating, fishing, and other activities to assure that the objectives of reserves are being met.

Appropriate Use and Management of Ecological Reserves

The following table is designed to serve as a foundation for determining which activities are compatible with the benchmark function of ecological reserves and which are not. It includes only those activities specifically discussed by the Scientific Advisory Panel to date and is limited to activities taking place *within* a reserve area over which land managers can have some control. We did not consider activities that influence reserve ecosystems indirectly, such as human-induced climate change, or production of airborne pollutants.

The compatibility of many of the activities listed can be thought of as a continuum. Effects will vary with the intensity and extent of the activity and the size and sensitivity of the reserve ecosystems in which the activity occurs. For example, heavy hunting pressure on a game population that is self-contained within an ecological reserve would have a much greater impact than low hunting pressure on a game population that is only partially-contained within a reserve boundary. The categories 'Probably Compatible' and 'Probably Incompatible' are used when the intensity of a given activity is a critical factor in determining its compatibility with ecological reserve objectives. It is also important to note that certain activities, such as habitat management to maintain a rare plant or animal population or a certain successional stage, could potentially conflict with the benchmark objective of ecological reserves. A case-by-case evaluation of situations like these is recommended.

TABLE 12. LAND MANAGEMENT ACTIVITIES AND THEIR APPROPRIATENESS ON ECOLOGICAL RESERVES

Activity	*Potential Effects*[1]	*Degree of Impact*	*Compatible with Reserve Objectives?**				*Comments*
			C	PC	PI	I	
RESOURCE EXTRACTION AND ASSOCIATED MANAGEMENT ACTIVITIES							
Timber harvesting (includes thinning, brush removal, and salvage cuts)	Change in biological community; artificial cycle of disturbance; truncated successional cycle; loss of biomass and nutrients from forest ecosystem; change in structural diversity and diversity of successional stages; change in stand shape; edge effects; soil compaction; erosion and sedimentation; noise pollution; impacts associated with roads.	High				I	Thinning and other silvicultural manipulations designed to restore plantations to more natural structure and composition may be appropriate. Fire containment policy for a reserve may include salvage cutting within designated fire breaks.
Planting/reseeding of exotics (non-native species) or genetically "improved" tree species	Replacement/displacement of native species; loss of genetic purity or genotypes of native stock.	High				I	
Pesticide spraying	Reduction of populations and diversity of non-target insect species; secondary effects on non-target vertebrates and other organisms; major disruption of ecosystem; toxic residues in soil and water.	High				I	Exception could be selective use to control non-native species.
Herbicide spraying	Reduction of populations and diversity of non-target plant and associated animal species; shortened successional cycle with loss of important successional processes (soil inoculation, etc.).	High				I	Exception could be selective point-specific use to control non-native species.
Fire suppression/control	Changes in ecosystem composition, pattern, structure and function, particularly in fire-prone or fire-dependent landscapes.	High			PI	I	Because of the risk to adjacent lands, fire containment policies specific to each reserve would need to be developed in cooperation with the Maine Forest Service. Exceptions include island reserves or other geographically isolated areas. Prescribed burns are included in the habitat management section.
Commercial mining and exploration for surface or sub-surface materials	Habitat destruction or alteration; changes in local or regional hydrology; soil erosion and sedimentation; toxic waste and residue; noise from machinery; impacts associated with roads and structures.	High				I	
Collecting of plants and animals	Changes in species abundance, possibly leading to local extirpation, especially of rare plant or animal species.	High				I	

* C=compatible with benchmark objective of ecological reserves; PC=probably compatible; PI=probably incompatible; I=incompatible.

[1] The lists of potential effects are summarized from MFBP Scientific Advisory Panel discussions and Noss and Cooperider 1994.

	DEVELOPMENT						
Roads	Habitat destruction (roadbed and rights-of-way); movement barriers, especially for some species of small vertebrates and invertebrates; increased mortality of animal populations due to roadkill; exposure to increased hunting pressure and harassment; soil erosion and source of sedimentation to streams; pathways for exotic species; edge effects; noise pollution.	High			PI	I	Locate alternative routes where feasible. Impacts vary with type, size, and density of roads and amount of use. Old roads that function as trails may be compatible. The panel recommends against new road construction.
Dams (artificial impoundments)	Destruction of riverine and riparian habitats; barrier to upstream movement of aquatic species; interception of downstream flow of nutrients; artificial flooding regime; water temp. increase.	High				I	Impacts vary with size and type of water-control structure.
	RECREATION (CONSUMPTIVE)						
Hunting	Shift in sex and age structure of populations resulting from harvest regulations to maximize yield; reduced abundance of predators; shifts in abundance of non-target species; changes in density and productivity of game populations; disruption of social interactions among hunted populations; impacts associated with motorized vehicle use and access.	Mod.		PC	PI		Compatibility depends on relative size of reserve, size and range of game populations, and hunting pressure. Low levels of hunting would probably be compatible. Case-by-case evaluation of proposed game management is recommended.
Fishing	Changes in density, age class, and size distribution of species; introduction of exotic species, particularly live bait fish and invertebrates.	Low to High		PC	PI		Case-by-case evaluation of reserve lakes and streams is recommended. Certain types of fishing could have minimal impacts, e.g., catch and release, fly-fishing only.
Habitat management	Change in biological communities; managed area may no longer function as a baseline.	Low to Mod.		PC	PI		Habitat management for rare, endangered, or threatened native species may be compatible. For example, prescribed burns may be appropriate where fire is an essential and natural process in a ecosystem (e.g., pine barrens). However, because reserves are to function as baselines, habitat alteration by humans is generally not recommended. Case-by-case evaluation of proposed management is recommended. Would want portion(s) of potential habitat for species or ecosystem of concern to serve as control.
Trapping	Similar to hunting.	Mod. to High			PI		Reserves could function as refugia for some species, depending on their size.
Reclamation	Disruption of aquatic ecosystem; can no longer function as a baseline reserve.	High			PI	I	Reclamation may be an appropriate restoration tool (on a case-by-case basis) to remove exotics and reintroduce native aquatic species.
Artificial stocking	Displacement of native populations; genetic deterioration of native populations; ecosystem disruption, particularly in ponds that were previously fishless.	High				I	

RECREATION (NON-CONSUMPTIVE)							
Non-motorized boating	Erosion and vegetation disturbance at put-in points.	Low	C				
Hiking, skiing, snowshoeing and other forms of low-impact recreation	Soil compaction and erosion; disturbance of herbaceous and bryophyte vegetation, especially on wet or cryic soils.	Low to Mod.	C	PC			Impacts will vary depending on trail location, type, density, and amount of use. Careful trail construction and maintenance and avoidance of areas with sensitive soils and vegetation would help alleviate negative effects.
Camping	Soil compaction and erosion; trampling and cutting of vegetation; risk of fire.	Low to Mod.		PC			Impacts will vary with amount of use and quality of management. Impacts of walk-in or water-access campsites are generally localized.
Motorboating	Water pollution from gasoline engines; aquatic vegetation damage from propellers; soil erosion and vegetation disturbance at launching ramps; noise pollution.	Low to Mod.		PC	PI	I	Electric motors would alleviate water quality and noise impacts and are probably compatible. Gasoline engines are incompatible.
Horseback riding, trekking with pack animals	Soil compaction and erosion; introduction of nonnative species through feed and manure; grazing.	Low to Mod.			PI		May be appropriate on designated trails and roads.
Off-road vehicle use and mountain biking	Soil compaction and erosion; stream sedimentation; degradation of herbaceous layer; noise pollution from ATVs and snowmobiles.	Mod. to High			PI	I	Mountain bikes on designated trails would have minimal impacts.
RESEARCH AND EDUCATION							
Non-manipulative research	Minimal effects, except for some types of sampling, e.g., lethal small mammal or invertebrate traps.	Low	C				Sampling protocol would need to be developed.
Education	Similar to hiking.	Low to Mod.	C	PC			May want to designate education areas within reserves and limit visits to areas for which the reserve has something unique to offer.
Manipulative research	Depends on type and extent (e.g., Hubbard Brook watershed manipulations preclude future use of area as baseline).	Mod. to High			PI	I	Focus manipulative research on areas outside of reserves. Research that has local and reversible impacts may be compatible.

Appendix C

GEOGRAPHIC VARIATION AND REPRESENTATION

Details of techniques and results
by Susan C. Gawler, Maine Natural Areas Program

This Appendix provides more detailed information to support the section on geographic variation found on pages 55-56 of the text. It is a condensed version of Gawler (in preparation), which will include a complete set of MRPP tables, maps representing those results, and ordination diagrams.

The Question

Would a potential ecological reserves system adequately represent Maine's biota (using ecosystems as the "coarse filter" for plant, animal, and other species) if one example of each ecosystem were included statewide; if one example of each ecosystem were included in each province (of occurrence); if one example of each ecosystem were included in each section; or if one example of each ecosystem were included in each subsection?

The question is, of course, more complex than stated, as different ecosystem types may reflect geographic variation to various degrees.

Methods

Visual Analysis

"Ordination" is a general class of tools for analyzing and representing multivariate data from ecological communities. First, species abundances (or presence) in each sample are used to calculate the similarity of each sample to each other sample. Second, axes are derived through the resulting cloud of points (samples in species space) to capture as much of the variation as possible. The samples are projected onto the first axis, and then residual distances are used to project onto the second and third (or more) axes, successively. The resulting ordination diagram represents the samples in terms of similarity, with similar samples being closer to each other and dissimilar samples being more distant. The axes themselves are not a direct measurement of any one variable, but a complex gradient of variation.

Interpreting an ordination diagram requires correlating either species or secondary variables (such as latitude, elevation, pH, etc.) with sample scores on each axis, or overlaying categorical variables (such as province, section, or subsection) on the diagram. In our case, for example, if the three provinces overlaid on the ordination are separated instead of completely overlapping, the conclusion is that differences among provinces are an important source of variation in this ecosystem type.

Statistical Analysis

Standard statistical analyses of ecosystem data such as these present problems on two fronts: the data generally do not meet distributional assumptions in parametric techniques such as Multiple Discriminant Analysis, and the sample sizes within each group are small. A nonparametric alternative to discriminant analysis, Multi-Response Permutation Procedures (MRPP, Zimmerman et al. 1985), provides a tool for testing for differences among groups, although results must still be interpreted in light of small sample sizes where those apply. Given a set of samples with *a priori* groups, such as samples of a particular forest type grouped by province (or section or subsection), MRPP calculates the dissimilarity between samples (as in an ordination) and uses the mean pairwise distance within groups to indicate the degree of clustering of each group. However, instead of assuming an underlying distribution of the data, MRPP then looks at all possible permutations of the samples to see if the groups being tested are more clustered than would be expected by chance.

A caution in interpreting results of MRPP is that, particularly because the technique relies only on the sample points rather than on an underlying distribution, it is important that the samples collectively represent the group as a whole. The present analyses allowed any group with at least three sample points to be included; that is a liberal parameter chosen to allow consideration of as many subsections as possible.

Results

Northern Hardwood Forests

Differences were tested across two provinces, three sections, and six subsections. Differences were clear at the province and section levels. At the subsection level, most but not all pairs of subsections differed significantly. Seven additional subsections had only one or two samples of this ecosystem type and were not included in this analysis. See MRPP tables, maps representing those results, and ordination diagrams (Table 13 and Figures 7-11).

Spruce-Fir Forests

Spruce-fir forests are currently divided into four types in Maine's ecosystem classification (Gawler et al. 1996), which differ in certain regards but overlap on the ordination diagrams. Subalpine spruce-fir forests and those maritime spruce-fir forests containing mountain ash (*Sorbus americana* and/or *S. decora*) are somewhat distinct. Some forests typed as "maritime spruce-fir" primarily because of their location, do not appear different from the other spruce-fir types. Maritime spruce-fir forests, spruce-fir flats, and spruce slope forests intergrade to a large degree. These results, supported by field experience, indicate that some redefinition of the types may be called for. Because of the overlap and the small sample sizes that would have resulted had the types been segregated, this analysis considered all four types together.

Differences were tested across two provinces, four sections, and five subsections. Differences were clear at the first two levels, with the exception that Sections F and E did not differ significantly. At the subsection level, certain but not all pairs of subsections differed significantly. Five additional subsections had only one or two samples of this ecosystem type and were not included in this analysis; other subsections (excluding those in the Eastern Broadleaf Forest Province) not sampled during the ecological reserves inventory also have these ecosystems. Thus, geographic coverage of these types in this analysis is spotty.

Appendix C

Mixed Hardwood-Conifer Forests

Mixed Hardwood-Conifer Forests have long been recognized as a heterogeneous type (MNHP 1991), containing elements of more southern affinity as well as those of more northern affinity. Because they are included in the ecological reserves design process as a single type, this analysis considered the type as a whole, but also looked at the two major variants within the type, here referred to as the "oak subtype" and the "yellow birch" subtype. Based on species presence alone, not abundance, the oak subtype is distinguished by the presence of red oak and white pine along with other conifers (hemlock or spruce) and hardwoods (red maple). The yellow birch subtype is distinguished by the presence of yellow birch in all layers, as well as herbs more characteristically found in northern regions, including wood sorrel (*Oxalis montana*) and wood ferns (*Dryopteris carthusiana* and *D. intermedia*). The oak subtype is the oak-pine-mixed forest of more southern affinity and typically on drier soils, while the yellow birch subtype is the red spruce - yellow birch association typical of parts of montane and northern Maine.

The ordination and MRPP analysis of the Mixed Hardwood-Conifer Forest as a whole show differences at the Province level and inconsistent differences at the Section and subsection level. However, the analysis of the subtypes alone suggests that considering the type as a whole may be obscuring some geographic differences that appear when each type is examined separately. Because of small sample sizes when analyzed separately, conclusions are hard to draw here. In testing for differences among subsections in the oak subtype, for example, five subsections had sufficient samples to be compared (with 3-8 samples in each subsection), but an additional eight subsections had only one or two samples of the ecosystem type and were excluded from the analysis. In the yellow birch subtype, only three subsections and two sections could be compared, but those all differed significantly. An additional six subsections contained only one or two samples and were excluded from the analysis.

Northern White Cedar Swamps

Differences were tested across five sections and three subsections. Significant differences were absent at the subsection level, although three comparisons would have been significant at $p < .10$ criterion instead of the $p < .05$ generally used. The ecosystem occurs in at least one other subsection that could not be included in the analysis because of sample size. At the section level, significant differences were inconsistent.

Northern White Cedar Swamps are more edaphically constrained than the larger-scale Northern Hardwood Forests and Spruce-Fir Forests, and occur in smaller patches on the landscape. Their lower variability probably reflects less influence of larger-scale climatic factors and more influence of local factors.

Acidic Fens

Acidic fens, a non-forested type of peatland ecosystem, are another heterogeneous type. The group as it is defined in the current Maine ecosystem classification (see extracts in Gawler et al. 1996) actually includes several distinct types as described by Anderson and Davis (1997) in their sampling of over 100 Maine peatlands.

Differences were tested across three provinces, six sections, and seven subsections. Differences were consistent at the province level (although one comparison, the Laurentian Mixed Forest Province vs. the New England-Adirondack Province, was significant at $p = .077$) and present but inconsistent at the section and subsection levels. Five additional subsections had only one or two samples and were excluded from the analysis; the ecosystem is known to be present in at least four other subsections that were not sampled in this inventory.

Using the vegetation types of Anderson and Davis, as modified for use as ecosystem types for the Maine Natural Areas Program, the acidic fen samples included sufficient samples of one common subtype, here called *Myrica-Spiraea* shrub fens, to analyze them separately. Differences were tested across two provinces, four sections, and three subsections. All but one comparisons were statistically significant, and the one remaining was significant at $p = .056$. Six additional subsections had only one or two samples of this subtype and were excluded from the analysis. Though the geographic coverage is limited, this analysis lends support to the idea that heterogeneity within the acidic fen type as a whole was obscuring geographic variation within more homogeneous subtypes.

<u>Sedge Meadows and Graminoid Swales</u>

These two ecosystem types were inconsistently identified to type in the field and showed considerable overlap on an ordination of non-forested wetland samples, so were combined for this analysis. Even so, numbers were smaller than for any other ecosystem type examined here and only a few comparisons could be made. Differences were tested across two provinces, three sections, and three subsections. The Laurentian Mixed Forest Province and the Eastern Broadleaf Forest Province differed significantly. Subsections and sections in central and eastern Maine differed from those in western Maine; one of the three subsection comparisons and two of the three section comparisons were not significantly different. Eight additional subsections had only one or two samples of this type, so geographic coverage of the analysis for this type was very limited.

<u>Dwarf Shrub Bog</u>

Differences were tested across three provinces, four sections, and five subsections. Differences were clear at all levels. At the subsection level, two pairs of adjacent subsections were not significantly different but all other comparisons were. Six additional subsections had only one or two samples of this ecosystem type and were not included in this analysis. See MRPP tables, maps representing those results, and ordination diagrams (Table 14 and Figures 12-17).

TABLE 13. GEOGRAPHIC VARIATION IN THE NORTHERN HARDWOOD FOREST ECOSYSTEM TYPE

Northern Hardwood Forests, presence/absence data from ERI samples

Multi-response Permutation Procedures (MRPP) – testing for differences between:

PROVINCES: Laurentian Mixed Forest vs. New England-Adirondack differed at $p < .05$.

SECTIONS with > 2 samples:

Section	D	E	F
D		**	*
E			*
F			

SUBSECTIONS with > 2 samples:

Subsect.	7	11	12	13	14	16
7		**	*	ns	**	ns
11			ns	ns*	**	**
12				*	**	**
13					*	*
14						**
16						

<u>Note:</u> ns: $p > .10$; ns*: $.05 < p < .10$; (*): $p = .05$; * : $p < .05$; **: $p < .01$. **Boldface** indicates the number of samples in each subsection or section (reading across). Matrix shows level of statistical significance for each pairwise comparison of provinces, sections, or subsections. Two provinces/ sections/subsections are significantly different if their intersection in the matrix contains one or two asterisks. Comparisons which were not statistically significant are noted as "ns".

FIGURE 7. SIGNIFICANT COMPOSITIONAL VARIATION BY SECTION

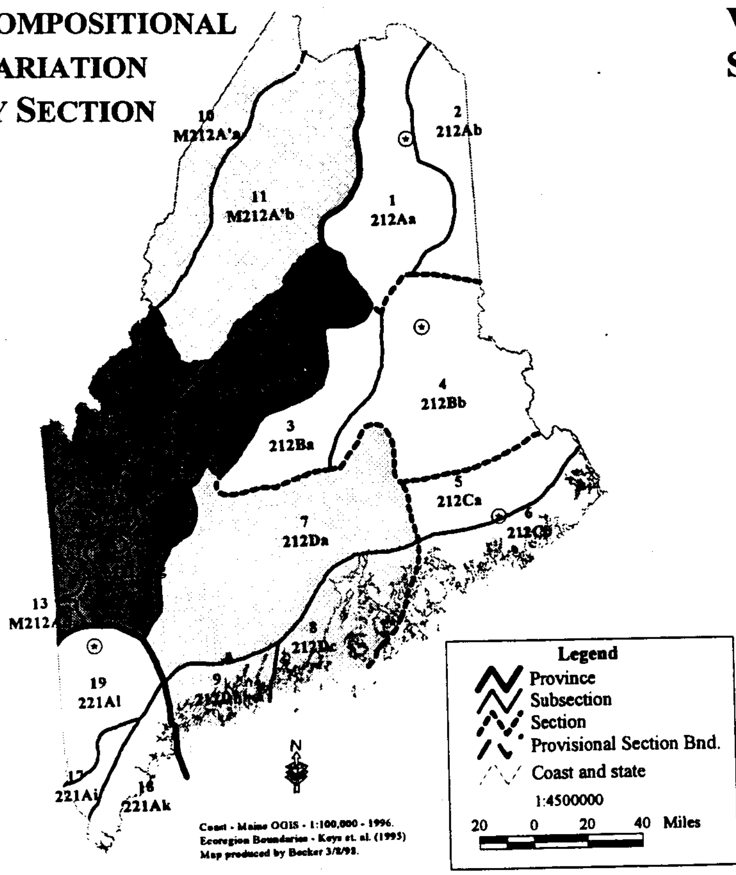
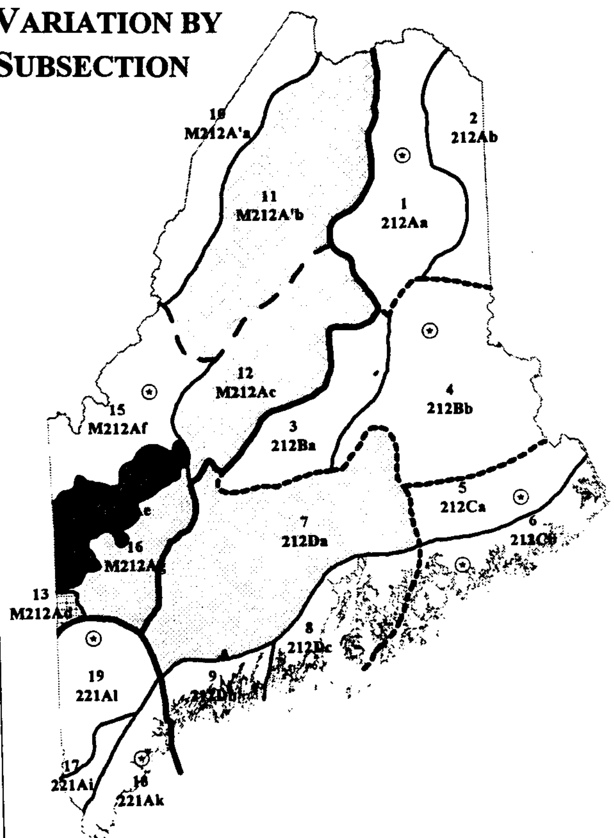


FIGURE 8. SIGNIFICANT COMPOSITIONAL VARIATION BY SUBSECTION

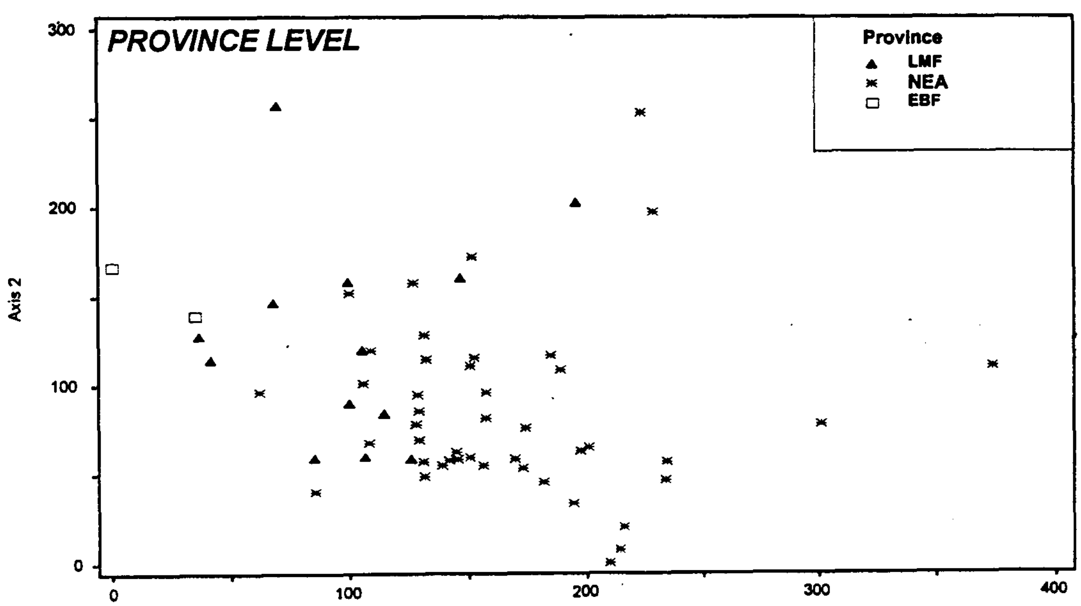


<u>Note:</u> Both maps are for Northern Hardwood Forests. Units that are significantly different have different shading patterns and units that are not significantly different have the same patterns. A "+" marks sections or subsections with only one or two samples for Northern Hardwood Forests in this inventory; these were not included in this analysis.

FIGURES 9, 10, AND 11. DETRENDED CORRESPONDENCE ANALYSIS ORDINATION OF PLANT SPECIES PRESENCE/ABSENCE DATA FROM NORTHERN HARDWOOD FORESTS.

Each point represents a sample; those that are close together are compositionally similar and those that are far apart are more different. (The axes do not represent any single variable but instead are used to indicate dissimilarity. Latitude and elevation were both significantly correlated with both axis 1 and axis 2, i.e., northern hardwood forests at lower elevations and/or more southern latitudes would tend to be found in the lower left portion of the scatterplot, and vice versa.) Each sample is coded according to its province, section, or subsection. The relative clustering or separation of the different provinces (or sections or subsections) on the scatterplot indicates whether, on average, northern hardwood forests from one province are more similar to each other than they are to those from other provinces. In cases where variation is not attributable to province (or section, or subsection), the different symbols would all overlap across the plot.

FIGURE 9. PROVINCE LEVEL



Note: LMF = Laurentian Mixed Forest Province; NEA = New England-Adirondack Province; EBF = Eastern Broadleaf Forest Province.

FIGURE 10. SECTION LEVEL

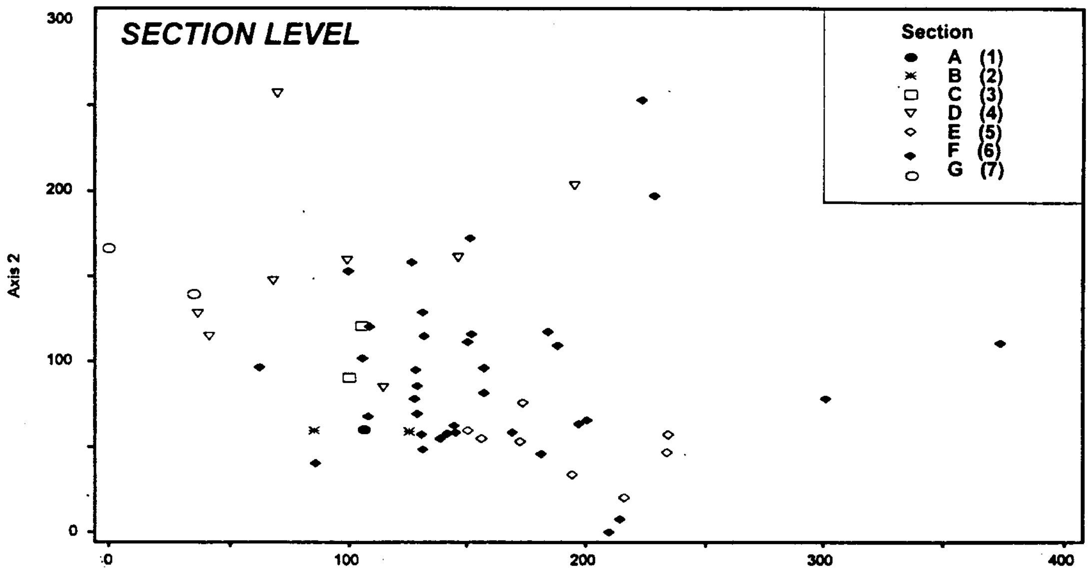


FIGURE 11. SUBSECTION LEVEL

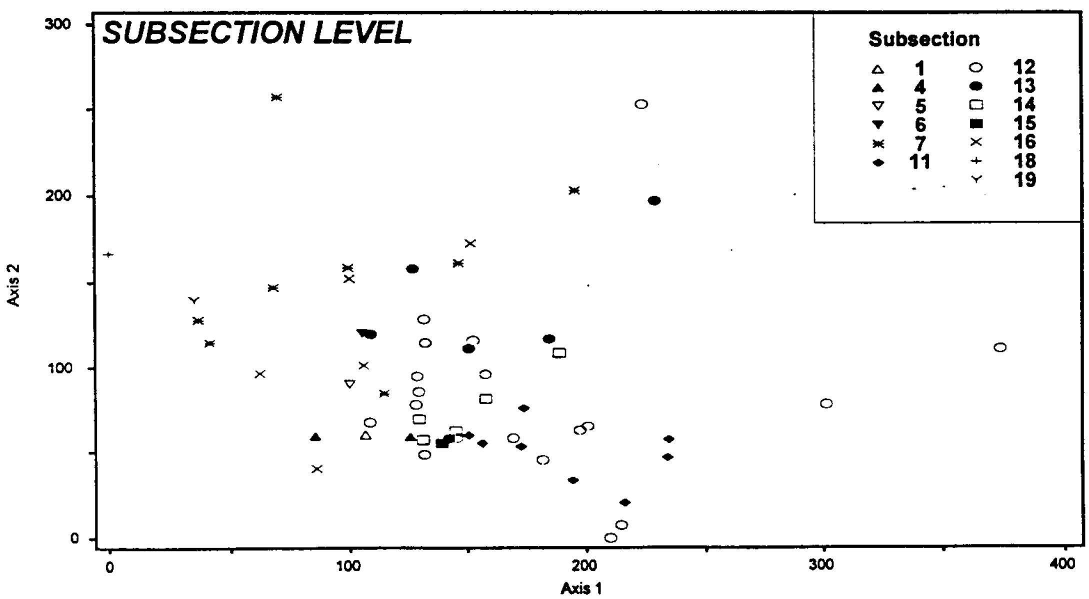


TABLE 14. GEOGRAPHIC VARIATION IN THE DWARF SHRUB BOG ECOSYSTEM TYPE

Dwarf Shrub Bogs, presence/absence data from ERI samples

Multi-response Permutation Procedures (MRPP) – testing for differences between:

PROVINCES with > 2 samples:

section	LMF	NEA	EBF	
LMF		**	**	
NEA			**	
EBF				

SECTIONS with > 2 samples:

section	C	D	F	G	
C		*	**	**	
D			*	*	
F				**	
G					

SUBSECTIONS with > 2 samples:

sub sect.	5	6	7	12	15	
5		ns	*	*	*	
6			**	**	**	
7				*	*	
12					ns	
15						

<u>Note:</u> ns: p > .10; ns*: .05 < p < .10; (*): p = .05; * : p < .05; **: p < .01. **Boldface** indicates the number of samples in each subsection or section (reading across). Matrix shows level of statistical significance for each pairwise comparison of provinces, sections, or subsections. Two provinces/sections/subsections are significantly different if their intersection in the matrix contains one or two asterisks. Comparisons which were not statistically significant are noted as "ns". LMF = Laurentian Mixed Forest Province; NEA = New England-Adirondack Province; EBF = Eastern Broadleaf Forest Province.

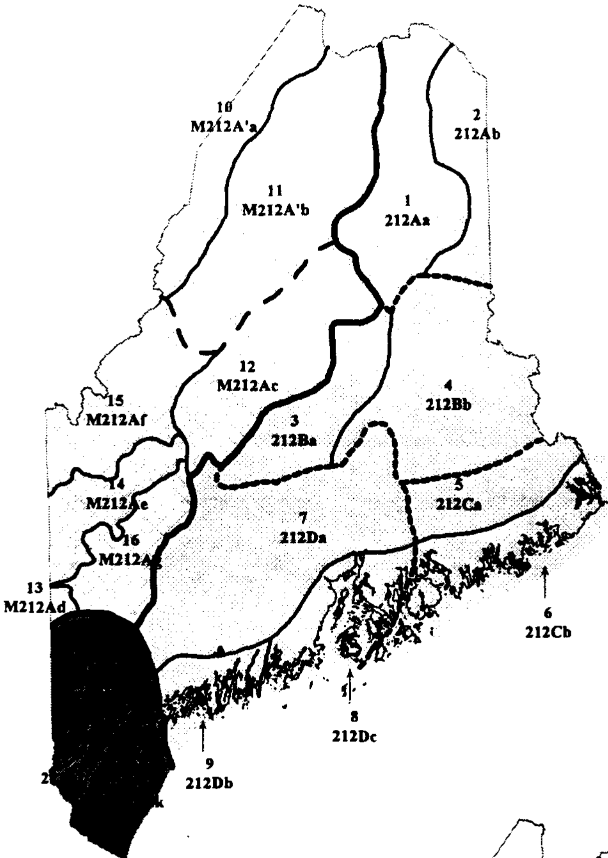


FIGURE 12.
PROVINCE LEVEL

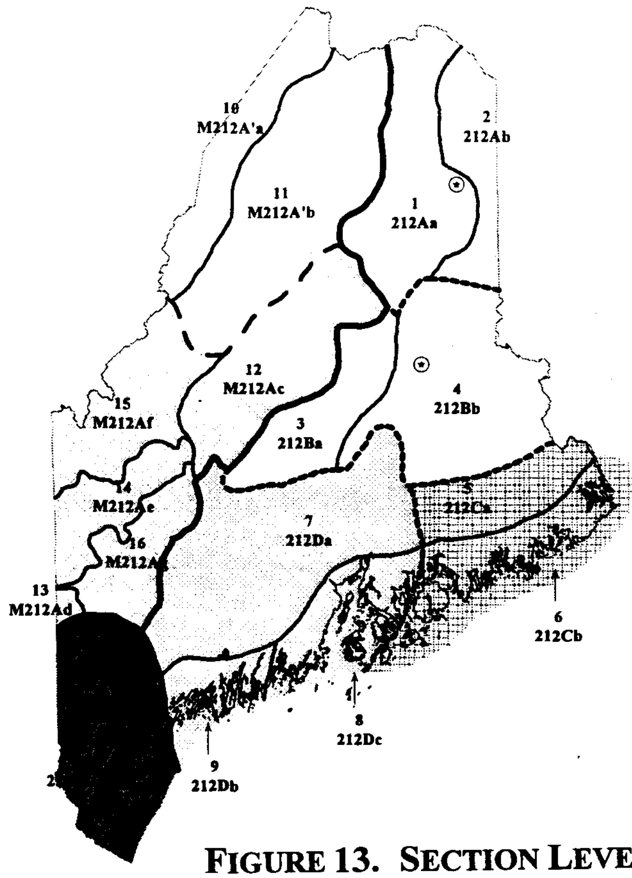


FIGURE 13. SECTION LEVEL

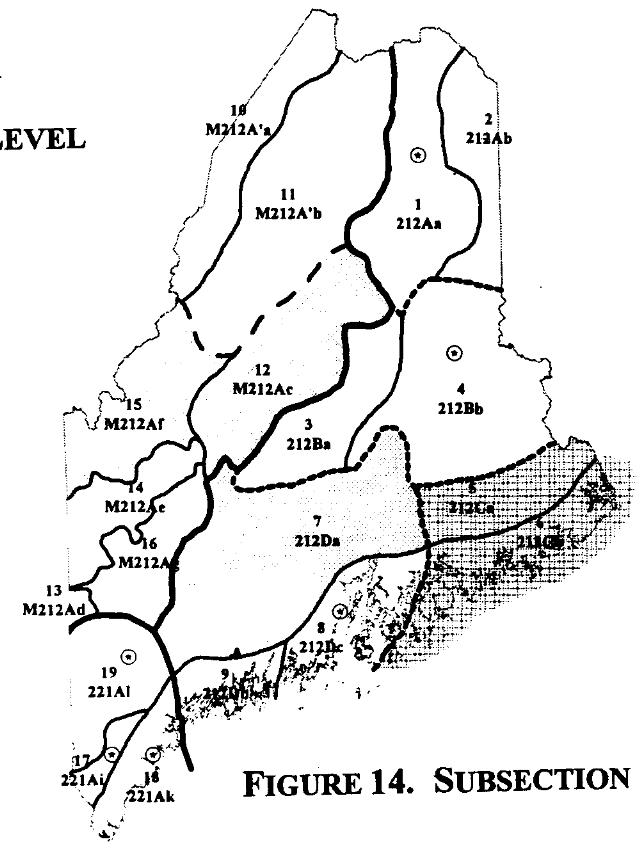
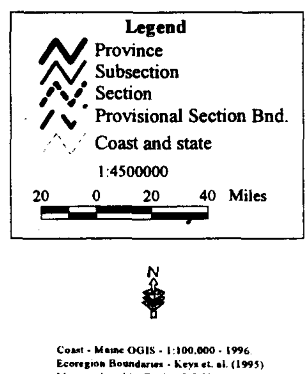


FIGURE 14. SUBSECTION LEVEL



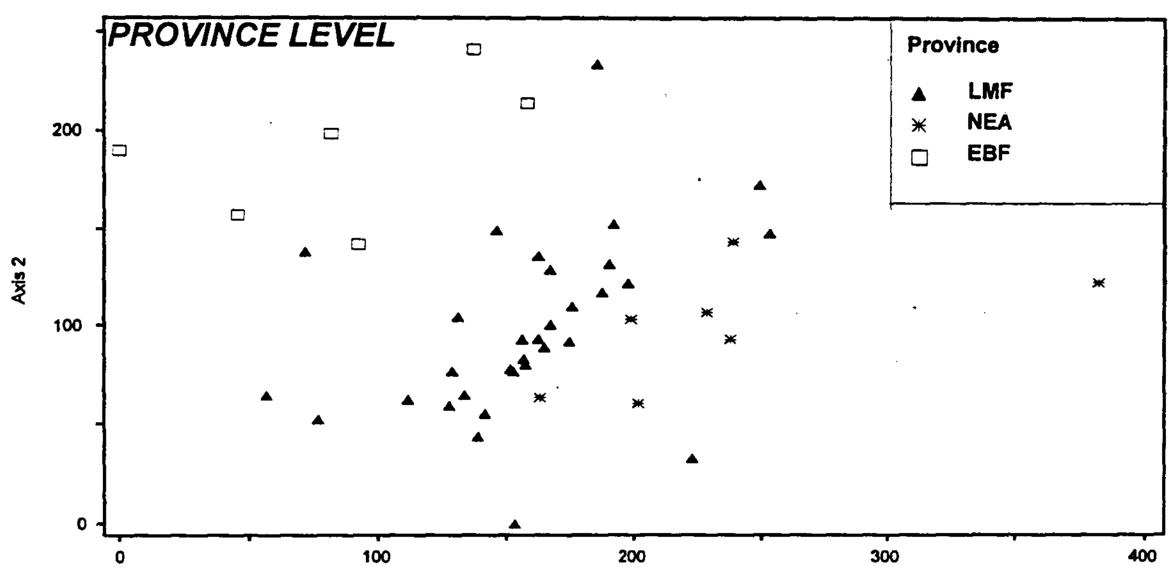
FIGURES 12, 13, AND 14. SIGNIFICANT COMPOSITIONAL VARIATION IN THE DWARF SHRUB BOG ECOSYSTEM TYPE AT THE PROVINCE, SECTION, AND SUBSECTION LEVEL

Note: Units that are significantly different have different shading patterns and units that are not significantly different have the same patterns. A "+" marks sections or subsections with only one or two samples for Dwarf Shrub Bogs in this inventory; these were not included in this analysis.

FIGURES 15, 16, AND 17. DETRENDED CORRESPONDENCE ANALYSIS ORDINATION OF PLANT SPECIES PRESENCE/ABSENCE DATA FROM DWARF SHRUB BOGS.

Each point represents a sample; those that are close together are compositionally similar and those that are far apart are more different. (The axes do not represent any single variable but instead are used to indicate dissimilarity. Latitude and elevation were significantly correlated with axis 1, i.e., more southerly and/or lower elevation dwarf shrub bogs tend to be to the left in the scatterplot; longitude was correlated with axis 2 – eastern bogs tend to be towards the bottom of the diagram.) Each sample is coded according to its province, section, or subsection. The relative clustering or separation of the different provinces (or sections, or subsections) on the scatterplot indicates whether, on average, dwarf shrub bogs from one province are more similar to each other than they are to those from other provinces. In cases where variation is not attributable to province (or section, or subsection), the different symbols would all overlap across the plot.

FIGURE 15. PROVINCE LEVEL



Note: LMF = Laurentian Mixed Forest Province; NEA = New England-Adirondack Province; EBF = Eastern Broadleaf Forest Province.

FIGURE 16. SECTION LEVEL

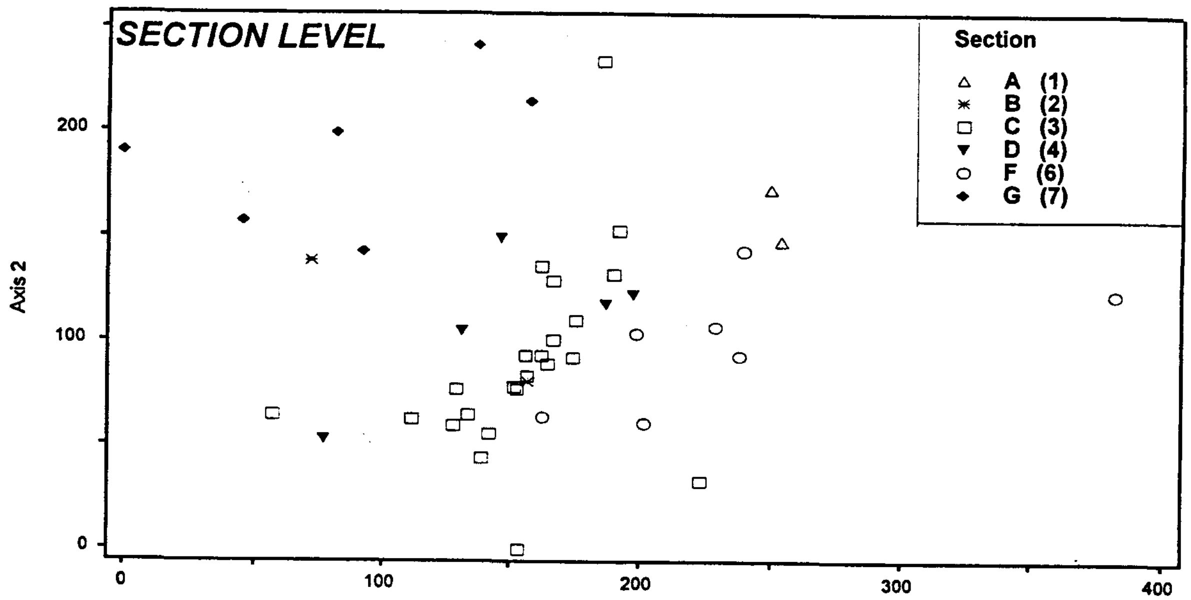
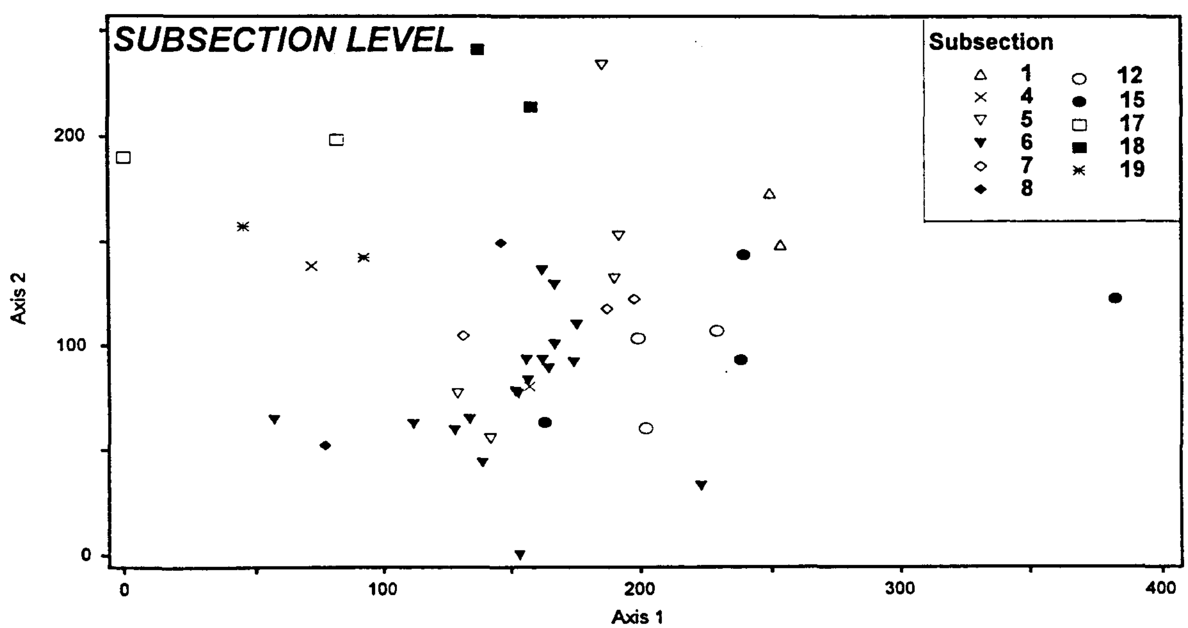


FIGURE 17. SUBSECTION LEVEL



APPENDIX D. SAMPLE ECOLOGICAL RESERVES INVENTORY FIELD FORM

NATURAL COMMUNITY DATA

Site: Deboullie
Surveyors: J. Royte, P. deMaynadier
Community type: Spruce slope forest
Obs. Point # 23
Date: 6/28/96

GEOGRAPHY

County: Aroostook

Township: T15R9

Quad: Deboullie Pond

(Quadcode:) MNAP

Lat: ° ' " Long ° ' "

UTM E N

Size of community (acres/hectares): ~ 14a

TOPOGRAPHY

Elevation: ~1300'

Aspect: N/NW

Slope: up 37°, 35° down 34°, 34°

Exposure: high

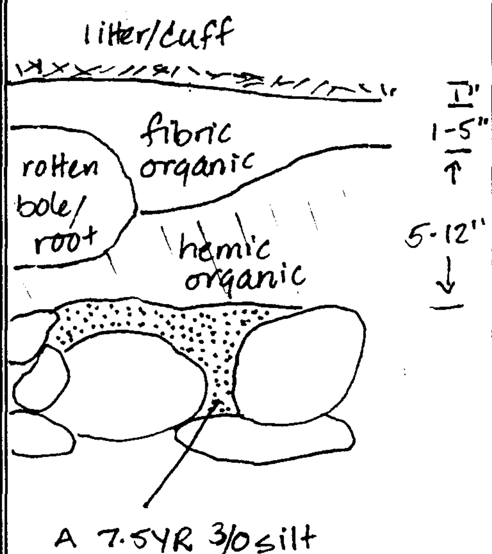
Topographic position: steep slope, north end of Whitman Mtn.

Microtopography (describe height & spacing of any microtopographic features): Some pit + mound development, abundant blowdown of many ages + sizes, including mature P. rubens. Scattered moss-covered boulders.

Habitat patchiness (describe zones or patches if present): Major source of patchiness - blowdown canopy gaps w/ dense regeneration of spruce + fir.

SUBSTRATE

Soil profile:



O horizon depth: 10-16"

A horizon depth/color (note +/- of A^p): 12-15" (pocket) or none

E horizon depth/color: 7.5YR 3/0 silt

B horizon depth/color:

Root penetration: 15"

Texture: organic

Stoniness: very stony

Depth to mottling: none

Depth to water table: none

Depth to obstruction: 10-20"

Depth of solum: "

Drainage (MAPSS): well-drained

Decomposition (von Post):

pH: 5.4 Kit type: H-Low

Soil temperature/depth: 43.4°F

Soil sample taken? Y (N)

SCS reference horizon: 3

Surface characteristics (relative amounts of boulders, litter, bare soil, etc.):
deadwood (bare) 5%
deadwood (mossy) 5%
fallen boles above gr. 20%
litter 40% rocks ~5%

Surficial deposit:

Bedrock type: slatey cleavage - bedrock or parent mat? - on Deboullie pluton

Inundation:
(N) never
I infrequent/irregular
R regular inundation/tidal
F usually (> 6 months)
SS always submerged (< 30 cm deep)
SD submerged (> 30 cm deep)

HISTORY (describe evidence of disturbance)

Fire:	Cutting:	Wind:	Agriculture:	Other:
no charcoal in soil samples	old logging rd. @ base of slope → hdw stand otherwise no obvious signs of cutting	mostly uneven-aged stand affected by wind storms in recent past	—	—

Site: Deboullie (BPL) Community Type: Spruce Slope Forest (e. end Whitney Mtn) Obs. Point #: 23 ERI 1996

VEGETATION (0.1 ha plots) (Regional Name:) (Physiognomy:)

Dominant species by strata		Total Cover (%)	Total # of species
Tree Canopy - T	Picea rubens	40	
Tree Subcanopy - SC	Picea rubens	10	
Shrub (1m to 2m) - Sl	Picea rubens, Abies balsamea, Betula cordifolia, Thuja occidentalis	30	
Shrub (>2m) - Sh	Picea rubens, Abies balsamea, Acer pensylvanicum	30	
Herb (1m to 2m) - Hh	scattered tree seedlings		
Herb (< 1m) - Hl	Cornus canadensis, Gaultheria hispidula, Trillium und.	15	
Moss/Lichen/Liverwort - M/L/LV (Bryophyte = B)	Bazzania triloba, Pleurozium schreberi	65	
Open Water / Bare Soil / Rock		20	

Canopy height: 62'
Crown depth: 52'
Canopy closure: 40%
Basal area: 30.49 m²/ha
dbh (median age): 8.75"
dbh (largest tree): 18.5" Picea rubens
Deadwood description:
low snaps – old + young – hard + soft from 4-15" dbh (most 5-12") - some barkless or completely decomposed to mounds; some moss-covered.

<2% standing dead

tip-up mounds for ~20% fallen boles

regen. responsive to canopy gaps

Species (JBS checklist nomenclature)	stratum	Q1*	1^	2	3	4	Q2	1	2	3	4	Q3	1	2	3	4	Q4	1	2	3	4
Bazzania triloba	B	1	13	35	13	13	1	3	3	13	13	1	13	13	62	90	1	13	62		13
Dicranum fuscescens	B	1	3	3			3			3		1	13	3		3	1	3			
Picea rubens	S	3		13			1	13			13	3		13		3	3		13		
Picea rubens	.	3					10					10					10				
Pleurozium schreberi	B	3				13	1	35	62	3	13	3					10		13		
Hylocomium splendens	B	3		3		13	3		13		3	10			13		3		3	35	
Picea rubens	H	3		3	3	3	1	3	3	3	3	1	3	3	35	3	3				
Dicranum montanum	B	3					3					3					10				
Usnea (on fallen twigs)	B	3					3					3					10				
Betula cordifolia	H	3			3		3		3	3	3	3		3		3	3				
Abies balsamea	H	10					10		3	3	1	13				3	10		13	13	
Gaultheria hispidula	H	10				3	3					25					10				
Cladonia cf. coniocrea	B	10					3			3		10					10				
Sphagnum cf cuspidatum (#1)	B	10		3			10				13			13					13		3
Sphagnum sp. (#2)	B	10					25														
Abies balsamea	S	10					1					3					10				
Dicranum scoparium	B	10			13		1	13	3			3					10				
Pinus strobus	H	10				3	10					25					1	13			
Betula cordifolia	S	10				3	3		3			10					10		13		
Sorbus americana	S	25					10					25					1	13		13	
Acer rubrum	H	10			3		10					10					10				
Acer pensylvanicum	H	–					25					25					25				

* Refers to plot quarter; indicate the first nested plot in which a species occurs by writing the dimension of the nested plot (1 = m²; 3 = 3.1 m²; 10 = 10 m²; 25 = 10 x 25m) in the appropriate column. ^Boxes labeled 1-4 refer to m² herbaceous cover plots. Record midpoint of cover class: <5% 3 6-20% 13 25-45% 35 50-75% 62 80-100% 90.
Note: For dense stands, fill out information for Q1 plots 1-4 and leave the rest blank.

Site: Debouille Community Type: Spruce slope forest Obs. Point #: 23   ERI 1996

NOTE: Use this page if more space is needed to document species present in plots and for incidental sightings of plants and animals. If used for the later purpose indicate general location of sighting, e.g., if a plant was seen between Obs. Pt. 1 and Obs. Pt. 2, write 1-2 after species name.

Species		Q1	1	2	3	4	Q2	1	2	3	4	Q3	1	2	3	4	Q4	1	2	3	4
Sphagnum sp. (#3)	B	25					25							3							3
Trientalus borealis	H	25					25					25					10				
Nemopanthus mucronata	S	25					3										25				
Nemopanthus mucronata	H	25					10										25				
Amelanchier cf. bartramiana	S	25					1	13				3					3				
Trillium undulatum	H	25										25					10				
Maianthemum canadense	H	25					10					3					3				
Dicranum polysetum	B	25				3				3		25									
Acer pensylvanicum	S	25					10										1	62		3	
Thuja occidentalis	H	25					3										3			62	
Vaccinium myrtilloides	H	25					10					25					10				
Hypnum imponens	B	–					1	3				10		3		3	1	13			
Dryopterus carthusiana	H	–					3					10					3				
Betula papyrifera	H	10					10									3	10				
Cladonia cf. pyxidata	B	25					10					10					10				
Aralia nudicaulis	H	–					10														
Cornus canadensis	H	–					10					25					10				
Ptilium crista-castrensis	B	–					10					10									
Betula alleghaniensis	H	–					10				3	25									
Aster acuminatus	H	–					25										10				
Thuja occidentalis	T	–					25										10				
Abies balsamea	T	–					25														
Betula cordifolia	T	–					25														
Viburnum alnifolium	H	–					25														
Polytrichum ontariense (cf)	B	–					25				3			3							
Ptillicium cilliare	B	–					–				3	25					10				
Ptillicum sp. (moss #1) on bark	B	–					–					25	3								
Acer rubrum	S	–					–					3									
Trillium erectum	H	–					–					10									
Sorbus americana	H	–					–					10									
Cladina rangerferina	B	–					–					10									
mnium sp. (moss #2)	B	–					–					10									
Betula papyrifera	S	–					–					25			35		10				
Clintonia borealis	H	–					–					25					10				
Coptis trifolia	H	–					–					25									
Plagiothecium cf denticulatum	B											25			3						13
needleduff/woody debris			62	35	35			35		62	3		62	13						62	62

Site: Deboullie

Community Type: spruce slope forest

Page 4 of 4 ERI 1996
Obs. Point #: 23

TREE STEM TALLY
(for 0.1 ha) or 10x25m² plots

Diameter in cm. or (in.)

Species																				
Picea rubens	18	3.5	14	7	12	11	2	14	11.5	3	7.5	5.5	8.5	10	6	7.5	11	10	2.5	5.5
	8.5	10	13.5	9	10.5	10.5	4.5	7	8	10	8	12	14	13	7.5	4	14.5	7	5	11
	15	12.5	5.5	8	5.5	11.5	12	12	6	7	18.5	5	11.5	9.5	5.5	10	14	8.5	4	
Abies balsamea	4																			
Betula papyrifera	4	7																		
Thuja occidentalis	10	5.5	4.5	4.5																
Σ 32.40 ft²																				
= 3.049 m²																				
BA = 30.489 m²/ha																				

(List species and DBH for each tallied tree· round to nearest cm or 0.5 inch; if halfway between cm graduations round down).

Tree Core Data

Coreboard #	Species	Dbh	Height	Crown Depth	Ring Count	
1	Picea rubens	11"	56'	39.5'	93	
2	Picea rubens	11"	66.5'	33'	158	
3	Picea rubens	12"	60'	36'	119	center missing
4	Picea rubens	12.5"	63.5'	55.5'	60	
5	Picea rubens	13"	62.5'	52.5'	85	

APPENDIX E. SAMPLE SITE DESCRIPTION DATA FORM

DESCRIPTION OF UNIT AND POTENTIAL RESERVE

- **Site Name:** Deboullie
- **Site No.:** 3
- **Owner/manager(s):** BPL
- **Size of unit:** 21871 ac.
- **Size of potential reserve:** 14400 ac.
- **Operable area within unit:** – ac. not calc.
- **Operable area within potential reserve:** ______ ac.

- **USFS subsection: (no:)** M 212 Ab **(name:)** Saint John Upland

- **Regional representativeness:**

	unit (Y/N/P)	reserve (Y/N/P) P=partial	comments
- topography	N	N	site has more relief at lower ave. elev.
- geology	P	P	Intrusive rocks present
- soil	N	N	3 major soil types of region are absent
- climate	Y	Y	assumed
- vegetation	P	P	montane/alpine comm absent
- surface water	Y	Y	more ponds than ave. – due to bedrock

PHYSICAL CHARACTERISTICS

- **Topography**

	unit	reserve	name of high/low feature -unit-	-reserve-
- average elevation (ft.):	~1350	~1400		
- highest elevation (ft.):	1945	1945	Deboullie Mtn →	
- lowest elevation (ft.):	985	1090	Rocky Brook →	

- topographic description[1] (use attached list to indicate subsystem code in appropriate topographic system)

	plains	plains w/ hills	open hills and mountains	hills and mountains	landforms[2]
unit				D4	12
reserve				D4	12

([1] classifications from Hammond 1970; [2] landforms:see attached list, use number followed by name, e.g. - 6-cirque, 49-gorge)

comments: 12 = talus slopes

- **Geology and Soils**

- **soils associations** (see attached list from Ferwerda et al. 1997; use number followed by name)	reserve (Y/N)	- **surficial geology** (see attached list from Thompson & Borns 1985; use letter followed by name)	reserve (Y/N)
1 - Monson-Elliottsville-Ricker-Telos	Y	16 - thin drift	Y
2 - Telos-Monarda-Monson-Elliotts.	Y		

comments: ~50% of each asso; soil types follow zonal pattern of bedrock in pluton.

comments:

- **lithology** (see attached list from Osberg et al. 1985; list protoliths or intrusive rock composition of bedrock preceded by letter or number)	reserve (Y/N)
Q (Ds) interbedded pelite + sandstone	Y
7,8 (D7,8) syenite, monzodiorite	Y
8 (D7) syenite	Y
2 (D2) granodiorite	Y

comments: Deboullie pluton is predominant bedrock feature; country rock = Q

 Completed by: JSM Date: 3/97

SAP/BPL review 4/97
revisions 1/98 (JSM)

Site Name: Deboullie

- **Water and watersheds:**
  - major drainage (see attached list): 1 - Saint John River
  - stream density index ________ mi./sq. mi.
  - stream tally (source: USGS 7.5' topos)
  - subdrainage(s):
    1. Red River → Fish -% of unit drained: 30 % reserve 50
    2. Rocky Brk → Red -% of unit drained: 15 % reserve 0
    3. Pelletier Brk → St. John -% of unit drained: 25 % reserve 0
    4. Conners Brk → Allagash -% of unit drained: 25 % reserve 40
    5. North Pond Brk -% of unit drained: 5 % reserve 10

	1st order	2nd order	3rd order	4th order	5th order
unit	17	6	1	0	0
reserve	10	3	1	0	0

-general comments: ________

-ponds/lakes

MIDAS code	name	type[1]	elev.	acres	% in unit	% in res	% wshed in unit	% wshed in res	reclaimed (Y / N / U)	% shore dev.[2]	boat access (H/T)[3]	dam (Y/N /U)	native fish spp.[4]	stocked fish spp.[5]	fishless (Y / N / U)
1504	Fifth Pelletier Brk L.	L02	1284	27	100	0	100	0	N	0	N	N	BKT	–	N
1502	Sixth Pelletier Brk L.	L02	1255	32	100	0	100	0	N	0	H	N	BKT	–	N
1508	Little Black P (north)	L06	1303	6	100	100	100	100	N	0	N	N	BKT	–	N
1510	L. Black P. (south)	L02	1276	7	100	100	100	100	N	0	N	N	–	BKT	N
1506	Black P.	L08	1225	147	100	100	95	95	N	0	H	N	BKT BBT	–	N
1528	Gardner P.	L08	1134	288	100	100	100	100	N	0	N	N	BKT BBT	–	N
1512	Deboullie P.	L08	1128	262	100	100	100	100	N	0	H	N	BKT BBT	–	N
1514	Pushineer P.	L08	1127	55	100	100	100	100	N	10	H	N	BKT BBT	–	N
1520	Fish P.	U	1125	5	100	100	100	100	U	0	U	U	U	U	N
1532	Mud P.	L02	1107	63	100	100	95	95	N	0	N	N	BKT?	–	N

([1]type: use code from community list or "U" if unknown; [2]estimate amount of shoreline development; [3] boat access: H=hand carry, T=trailerable; [4,5] fish: BKT=brook trout, LKT=lake trout, SPK=splake, LLS=land-locked salmon, BBT=blue-backed trout, BRT=brown trout, SPT=sunapee trout, SRA=sea run alewife)

- specific comments: (use code/name before each comment) 1504 - trail access to lake; 1510 - BKT stocked every other yr; 1514 - southernmost occurrence of amphipod (Grammarus lacustris) - doc. 1969; breached dam; campground @ outlet; 1532 - no sport fish potential

- general comments Access to all ponds requires NMW permit; highest concentration of native fish pops. in state. Ponds well-buffered (pH 6.5 - 7.5 - moderate alkalinity). High fishing pressure is increasing the demand for campsites - most are on pond shorelines.

CDH 9/8/97 Description - 2 Completed by: JSM Date: 3/97

Site Name: Deboullie

Ponds/lakes (cont'd)

MIDAS code	name	type[1]	elev.	acres	% in unit	% in res	% wshed in unit	% wshed in res	reclaimed (Y / N / U)	% shore dev.[2]	boat access (H/T)[3]	dam (Y/N /U)	native fish spp.[4]	stocked fish spp.[5]	fishless (Y / N / U)
1526	Galilee P.	L08	1167	9	100	100	100	100	N	0	N	N	BKT	–	N
1524	Denny P.	L08	1276	25	100	100	100	100	N	10	H	N	BKT	–	N
1516	Island P.	L08	1245	32	100	100	100	100	Y	10	N	N	BKT?	–	N
1518	Stink P.	L02	1106	16	100	100	95	95	N	0	H	N	BKT	–	N
1521	Upper P.	L09	1261	17	100	100	100	100	N	0	H	N	BKT	–	N
1522	Perch P.	L09	1262	17	100	100	100	100	Y	10	H	Y	–	BKT	N
1530	Togue P.	L08	1189	388	100	100	90	90	N	10	T	N	LKT	LLS	N
0487	Crater P.	L02	1190	12	100	100	100	100	Y	0	H	Y	–	–	N

([1]type: use code from community list or "U" if unknown; [2]estimate amount of shoreline development; [3] boat access:H=hand carry, T=trailerable; [4,5] fish:BKT=brook trout, LKT=lake trout, SPK=splake, LLS=land-locked salmon, BBT=blue-backed trout, BRT=brown trout, SPT=sunapee trout, SRA=sea run alewife)

- specific comments: (use code/name before each comment) 1524 - campground on e. shore; 1516 - restocked w/ native trout captured prior to 1977 reclamation to preserve original gene pool; Red River Camps clustered on N shore; 1522 - reclaimed in 1962; dam - <50% flowed; 1530 - 3 campsites on N shore; 0487 reclaimed in 1967 w/antimycin followed by rotenone; dam - <50% flowed.

- general comments

CDH 7/16/97 Description - Appendix 1 Completed by: JSM Date 3/97

106

Site Name: Deboullie

ECOLOGICAL CHARACTERISTICS

- **Ecosystem Diversity**

- focal points:

place name	community / ecosystem type	comments
Deboullie/ Gardner Ponds watershed	T05, T12, T15, P06	native fish pops incl. BBT; intact watersheds; elev gradients complete; asso. talus + cliff comm.
Rocky Brk cedar swamp/ seepage forest	P23	one of most extensive examples documented; partially harvested on W end

general comments:

- community types present (all listed are present on unit; indicate presence on reserve)

Terrestrial (code/name)	range[1] assmnt.	pattern[2]	# of high quality[3]	# in res.[4]	more?[5] (Y/N/U)	Palustrine (code/name)	range[1] assmnt.	pattern[2]	# of high quality[3]	# in res.[4]	more?[5] (Y/N/U)
T05 spruce slope forest		S/L/M	6	6	U	P06 nwc swamp		S/L	1	1	U
T08 mixed hdw-conifer "		M				P23 nwc seepage forest		S/L	1	1	N
T12 beech-birch-maple "		L/M	2	2	U	P07 spruce-fir swamp		L/M	U		
T13 cold air talus woodland		S	1	1	N	P08 forested bog		S/L	U		
T14 circumneutral talus		S	U	2		P16 acidic fen		S/L	U		
T15 acidic talus		S	1	1		P18 beaver flowage		S/L	U		
T46 circumneutral cliffs		S	U	2							
T48 acidic cliffs		S	U	1	U						
Riverine (code/name)											
several types - not classified											
						Lacustrine (code/name)					
						L02 eutrophic lake		A	4	2	U
Estuarine (code/name)						L06 monomictic mesotro.		A	1	1	U
—						L08 dimictic mesotrophic		A	6-7	6-7	U
						L09 dimictic oligotrophic		A	1	1	U

([1] assessment: R=restricted, L=limited, W=widespread, P=peripheral; [2] pattern: S=small patch, L=large patch, M=matrix-forming, A=aquatic (list pond/lake names), U=unknown; [3] tally all A or B ranked (NAP) communities of this type - note NO ranking for lacustrine or riverine communities; [4] number of well-represented communities in reserve; [5] likely high quality communities but not sampled)

comments: T05 = small remnants, typically on steep slopes; P16 includes patterned fen - outside of potential reserve area

 Completed by: JSM Date: 3/97

Site Name: Deboullie

- **Populations of rare species** (use appendix list if more than 5)

scientific name	common name	global rank	state rank	number of A/B ranked occurrences -unit-	-reserve-
see attached list:	8 rare plant spp +				
	2 rare animal spp.				
	documented				

comments: No systematic surveys for plants, birds + other groups of spp. have been done. Lichens were inv. by S. Selva.

- **Natural disturbance regime**

type	unit	res.	scale* 1	2	3	comments
fire	✓	✓	✓			1886 exploration reports doc. ~320 a. burned*
wind	✓	✓	✓			widespread blowdown in 1872 in NE 1/4
spruce budworm						
pathogens						
beaver	✓	✓	✓			local
other mammal herbivory						
seasonal/episodic flooding						
snow /ice	✓	✓	✓	✓		affects high elev. fir (1983 ice storm killed
other						~1/3 fir on ridges)

* (scale classifications: 1 = tens of acres, 2 = hundreds of acres, 3 = thousands of acres)

comments: *land (in patches) in NW 1/4 of twp; charcoal bits in hdw. stands. Disturbances probably patchy due to topographic variability.

LAND USE

- **Cutting history**

episodes	time period[1]	harvest type[2]	location
most recent major	1970's	H/C	spruce/fir salvage cuts (budworm)
other			
other			

([1] indicate decade: 1=1990s, 2=1980s, ...12=before 1890, [2] type = Light selection, **H**eavy selection, or **C**learcut)

comments: earliest record of harvesting 1884; first widespread sawlog cut - early 1900s; widespread pulpwood cut by GNN 1950-63. All operable land harvested.

- **Documented old growth stands**

community type	acres	landscape position[1]	unit	reserve
T05 - spruce slope forest	~134 total	mid to upper slopes	✓	✓

([1] position: indicate whether **crest, upper slope, mid-slope, lower slope, entire slope,** or **valley**)

comments: 5 stands doc. by BPL ranging in size from 8 to 48 a. Remnants probably not representative of original spruce slope - once more widespread

- **Other uses** {indicate whether **R**ecent (< 50 y. a.) or **N**ot recent (> 50 y.a.) in first column; indicate extent (**low / mod / high**) in 2nd col}

	pesticides		cultivation		pasturing		ditching		buildings		exotics		water control	
unit									R	L			R	M
reserve									R	L			R	M

comments: Red R. Camps on Island P. - built prior to 1940s; dams on Perch P., Crater P. + breached dam on Pushineer. Pesticides: BPL records suggest twp was never sprayed for budworm due to high hardwood + mixedwood component.

 Completed by: JSM Date: 3/97

SITE #3 - DEBOULLIE (BPL)

SPECIES NAME	COMMON NAME	GRANK	SRANK	EORANK	LASTOBS	SITE NAME
CYPRIPEDIUM REGINAE	SHOWY LADY'S-SLIPPER	G4	S2S3		1984-	DEBOULLIE POND BLUEBACK TROUT AREA & ROCK SLIDE
DRYOPTERIS FRAGRANS	FRAGRANT CLIFF WOOD-FERN	G5	S3	A	1985-08-22	DEBOULLIE PONDS
EPILOBIUM CILIATUM	HAIRY WILLOW-HERB	G5	SSYN	A	1983-10-13	DEBOULLIE CLIFFS
EQUISETUM VARIEGATUM	VARIEGATED HORSETAIL	G5	S3	E	1984	DEBOULLIE PONDS, T15 R09 WELS
FALCO PEREGRINUS	PEREGRINE FALCON	G4	S1	H	1922	DEBOULLIE PONDS
GOODYERA OBLONGIFOLIA	GIANT RATTLESNAKE-PLANTAIN	G5?	S1	H	1905-07-24	DEER POND TRAIL
MINUARTIA RUBELLA	BOREAL STITCHWORT	G5	S1	A	1983-10-13	DEBOULLIE CLIFFS
SALVELINUS ALPINUS OQUASSA	BLUE BACKED TROUT	G5T2Q	S2	A	1985	PUSHAW LAKE ACCESS
SALVELINUS ALPINUS OQUASSA	BLUE BACKED TROUT	G5T2Q	S2	A	1994	BLACK POND BLUEBACK TROUT AREA
SALVELINUS ALPINUS OQUASSA	BLUE BACKED TROUT	G5T2Q	S2	A	1994	DEBOULLIE POND BLUEBACK TROUT AREA & ROCK SLIDE
SALVELINUS ALPINUS OQUASSA	BLUE BACKED TROUT	G5T2Q	S2		1984-SUMMR	GARDNER POND BLUEBACK TROUT AREA & ROCK SLIDE
WOODSIA ALPINA	NORTHERN WOODSIA	G5	S1	H	1932	DEBOULLIE PONDS
WOODSIA GLABELLA	SMOOTH WOODSIA	G5	S1		1984-	DEBOULLIE CLIFFS
ACIDIC CLIFF	ACIDIC CLIFF		S4	A	1985-07	DEBOULLIE CLIFFS
BEECH - BIRCH - MAPLE FOREST	NORTHERN HARDWOOD FOREST		S5	B	1985-07	DEBOULLIE CLIFFS
BOREAL CIRCUMNEUTRAL OUTCROP	BOREAL CIRCUMNEUTRAL OUTCROP		S1	A	1985-07	DEBOULLIE CLIFFS
COLD-AIR TALUS WOODLAND	COLD-AIR TALUS WOODLAND		S2	A	1985-07	DEBOULLIE CLIFFS
COLD-AIR TALUS WOODLAND	COLD-AIR TALUS WOODLAND		S2	AB	1985-07	DEBOULLIE CLIFFS
NORTHERN WHITE CEDAR SEEPAGE FOREST	NORTHERN WHITE CEDAR SEEPAGE FOREST		S3	B	1985-07	DEBOULLIE PONDS
NORTHERN WHITE CEDAR SWAMP	NORTHERN WHITE CEDAR SWAMP		S4	AB	1985-07	DEBOULLIE CLIFFS
NORTHERN WHITE CEDAR SWAMP	NORTHERN WHITE CEDAR SWAMP		S4	B	1985-07	DEBOULLIE CLIFFS
PATTERNED FEN ECOSYSTEM	PATTERNED FEN ECOSYSTEM		S3	E	1985-08-22	GARDNER POND STRING BOG
SPRUCE SLOPE FOREST	SPRUCE SLOPE FOREST		S4	A	1985-07	DEBOULLIE CLIFFS
TALUS SLOPE	TALUS SLOPE					GARDNER POND BLUEBACK TROUT AREA & ROCK SLIDE
TALUS SLOPE	TALUS SLOPE					DEBOULLIE PONDS

Site Name: Deboullie

LAND USE cont'd

- **Access / Recreation**

  - distance to nearest town or development unit: ~11 mi. reserve: ~14 mi.

    comment: north to Allagash

  - year-round vehicular access TO site unit: Y / N reserve: Y / N

    comment: maintained gravel rd. serves as throughway from Portage to St. Francis

  - **number of access points**

	major road	2WD	4WD	RR	utility	trail
unit	0	1	5	0	0	5
reserve	0	1	2	0	0	4

(DeLorme Mapping classifications used: major=secondary roads and greater, 2WD = other passable road, 4WD = unimproved road, includes abandoned railroad, trail=foot access)

comment: gravel rd. cuts across twp from SE ⇒ NW

primary source of info. – DeLorme / BPL staff

  - **type and amount of use** (indicate whether use is Light, Moderate, Heavy, Prohibited or Unknown for each type)

	boating	camping	fishing	hiking	hunting	ATV / mtn biking	snow-mobiling
unit	M	H	H	L	L	U	U
reserve	M	H	H	L	L	U	U

>BPL?

comment: NMW tally of user days = 6320 in 1996 – most heavily used twp in NMW jurisdiction; 5 boat launches; 30 indiv. campsites

- **Fragmentation**

	major road	2WD	4WD	RR	utility	trail
unit distance (mi.)						
unit density (mi./sq.mi.)						
reserve distance (mi.)						
reserve density (mi./sq.mi.)						

comments:

  - total road/corridor **density index**: ____ mi./sq. mi. ← not calculated →

  - largest roadless (2WD or 4WD) area in: unit: ____ ac. reserve: ____ ac. % in unit: ____ % in reserve: ____

  - landscape fragmentation

    compatible land management in adjacent tracts

    unit: (Y) / N / U /partial reserve: (Y) / N / U /partial

    comment: BPL mgmt. assumed to be compatible

- **Reserve Viability**

  - protection status

    current management compatible with ecological reserve objectives? Y / N / (partial) / U

  - proposed boundaries

    proposed reserve viable *within* the current proposed boundaries? (Y) / N / U

    if not, proposed reserve viable if *adjacent lands* are protected? Y / N / U

  - comment: BPL has established a ~4,000 acre no harvest zone; intact watersheds (ponds + hdw streams)

Site Name: Deboullie

OPPORTUNITIES

- high quality communities? several upland, wetland + lake types
- old-growth stands? remnants of larger spruce stands
- unit topography ranges from 1090 - 1945'
- large enough to incorporate natural disturbance regime? apparently
- boundaries mostly compact? yes
- portions of unit are relatively unfragmented by roads or large openings? yes
- large enough to incorporate internal buffer? yes
- surrounding land mostly undeveloped and in compatible land use? yes

OUTSTANDING QUESTIONS

- relative importance of different fish pops. rangewide?
- is Togue P. lake trout pop. native? - confirm w/ IFW
- how much potential matrix forest should be included (hatched area) - should cedar seepage forest be connected?
- statewide significance of " ?
- value of tieing Mud L. into design from aquatic perspective?

PRELIMINARY ECOLOGICAL BOUNDARIES

Description of key areas:

(a) watersheds of ponds supporting blueback trout; (b) forests between Deboullie P., Gardner P., and southeastern slopes of Whitman Mtn. contain least disturbed stands in unit + most of the old growth remnants. Areas a+b contain highest topographic div. as well. (c) Togue P. watershed contains native lake trout; Mud P. + surrounding wetlands add to overall diversity of wetland types; (d) Rocky Brk headwaters contains cedar seepage forest. Statewide sign. needs to be documented.

Boundary justification:

This potential reserve design is defined by watershed boundaries, which buffer lake and stream networks, wetlands along Rocky Brook, and encompass all documented high quality ecosystems. The Togue Pond watershed (southern hatched area) is considered marginal until status of togue population is verified - it is allegedly a native pop. The Rocky Lake cedar seepage forest needs to be evaluated in regional (subsection / section) context.

CDH 7/30/97 Description - 6 Completed by: JSM Date: 3/10/97

revised 1/98

References (Deboullie)

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Thompson, W.B. and H.W. Borns. 1985. Surficial Geologic Map of Maine. Maine Geological Survey, Augusta, Maine.

Other maps, photos and field data consulted:
- Ecological reserves inventory field forms.
- Maine Natural Areas Program Biological Conservation Database.
- 1983 color infrared aerial photography 1:15,840.
- 1968 black/white aerial photography 1:15,840.
- BPL high elevation composite black and white photo.
- BPL draft timber type map 1997.
- U.S.G.S. topographic sheets: Pelletier Brook Lakes, McLean Mountain, Deboullie Pond, Gardner Pond.
- Annual small scale spruce budworm spray maps. Maine Forest Service.
- Washington County soil survey field sheet.
- MIDAS Lakes database.
- BPL compartment maps and descriptions.

APPENDIX F. DISQUALIFIED SITES

(Areas that do not meet selection criteria outlined in Table 4.)

***DISQUALIFIED** ERI sites: areas with low quality ecosystems and/or that are embedded in an incompatible landscape. C = disqualified if other examples exist on public/private conservation land in subsection; D = disqualified.*				
Site Name (Owner/Manager)[1]	**Map #**	**Level of Disqual.**	**Unit Size (ac)**	**Comments**
Bald Mountain (BPL)	33	D	1,792	recent harvests; bounded by roads
Dwinal Flowage (IFW)	28	D	2,600	altered by former impoundment
Eastern Head (BPL)	95	D	263	recent harvests
Fields Pond (MAS)	44	D	192	fragment; pasture origin; stocked pond
Great Duck Island (TNC)	79	C	245	pasture origin ecosystems; reevaluate with other islands
Holbrook Sanctuary (BPL)	77	D	1,230	widespread recent harvesting; pastures
Hurds Pond (IFW)	55	D	100	fragment; ditches; harvesting
Indian/Fowl Meadow Isl. (TNC)	39	C	32	Wyman Dam upstr.; qualifies if no other ex. in subsection
Jamies Pond (IFW)	50	D	550	recent harvesting; stocked pond
Lake George (BPL)	40	D	254	fragment; recent harvesting
Lake St. George (BPL)	53	D	358	fragment; stocked lake
Lobster Lake (BPL)	14	D	2,300	fragment; stocked lake
Loring (USDOD)	6	D	8,702	recent clearing; harvesting
Martin Stream (IFW)	41	D	195	fragment; no upland
Mattawamkeag Wildern. Pk. (town)	24	C	1,100	widespread recent harvesting
Moosehead Unit (except Kineo)	19	C	~4,000	widespread recent harvesting
Newman Sanctuary (MAS)	70	D	119	small size for matrix-forming ecosystems
Placentia Island (TNC)	78	D	500	pasture origin; reevaluate with other islands
Round Pond (BPL)	4	C	23,114	widespread recent harvesting
Scraggly Lake (BPL)	10	C	9,092	widespread recent harvesting; stocked lake
Swan Island (IFW)	73	D	1,770	pasture origin; managed for game
The Basin (MCHT)	76	C	225	pasture origin; recent harvesting; fragment
Turner/Leeds (BPL)	49	C	2,282	widespread recent harvesting; dam
Tyler Pond (IFW)	51	D	128	gravel mining; recent harvesting; reclaimed pond
Western Head (MCHT)	93	D	247	fragment; not contiguous with Cutler

n=26

[1] Key to abbreviations: BPL=Maine Bureau of Parks and Lands; BSP=Baxter State Park; TNC=The Nature Conservancy; FSM=Forest Society of Maine; NAS=National Audubon Society; IFW=Maine Department of Inland Fisheries and Wildlife; USFS=United States Forest Service; USFWS=United States Fish and Wildlife Service; MAS=Maine Audubon Society; MCHT=Maine Coast Heritage Trust; NPS=National Park Service; USDOD=United States Department of Defense.

APPENDIX G. ACREAGE OF POTENTIAL RESERVE SITES CURRENTLY IN A COMPARABLE[1] FORM OF MANAGEMENT

Map #	Site Name	Unit Acreage	Pot. Reserve Acreage	~Acreage in Compar. Mgmt.	~% of Pot. Res. Acreage	Description of Management/Protection
MAINE BUREAU OF PARKS AND LANDS						
1	Allagash (Wesley Brook)	1,000	250	14	6%	state critical area -- voluntary agreement
2	Cross Lake Fen	83	83	83	100%	special protection zone in management plan
3	Deboullie	21,871	~14,400	4,000	28%	back country/special protection zone in management plan
5	Salmon Brook Lake Bog	1,857	~1,320	0	0%	currently no official designation
7	Squa Pan	16,731	~11,770	31	0.3%	unofficial special protection zone
9	Chamberlain	9,557	5,910	100	2%	state critical area -- voluntary agreement
12	Gero Island	3,185	3,185	70	2%	state critical area
15	Nahmakanta	44,586	29,060	9,492	33%	back country - no harvest/10 year management plan
16	Wassataquoik	2,162	2,162	15	0.7%	critical area -- voluntary agreement
18	Kineo	800	800	0	0%	
20	Holeb	19,231	6,750	15	0.2%	special protection zone -- 10 year management plan
22	Little Squaw	15,074	10,360	1,050	10%	10 year management plan (expires 1998)
29	McGoon Lot	265	265	0	0%	
31	Duck Lake	25,200	7,160	326	5%	per compartment prescription
32	Bigelow	35,027	22,040	6,060	27%	high elevation -- no harvest zone; AT corridor
34	Redington Lot	1,000	400	25	6%	AT corridor; state statute
35	Mt. Blue State Park	5,012	3,200	0	0%	
36	Mahoosucs	27,253	14,200	~10,000	~70%	high elevation no harvest zone; trail buffer
37	Little Concord Pond State Park	622	622	0	0%	
43	Bradley	8,843	7,840	494	6%	per compartment prescription
45	Branch Lake State Park	1,273	1,273	0	0%	
47	Middle Pond State Park	1,853	1,605	0	0%	
48	Sebago Lake State Park	1,342	1,120	111	10%	critical areas -- voluntary agreement
63	Laudholm Farm	229	170	170	100%	
64	Ferry Beach State Park	117	117	11	9%	critical areas -- voluntary agreement
68	Popham Beach State Park	555	450	293	65%	critical area and essential wildlife habitat
71	Reid State Park	770	650	177	27%	critical area and essential wildlife habitat
74	Camden Hills State Park	5,600	4,766	50	1%	critical area -- voluntary agreement
83	Donnell Pond	7,034	3,755	313	8%	10 year management plan
84	Spring River Lake	7,187	5,388	0	0%	
86	Great Heath	6,067	6,067	6,067	100%	10 year policy document
89	Rocky Lake	10,250	5,280	0	0%	
94,92	Cutler Coast/Grasslands	12,674	6,570	550	8%	10 year management plan
97	Quoddy Head State Park	532	532	137	26%	critical area -- voluntary agreement

Map #	Site Name	Unit Acreage	Pot. Reserve Acreage	~Acreage in Compar. Mgmt.	~% of Pot. Res. Acreage	Description of Management/Protection
MAINE DEPARTMENT OF INLAND FISHERIES AND WILDLIFE						
25	Mattagodus Stream	1,425	1,425	0	0%	
26	Mattawamkeag	4,119	4,119	0	0%	
27	Forest City	650	480	0	0%	
46	Brownfield Bog	5,700	4,100	0	0%	
52	Alonzo Garcelon	1,276	1,276	0	0%	
57	Little Ossipee/Killick	1,893	1,893	0	0%	
60	Kennebunk Plains	1,041	1,041	?	?	compatibility of prescribed burning not resolved
61	Mt. Agamenticus	1,644	1,644	0	0%	
66	Scarborough Marsh	3,100	3,100	~3,000	~97%	protected under Maine wetland regulations
69	Swett Marsh	648	648	~319	~49%	protected under Maine wetland regulations
72	Merrymeeting/Muddy River	~664	380	~250	~66%	unit acreage unclear; not confirmed by IFW staff
85	Narraguagus Junction	1,450	1,450	0	0%	
NATIONAL PARK SERVICE						
80	Acadia National Park -MDI	30,241	21,160	21,160	100%	NPS federal regulations and policies
98	ANP -Isle au Haut	2,728	2,700	2,700	100%	NPS federal regulations and policies
99	ANP -Schoodic	2,194	2,194	2,194	100%	NPS federal regulations and policies
US FOREST SERVICE						
38	White Mtn. Nat. Forest	49,166	30,710	16,410	53%	federally designated wilderness; existing management zones
58	Massabesic - Lyman	1,900	1,460	0	0%	currently not addressed, but may be addressed in management plan
59	Massabesic - Alfred	1,784	1,650	0	0%	currently not addressed, but may be addressed in management plan
MAINE COAST HERITAGE TRUST						
96	Boot Head	377	300	300	100%	current management plan
US FISH AND WILDLIFE SERVICE						
42	Sunkhaze NWR	9,337	9,337	~4,000	~43%	management intent -- not in official policy
62	RCNWR - Braveboat Harbor	644	644	634	98%	management plan
63	RCNWR - Upper Wells/Mousam R.	859	478	468	98%	management plan
82	Petit Manan NWR	3,335	2,310	0	0%	management plan
90	Moosehorn - Baring	17,594	6,160	4,680	76%	federally designated wilderness area
91	Moosehorn - Edmunds	7,191	2,782	2,782	100%	federally designated wilderness area
NATIONAL AUDUBON SOCIETY						
23	Borestone Sanctuary	1,639	1,639	1,200	73%	management intent -- not official policy
US DEPARTMENT OF DEFENSE						
34	Redington Twp. (incl. AT corridor)	13,180	12,180	~1,000	~8%	AT corridor protected under federal statute
81	Winter Harbor	566	200	200	100%	follows ANP policies
BAXTER STATE PARK						
13	Baxter State Park	204,733	181,360	171,412	95%	state regulations (Baxter State Park Authority)

Map #	Site Name	Unit Acreage	Pot. Reserve Acreage	~Acreage in Compar. Mgmt.	~% of Pot. Res. Acreage	Description of Management/Protection
FOREST SOCIETY OF MAINE						
21	No. 5 Bog/Jack Pine	973	973	973	100%	conservation easement on 973 acres and 200' perimeter buffer
BATES COLLEGE						
67	Morse Mountain	673	673	673	100%	Bates College policy (? not confirmed)
THE NATURE CONSERVANCY						
8	Big Reed Forest Reserve	4,853	4,853	4,853	100%	TNC policy and management plan
11	Marble Fen	265	265	265	100%	TNC policy and management plan
17	Crystal Bog	4,102	4,102	4,102	100%	TNC policy and management plan
30	Ayers Brook	2,075	2,075	2,075	100%	TNC policy and management plan
54	Appleton Bog	987	987	987	100%	TNC policy and management plan
56	Waterboro Barrens	2,369	2,369	2,369	100%	TNC policy and management plan
60	Kennebunk Plains	136	136	?	?	compatibility of prescribed burning policy not resolved
61	Mt. Agamenticus	18	18	18	100%	TNC policy and management plan
65	Saco Heath	839	839	839	100%	TNC policy and management plan
67	Morse Mountain	37	37	37?	100%	TNC policy and management plan
69	Back River	585	585	585	100%	TNC policy and management plan
75	Knights Pond	304	304	304	100%	TNC policy and management plan
87	Great Wass	1,579	1,579	1,579	100%	TNC policy and management plan
88	Larrabee Heath	427	427	427	100%	TNC policy and management plan
99	Turtle Island	136	136	136	100%	TNC policy and management plan

[1] The overriding management guideline recommended for ecological reserves is that natural processes be allowed to proceed without human interference (e.g., no timber harvesting, no introductions of exotic species, no permanent development). See Appendix B, entitled: Appropriate Uses of Reserves, for a detailed discussion of appropriate uses and management of reserves. Acreage modified because of recreational use has not been factored into this assessment.

APPENDIX H. OPERABLE ACREAGE CALCULATIONS FOR POTENTIAL RESERVE SITES

This table provides an estimate of acres of operable timberland within the potential reserve boundary drawn for each unit. The calculation given in the operable acres column includes any acres that can be harvested (for forest management, wildlife management, or other purposes) under Maine state statute, agency mandate, or management plans that are now in effect. For example, special protection areas, no cut zones, and land within the Allagash Wildernes Waterway or Appalachian Trail Corridor were not counted.

Map #	Site Name	Unit Acreage	Pot. Res. Ac. In Unit	Op. Ac. In Pot. Res. In Unit[1]	Comments (including method of calculation)
MAINE BUREAU OF PARKS AND LANDS					
1	Allagash (Wesley Brook)	1,000	250	200	dot grid
2	Cross Lake Fen	83	83	0	dot grid
3	Deboullie	21,871	~14,400	9,537	dot grid
5	Salmon Brook Lake Bog	1,857	~1,320	388	dot grid
7	Squa Pan	16,731	~11,770	10,800	dot grid
9	Chamberlain	9,557	5,910	5,531	dot grid (reserve acreage excludes Allagash Lake)
12	Gero Island	3,185	3,185	3,150	total minus BPL special protection area
15	Nahmakanta	44,586	29,060	19,241	dot grid; includes AT acreage
16	Wassataquoik	2,162	2,162	2,000	dot grid
18	Kineo	800	800	650	dot grid
20	Holeb	19,231	6,750	5,750	dot grid
22	Little Squaw	15,074	10,360	7,100	dot grid
29	McGoon Lot	265	265	263	estimated by eye
31	Duck Lake	25,200	7,160	6,587	dot grid
32	Bigelow	35,027	~22,040	15,050	GIS
34	Redington Lot	1,000	400	388	dot grid
35	Mt. Blue State Park[2]	5,012	3,200	3,243	planimeter
36	Mahoosucs	27,253	14,200	4,200	dot grid
37	Little Concord Pond State Park	622	622	535	estimated by eye
43	Bradley	8,843	7,840	6,666	dot grid
45	Branch Lake State Park	1,273	1,273	1,000	estimated by eye
47	Middle Pond State Park	1,853	1,605	1,204	planimeter
48	Sebago Lake State Park	1,342	1,120	553	planimeter
63	Laudholm Farm	229	170	0	estimated by eye
64	Ferry Beach State Park	117	117	54	planimeter
68	Popham Beach State Park	555	450	173	planimeter

Map #	Site Name	Unit Acreage	Pot. Res. Ac. In Unit	Op. Ac. In Pot. Res. In Unit[1]	Comments (including method of calculation)
71	Reid State Park	770	650	330	planimeter
74	Camden Hills State Park	5,600	4,766	3,511	planimeter
83	Donnell Pond	7,034	3,755	2,885	dot grid, GIS; contiguous w/ Spring R.
84	Spring River Lake	7,187	5,388	3,920	dot grid, GIS; contiguous w/ Donnell P.
86	Great Heath	6,067	6,067	0	
89	Rocky Lake	10,250	5,280	4,798	dot grid, GIS.
94,92	Cutler Coast/Grasslands	12,674	6,570	3,167	dot grid, GIS.
97	Quoddy Head State Park	532	532	227	planimeter
MAINE DEPARTMENT OF INLAND FISHERIES AND WILDLIFE					
25	Mattagodus Stream	1,425	1,425	520	= forested acreage in management plan
26	Mattawamkeag	4,119	4,119	1,446	= forested acreage in management plan
27	Forest City	650	480	480	= forested acreage in management plan
46	Brownfield Bog	5,700	4,100	4,000	= forested acreage in management plan
52	Alonzo Garcelon	1,276	1,276	~1,150	estimated by eye
57	Little Ossipee/Killick	1,893	1,893	1,600	estimated by eye; Little Oss. ac. unconfirmed by IFW
60	Kennebunk Plains	1,041	1,041	440	= forested acreage in management plan
61	Mt. Agamenticus	1,644	1,644	1,100	= forested acreage in management plan
66	Scarborough Marsh	3,100	3,100	0	
69	Swett Marsh	648	648	~200	estimated by eye; unconfirmed by IFW
72	Merrymeeting/Muddy River	~664	380	~130	estimated by eye (unit acreage unclear); incl. BPL acr.
85	Narraguagus Junction	1,450	1,450	1,450	= forested acreage in management plan
NATIONAL PARK SERVICE					
80	Acadia National Park -MDI	30,241	21,160	0	
98	ANP -Isle au Haut	2,728	2,700	0	
99	ANP -Schoodic	2,194	2,194	0	
US FOREST SERVICE					
38	White Mtn. Nat. Forest	49,166	30,710	14,300	based on existing management zones
58	Massabesic - Lyman	1,900	1,460	1,260	estimated by eye; not confirmed by USFS
59	Massabesic - Alfred	1,784	1,650	1,550	estimated by eye; not confirmed by USFS
MAINE COAST HERITAGE TRUST					
96	Boot Head	377	300	0	estimated by eye
US FISH AND WILDLIFE SERVICE					
42	Sunkhaze NWR	9,337	9,337	4,600	estimated by eye

Map #	Site Name	Unit Acreage	Pot. Res. Ac. In Unit	Op. Ac. In Pot. Res. In Unit[1]	Comments (including method of calculation)
62	RCNWR - Braveboat Harbor	644	644	150	dot grid
63	RCNWR - Upper Wells/Mousam R.	859	478	350	dot grid
82	Petit Manan NWR	3,335	2,310	1,610	estimated by eye
90	Moosehorn - Baring	17,594	6,160	770	total minus wilderness area; estimated by eye
91	Moosehorn - Edmunds	7,191	2,782	0	within wilderness area
NATIONAL AUDUBON SOCIETY					
23	Borestone Sanctuary	1,639	1,639	400	estimated by eye
US DEPARTMENT OF DEFENSE					
34	Redington Twp. (incl. AT corridor)	13,180	12,180	~11,180	estimated by eye; unconfirmed by USDOD staff
81	Winter Harbor	566	200	200	unconfirmed by USDOD staff; contig. w/ ANP-Schoodic
BAXTER STATE PARK					
13	Baxter State Park	204,733	181,360	9,948	planimeter - SFMA
FOREST SOCIETY OF MAINE					
21	No. 5 Bog/Jack Pine	973	973	~100	estimated by eye
BATES COLLEGE					
67	Morse Mountain	673	673	0	contiguous w/ TNC tract
THE NATURE CONSERVANCY					
8	Big Reed Forest Reserve	4,853	4,853	0	
11	Marble Fen	265	265	0	
17	Crystal Bog	4,102	4,102	0	
30	Ayers Brook	2,075	2075	0	
54	Appleton Bog	987	987	0	
56	Waterboro Barrens	2,369	2,369	0	
60	Kennebunk Plains	136	136	0	contiguous w/ IFW tract
61	Mt. Agamenticus	18	18	0	contiguous w/ IFW tract
65	Saco Heath	839	839	0	
67	Morse Mountain	37	37	0	contiguous w/ Bates tract
69	Back River	585	585	0	contiguous w/ IFW tract
75	Knights Pond	304	304	0	contiguous w/ Camden Hills State Park
87	Great Wass	1,579	1,579	0	
88	Larrabee Heath	427	427	0	
99	Turtle Island	136	136	0	part of Schoodic potential reserve area

[1] Number of operable acres in the portion of the potential reserve that is in the unit.

[2] Calculation of operable timberland in state parks excludes forested and non-forested wetlands, essential wildlife habitat, water, shoreland areas, roads and other developed areas.