AN ECOLOGICAL RESERVES SYSTEM FOR MAINE:

BENCHMARKS IN A CHANGING LANDSCAPE

Report to the 116th Maine Legislature

May 1993

Natural Resources Policy Division
MAINE STATE PLANNING OFFICE

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An Ecological Reserves System for Maine: Benchmarks in a Changing Landscape

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TABLE OF CONTENTS

PROLOGUE

This report is the product of uncertain budgetary times for State government and a great deal of cooperation between the public and private sectors.

LD 1241, passed in June 1989, called for the State Planning Office to coordinate a study effort to design a system of ecological reserves in Maine by inventorying representative examples of the State's characteristic natural ecosystems on public or conservation ownerships (see Appendix I). An appropriation of $106,500 was passed in 1989 to fund a Senior Planner position through the first half of 1991. Janet McMahon was hired in January 1990 and six weeks later was notified her job was being eliminated as part of the initial round of budget cuts.

By using 1989 unspent funds, a timely $6,500 donation from The Nature Conservancy, and a $5,000 grant from the Maine Research Fund, the State Planning Office was able to cover the personal services costs of the Senior Planner position and ultimately take the mandate of the legislative resolve as close to completion as possible.

A Steering Committee called for by the legislative resolve met ten times to advise and oversee the study effort (see Appendix II).

It should be noted that while the inventory of potential ecological reserve sites on public and conservation ownerships was completed from an aerial perspective, funding was not available to take the study to the next level of ground-based investigation and planning with the titleholding State agencies and non-profit organizations. Although the State Planning Office sought additional funding to undertake this essential phase of the study, we have been unsuccessful to date.

However, this report breaks essential new ground both in the methods used to evaluate the lands and in the options presented for implementing the ecological reserves concept.

James R. Bernard
May 1993

EXECUTIVE SUMMARY

The Ecological Reserves Study

Maine's environment is changing. Complex issues such as acid deposition, global warming, and species extinctions have the potential to dramatically alter natural communities and the resources upon which many of Maine's traditional industries depend. A group of Maine's natural resource managers, scientists, and conservationists proposes a carefully selected network of reserves be established to achieve three broad purposes: research and environmental monitoring activities, conservation of biological diversity, and environmental education.

A legislative resolve was passed by the 114th Maine Legislature in June 1989 that provided funds for a study to design a system of ecological reserves in Maine. The Ecological Reserves Study took place between January 1990 and January 1991. The study was conducted by the Natural Resources Policy Division of the State Planning Office with input and oversight from a ten-member steering committee. Initially, a concept paper describing the rationale for establishing ecological reserves was developed. Issues addressed during the study included a review of programs in other states and countries; an inventory of public and private, non-profit conservation lands to determine which natural, characteristic ecosystem types were already represented and adequately protected; reserve design; appropriate uses of reserves; protection strategies for reserves; and ways to integrate an ecological reserves system with other natural areas programs in Maine.

The Ecological Reserves Concept

Maine is a state with enormous natural variety. The ecological reserves concept is being developed to provide a mechanism for preserving a network of sites that represent the full range of Maine's natural diversity and to make characteristic areas available for scientific research, long-term environmental monitoring, and education.

The ecological reserves approach differs from other conservation strategies in several respects. First, emphasis is place on representative ecosystems rather than rare and endangered species. An ecosystem is a community of interacting plant and animal populations and the environment (geology, air and water)in which it occurs. Second, ecological reserve systems are designed to provide a framework for baseline monitoring and long-term research. Consequences of human activities on the environment extend far beyond immediate health effects or short-term environmental damage. Sites are chosen systematically, using classifications of both regional landscapes and natural ecosystems to ensure that a full range of biological and landscape diversity is included in a ecological reserve system. Third, specific design criteria are generally drawn from the discipline of conservation biology (the application of science to the conservation populations, species, and ecosystems), providing principles and tools for maintaining natural levels of biological diversity in ecosystems.

Reserve Programs in Other States and Countries

Maine's situation is unique in North America. Although some Maine ecosystems, such as barrier beaches and coastal dune systems, have been greatly altered by human activities,

relatively undisturbed examples of many of the State's natural ecosystems still exist. However, less than five percent of Maine's landscape is publicly owned, a fact that necessitates a comprehensive natural areas protection strategy if reserves are to be permanently protected.

Although no single state or provincial program can serve as a model for an ecological reserves system in Maine, the most successful programs share one or more of the following characteristics: (1) Comprehensive legislation which clearly defines the roles of the various agencies involved in natural areas protection, resulting in enhanced cooperation among state agencies, increased effectiveness in land protection efforts, and elimination of redundancy among the various programs; (2) Specific legislation that establishes an ecological reserves system and an administering agency than can acquire and dedicate reserves on private and public lands; and (3) An advisory council or commission comprised primarily of scientists, conservationists, and natural resources managers. Such a group can serve as a critical link between private, state, and federal conservation efforts and can ensure that the long-term goals of the ecological reserve system and other natural areas conservation efforts are carried forward consistently.

The Ecological Reserves Study Inventory

An essential part of the Ecological Reserves Study was to inventory natural ecosystems on public and private non-profit conservation lands to catalog those represented on each holding and to assess their viability. Between June 1, 1990 and October 31, 1990, a total of 796 areas and approximately one million acres, including public lots, wildlife management areas, state and national parks, national forests and wildlife refuges, and private nature preserves and sanctuaries, were evaluated.

An ecosystem classification was developed for Maine that lists and describes the kinds of ecosystems (typical and unusual) that occur in the state. The classification describes 102 different ecosystems, defined for this purpose as a group of plant and animal populations that share a common environment. Some familiar examples are northern hardwood forests, alpine meadows, raised bogs, and sand beaches. The list is divided into six categories: terrestrial, wetlands, lakes, riverine, estuarine, and marine.

To capture regional variation in Maine, a biophysical classification was developed that divides the state into fifteen regions based on climate, landform, soils, and vegetation. Naturalness and size criteria were also applied to the overall list as a screening mechanism, reducing the number to be inventoried from 796 to 289. An additional 139 sites were removed after consultation with State biologists and foresters who identified these areas as either recently harvested or artificially impounded.

Aerial reconnaissance composed of ten flights totaling 47 hours of flying time surveyed 160 sites. An additional 39 sites were eliminated during the aerial reconnaissance because of recent timber harvests or active impoundments. The remaining 121 sites were field checked by field ecologists. Thirty-seven sites, including many of the larger tracts, are in need of further inventory work. Data collected during each field survey included a list of the ecosystem types present, a general description of each ecosystem, an assessment of the site's condition, a list of plant species present, and, for sites with ecological reserve potential, a site summary.

Overall, the results of the inventory are:

1. Approximately 45 percent of Maine's natural ecosystem types are represented on existing public and private non-profit conservation lands.
2. Representation of ecosystem types by biophysical region is uneven.
3. Twelve ecosystem types are not known to be represented on public and private non-profit conservation lands.
4. Only nine percent of original list of public and private ownership have potential to be ecological reserves.
5. On many of the areas with reserve potential, proposed management in the next five years (primarily timber harvesting and impoundments) will significantly alter the ecosystem within the areas.
6. Of the 66 areas with potential to be ecological reserves, 24 percent are owned by private conservation organizations.
7. Excluding Baxter State Park and Acadia National Park, the approximate acreage of all areas on the potential reserve list is 67,820. Of these, approximately 31,700 acres are on ownerships such as state parks, wilderness areas, or nature preserves, where commercial timber harvesting is not permitted. At least 40 percent of the remaining acreage is not productive timber land. The total number of acres that would need to be removed from timber production if all sites listed were included in an ecological reserves system is approximately 21,680, representing approximately 0.1 percent of the land base currently managed for commercial timber production in Maine.
8. The average site inventoried has seven different ecosystem types represented.
9. The sites with potential as ecological reserves comprise approximately seven percent of Maine's public and private conservation lands and approximately one third of one percent of the state's total land area. A complete ecological reserves system could be expected to include roughly twice this percentage.

Designing an Ecological Reserves System

Identifying characteristic ecosystems is only the first step in designing an ecological reserves system. Although the inventory results show that nearly half of Maine's ecosystem types occur on conservation ownerships, their protection is not assured. Many of these lands are managed for specific species rather than the ecosystem as a whole or for purposes that may not be compatible with the objectives of an ecological reserve. For example, many of the forest ecosystems identified during the inventory will be harvested within five years if current management plans are followed. Two important facets of ecological reserve design include an assessment of the condition and viability of the reserve (inside specific boundaries) and the landscape context (the compatibility of land uses outside the reserve).

A variety of factors will enhance the value of a site selected to represent one or more ecosystem types. Factors to consider include:

1) Ecological diversity - the greater the variety of ecosystem types, the greater the biological diversity of a site.
2) Physiographic diversity - the greater the physiographic diversity (landforms and topography), the higher the value of the site.

3) Naturalness (degree of human disturbance) - the goal is to include sites that are as undisturbed by human activities as possible.
4) Size - all else remaining the same, large areas are always more valuable for conservation than small areas.
5) Proximity to corridors and other conservation ownerships - the problems of habitat isolation that arise from fragmentation can be mitigated by connecting natural areas by corridors of suitable habitat.
6) Hydrologic considerations - intact watersheds will be more viable in the long term than fragmented watersheds.
7) Location with respect to the geographic range limit of an ecosystem type - ecosystems at the edge of their range are more sensitive to environmental stress and as a result will be responsive indicators of environmental change.
8) Presence of rare species or species with restricted distributions - the presence of rare or disjunct species increase the overall diversity of a reserve.
9) Current and proposed use by existing landowner or managing agency - a frank evaluation of existing and proposed management practices would be needed before a site can be recommended as an ecological reserve.
10) Compatibility of surrounding land use - a reserve surrounded by a compatible land use would be more viable over the long term than one that is not.
11) Appropriate boundaries - reserve boundaries should follow natural ecological boundaries where possible and, to reduce the potential impacts of surrounding land uses, the amount of edge should be minimized.

Little Concord Pond owned by the Bureau of Parks and Recreation is used as a case study for a potential ecological reserve site because it is intermediate in both size and diversity.

Implementing an Ecological Reserves System

Establishing an ecological reserves system will involve several steps. Once areas with potential as ecological reserves have been identified and actual reserve boundaries have been delineated, protection and management strategies will need to be developed.

Strategies for Protecting Ecological Reserves

A variety of techniques have been used to establish reserves in the United States. The most widely used include (1) landowner notification and registration, (2) management agreements and leases, (3) designation by public agencies, (4) public agency regulations, (5) conservation easements, (6) fee acquisition, and (7) dedication.

Appropriate Uses of Ecological Reserves

Two fundamental and complementary objectives of an ecological reserves system are (1) to develop a comprehensive and permanent system of ecological reserves representing all of Maine's ecosystems and (2) to encourage their use for learning about the ecology of natural ecosystems, and, on a larger scale, the overall environment. A third objective is to interpret and disseminate the scientific data gathered and to integrate this information into planning efforts at the state level.

Possible uses and activities on ecological reserves are summarized below:

(1) Scientific research and baseline monitoring should be encouraged.
(2) Education should be encouraged.
(3) Hunting and fishing should be permitted except in designated areas.
(4) Timber harvesting should not be permitted on reserves.
(5) Oil and mineral exploration and mining should be prohibited.
(6) Camping and campfires should be prohibited except in preexisting sites.
(7) Motorized and nonmotorized vehicles should be prohibited.
(8) Day use and passive recreation should be permitted.
(9) Construction of trails, roads, service areas, parking lots and other permanent structures should be kept to a minimum level or located outside the reserve.

The overriding management guideline for ecological reserves is that natural processes be allowed to proceed without human interference. Management issues such as fire control, erosion and water level control, vegetation and wildlife management, and public access need to be addressed for the ecological reserves system as a whole and in individual management plans.

Recommendations

From the outset, the Ecological Reserves Steering Committee advised against creating yet another independent natural areas program housed in yet another agency. The Committee found it made more sense to define how an ecological reserves program would complement existing efforts to protect natural diversity and to look for ways to formally link the various programs. In short, this would allow Maine's natural area conservation needs to be met through a unified conservation strategy instead of the fragmented, uncoordinated approach that has characterized natural areas conservation efforts in Maine to date.

The inventory results of the Ecological Reserves Study lend a sense of urgency to the ecological reserves initiative. The sooner an ecological reserves system is established, the higher the quality of the ecosystems contained within it and the greater their value as ecological benchmarks. Once established, the system as a whole would improve our ability to anticipate future environmental problems and design solutions before irreversible consequences occur.

Specific recommendations are:

1. **Authorize an Ecological Reserves Program through legislation.** The primary function of this program would be to establish, manage, and oversee the protection of a system of ecological reserves in Maine. by working with public landholding agencies to protect sites already owned by the public and by identifying sites that should be acquired by the state to complete and ecological reserves system and by promoting research ad monitoring on reserves.

2. **Establish dedication as a protection tool for protecting ecological reserves.** Dedication is the voluntary placement of a natural area into a legally established statewide system of ecological reserves.

3. **Consolidate or link programs involved with the protection of natural diversity.**

Consolidation of the Critical Areas Program at the State Planning Office, the Natural Heritage Program in the Department of Economic and Community Development and several programs of the Department of Inland Fisheries and Wildlife and the proposed Ecological Reserves Program within a single agency or through oversight of all four programs to achieve a consistent, integrated focus would yield major benefits.

4. **Develop a natural diversity conservation strategy for Maine.** An integrated conservation strategy is needed that seeks to (1) identify and acquire essential habitat for rare and endangered species, and representative examples of characteristic ecosystems, (2) identify gaps in current legislation and evaluate the effectiveness of various protection strategies in conserving the state's natural diversity, including more protective management of these areas on public lands, (3) determine the appropriate protection tool (i.e., registration, dedication, or acquisition) for sites identified by staff of the various natural areas programs, (4) develop a system of broad habitat corridors and buffer zones surrounding and connecting reserves, and (5) tie natural areas protection and management into planning efforts at local and regional scales.

CHAPTER 1: INTRODUCTION

THE ECOLOGICAL RESERVES STUDY

We hear -- on almost a daily basis -- that Maine's environment is changing. Complex issues such as acid deposition, global warming, and species die-offs and extinctions have the potential to dramatically alter natural communities and the resources upon which many of Maine's traditional industries depend. To successfully address these issues, a basic understanding of how natural systems function is essential. In the mid-1980's, a group of natural resource managers, university scientists, and conservationists proposed that a carefully selected network of reserves be established to accommodate three broad purposes: research and environmental monitoring activities, conservation of biological diversity, and environmental education. Their recommendations were incorporated into a background paper: *"Establishing a System of Ecological Reserves in Maine"* (Giffen and Parkin 1989), which ultimately led to a legislative resolve, L.D. 1241, (see Appendix I) that provided funds for a study to design a system of ecological reserves in Maine.

The Ecological Reserves Study took place between January 1990 and January 1991. The study was conducted by the Natural Resources Policy Division of the State Planning Office with input from a ten-member steering committee. Initially, a concept paper describing the rationale for establishing ecological reserves was developed. Topics addressed during the study included a review of programs in other states and countries, an inventory of public and private non-profit conservation lands to determine which natural ecosystem types were already represented and adequately protected, reserve design, appropriate uses, protection strategies, and finally, ways to integrate an ecological reserves system with other natural areas programs in Maine. Each of these topics is discussed in this report.

An ecological reserves system in Maine would serve many purposes. An objective design for an ecological reserves system could serve as a framework for existing data, future inventory work, and developing a monitoring database. Reserves would provide benchmarks against which changes in the state's environment could be measured. Studying ecological reserves could provide helpful information for managing forests, farms, commercial fisheries, recreational lands, and other natural resources. For example, studies in Baxter State Park conclusively demonstrated that spruce suffered less damage than fir from an uncontrolled budworm outbreak, and helped researchers understand which factors predispose a stand to budworm damage. From an educational perspective, a reserves system would offer outdoor laboratories for a variety of research and monitoring programs, and outdoor classrooms to serve science education needs. From a conservation perspective, a complete system of the Maine's characteristic ecosystems would complement existing programs that focus primarily on rare and endangered species.

In essence, this study recommends establishing 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 will provide an invaluable and irreplaceable resource for science, teaching, and natural resource planning today and in the future.

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 archipelagos, 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 natural 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. The ecological reserves concept is being developed to provide a mechanism for preserving a network of sites that represent the full range of Maine's natural diversity and to make these areas available for scientific research, long-term environmental monitoring, and education.

The ecological reserves approach differs from other conservation strategies in several respects. First, the emphasis is on representative ecosystems rather than rare and endangered species. An ecosystem is a community of interacting plant and animal populations and the environment (bedrock, soils, air, and water) in which it occurs. Some common types of ecosystems in Maine include northern white cedar swamps, hemlock forests, and raised bogs. By 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 landscapes as well. This reflects the view that, 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.

Second, ecological reserve systems are designed to provide a framework for baseline monitoring and long-term research. It has become clear that the consequences of human activities on the environment extend far beyond immediate health effects or short-term environmental damage. Only long-term monitoring and study of ecosystems can provide reliable baseline information on fundamental natural processes and help to define the range of natural variation that characterizes undisturbed systems. This information is essential for establishing benchmarks against which changes in ecosystem structure and function can be measured. Without these benchmarks, an evaluation of either the extent or the causes of changes that occur in ecological systems would be impossible (Caines 1989). In order to maximize the value of a reserve system for monitoring and research, reserves are designed to reflect ecological rather than political boundaries. Because a purpose of the system is to provide insights into how ecosystems respond to disturbance, the intent is to allow natural processes to continue rather than to manage in favor of a given species or successional stage. Sites are chosen systematically, using classifications of both regional landscapes and natural ecosystems to ensure that a full range of biological and landscape diversity is included in the system.

Finally, specific design criteria for reserves are generally drawn from the discipline of conservation biology. The goal of conservation biology, which is the application of science to

the conservation of populations, species, and ecosystems, is to provide principles and tools for maintaining natural levels of biological diversity in ecosystems. Some important concepts that are relevant to the design of an ecological reserves system in Maine are described below.

Biological diversity

Biological diversity 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. Species diversity varies considerably from place to place. For example, there are more than twice as many tree species in southern Maine as in the northwestern part of the state. The same is true for reptiles and amphibians. Although the species diversity of a region includes all organisms from trees and mammals to bacteria, in most ecosystems it is the vertebrates and vascular plants that capture most of our attention. Our understanding of the multitude of species that comprise entire ecosystems, whether a forest or a tidal marsh, is cursory at best.

A less obvious level of biological diversity is the genetic variation among members of the same species. If two members of the same species from different parts of their range were examined, they would differ in certain respects. For example, northern flickers in the eastern United States can breed successfully with flickers in the western part of the country. However, populations in the west have red feathers in their wings and tails while eastern birds have yellow feathers (Ecological Society of America 1986). Such 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 larger and healthier the individuals tend 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. As a general rule, mountainous areas often have more communities, and therefore greater ecosystem diversity, than areas of low relief.

From species to ecosystems

A species consists of those organisms that successfully reproduce among themselves but cannot reproduce successfully with other organisms. For example, a pitch pine tree is recognized as a different entity than a white pine. A population refers to all of the interbreeding individuals of a given species living in a particular area. Biologists might refer to a population of brook trout in a stream, or a population of butterflies in a pine barren. Neither individuals or populations occur by themselves. Rather, they form communities -- populations of species, often co-adapted with one another -- that occur together in time and space. The assemblage of plants, animals, and microorganisms in a stand of pitch pine-scrub oak is an example. A community grouped together with its surroundings (the physical landscape and climate), constitute an ecosystem. A pine barren ecosystem, for example, typically includes a woodland of pitch pine and hundreds of associated plant and animal species that are adapted to a dry sandy environment.

Pitch pine barrens are often associated with other ecosystems such as dry ridgetop oak-pine forests, sandplain grasslands, kettlehole bogs, and sandy aquifer ponds. What links these

ecosystems is the landscape of which they are a part -- in this case, a sandy glacial outwash deposit. Given similar environmental conditions, one would expect ecosystems to repeat themselves across a region. A pine barrens ecosystem in Maine, for example, is superficially similar to the pine barrens of Cape Cod and New Jersey. Although overall species composition may vary due to regional differences in climate and other environmental conditions, pine barrens in all three areas will have a canopy of pitch pine over an understory of heath plants.

From ecosystems to ecological reserves

An ecological reserve is 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 the long-term survival and adaptation of constituent species and populations. Pine barrens ecosystems reach their northern limit in Maine where they are restricted to the southwestern part of the state and sandy areas along the coast. This ecosystem type is an example of a potential candidate for an ecological reserve.

The ecological reserve system proposed for Maine is designed to encompass the full range of biological and landscape diversity of the state to provide representative natural ecosystems for scientific study, environmental monitoring, and education. The Maine landscape varies dramatically from north to south and east to west. The Jackman area, for example, has a growing season that is half as long as that of the southern coast, and it receives more than three times as much snow in an average year. Steep climatic gradients like these are reflected in the state's flora and fauna, resulting in striking regional variation in patterns of diversity. Because Maine is so diverse, a given ecosystem in one part of the state will be subtly different from the same ecosystem type in another part of the state. For example, although the dominant species are the same, pine barrens in the Fryeburg area contain different sets of species than the barrens associated with sand dunes in Phippsburg. To capture this regional variation, examples of each of these ecosystems would merit inclusion in a reserves system.

While ecologists have documented the geographic variation present in pine barren ecosystems, our understanding of most community and ecosystem types is far from complete. Integrating an ecosystem approach with a regional landscape approach for reserve selection provides a safety net to capture variation that is known to exist but has yet to be documented. This approach results in a whole -- the ecological reserves system -- that is greater than the sum of its parts -- ecological reserves.

CHAPTER 2: LESSONS FROM OTHER STATES AND COUNTRIES

INTRODUCTION

The idea that a system of reserves should represent the range of biological variation in a given region has been advocated for nearly three decades (Austin and Margules 1986), and yet very few such systems have been established and none are actually complete. The most successful attempts are in states, provinces, and countries with large tracts of relatively undisturbed land under public ownership, such as Washington, Oregon, British Columbia, Quebec, and the Soviet Union. Not only can examples of most of the natural ecosystems in these regions still be found, but reserves can be designed to allow natural processes to occur. Since there are often many areas to choose from, systematic inventories can be conducted. In many parts of the United States, however, the landscape is too fragmented, or is developing too rapidly, to consider such an approach. Systematic inventories are often abandoned to focus attention on ecosystems that are immediately threatened or their emphasis falls on small relics of once extensive ecosystems because these are all that remain.

Maine's situation is unique in North America. Although some Maine ecosystems, such as barrier beaches and coastal dune systems, have been greatly altered by human activities, relatively undisturbed examples of many of the State's ecosystems still exist. Unlike most western states and Canadian provinces, however, less than five percent of Maine's landscape is publicly owned -- a fact that necessitates a more complex protection strategy if reserves are to be permanently protected.

Although no single state or provincial program can serve as a model for an ecological reserves system in Maine, the most successful programs share one or more of the following characteristics: (1) Comprehensive legislation which clearly defines the roles of the various agencies involved with natural areas protection. This fosters cooperation among state agencies, increases the effectiveness of land protection efforts, and avoids redundancy among the various programs; (2) Specific legislation that establishes an ecological reserves system and an administering agency that can acquire and dedicate reserves on private and public lands (the best legislation explicitly specifies what uses are appropriate on ecological reserves); and (3) An advisory council or commission comprised primarily of scientists, conservationists, and natural resource managers. Such a committee can serve as a critical link between private, state, and federal conservation efforts. It also helps ensure that the long-term goals of the ecological reserve system and other natural areas conservation efforts are carried forward from one administration to the next.

In addition, a number of general recommendations and insights surfaced during conversations with the resource managers of the programs reviewed in the following pages. There was a general consensus that public use should be encouraged if it does not have a negative impact on a reserve. In many areas, ecological reserves are seen as apart from and often in competition with other kinds of land use. There is a need to broaden the concept of ecological reserves. The importance of reserves for base-line monitoring, for example, has been underemphasized in most states and provinces. Very little effort has been made to tie in local

communities or integrate monitoring programs into the science curricula of public schools. Instead of being a small fraction of land valued only for research and education, reserves ought to be looked upon as important components of land uses such as forestry, agriculture, commercial fishing, recreation, and natural resource management in general.

There was also consensus that reserve size should be based on ecological factors rather than political ones. The major criterion for size is that a reserve be sufficiently large to maintain the ecosystem of interest over the long term. Reserve design should not hinge on a single species or community.

Finally, there is universal agreement among the staff of the various programs that the decade of the 1990's is the window of opportunity. Soulé (1989) points out that conservation efforts will have to become increasingly opportunistic in the next century. As natural ecosystems disappear or become prohibitively expensive to acquire, the opportunities to establish new reserves containing undisturbed ecosystems will be lost. The emphasis in conservation biology will gradually shift to the restoration of degraded land and impoverished biotic communities. A cogent argument for designing and completing an ecological reserves system as soon as possible is that there are still functioning and representative ecosystems from which to choose.

The following pages review selected ecological reserves and natural areas programs of other states and countries that offer lessons for the ecological reserves effort in Maine. Although these programs differ in their focus, in the scale at which they operate, and in the protection strategies used, there are several common threads shared by the most successful programs. This chapter evaluates these common threads with respect to Maine and discusses the successes and failures of selected programs in meeting conservation, research, and education goals. Complementary programs in Maine are also briefly examined to determine how well they meet the primary objective of an ecological reserves system -- encompassing the biological diversity of the state in a permanent system of reserves.

PROGRAMS AT THE BIOME SCALE

Biosphere Reserves

The first widespread attempt to locate, document, and seek protection for samples of natural ecosystems began with the work of the International Biological Program (IBP) in 1964. Fifty-eight nations joined in an international effort to preserve examples of the world's ecosystems for present and future biological research, as datum points by which to measure changes in ecosystems caused by human activities, and for educational and demonstration purposes (Taschereau 1985). During the next ten years, many participating nations surveyed their lands and nominated candidate sites. While this did not result in the establishment of an international reserves system, IBP laid the groundwork for the Man and the Biosphere Program, which began in 1970.

The Man and the Biosphere Program was initiated to conserve natural areas throughout the world by establishing biosphere reserves (UNESCO 1974). Biosphere reserve designation seeks to link fully protected "core" areas with adjacent lands where agriculture, forestry, or other

human activities may be taking place. The Man and the Biosphere effort has been moderately successful in achieving this aim. To date, more than 285 biosphere reserves have been established, forty-five of these in the United States. One reserve has been proposed for the Bay of Fundy region. This biosphere reserve, which represents the Acadian boreal biotic province, would span the entire mouth of the Bay of Fundy from Campobello Island, New Brunswick to Brier Island, Nova Scotia, and south to include Grand Manan Island, Machias Seal Island, a portion of Jeffreys Bank, and Mount Desert Island (Agardy and Broadus 1989).

A criticism of the Man and the Biosphere Program is that it does not ensure permanent protection of reserves through dedication[1] or acquisition. In the United States, biosphere reserve designation has been conferred only to existing national parks. Very little effort has been made thus far to reach beyond the core parks to surrounding buffer areas (Graber and Hermann 1990). The intent is to encourage existing organizations and government agencies to plan on a regional scale. In populated areas such as the Northeast, however, there are often so many interest groups to coordinate that efforts typically become bogged down. The Fundy/Maine Biosphere Reserve proposal, which involves the governments of two countries, has seen little progress in five years for this reason (Agardy 1988).

In addition, it can be argued that a system based on biomes is so coarse that entire ecosystems could slip through the cracks. As an example, in the Man and the Biosphere Program classification, Maine is divided into only two biotic provinces. Because the character of Maine's biota changes markedly from north to south and from the coast inland, one coastal reserve will obviously not capture the range of biological diversity in the state.

* * * * *

If the primary purpose of an ecological reserves system is to permanently protect a full complement of Maine's biological diversity, then it becomes apparent that there are limitations to protection strategies that focus only on either species and communities or biomes. A scale that incorporates both species and landscape diversity provides a missing link. This scale would be coarse enough to incorporate as much physiographic diversity as possible (from ridge-top to valley, for example), and yet fine enough to include most of the species native to Maine. Few programs operate at this intermediate scale. The remaining pages of this chapter focus on those that do, or on facets of programs where scale is not important.

The Nature Conservancy - Preserves and Bioreserves

The Nature Conservancy is a national, private, non-profit organization that seeks to preserve animals, plants, and natural communities that represent the diversity of life on earth by

[1] Dedication means the placement of a natural area into a legally established system of reserves, whose member properties are protected by strong statutory language against condemnation or conversion to a different use (Hoose 1981). Dedication, designation, and other protection strategies are described in greater detail in Chapter 5.

protecting the land and water they need to survive. It operates by systematically identifying threatened and endangered plant and animal populations and exemplary natural communities and then seeking to protect them through fee or less-than-fee acquisition (The Nature Conservancy 1982). In its early years, The Nature Conservancy focused protection efforts in Maine and elsewhere on individual populations of species based on a ranking scheme of global and state significance. With the establishment of state natural heritage programs, which now exist in all fifty states, The Nature Conservancy expanded its focus to include communities. Heritage programs are essentially conservation data bases or inventories that are directed toward specific elements of diversity such as species and community types (Noss 1987a). A goal of many state heritage programs is to identify an outstanding example of each major community type in each physiographic region in the state (Noss 1987a). This information can then be used by The Nature Conservancy chapter in that state to set priorities for protection.

It has been argued that this expanded focus on natural communities may not capture all of the ecological complexity and processes that scientist and resource managers seek to preserve (Noss 1987a). If a reserve system is designed to be a permanent resource -- one that is likely to represent a region's biological diversity into the future -- then drawing lines around a population of a species or an assemblages of species may be ineffective over the long term. The Nature Conservancy recognizes this and has embarked on an ambitious program to look at diversity on a landscape scale. Their bioreserve effort uses an ecoregion classification developed by Omernick (1987), which divides the United States into seventy-six regions. In concept, bioreserves are large areas (tens of thousands of acres) that are designed around a core protected area and would include and accomodate compatible land uses in and around them. They are protected using a combination of conservation tools including easements, and fee acquisition.

NATIONAL PROGRAMS

Research Natural Areas

The Federal Committee on Research Natural Areas was formed in 1966 to promote and guide the selection of ecologically significant areas on federal land (Pearsall et al. 1986). Although Research Natural Areas can be designated by any land-managing agency within the Departments of Interior or Agriculture, since the early 1980's only the USDA Forest Service has maintained an active program. The Forest Service's goal is to protect an example of each of the forest types described by the Society of American Foresters (Eyre 1980). As of 1986, 150 Research Natural Areas had been established on national forest land and proposals for at least as many more have been submitted in forest plans recently developed for each national forest (Juday 1986). In this planning process, Research Natural Areas have emerged as an important use of the United States National Forest system.

Research Natural Area designation offers an effective tool for representing biological diversity in states that have large acreages under federal ownership. In Oregon and Washington, for example, a concerted effort has been made to dovetail Research Natural Area designations with The Nature Conservancy's work on private land. In Maine, however, because 95% of the state is in private ownership (the U.S. Forest Service manages approximately 53,000 acres in Maine), Research Natural Area designation is of little relevance to a statewide ecological reserves

effort. To date, no Research Natural Areas have been designated in Maine, although one has been proposed for the Caribou-Haystack area of the White Mountain National Forest.

Society of American Foresters Natural Areas

The Society of American Foresters (SAF) Natural Areas Program is similar to the Research Natural Areas effort in that it seeks to establish a system of natural areas that represent all forest and forest-related vegetation types for scientific and educational purposes. Like the U.S. Forest Service program, it is essentially a registry; however, designation, which requires landowner consent, can occur on both public and private land. Designation carries no legal constraints on the land or its uses and, although the intent is to designate sites that are large enough to protect examples of forest ecosystems over the longterm, as with Research Natural Areas, reserves are generally designed around a single stand of trees. In Maine, seven SAF natural areas have been designated. All, except a twenty acre stand of jack pine in Bradstreet, are in Acadia National Park or Moosehorn National Wildlife Refuge (Society of American Foresters 1972). No designations have been made since 1981 (Society of American Foresters 1981).

National Natural Landmarks

The National Natural Landmarks Program was created in the early 1960's and is administered by the National Park Service. The objective of the program is to assist in the preservation of a variety of significant natural areas which, when considered together, illustrate the diversity of the country's natural history (The Nature Conservancy 1977a). This objective is attained through the identification of sites on private and public land that are eligible for inclusion in a national registry. Natural landmark registration is voluntary and does not change ownership. The program is nonregulatory and as such there are no specific regulations affording protection to landmarks. Sites are typically small and object-oriented (i.e., centered around a single feature such as a rock outcrop or scenic vista) and landmark design does not address the long-term viability of the features of interest.

SELECTED PROGRAMS IN OTHER STATES AND CANADIAN PROVINCES

California

The University of California's Natural Reserve System was formed in 1965 to protect for study a series of undisturbed natural areas representing the state's ecological diversity. Since then the system has grown to include thirty-one reserves specially designated for use as outdoor classrooms and laboratories by students, teachers, and researchers from any institution of higher education (Natural Reserve System 1987; J. Kennedy, personal communication).

Although a systematic inventory has not been conducted to identify representative examples of the state's ecosystems, as many habitats as possible are included in the major reserves to increase their effectiveness and to reduce the total number of special habitat reserves needed to fill out the system. Of the 178 major habitat types that have been identified in an

ecosystem classification developed for California, the thirty-one existing reserves encompass more than 100 types (Gustafson 1985). Reserve size ranges from 16 to 54,488 acres.

A variety of criteria are considered before a site is acquired. Major scientific criteria include habitat diversity, degree of disturbance, and habitat significance -- particularly the presence of habitat types not currently included in the Natural Reserve System or comparable programs. Special features such as different successional stages, isolated populations, species at the extreme limits of their range, transition zones, type localities, rare or endangered species, and features of geologic, paleontological, or archaeological significance add value to a prospective reserve. Administrative and management criteria such as accessibility, protectability, degree of threat by development, degree of present academic use, potential for future use, and geographic distribution are also considered.

Unlike the system proposed for Maine, reserve design hinges on suitability for research rather than long-term protection and management. The system includes many partially protected ecosystems that are susceptible to disruption by influences beyond the boundaries of the reserve. This has necessitated coordination with adjacent landowners.

The California system is extremely restrictive in terms of the uses it permits on reserves. In general, no use is allowed that will degrade the habitat of a reserve for any appreciable period of time. Recreational uses, such as camping, picnicking, horseback riding, hunting, fishing, and rock climbing are strictly prohibited. Scientific and educational use is by permit only, and non-university educational programs are not actively encouraged.

The success of the program reflects the University of California's strength in the ecological sciences and a state legislature with a long history of support for higher education. This has enabled the Natural Reserve System to be established without a major public initiative. No other academic institution in the United States has a comparable array of sites for field work -- with respect to size, scope, and ecological diversity.

Washington

The state of Washington's Natural Area Preserve Program was established by the State Legislature in 1972 (Dyrness 1975). The Washington Department of Natural Resources coordinates the natural areas initiatives of state, federal, and private groups. As of 1989, more than eighty natural areas had been established, including thirty Natural Area Preserves in the Department of Natural Resources, four in the Department of Wildlife, two in the State Parks and Recreation Commission, and thirty-six Research Natural Areas managed by federal agencies. In addition, the Bureau of Land Management has several "areas of critical environmental concern", -- a designation used primarily to protect rare plant populations, and The Nature Conservancy has acquired twenty-four Natural Area Preserves (Washington DNR 1989). The Department of Natural Resources recognizes each of these preserves as effective ways to protect the state's natural diversity. Each are acknowledged in the state's biennial Natural Heritage Plan. Both a Registry of Natural Areas (which is similar to the Maine Critical Areas Program) and the Washington Natural Heritage Program are administered by the Department of Natural Resources. A Natural Heritage Advisory Council advises the Department on the establishment and management of Natural Area Preserves. The Council is made up of fifteen members. Six are

government professionals and five of the remaining nine appointed citizens are recognized experts on the ecology of natural areas. The Council oversees the plan, which identifies the types of areas that should be protected, and keeps attention focused on gaps in the system. This information is updated every two years.

As proposed for Maine, both Washington and Oregon use a two-tiered inventory approach where physiographic regions are surveyed to see which ecosystems are represented. The emphasis is on representativeness rather than rarity. Unlike Maine, substantial portions of both states are publically owned. In Washington, the natural areas effort is greatly enhanced by the large number of complementary state and federal programs, many of which devote both funds and staff time to the acquisition and management of natural areas.

Wisconsin

Wisconsin's Natural Areas Program, which was established in 1951, is the oldest in the country. The program's goal is to protect several examples of each of the state's ecosystems in all of the natural divisions in which they occurred in presettlement time (circa 1800) -- if representative sites remain (Hine 1983). As of 1990, 226 natural areas, encompassing approximately 45,000 acres, were legally protected. Scientific research, monitoring, and environmental education, are considered the highest and best uses of these areas. The Department of Natural Resources, which houses the Natural Areas Program, uses acquisition, dedication, and to a lesser extent, designation to protect natural areas. The program is comprehensive in that it evaluates the ecological significance of public and private lands.

From the outset, the program has had strong input from the state's conservation and scientific communities. In 1986, the Natural Areas Preservation Council was established to advise the Department of Natural Resources and other departments involved in the acquisition, development, utilization, and maintenance of state natural areas. The Natural Areas Preservation Council also oversees the Endangered and Nongame Species Program and the Natural Heritage Inventory. This oversight provides a coordinated mechanism for determining conservation priorities.

Although the Wisconsin system offers some useful ideas for a Maine ecological reserves effort, there is an important difference -- scale. The Wisconsin landscape is far more fragmented than Maine's. Most of the state's natural ecosystems have been converted to agricultural land. As a result, natural areas are generally small remnants of former ecosystems. The pace of conversion is not abating and protection efforts have become more reactive as a result. The program director has estimated that Wisconsin is losing approximately ten percent of its significant natural areas each year. As a result, priorities are set based on the rate of land conversion in different areas. There is no time to take a systematic approach.

Illinois

The Illinois Nature Preserves system, which, as of 1990 contained 188 preserves totaling 28,750 acres, is adminiustered by the Illinois Nature Preserves Commission. This commission resembles Wisconsin's Natural Areas Program in several respects. It can legally acquire and dedicate land, it has an advisory council comprised primarily of scientists, conservationists, and

government professionals, and, because of the state's land use history, conservation efforts are generally directed toward rare species and remnants of plant communities. The Illinois Nature Preserves Commission identifies and evaluates natural areas, promotes their acquisition and dedication within a statewide nature preserve system, and participates in the development of plans for their management and use. The commission works directly with the Illinois Department of Conservation which has the principal responsibility for acquiring, managing, and protecting nature preserves representative of the significant natural features of the state and for protecting habitats of rare and endangered species. In addition to the Department of Conservation, several other public agencies recognize the establishment of nature preserves as one of their functions.

Unlike Wisconsin, Illinois uses an extremely systematic approach to identify potential natural areas. In the early 1970's, the state developed a comprehensive plan to find, describe, and protect natural areas (Illinois Nature Preserves Commission 1972). A comprehensive inventory was conducted over a three year period using a list of features to be protected and a map of the natural divisions of the state. The inventory, which involved a review of existing information, aerial photo interpretation, an aerial survey, and a ground survey, identified 1,089 sites, 25% of which were already on nature preserves. Again the scale of sites inventoried is small, but the systematic approach, and the existence of a commission that monitors the progress and effectiveness of the program and sets priorities, are approaches that are relevant to the design of a Maine ecological reserve system.

Virginia

In 1989, Virginia enacted legislation that created a statewide natural Reserve System. This legislation, called the Virginia Natural Area Preserves Act, codified and established the Natural Heritage Program, the Natural Area Preservation Fund, the Natural Area Preserves System, and the Natural Areas Registry. In addition, it included a strong land dedication law. The law and accompanying programs are administered by the Division of Natural Areas in the Department of Conservation and Historic Resources.

Virginia intended to conduct a systematic inventory, but because of intense development pressure in the eastern half of the state, the most threatened areas are being inventoried first. As in Wisconsin and Illinois, the state is looking at a window of ten to fifteen years before there will no longer be natural areas of state significance to acquire. Although the legislation is comprehensive, there is no advisory council to provide scientific expertise on the design of the system as a whole or a long-term perspective to ensure that the goals of the legislation are carried forward from one administration to the next. Such a council is currently being proposed (Michael Lipford, personal communication).

Canada

In the early 1970's, the International Biological Program (IBP) identified hundreds of sites across Canada as candidates for ecological reserves. The program advocated legal protection through dedication of sites on crown land and petitioned the individual provincial governments to enact legislation. In 1971, the government of British Columbia enacted the first ecological reserves legislation, and by 1972 had dedicated fifty-four ecological reserves (Taschereau 1985). Today only two provinces are without specific ecological reserves legislation -- Ontario and

Prince Edward Island. Ontario does have an active nature reserves program under its Provincial Parks Act. Only Prince Edward Island lacks a systematic program or the legislative means to protect natural areas. This reflects the fact that, unlike the other Canadian provinces, most of the island (98%) is privately owned.

Although comprehensive reserves legislation exists in most parts of the country, its effectiveness varies greatly from one province to the next. In spite of the fact that most reserves are located on crown land, the majority of sites recommended outside of existing national parks are unprotected (i.e., the rights to timber and minerals are often leased to private industries). With the exception of the Quebec and British Columbia systems, reserves are often too small to meet conservation objectives. A number of IBP sites, when investigated and reevaluated, proved not to be good examples of regional ecosystems. In the Maritimes, for example, IBP sites were never intended to be representative. As a result, designated and candidate sites are generally localized examples of rare or unique features (Taschereau 1985).

Several provinces have allocated funds to move beyond the preliminary IBP list and conduct a more thorough inventory. Quebec employs the most systematic and scientific approach to reserve selection and design. The province's overall aim is to create a system of ecological reserves which will form a permanent network of areas representing all of the natural ecosystems in Quebec. Initial selection is based on representation within the province's biophysical regions. Each reserve consists of a core area in which observational research is permitted, but no modification of the environment is allowed, and a buffer, which provides an area for regular monitoring and a place for educational activities. An advisory committee oversees the selection, design, and management of reserves.

In Canada, most arguments for preserving natural areas have emphasized their scientific and ecological values. Because reserves serve primarily for conservation and research, they are often designed and managed to discourage public use, and access is generally by permit only. Although such restrictive policies are in keeping with the primary purposes of ecological reserves, excluding the public is both politically unpopular and very expensive. In British Columbia and Quebec, for example, the legislation is so restrictive that most government officials are reluctant to designate land under it. Restrictions on hunting and fishing in British Columbia have created strong opposition to new proposals by the Fish and Wildlife Branch of the government -- and only one objection by a government agency is needed to kill a proposal for a reserve. As a result, program managers in both provinces recommend against such tight restrictions in Maine (Courtemanche, Tinder-Moss, personal communication).

An important provision in the legislation of four provinces (British Columbia, Quebec, Newfoundland, and Alberta), is the appointment of an advisory committee by the minister of the agency that administers the act. The advisory committee provides overall direction for the program; reviews proposals for new sites; oversees the development of management plans; provides a forum for scientists, educators, and government professionals; and coordinates the reserves program with other land use efforts and with related activities in other provinces, the federal government, and various public and private groups.

THE SITUATION IN MAINE

A number of private organizations and state agencies have mandates that could complement an ecological reserves system. These are briefly described below.

Private Agencies

The Maine Chapter of the Nature Conservancy has 86 preserves in Maine. In its early years, most preserve designs were species-centered, or were determined by the boundaries of donated lands. Because of this, the majority of existing preserves do not fulfill the functions of an ecological reserve. Although most of the chapter's protection efforts to date have focused on rare species (Big Reed Pond is a notable exception), the organization is extremely supportive of the ecological reserves concept and is beginning to expand its focus to include larger representative sites. In addition, it is one of the only conservation organizations in the state to actively encourage and fund research and monitoring on its preserves. Funds are generally devoted to research and monitoring efforts that increase understanding or enhance the condition of the species or communities of interest. The Nature Conservancy's expertise in the legal protection of natural areas has been invaluable to land conservation efforts in Maine -- at local, state, and federal levels. While the Maine Chapter's goals would be extremely complementary with those of an ecological reserves initiative, it does not have the resources to protect and manage a statewide system of ecological reserves.

Apart from The Nature Conservancy, a variety of other conservation organizations such as the Maine Audubon Society, National Audubon Society, Maine Coast Heritage Trust, and dozens of local land trusts hold land for conservation purposes. These organizations tend to be opportunistic in their approach -- land is protected through donations or conservation easements -- or they have a local focus because they do not have the mandate, staff, or money to actively acquire land in other parts of the state. However, some sites identified by land trusts, such as the Cutler area in Washington County, which is currently being evaluated by Maine Coast Heritage Trust, have ecological reserve potential.

Critical Areas Program

The Critical Areas Program, which is housed in the State Planning Office, identifies and registers areas of botanical, zoological, geologic, or scenic significance on private and public lands. Landowners are notified of critical areas that they own and are encouraged to allow these areas to be listed on an official Register of Critical Areas, which as of 1990 included approximately 650 areas. There is no regulatory aspect to the program. Voluntary protection is promoted through education and, in the case of large landowners, negotiated management agreements. These agreements are essentially temporary, non-binding contracts that obligate the landowner to manage property in a mutually agreeable manner for a fixed period of time. Two other program responsibilities include compiling the Official List of Endangered Plants and identifying and designating Heritage Coastal Areas, which are areas in the coastal zone with outstanding scenic, natural, and historical value.

While the registration approach is generally successful, and has won the program broad public support, long-term protection is not ensured. Sites are typically small, i.e., often a single

population of plants or animals surrounded by a narrow, arbitrarily defined buffer zone. The boundaries of a site may not be extensive enough to ensure the viability of the features they are intended to protect and geographic distribution is based primarily on political rather than ecological boundaries. The program attempts to contact landowners (by mail) on a biennial basis to monitor the status of registered critical areas.

Natural Heritage Program

The Maine Natural Heritage Program was established in 1983 and transferred to State government in 1989, through a cooperative agreement between the Maine Chapter of The Nature Conservancy and the Department of Economic and Community Development's Office of Comprehensive Planning. A national heritage program network was developed by The Nature Conservancy as a way to provide a common method to identify priority areas on a state-by-state basis, regardless of ownership. Maine's Natural Heritage Program maintains a centralized database that tracks the state-wide distribution and status of plants, animals, and natural communities that are endangered, threatened, or of special concern at the federal and state levels. Although it collects data on exemplary natural ecosystems, no systematic inventory has been conducted for the majority of natural ecosystem types in Maine, particularly those that are typical. With the recent addition of an ecologist to the staff, this gap will begin to be filled.

Like the Critical Areas Program, the Natural Heritage Program is primarily informational. Both conduct detailed inventories of special features and maintain extensive data bases. Neither afford legal protection to sites. A variety of agencies and organizations do protect land through acquisition and easements. The Nature Conservancy, as already discussed, is the closest analog to the Ecological Reserves concept. However, its efforts to date have focused on species rather than ecosystems and landscapes. Three state agencies, the Bureau of Public Lands, the Department of Inland Fisheries and Wildlife, and the Bureau of Parks and Recreation, hold lands for conservation purposes. All have specific mandates established by the Legislature that guide land management. A fourth agency, the Bureau of Forestry, is empowered to set aside "lands or portions there of as natural areas on which alteration or development would be extremely limited", but has yet to exercise this power.

Bureau of Public Lands

The Bureau of Public Lands, in the Department of Conservation, holds the largest amount of public land in Maine (approximately one half million acres), most of which is in the unorganized townships. This northern and western orientation reflects the original locations of the public reserved lots. Hundreds of these public lots have been consolidated into twenty-three large units. The Bureau's legislative mandate is to manage land in a manner consistent with the principles of multiple land use and to produce a sustained yield of products and services. In management plans for the various public lands, a dominant use and one or more secondary uses are assigned to most acres. These may include forest management, backcountry, general recreation, remote recreation, special protection, and visual areas. Forest management is a dominant or secondary use on extensive portions of most of the Bureau's holdings.

Bureau of Parks and Recreation

The Bureau of Parks and Recreation, also in the Department of Conservation, was established to administer programs to acquire, design, construct, operate, and maintain areas for public enjoyment and recreation. The Bureau also has the specific statutory authority to acquire any area of land largely in a natural condition and containing natural features of scenic, ecological, or scientific interest or importance. In addition, it can establish and manage both wilderness areas and natural areas to preserve their natural character and features by prohibiting any uses or development which pose a threat. Holbrook Island Sanctuary is an example of a tract managed primarily for scientific purposes. Most of its holdings (which comprise approximately 71,000 acres) are located in the southern half of the state.

Department of Inland Fisheries and Wildlife

The Department of Inland Fisheries and Wildlife was established to preserve, protect, manage, and enhance Maine's inland fisheries and wildlife for the use and enjoyment of the citizens of the state. The agency's priorities include: (1) improving species assessment capabilities; (2) developing species management and habitat protection programs; (3) helping with land use planning and control at local, state, and federal levels; and (4) improving conditions for inland fisheries and wildlife on the state's public lands.

In addition to traditional game management programs such as fish and game law enforcement, propagating fish, and acquiring wildlife management areas (which to date encompass more than 65,000 acres), many of the Department's programs focus on the conservation of non-game species and protection of their habitats. The agency administers the Maine Endangered Species Act, which provides legal protection to listed species (this law currently applies to 94 vertebrate species). Habitat management techniques, such as timber harvesting, water level control, and vegetation management, are used to enhance the diversity of game and, to a lesser extent, non-game species on wildlife management areas. There is currently no specific program for the protection of entire ecosystems in their natural state.

Land for Maine's Future

The Land For Maine's Future Program, which is housed in the State Planning Office, was designed specifically to administer bond money allocated for the purchase of public lands in 1987. The Program's staff and board evaluate proposals submitted by the general public, various state agencies, and conservation groups. Lands are evaluated using a variety of criteria including ecological and educational value. Although the Land for Maine's Future Program provides a potential funding mechanism for ecological reserves, the State Planning Office cannot hold land. Parcels are conferred to an appropriate state agency that can legally hold land -- either the Bureau of Public Lands, the Bureau of Parks and Recreation, or the Department of Inland Fisheries and Wildlife.

CONCLUSIONS

Protecting the natural diversity of a state such as Maine and establishing a network of reserves to serve as environmental benchmarks is no small task. Few states or countries have succeeded in building even a basic framework for meeting these objectives. Based on programs that have reserves programs in place, two tools appear to be essential: (1) legislation that establishes a reserve system as well as a mechanism to legally protect the areas placed within it; and (2) a formal link between the various state, federal, and private programs involved with land conservation. This link is typically achieved by creating a council of natural resource managers, conservationists, and scientists that sets conservation priorities, evaluates the levels of protection afforded by different private, state, and federal programs, and makes sure long-term goals are being met. Two other important lessons offered by the most successful programs are to establish a systematic approach for the careful identification, selection, and design of reserves (and natural areas in general) and to encourage the public to use and learn from the ecological reserves system.

CHAPTER 3: THE INVENTORY

An essential part of the Ecological Reserves Study was an inventory of natural ecosystems on public and private non-profit conservation lands. The purpose of the inventory was to catalog the ecosystems represented on each holding and to assess their viability. The inventory took place between June 1, 1990 and October 31, 1990. A total of 796 areas, comprising approximately one million acres were evaluated. 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 Public Lands, Maine Bureau of Parks and Recreation, Maine Department of Inland Fisheries and Wildlife, Baxter State Park, U.S. Forest Service, U.S. Department of Fish and Wildlife, National Park Service, and The Nature Conservancy. Lands held by local municipalities, local land trusts, water districts, and the U.S. military were not surveyed. To ensure systematic coverage, the inventory included the following phases:

Phase 1 -- Preparation of ecosystem and biophysical region classifications which identified the units to be inventoried.

Phase 2 -- Development of threshold criteria for preliminary screening.

Phase 3 -- Aerial reconnaissance of sites meeting threshold criteria.

Phase 4 -- Field survey.

Phase 5 -- Preparation of matrices showing which ecosystem types are represented in each biophysical region and selection of ecosystems or complexes of ecosystems that have potential as ecological reserves.

Each of these stages is discussed in more detail below.

PHASE I: CLASSIFYING DIVERSITY

The ecological reserve system proposed for Maine is designed to encompass the full range of biological and landscape diversity of the state in order to provide representative natural ecosystems for scientific study, environmental monitoring, and education. 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 is defined as a group of plant and animal populations that share a common environment (Reschke 1990). The classification, which is an expansion of a natural community classification developed by the Natural Heritage Program, describes 102 different ecosystem types. Some familiar examples are northern hardwood forests, alpine meadows, raised bogs, and sand beaches. These are grouped into six categories: terrestrial, palustrine (wetlands), lacustrine (lakes), riverine, estuarine, and marine. All ecosystem types are listed on pages 34 and 35 and descriptions are given in the Appendix III.

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 (see Figure 1 on page 23 and map in back cover pocket) (McMahon 1990). The distinctive landscape and climate of each region produce characteristic soil and vegetation patterns.[2] Within each region, similar ecosystems can be expected in similar positions in the landscape. For example, in Region 15, 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 inland spruce-fir forests and bogs.

Using the ecosystem and biophysical classifications in tandem 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 the reserve system and in what parts of the state these reserves should be located. A complete ecological reserves system would 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.

PHASE II: INVENTORY CRITERIA

In addition to representing Maine's biological diversity, an ecological reserves system has a second important objective -- to maintain this diversity into the long-term. Two criteria relevant to this second objective -- naturalness and size -- were used to come up with a list of sites to include in the aerial reconnaissance. These are described briefly below.

Naturalness

There are probably no completely "natural" ecosystems in Maine. Many have been altered directly by human activities such as impoundments, timber harvesting, species introductions, and hunting. And it is probably safe to say that all of Maine's ecosystems have been modified indirectly by acid deposition, ozone, and other ambient pollutants. With the exception of ecosystems that are relatively undisturbed, such as alpine areas, old growth forests, peatlands, and unstocked ponds, this criterion needs to be flexible. The goal is to identify potential reserves that are as undisturbed as possible.

[2] Biophysical region descriptions are given on the reverse side of the map in the back cover.

Size

In parts of the world where natural habitats have been fragmented, it is generally agreed that the larger the reserve, the greater its biological diversity. This presumes that a larger site is more likely to include the minimum population sizes necessary for long-term survival of constituent species, and that the number of species conserved increases with reserve size. The goal is to establish a reserve that is large enough to allow populations to adjust to natural disturbances and gradual environmental changes, and thus allowing natural processes to continue. An example might be the watershed surrounding a stream or pond. Because watersheds are self-contained -- at least from the standpoint of surface water hydrology -- a watershed approach would minimize the potential impact of land uses outside of the reserve boundary.

Prescreening criteria

Four prescreening criteria were developed to set minimum standards for size and naturalness. Sites were excluded from further analysis if (1) they were smaller than 20-30 acres (unless they represent 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 have been harvested within the last 40-50 years, or (4) they were created and are maintained by artificial impoundments. Reclaimed lakes and ponds (where existing fish populations have been replaced with species preferred for sport fishing) were also not considered natural ecosystems.

Using the first two criteria, the list of private and public conservation lands was winnowed from 796 to 289 sites. Most of the areas excluded during this preliminary screening phase were historic monuments, small state parks, U.S. Coast Guard Stations, and small coastal islands. In addition, sites for which there was adequate information, (such as Nature Conservancy preserves), were removed from the list until the analysis phase. An additional 139 sites were removed from the list after meetings with IFW regional biologists and BPL regional foresters who identified these areas as either recently harvested or artificially impounded.

PHASE III: THE AERIAL RECONNAISSANCE

The aerial reconnaissance included 160 sites which were surveyed in ten flights (47 hours of flying time). The purposes of the overflights were to (1) determine the presence and extent of recent harvests and impoundments, (2) determine which portions of the larger tracts should be surveyed on the ground (3) identify access points, and (4) obtain a cursory view of surrounding ecosystems and land uses. An additional 39 sites were eliminated during the aerial reconnaissance because of recent timber harvests or active impoundments. A sample aerial survey form is shown on page 37.

PHASE IV: THE FIELD SURVEY

The remaining 121 sites were divided among four field ecologists for ground-truthing. Eighty-four of these were surveyed in the field. Thirty-seven sites, including many of the larger

tracts, are in need of further inventory work. Before visiting each site, aerial photography and topographic maps were examined to delineate ecosystem boundaries and determine the best routes for survey transects. Representativeness and long-term viability of each site were assessed in the field. Data collected during each field survey included a list of the ecosystem types present, a general description of each ecosystem (dominant species, physiography, nutrient and moisture regimes, etc.), an assessment of the site's condition, and a plant species list. In addition, a site summary was prepared for all sites with ecological reserve potential. Samples of the field survey and site summary forms used during this phase of the inventory are shown at the end of the chapter.

PHASE V: THE INVENTORY RESULTS

The inventory results are presented in two ways. A matrix of ecosystem type by biophysical region provides a quick assessment of which ecosystems are adequately represented on public and private conservation ownerships. This is followed by a list of areas that could potentially be ecological reserves. Areas are grouped by biophysical region and their surveyed ecosystems are listed (by the same numbers used before each ecosystem type in the matrices).

The following generalizations can be made from the matrices and list of potential ecological reserves:

1. Approximately 45% of Maine's natural ecosystem types are represented on existing public and private non-profit conservation lands. The breakdown by major system is:

Terrestrial -- 50-60% ecosystem types represented
Palustrine -- 50-60% ecosystem types represented
Lacustrine -- 30-40% ecosystem types represented
Riverine -- 25-35% ecosystem types represented
Estuarine & marine -- 45-55% ecosystem types represented

These percentages reflect the regional distribution of each ecosystem type and are derived from the ecosystem matrices on pages 23 through 27. For example, the alpine meadow ecosystem is represented in both of the biophysical regions in which it occurs, so it has 100% representation. The pine woodland ecosystem type, on the other hand, is represented in only six of the twelve regions in which it is likely to occur -- a representation of 50%.

2. Representation by biophysical region is uneven. Three biophysical regions (1, 3, and 7) have no known examples of their characteristic ecosystems on public and private non-profit conservation lands. In contrast, coastal regions have relatively high representation. For example, characteristic examples of more than 90% of the ecosystem types known to occur in Region 15 are represented on conservation ownerships.

3. Twelve ecosystem types (some of which are rare in Maine) are not known to be represented on public and private non-profit conservation lands. These include:

serpentine outcrop/bald	calcareous rocky lake shore
calcareous outcrop/bald	meromictic lake
calcareous talus slope	calcareous rocky river shore
black willow/alder swamp	riverwash barrens
rich patterned fen	high energy riverbank
poor patterned fen	salt pond

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

5. Only 8% of the original list of public and private non-profit ownerships have potential to be ecological reserves. This reflects the management regimes that currently exist on public land in Maine -- the majority of the state's public lands are actively managed for forestry, recreation, or wildlife.

6. On many areas with reserve potential, proposed management in the next five years (primarily timber harvesting and impoundments) will significantly alter the ecosystems within them.

7. Of the 66 areas with potential to be ecological reserves listed on pages 28 through 33, 16 areas (24%) are owned by private conservation organizations (primarily The Nature Conservancy).

8. Excluding Baxter State Park and Acadia National Park,[3] the approximate acreage of all areas on the potential reserve list is 67,820. Of these, approximately 31,700 acres are on ownerships such as state parks, wilderness areas, or nature preserves, where commercial timber harvesting is not permitted. At least 40% of the remaining acreage is not productive forest land. The total number of acres that would need to be removed from timber production if all sites listed were included in an ecological reserves system is approximately 21,680 acres. This represents approximately 0.1% of the land base currently managed for commercial timber production in Maine (Powell and Dickson 1984).

9. The sites with potential as ecological reserves comprise approximately 8% of Maine's public and private non-profit conservation lands and approximately one third of one percent of the state's total land area. A complete system could be expected to include roughly twice this percentage.

[3] For the most part, Baxter State Park (201,018 acres) and Acadia National Park (>40,000 acres) are managed in a manner that would be consistent with the objectives of ecological reserves. Because of their large size, systematic inventories to identify areas with the greatest reserve potential were not identified. As a result, estimates of acreages within these two ownerships are not given.

USING THE ECOSYSTEM MATRICES

The matrices on the next four pages provide several pieces of information. The ecosystem types included in the Maine Ecosystem Classification are listed on the left. The biophysical region numbers shown at the top of each matrix are keyed to the map below. The colored blocks on the right side of each matrix indicate whether an ecosystem type is known to occur in a given region. **White** indicates that the ecosystem is known to occur in that region. **Dots** indicates that the ecosystem type may occur in that region, but no documentation exists. **Black** indicates that the ecosystem type does not occur in that part of the state. The numbers in the boxes indicate how many representative examples of a given ecosystem type occur on public or private conservation ownerships in a particular region.

As an example, calcareous cliffs (ecosystem #5) are known to occur in regions 5 and 6. Bedrock geology maps show calcareous areas in regions 3, 4, and 8, which suggests that this ecosystem type may occur in these regions as well. Only one representative example of a calcareous cliff ecosystem was found on public and private conservation ownerships (in region 6) during the ecological reserves inventory.

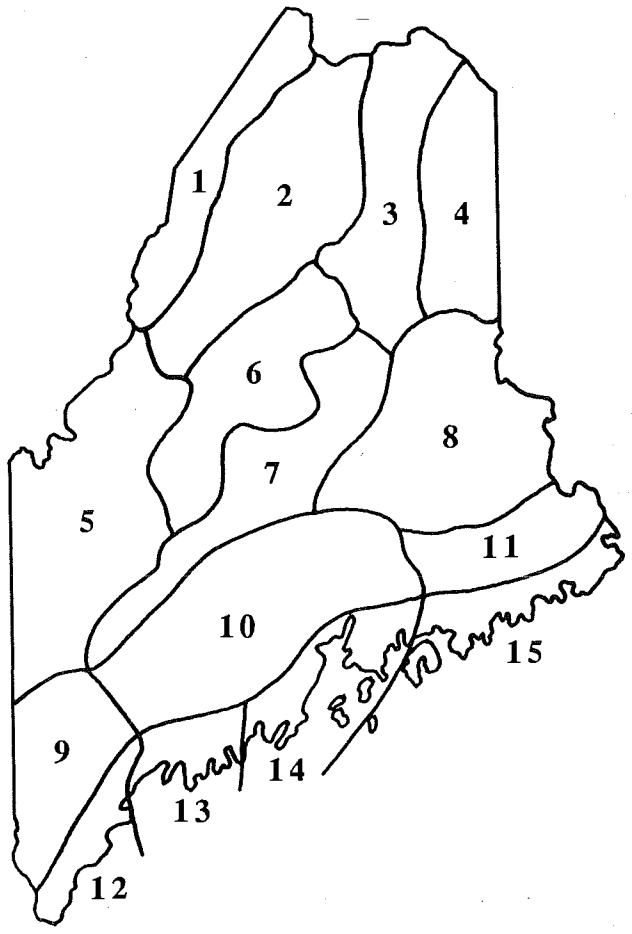


Figure 1

BIOPHYSICAL REGIONS OF MAINE

1. **Boundary Plateau**
2. **Saint John Uplands**
3. **Aroostook Hills**
4. **Aroostook Lowlands**
5. **Western Mountains**
6. **Central Mountains**
7. **Western Foothills**
8. **Eastern Lowlands**
9. **Southwest Interior**
10. **Central Interior**
11. **Eastern Interior**
12. **South Coastal Region**
13. **Midcoast Region**
14. **Penobscot Bay Region**
15. **East Coastal Region**

Terrestrial Ecosystem Matrix

Biophysical Region

Ecosystem type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Serpentine outcrop/bald															
2. Acidic/circumneutral outcrop/bald		1			4	3						1	2	1	4
3. Calcareous outcrop/bald															
4. Acidic/circumneutral cliff		1			4	2								1	1
5. Calcareous cliff						1									
6. Acidic/circumneutral talus slope/boulderfield		1			1	1								1	1
7. Calcareous talus slope/boulderfield															
8. Cold-air talus slope		1													
9. Fellfield					2	1									
10. Alpine meadow/snowbank/headwall					2	1									
11. Sand barren/grassland												1			1
12. Maritime shrubland/rocky headland													1		
13. Boreal shrub heath headland															6
14. Alpine krummholz					3	1									
15. Talus slope/boulderfield woodland		1			2	1									
16. Pitch-pine barren									2			1	1		1
17. Pine-heath woodland						1							1	1	4
18. Red pine-heath woodland					1	1		1							
19. Jack pine-heath woodland						1									2
20. Pine-oak woodland					1								3	1	
21. Oak-hickory woodland												1			
22. Maritime spruce-fir forest															7
23. Spruce-fir flat		1			1			2					1		2
24. Spruce slope forest		2		1	2	3		1		1	1		1	2	1
25. Subalpine spruce-fir					3	1									
26. Mixed hardwood-spruce-fir forest		3			3	4		1					1	1	4
27. Northern hardwood forest		3		1	4	1		1							1
28. Cove forest		1		1	1										
29. Hemlock forest				1	3	1			2	2	1	1	1	1	1
30. Red oak/mixed hardwood-hemlock-pine forest									3	4		2	3	1	
31. Dry oak-pine forest					1				1	1	1	1			
32. Central hardwood forest												1			
33. Birch-aspen forest		1				2		1	3			1			3

Palustrine Ecosystem Matrix

Biophysical Region

Ecosystem type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
34. Coniferous seepage forest		1				1							2	1	2
35. Outwash seepage forest												1			1
36. Hardwood floodplain forest								3	2		1				
37. Coniferous floodplain forest					1			2			1				
38. Black willow-alder swamp															
39. Shrub swamp		1			2	1		4	4	2	2	2	2	2	4
40. High elevation shrub swamp					1	1									
41. Acidic shrub swamp					1										
42. Red maple-hardwood swamp					2	1		2	2	2		1	1	1	1
43. Tupelo swamp												1			
44. Atlantic white cedar swamp									1			2		1	
45. Northern white cedar swamp		2			2	2		1					1	1	4
46. Deep emergent marsh								3		1				2	2
47. Shallow emergent marsh								3		1			1	1	2
48. Sedge meadow		1			2	2		5	3	2	2			2	5
49. Beaver flowage		1						2		2	1		1	1	1
50. Tidal fresh marsh and mudflats										1			1		
51. Maritime slope bog															2
52. Subalpine/alpine slope bog					2	1									
53. Kettlehole bog									2			1			
54a. Patterned raised bog								1			1				
54b. Unpatterned raised bog					1			1	1		1	1			2
55. Coastal plateau bog															5
56a. Level bog									2		2			2	2
56b. Semi-bog						1									
57a. Rich patterned fen															
57b. Rich unpatterned fen								3							
58a. Poor patterned fen															
58b. Poor unpatterned fen		2						2	2		1	1		1	3

Lacustrine Ecosystem Matrix

Biophysical Region

Ecosystem type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
59a. Acidic/circumneutral rocky shore		1			2	3		1			1			1	1
59b. Calcareous rocky shore															
60. Mud shore/nonpersistent marsh						1		1		1				1	
61. Sand/gravel beach		1				3		1							1
62. Lake side seep						1									
63. Cobble shore		1				2									
64. Monomictic oligotrophic lake					2	1*									2
65. Monomictic dystrophic lake								1							
66. Monomictic mesotrophic lake		1		1	2	1*		1	1					1	
67. Dimictic oligotrophic lake		1				4*								1	1
68. Dimictic mesotrophic lake					2	1*			1	1	1			1	1
69. Meromictic lake															

*At least one example of this lake type occurs within Baxter State Park.

Riverine Ecosystem Matrix

Biophysical Region

Ecosystem type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
70a. Acidic/circumneutral rocky shore						1									
70b. Calcareous rocky shore															
71. Riverside seep		1													
72. High energy riverbank															
73. Low energy riverbank									1					1	
74a. Sand and gravel bar									1						
74b. Riverwash barrens															
75. Rocky headwater stream		2			2	2									1
76. Wetland headwater stream		1			2			4		1	1			1	3
77. Midreach stream		1			1			2	1		1				
78. Main channel											1	1			
79. Deadwater		1								1					
80. Intermittent stream		1			3	1			1				1		1
81. Peatland outlet stream								3	1		1	1		1	

Estuarine and Marine Ecosystem Matrix

Biophysical Region

Ecosystem type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
82. Coastal dunes												1	2		
83. Fresh-brackish pond															1
84. High energy rocky shore												1	2		6
85. Low energy rocky shore													1		4
86. Back-barrier salt marsh												2	2		
87. Fluvial-minor salt marsh												1	3		
88. Fluvial-major salt marsh												1			
89. Bluff-fringing salt marsh													1		2
90. Transitional salt marsh													1		
91. Brackish tidal marsh and flats															2
92a. Mud flat													1		3
92b. Mussel bar															
93a. Sand and gravel flat															
93b. Cobble flat															
94. Sand beach												1	2		2
95. Gravel beach															1
96. Cobble beach												1			2
97. Boulder beach															1
98. Salt pond															
99a. Mud bottom															
99b. Eel grass meadow															
100. Sand and gravel bottom															
101. Cobble bottom															
102. Rocky bottom															

Public and Private Conservation Lands with Potential as Ecological Reserves

This list includes sites that have potential to be ecological reserves. The numbers on the right refer to the ecosystem types represented in a particular public or private conservation ownership. These numbers are keyed to the ecosystem checklist and matrices. Where enough information is available, approximate acreages of the portions of an ownership with the highest reserve potential are given. During the inventory, contiguous ownerships were treated as one parcel. The abbreviations following site names indicate the current owner. The following abbreviations are used: BPL=Bureau of Public Lands, BPR=Bureau of Parks and Recreation, IFW=Department of Inland Fisheries and Wildlife, NPS=National Park Service, USFS=U.S. Forest Service, USFW=U.S. Fish and Wildlife, BSP=Baxter State Park, TNC=The Nature Conservancy, NAS=National Audubon Society, MAS=Maine Audubon Society, MCHT=Maine Coast Heritage Trust, and BATES=Bates College.

The inventory focused on identifying which ecosystem types are present, and generally what condition they are in, rather than reserve design. Because of this, the list of areas with potential as ecological reserves is preliminary. A final list will entail a case by case evaluation of each site. For many areas, the list of ecosystem types represented is not complete because of the small amount of time available for actual field surveys or lack of information about certain ecosystem types. In others, the boundaries of public or private ownerships do not conform to natural ecosystem boundaries. On many tracts, proposed management will significantly alter the ecosystems identified. There are also several cases where more than one good example of an ecosystem type occurs in a single biophysical region. The design of individual reserves and the reserve system as a whole will need to take these and other factors into account. Factors to consider when selecting and designing reserves are discussed in Chapter 4.

Site Name and Owner (be region)	**Ecosystems represented**

Region 1

No public or private conservation lands occur in this region.

Region 2

DEBOULLIE (BPL) ring of ponds, ~2500a	2 4 6 8 15 24 26 27 33 39 45 58b 59a 61 63 64 66 67 68
ROUND POND (BPL) ~500a	23 75 76 78 79 (more information needed)
ALLAGASH (BPL) along Saint John River, ~200a	26 27 71 77

Site Name and Owner	Ecosystems represented
BIG REED POND (TNC) ~5000a	24 26 27 28 34 45 48 49 58b 75 80 unclassified lakes
GERO ISLAND (BPL)	(more information needed)

Region 3

No representative examples of Maine's characteristic ecosystems occur on the sites inventoried in this region.

Region 4

SQUA PAN (BPL) ~1000a	24 27 28 29 66 (more information needed)

Region 5

WHITE MTN NATIONAL FOREST (USFS) 3 separate areas COMPRISING ~2500a	2 4 6 9 14 15 18 24 25 26 27 28 29 41 52 75 80
L. CONCORD POND (BPR) ~600a	2 3 4 15 20 27 29 31 42 68 80
MAHOOSUCS (BPL, BPR) slopes and peak of one mountain/tarn- there are several choices, ~1000a	2 4 9 10 14 25 26 27 29 52 59a 64 75 76 77 80
HOLEB (BPL) southern portion, ~1500a	23 37 39 42 45 48 54b 66 68 76 unclassified lakes (more information needed)
BIGELOW (BPL, BPR) Bigelow Mt., Wyman Twp., ~1500a	2 4 10 14 24 25 26 27 39 45 48 59a 64 66 (more information needed)

Region 6

BORESTONE MT (NAS) ~1200a	2 24 26 29 33 34 67 75 unclassified lakes
NAHMAKANTA/T1R12 (BPL) northeastern quarter	(more information needed)

Site Name and Owner	Ecosystems represented
BAXTER STATE PARK (BSP) south of Scientific Management Area	2 4 6 9 10 14 15 19 24 25 26 27 33 39 40 45 48 52 56b 59a 60 61 62 63 64 66 67 68 70a 75 80 (more information needed)
KINEO/FARM I/DAYS ACAD. (BPR, BPL)	4 17 26 59a 61 63 67 (more information needed)
LOBSTER LAKE (BPR) Big Island ~1000a	2 18 24 26 42 45 48 59 61 67
LITTLE SQUAW (BPL)	67 (more information needed)

Region 7

With the possible exception of a small portion of the Nahmakanta tract which may extend into Region 7, no representative examples of Maine's characteristic ecosystems occur on the sites inventoried in this region.

Region 8

DWINAL POND (IFW) ~2600a	26 39 46 47 48 57b 76
MATTAGODUS STREAM (IFW) ~1425a	23 36 37 45 46 47 48 57b 77 81
MATTAWAMKEAG (IFW) ~1500a	36 37 39 58b 65 76 77 (more information needed)
DUCK LAKE (BPL) southeast quarter, ~3000a	18 27 33 39 42 48 59a 60 61 66 76 77
SUNKHAZE MEADOWS (USFW) ~6000a	36 46 47 48 49 54a 54b 81 (ecosystem extends beyond refuge boundaries)
CRYSTAL BOG (TNC) ~4100a	23 24 39 42 48 49 54a 57b 58b 65 76 81

Region 9

MASSABESIC-ALFRED (USFS) ~250a	44

Site Name and Owner	Ecosystems represented
MASSABESIC-LYMAN (USFS) ~1000a	39 42 48 54b 56a 58b 68 81 (ecosystems extend beyond USFS boundaries)
L. OSSIPPEE/KILLICK POND (BPR, IFW), ~2000a	16 29 30 33 36 39 42 53
WATERBORO BARRENS (TNC) ~1100a	16 31 33 53 66 77 80 unclassified ponds
MIDDLE POND (BPR) ~1800a	29 30 33 39 48 56a 58b
SEBAGO LAKE (BPR) Songo River floodplain, ~800a	30 36 39 48 73 74a
Region 10	
SWAN I./POWELL (IFW) western half of Swan I., ~500a	30 31 39 42 50 (more information needed)
MARTIN STREAM (IFW) ~195a	39 42 48 49 76 79 (more information needed)
TYLER POND (BPR) ~126a	29 30 60 (ecosystem extends beyond BPR boundaries)
ALONZO GARCELON (IFW) SPECTACLE POND, ~2000a	29 30 46 47 48 49 68 76
LAKE ST.GEORGE (BPR) west of Rt. 3, ~200a	24 30 (more information needed)
Region 11	
GREAT HEATH (BPL) ~4125a	39 54a 54b 56a 65 76 77 81 (ecosystem extends beyond boundaries)
NARRAGUAGUS JCT. (IFW) ~1450a	36 37 39 48 49 73 78 (more information needed)
MOOSEHORN NWR-BARING (USFW) Bearce Pond area, ~2000a	24 29 31 48 56a 58b 59a 68

Site Name and Owner	Ecosystems represented
Region 12	
MT. AGAMENTICUS (IFW) Second, Third Hills and wetlands ~500a	2 21 29 32 39 42 43 44 53 (ecosystems extend beyond IFW boundaries; more information needed)
KENNEBUNK PLAINS (IFW, TNC) ~1000a	11 33 35
RACHEL CARSON NWR/ LAUDHOLM (USFW, BPR) ~500a	16 30 31 39 78 82 86 87 94
RACHEL CARSON NWR (USFW) Brave Boat Harbor, ~400a	30 84 86 94 96
SACO HEATH (TNC) ~465a	44 54b 58b 81 (ecosystem extends beyond TNC boundaries)
Region 13	
MORSE MT/POPHAM BEACH (BATES, BPR), ~400a	2 16 20 26 30 82 84 86 87 94
REID STATE PARK (BPR) along Little River, ~250a	12 17 23 34 82 84 86 87 90 94
JOSEPHINE NEWMAN (MAS) ~120a	20 29 30 39 42 47 80 85 87 89 92a
MUDDY RIVER (IFW, BPR) ~400a	39 45 50
Region 14	
CAMDEN HILLS (BPR) ~1000a	2 4 6 17 20 24 30 34 56a
HURDS POND (IFW-53) ~100a	46 47 48 49 56a 76 68 (more information needed; ecosystem extends beyond IFW boundaries)
HOLBROOK SANCTUARY (BPR) mainland, ~1000a	2 20 24 26 30 34 49

Site Name and Owner	Ecosystems represented
BRANCH LAKE (BPR) ~1200a	29 30 42 59a 61 67
APPLETON BOG (TNC) ~85a	39 42 44 81 (ecosystem extends beyond TNC boundaries)
KNIGHTS POND (TNC) ~300a	24 26 39 42 45 46 48 58b 66
Region 15	
ACADIA (NPS) three separate areas	2 4 6 13 16 17 19 22 26 27 29 33 39 42 45 46 47 48 55 59a 64 68 75 80 84 91 (more information needed)
DONNELL POND (BPL) between Black and Caribou Mts ~2000a	2 17 24 26 34 64 76 80 unclassified lakes (more information needed)
BELLIER COVE/MOOSEHORN - EDMUNDS UNIT (TNC, USFW) ~400a	2 26 85 89 92a (more information needed)
FAIRY HEAD/CUTLER (BPL, MCHT) two separate areas ~2000a	13 17 22 26 35 39 45 48 54b 55 58b 76 81 84 95 (more information needed)
PETIT MANAN (USFW) eastern portion of Point, Bois Bubert Island, ~2000a	2 13 17 19 22 34 39 45 46 47 48 49 51 55 56a 76 83 84 85 89 92a 94 96
EASTERN HEAD (BPR), ~300a	13 22 33 84 85 94 96
GREAT WASS ARCHIPELAGO (TNC), ~1600a	13 19 22 33 39 45 51 54b 55 56a 58b 84 85 89 92a
GREAT DUCK (TNC), ~245a	12 13 22 48 58b 84 91 97
PLACENTIA (TNC), ~500a	22 23 84 (more information needed)
LARRABEE HEATH (TNC) ~150a	23 48 55 (ecosystem extends beyond TNC boundaries)

MAINE ECOSYSTEM CHECKLIST[4]

TERRESTRIAL

Open
1. Serpentine outcrop/bald
2. Acidic/circumneutral outcrop/bald
3. Calcareous outcrop/bald
4. Acidic/circumneutral cliff
5. Calcareous cliff
6. Acidic/circumneutral talus slope/boulderfield
7. Calcareous talus slope/boulderfield
8. Cold-air talus slope/boulderfield
9. Fellfield
10. Alpine meadow/snowbank/headwall
11. Sand barren/grassland

Shrublands
12. Maritime shrubland/rocky headland
13. Boreal shrub-heath headland
14. Alpine krummholz

Woodlands
15. Talus slope/boulderfield woodland
16. Pitch pine barren

Woodlands (con't.)
17. Pine-heath woodland
18. Red pine-heath woodland
19. Jack pine-heath woodland
20. Pine-oak woodland
21. Oak-hickory woodland

Upland Forests
22. Maritime spruce-fir forest
23. Spruce-fir flat
24. Spruce slope forest
25. Subalpine spruce-fir forest
26. Mixed hardwood-spruce-fir forest
27. Northern hardwood forest
28. Cove forest
29. Hemlock forest
30. Red oak/mixed hardwood-hemlock-pine forest
31. Dry oak-pine forest
32. Central hardwood forest
33. Birch-aspen forest

PALUSTRINE

Swamps
34. Coniferous seepage forest
35. Outwash seepage forest
36. Hardwood floodplain forest
37. Coniferous floodplain forest
38. Black willow-alder swamp
39. Shrub swamp
40. High elevation shrub swamp
41. Acidic shrub swamp
42. Red maple-hardwood swamp
43. Tupelo swamp
44. Atlantic white cedar swamp
45. Northern white cedar swamp

Marshes
46. Deep emergent marsh
47. Shallow emergent marsh
48. Sedge meadow

Marshes (con't.)
49. Beaver flowage
50. Tidal fresh marsh & mudflats

Bogs
51. Maritime slope bog
52. Subalpine/alpine slope bog
53. Kettlehole bog
54a. Patterned raised bog
54b. Unpatterned raised bog
55. Coastal plateau bog
56a. Level bog
56b. Semi bog

Fens
57a. Rich patterned fen
57b. Rich patterned fen
58a. Poor unpatterned fen
58b. Rich unpatterned fen

[4] Descriptions of each of these ecosystem types are given in the Appendix.

LACUSTRINE

Shorelines

59a. Acidic/circumneutral rocky shore
59b. Calcareous rocky shore
60. Mud shore/nonpersistent marsh
61. Sand/gravel beach
62. Lakeside seep
63. Cobble shore

Lakes

64. Monomictic oligotrophic lake
65. Monomictic dystrophic lake
66. Monomictic mesotrophic lake
67. Dimictic oligotrophic lake
68. Dimictic mesotrophic lake
69. Meromictic lake

RIVERINE

Riverbanks

70a. Acidic/circumneutral rocky shore
70b. Calcareous rocky shore
71. Riverside seep
72. High energy riverbank
73. Low energy riverbank
74a. Sand and gravel bar
74b. Riverwash barrens

River and Streams

75. Rocky headwater stream
76. Wetland headwater stream
77. Midreach stream
78. Main channel
79. Deadwater
80. Intermittent stream
81. Peatland outlet stream

ESTUARINE AND MARINE

Coastal strand

82. Coastal dunes
83. Fresh-brackish pond

Intertidal

84. High energy rocky shore
85. Low energy rocky shore
86. Back-barrier salt marsh
87. Fluvial-minor salt marsh
88. Fluvial-major salt marsh
89. Bluff-fringing salt marsh
90. Transitional salt marsh
91. Brackish tidal marsh and flats
92a. Mud flat
92b. Mussel bar

Intertidal (con't.)

93a. Sand and gravel flat
93b. Cobble flat
94. Sand beach
95. Gravel beach
96. Cobble beach
97. Boulder beach

Subtidal

98. Salt pond
99a. Mud bottom
99b. Eelgrass meadow
100. Sand and gravel bottom
101. Cobble bottom
102. Rocky bottom

SITE SUMMARY

Site Name: Little Concord Pond
Source: S.C. Gawler

Site Code: BPR-43
Source Code: PNDGAW11MEUS

Survey Area: Southern 1/2 of parcel

Quad: Mt. Zircon 7.5'
Flight Survey Date: 19 Sept. 90

Town: Woodstock
Ground Survey Date: 21 Oct. 90

County: Oxford
Owner/Managing Agency: Parks & Recreation

Biophysical Region: 5

Ecosystem types represented:

northern hardwood forest
(late birch-aspen successional forest)
hemlock forest (w/ pine)
shrub swamp (limited in extent)
dry oak-pine forest
pine-oak woodland
acidic rock outcrop
acidic cliff
talus slope/boulderfield woodland
red maple-hardwood swamp
intermittent stream
dimictic mesotrophic lake
(was stocked w/ brook trout)

General description (geographic setting, landscape position, ecological processes, ecological diversity, unusual species, etc.): Little Concord Pond (1082') is a remote, unspoiled lake surrounded by wooded hills. BPR's ownership includes most of the L. Concord Pond watershed. Most of the lower elevation forest is mid-successional second growth which appears to have been cut w/in the last 40-50 yrs and is now developing into a n. hardwood forest. Ecosystem diversity is high - reflects varied topography. Several forest + woodland types provide good example of the effects of elevation, exposure, and aspect.

Ecological reserve potential (disturbance, ecological diversity, watershed, topographic diversity, surrounding land use, proximity to corridors, etc.): Trail to pond has been used by motorized vehicles (ATV's or 4-W drive); trail to Bald Mt. appears to sustain regular but not heavy hiker use. Quality of site is high. Pond shoreline is undeveloped. Topographic diversity includes not only forested slopes but rocky woodlands, bare ledges, cliffs and talus slope on Bald Mt. Parcel includes most of pond watershed. Adjacent land use appears to be compatible - forest mgmt.

AERIAL SURVEY FORM

Site Name: Little Concord Pond Sources: SG, JM

Site Code: BPR-43

Quad: Mt. Zircon 7.5' Source Codes: PNDGAWIIMEUS

Town: Woodstock

County: Oxford Date: 19 SEPT 90

Biophysical Region: 5 Owner/Managing Agency: BPR

Film Roll(s) and Frame Number(s): Roll 3: 12-21

General description (geographic setting; ecological processes; ecological and physical diversity, etc.):
Remote pond surrounded by wooded hilly terrain. Bald Mt. rises 600+ feet above pond to ESE and has deciduous woods on s. side + conifers on n. side. Spectacular cliff near pond w/ some exposed outcrops. Forests cut fairly recently to north. ± 50 yrs - rest ≥40 yrs or older.

Evidence of human disturbance (timber harvesting, degree of fragmentation, dams, ATVs):
no road access visible from air; no recent timber harvest - lots of birch - forest looks fairly young especially n. of pond.

Threats: none obvious from air

Adjacent Ecosystems: mostly 2nd growth deciduous and mixed woods

Potential Access Points (describe landmarks): hiking trail marked on topo - not visible from air - ~~small~~ place to park near landing on Shagg Pond.

Portion(s) recommended for ground-truthing (describe and attach topo map or aerial photo):
focus on L. Concord P. watershed; determine location of new LMF acquisition; check summit & slopes of Bald Mt.

FIELD SURVEY FORM

Site Name and Code: Little Concord Pond S.C. Gawler 21 Oct. 90

Survey Area: southern ½ of parcel including s. shores of pond

Directions to Site: follow trail (old woods road) from sm. parking area near outlet of Shagg P. Trail is clear to pond; then c. 100' before pond, look for cairn - much smaller side trail to Bald Mt. (trail marked by cairns).

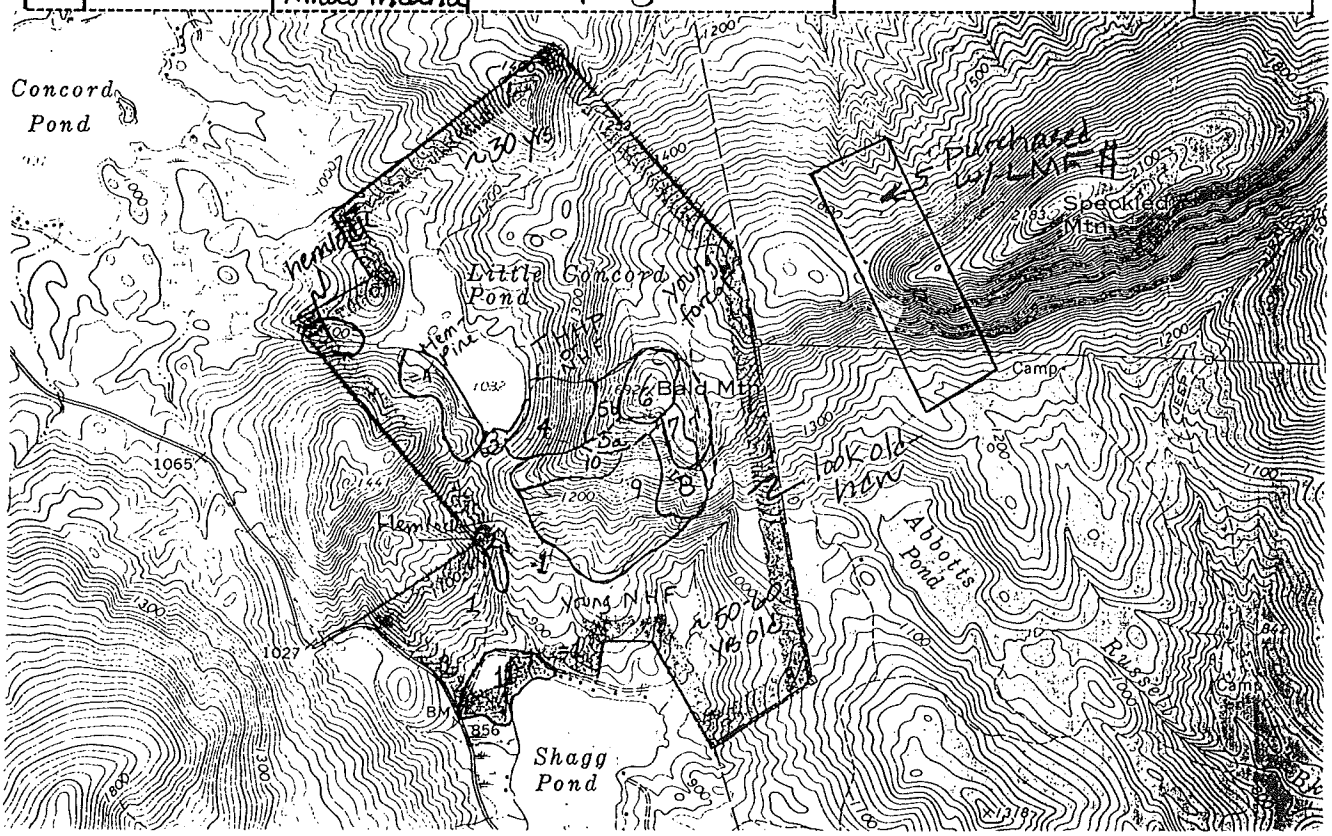
Reconnaissance

Walk through the survey site and stop at various observation points to record changes in vegetation and habitat physiography (i.e., aspect, slope), and general condition. Mark the location of observation points on topo sheet or aerial photo. Continue, if necessary, on additional sheets. List species and the stratum in which they occur on the species list page. Highlight dominant species with an asterisk.

Obs. #	Ecosystem type	Dominant species	General description (physiography, nutrient and moisture regimes, etc.)	Condition (age, evidence of human & natural disturbance, etc.)	Slides
1	former birch-aspen successional forest - succeeding to n. hdw.	Fagus grandifolia Populus grandidentata Acer pensylvanicum Aster acuminatus	SE-facing slope bouldery	woods may be 50 yrs. old Populus up to 20" dbh Fagus up to 18" DBH though most stems much smaller (6-10")	✓
2	Hemlock forest	Tsuga canadensis Viburnum alnifolia Lycopodium lucidulum Gaultheria procumbens	Only along brookside Moderate to steep slopes bouldery, with some extensive bedrock outcrops	Trees not large - previously logged; little current disturbance except along trail (ATV's)	✓
3	Shrub swamp	Alnus incana Acer rubrum Ilex verticillata	Pond shore, not including upland hemlock/pine forest (#2). Narrow zone around perimeter of pond - flat, wet, no standing water in most places, veg. goes to pond shore.	Apparently undisturbed except by trail that runs to pond shore	✓

Obs. #	Ecosystem type	Dominant species	General description (physiography, nutrient and moisture regimes, etc.)	Condition (age, evidence of human & natural disturbance, etc.)	Slides
4	Hemlock forest w/ pine	Pinus strobus Tsuga canadensis Vaccinium angustifolium	steep NW-facing shore of pond, up side of Bald Mt. (some occurs on NE-facing shore) Dense canopy, no herb layer, few shrubs rocky, some tip-ups	few stumps but trees not large (hemlocks ~14" DBH; pines c. 22") Some decaying birches on ground.	too dark
5 a	pine-oak woodland	Quercus rubra Pinus strobus Diervilla lonicera	S-facing slope looking toward Shagg P., elev c. 1500', canopy ≈ 75% trees ~30' tall on ledge fallen on protected spots w/ Fagus	No stumps, many fallen (snapped) trees	shot 1 looks S shot 2 looks E.
b	Northern hardwood forest	Acer pensylvanicum A. saccharum Fagus grandifolia	on W-facing slope – ledgy		
6	pine-oak woodland	Quercus rubra Prunus virginiana Dryopteris marginalis	Ledgy woodland-like summit, Quercus grows to 40', elev. 1700'; dry; diverse shrub herb layers	no evidence of recent disturbance. Hiking trail bypasses this summit, heading to ledges to east.	Geranium + 2 following shots
7	acidic rocky outcrop (summit)	Quercus rubra Picea rubens Vaccinium angustifolium Pteridium aquilinum only	Open ledges on top of SW-facing cliffs. Canopy very sparse; few stunted trees; mostly dry except few moist pockets Grades into oak-spruce forest, E-SE flanks oaks reach 14" dbh, spruce 10"	Little disturbance - hiking trail labelled 7 on map	
8	working downhill acidic cliff, then talus slope/ boulderfield woodland	Betula papyrifera Quercus rubra Picea rubens Diervilla lonicera Polypodium virginianum	wooded talus slop at base of SSW-facing cliff. Dry. Slope ≈ 30°	no sign of human disturbance	

Obs. #	Ecosystem type	Dominant species	General description (physiography, nutrient and moisture regimes, etc.)	Condition (age, evidence of human & natural disturbance, etc.)	Slides
9	dry oak-pine forest (mostly oak)	Quercus rubra (canopy) Fagus (sub-canopy) Acer pensylvanicum Solidago arguta Dryopteris marginalis	SW-facing slope, c. 20°, rocky, dry elev. ~1400' canopy closed beech drops out as you move w. thru forest + pine becomes more common. but herb layer fairly sparse	oak quite uniform in size - most 14-18" dbh fallen trees frequent (but not enough to make going difficult)	✓
10	dry oak-pine forest	Quercus rubra Pinus strobus Deschampsia flexuosa Gaultheria procumbens Acer pensylvanicum	W. flank of Bald Mt., oak + pine co-dominant, bouldry terrain, ~ 20° slope; canopy closed Trees become stunted as you go uphill - resembles obs. 5	most trees < 14" dbh, no stumps visible	
11	red maple-hardwood swamp	Acer rubrum Calamagrostis canadensis Rubus hispidus Osmunda cinnamomea Ilex verticillata Alnus incana	floodplain on n. shore of Shagg Pond flat, mostly above water table (this yr.) except drainage rivulets small amt. of Sphagnum	no cut stumps seen, though some well-rotted stumps by lakeshore. Looks like little if any current disturbance	



SPECIES LIST

NOTE: C = canopy S = shrub layer
SC = subcanopy H = herb layer

* means species was dominant at that obs. point.

Obs. #	Stratum	Species
1	C	Fagus grandifolia *
1	C	Betula papyrifera
1	C	Populus grandidentata *
1	C	Quercus rubra
1	C	Acer saccharum
1	SC	Tsuga canadensis
1	SC-C	Acer pensylvanicum *
1	H	Aster acuminatus *
1	H	Mitchella repens
1-2	H	Polypodium virginiana
2	S	Diervilla lonicera
2	S	Viburnum alnifolium *
2	S	Acer pensylvanicum
2	C	Fagus grandifolia
2	C	Tsuga canadensis
2	C	Quercus rubra
2	H	Lycopodium lucidulum *
2	H	Gaultheria procumbens *
2	H	Epifagus virginiana
2	H	Dryopteris intermedia
2	H	Coptis groenlandica
2	H	Cornus canadensis
2	S	Vaccinium angustifolium } by brook
2	S	Viburnum cassinoides } by brook
2	S	Ilex verticillata (by brook)
2	S	Alnus incana
2-3	H	Dryopteris marginalis
2-3	S	Taxus canadensis * locally
2-3	C	Picea rubens
2-3	S	Acer spicatum
2-3	C	Betula alleghaniensis
3	S	Alnus incana *
3	S	Acer rubrum *
3	S	Spiraea latifolia
3	S	Ilex verticillata
3	S	Salix sp. (no herbs were recorded at 3)
4	C	Tsuga canadensis *
4	C	Pinus strobus *
4	C	Picea rubens
4	SC	Abies balsamea
4	S	Vaccinium angustifolium *
4	S	Viburnum cassinoides
4	S	Acer pensylvanicum
4	SC	Quercus rubra (infrequent)
4	S	Kalmia angustifolia
4	S	Gaultheria procumbens
4-5	H	Polypodium virginianum
4-5	C	Pinus resinosa

Obs. #	Stratum	Species	Obs. #	Stratum	Species
4-5	H	Dryopteris intermedia	6	H	Geranium robertianum
5	C	Quercus rubra*	6	H	Polygonum cilinode
5	SC	Pinus strobus*	6	H	Solidago rugosa
5	S	Acer pensylvanicum*	6	S	Rubus idaeus
5	H	Deschampsia flexuosa*	6	SC	Prunus serotina
5	H	Dryopteris marginalis	6	S	Prunus virginiana*
5	S	Diervilla lonicera*	6	S	Crataegus sp.
6	H	Aster macrophyllus	6	S	Sambucus pubens
5	S	Prunus virginiana	6	C	Pinus strobus (N side)
5	S	Vaccinium myrtilloides	6	S	Acer pensylvanicum
5	H	Cornus canadensis	6	C	Acer rubrum
5	S	Rubus allegheniensis (uncommon)	7	C	Quercus rubra* } edges of
5	H	Aster acuminatus	7	C	Picea rubens* } bare lesages
5	C	Fagus grandifolia } protected microsites, esp. N slope	7	S	Aronia prunifolia
5	C	Picea rubens	7	C	Betula papyrifera
5	C	~~Picea rubens~~ Tsuga canadensis	7	H	Solidago puberula
6	C	Tsuga canadensis	7	C	Pinus strobus
5	C	Acer saccharum	7	S	Diervilla lonicera
5	H	Dryopteris intermedia	7-8	S	Viburnum cassinoides
5	C	Betula papyrifera (N slope)	7-8	S	Kalmia angustifolia } in small moist pockets
5-6	H	Solidago bicolor	7-8	S	Rhododendron canadensis
6-6	H	Solidago cf. caesia	7-8	H	Gaultheria procumbens
5-6	H	Polygonum cilinode	7-8	S	Nemopanthus mucronata
5-6	SC	Prunus serotina	7-8	S	Gaylussacia baccata
6	C	Quercus rubra*	7-8	S	Sorbus americana
6	H	Dryopteris marginalis*	7-8	H	Pteridium aquilinum
6	C	Acer saccharum	8	C	Quercus rubra*

Obs. #	Stratum	Species	Obs. #	Stratum	Species
8	C	Betula papyrifera*	9	H	Solidago arguta*
8	SC	Picea rubens	9	C	Acer rubrum
8	S	Fagus grandifolia	9	C	Picea rubens
8	S	Vaccinium angustifolium	9	H	Dryopteris marginalis*
8	SC	Acer saccharum- infrequent	9	S	Pinus strobus
8	S	Diervilla lonicera*	9	H	Polystichum agrosticoides
8	C	Populus grandidentata	9	H	Polypodium virginianum
8	H	Polypodium virginianum*	9	H	Aster macrophyllus
8	S	Acer pensylvanicum	9-10	H	Polygonatum pubescens
8	S	Acer rubrum	9-10	S	Viburnum acerifolium
8	H	Solidago bicolor	9-10	S	Viburnum cassinoides
8	H	Dryopteris marginalis	9-10	S	Prunus serotina
8	S	Spiraea latifolia	9-10	S	Diervilla lonicera
8	S	Alnus crispa var. mollis	9-10	H	Pteridium aquilinum
8-9	H	Dennstaedtia punctiloba	9-10	S	Prunus virginiana
8-9	S	Sorbus americana	9-10	C	Picea rubens
8-9	H	Pteridium aquilinum	9-10	S	Vaccinium angustifolium
8-9	H	Polypodium virginianum	9-10	H	Solidago rugosa
8-9	C	Acer rubrum	9-10	H	Fragaria virginiana
8-9	S	Acer spicatum	9-10	H	Agropyron trachycaulum
8-9	H	Polygonum cilinode	9-10	H	Deschampsia flexuosa
9	C	Quercus rubra*	9-10	H	Achillaea millefolium
9	SC	Fagus grandifolia*	9-10	C	Fraxinus pennsylvanica (infreq.)
9	SC	Acer saccharum	10	C	Quercus rubra*
9	SC	Acer pensylvanicum*	10	C	Pinus strobus*
9	SC	Ostrya virginiana	10	SC	Picea rubens
9	H	Aster acuminatus	10	SC	Acer pensylvanicum*

9-10 like #5 oak woodla variation

Obs. #	Stratum	Species	Obs. #	Stratum	Species
10	C	Fraxinus pennsylvanica (wet spots only)	11	S	Pinus strabus - uncommon
10	H	Pteridium aquilinum	11	H	Rubus hispidus*
10	S	Prunus serotina	~11	H	Carex spp. (vegetative)
10	S	Vaccinium myrtilloides	11	S	Spiraea latifolia
10	H	Gaultheria procumbens*	11	S	Viburnum recognitum
10	S	Prunus virginiana	H	H	Iris versicolor
10	H	Solidago bicolor	11	C	Betula papyrifera - infreq.
10	H	Deschampsia flexuosa*			
10	H	Aster macrophyllus			
10	S	Acer rubrum			
10	S	Vaccinium angustifolium			
10	S	Diervilla lonicera			
10	H	Dryopteris marginalis			
10	H	Solidago rugosa			
11	C	Acer rubrum*			
11	C	Betula alleghaniensis (on hummocks)			
11	C	Fraxinus pensylvanica			
11	H	Calamagrostis canadensis*			
11	H	Osmunda cinnamomea*			
11	H	Thalictrum polygonum			
11	S	Viburnum cassinoides (co-dominant @ upland border)			
11	S	Ilex verticillata*			
11	S	Alnus incana* in wettest spots			
11	SC	Abies balsamea - accessional			
11	S	Tsuga canadensis			
11	S	Fagus grandifolia			
11	S	Vaccinium corymbosum			

CHAPTER 4: DESIGNING THE SYSTEM

THE SYSTEM AS A WHOLE

The first step in creating an ecological reserves system is to decide which natural areas in the landscape to propose as ecological reserves. Through the study inventory, this process was about half completed -- roughly 45% of Maine's ecosystem types are currently represented on public and private conservation lands. To fill in the gaps of a complete ecological reserves system, additional inventory work would need to be conducted on private landholdings. By clearly showing which ecosystem types are adequately represented and which are not, the ecosystem classification and matrices provide a blueprint for this next generation of inventory work.

Identifying characteristic ecosystems is only the first step in designing an ecological reserves system. Although the inventory results show that nearly half of Maine's ecosystem types occur on conservation ownerships, their protection is not assured. Many of these lands are managed for specific species rather than the ecosystem as a whole or for purposes that may not be compatible with the objectives of an ecological reserve. For example, many of the forest ecosystems identified during the inventory will be harvested within five years if current management plans are followed. Two other important facets of ecological reserve system design include an assessment of (1) the condition and viability of the reserve (what is inside the specified boundaries of a given reserve) and (2) the landscape context (the compatibility of land uses outside of the reserve). Because their value as benchmarks is so fundamental to the ecological reserves concept, designing individual reserves to be viable over the long term is essential. This requires a shift in the way conservationists and others have traditionally viewed reserves.

DESIGNING FOR THE FUTURE

Scientists have long recognized that ecosystems are dynamic, changing entities and that natural disturbance is as much a part of an ecosystem as the plants and animals within it. The traditional view of succession holds that disturbance is followed by the replacement in time of one community by another. However, in recent years, the theory that communities eventually reach a balance (climax) with their environment has been challenged. The paleoecological record reveals that communities are in fact not constant over time. Instead, the composition of communities is constantly changing as species individualistically shift their geographic ranges in response to climate change. For example, the ranges of beech and hemlock, which are currently dominants in the northern hardwood forest, used to be hundreds of miles apart. The northern hardwood forest as we know it did not exist (Jacobson et al. 1987).

Given the prospect of global warming, the discovery that communities are ephemeral during periods of rapid climate change is forcing conservationists and natural resource managers to reevaluate the effectiveness of reserves designed to maintain species assemblages as they exist today. Because the projected rate of climate change is unprecedented, it is not known if species

will be able to migrate quickly enough to keep up with the climatic conditions that they require for survival. Perhaps more importantly, fragmentation of the land surrounding reserves due to urbanization, silviculture, and agriculture present barriers to migration that did not exist before. Because of these scenarios, reserve design needs to occur within a landscape context. Ideally, factors such as topographic and habitat diversity within reserves and, where possible, corridors between reserves (to allow species room to move in response to climate and other environmental changes) need to be integrated into the overall design of the system. Ecological reserves can be viewed as dynamic landscapes that are selected to support the greatest diversity of species and communities even though the actual species composition of a given reserve may change over time (Hunter et al. 1988).

DESIGN OF INDIVIDUAL RESERVES

A variety of factors will enhance the value of a site selected to represent one or more ecosystem types. These can be used to refine the list of potential sites identified during the inventory and as general criteria for "building" an ecological reserve that is likely to be viable over time. They can also be used to set priorities when there is more than one qualified candidate of an ecosystem type in a biophysical region. Factors to consider are summarized below:

1. **Ecological diversity** - the greater the variety of ecosystem types, the greater the biological diversity of a site. Including several ecosystems in each reserve will reduce the total number needed to complete the system. The resulting reserves system would be easier to manage than one composed of hundreds of single ecosystem reserves.

2. **Physiographic diversity** - the greater the physiographic diversity (landforms and topography) the higher the value of the site. The factors that define physical environments such as slope, aspect, altitudinal gradients, soil characteristics, and geological features are enduring characteristics that are of critical importance in determining the suitability of habitat to an organism. Serpentine bedrock in Maine, for example, supports unique floristic assemblages that are distinct from plant communities on other rock types in similar climatic regions (Colnes 1989). Reserves encompassing hills and valleys will have more microsites and microclimates, which will result in greater species diversity, more resilience to disturbance, and room for species to migrate in response to climate and other environmental changes.

3. **Naturalness (degree of human disturbance)** - the goal is to include sites that are as undisturbed by human activities as possible. The less disturbed a site, the greater its value as a benchmark. For ecosystems with few occurrences, the amount of disturbance considered acceptable would be greater.

4. **Size** - all else remaining the same, large areas are always more valuable for conservation than small areas (Noss 1987b). Not only are larger reserves likely to contain more species, but species populations will be larger and, as a result, less vulnerable to extinction. In addition, large reserves can provide their own buffering against certain kinds of disturbance -- human and otherwise -- resulting in lower management costs over

the long term. Ideally, a reserve should be large enough to encompass a minimum dynamic area which is defined as "the smallest area with a natural disturbance regime" (Noss 1987b). While few if any natural areas are this large, a system of natural areas, interconnected with each other and integrated with the land use of the surrounding landscape, may provide some of the functions of a minimum dynamic area, such as recolonization sources, gene flow, a mix of habitats in the system as a whole, and alternative habitats for species to escape natural enemies and disturbance episodes. This minimum dynamic area can be expected to vary with ecosystem type. For example, the scale and frequency of disturbance in forests will be very different from those in a peatland. In addition, these disturbance regimes may vary regionally. The size of patches created by windthrow in spruce-fir forest ecosystems, for example, varies in different parts of the state (Hunter 1990).

5. **Proximity to corridors and other conservation ownerships** - the problems of habitat isolation that arise from fragmentation can be mitigated by connecting natural areas by corridors or zones of suitable habitat. An archipelago of isolated reserves can be transformed by corridors into a larger functional unit. This will facilitate movement of species in response to environmental change. Reserve design should include an evaluation of riparian strips, coastal strips, ridge systems, trail systems such as the Appalachian Trail, and other landscape features as potential corridors to functionally interconnect isolated natural areas.

6. **Hydrologic considerations** - intact watersheds will be more viable in the long term than fragmented watersheds. From an environmental monitoring standpoint, aquatic ecosystems are invaluable. The biotic and chemical composition of lakes, ponds, rivers, or coastal waters provide important information about the ecosystems they drain. Because lakes, rivers, estuaries, and marine ecosystems are less well characterized than terrestrial and palustrine systems, it will be more difficult to ensure that the wide range of diversity within these ecosystems is included in the reserve system. Including water bodies within reserves wherever possible would increase the scientific potential, the landscape diversity, and the species diversity of a reserve. In addition, the ecological diversity of the reserves system as a whole would be greater.

7. **Location with respect to the geographic range limit of an ecosystem type** - ecosystems at the edge of their range are more sensitive to environmental stress and as a result will be responsive indicators of environmental change. Alpine areas, for example, are extremely sensitive to the effects of acid precipitation (Mosello and Tartari 1983, Colnes 1989).

8. **Presence of rare species or species with restricted distributions** - the presence of rare or disjunct species increase the overall diversity of a reserve. In addition, species with range boundaries in the state, like the ecosystems described above, can provide early warning signals of environmental change.

9. **Current and proposed use by existing landowner or managing agency** - a frank evaluation of existing and proposed management practices would be needed before a site can be recommended as an ecological reserve. A question that would need to be

answered is whether a functioning ecological reserve can be integrated into the management plan for the landholding as a whole.

10. **Compatibility of surrounding land use** - a reserve surrounded by a compatible land use would be more viable over the long term than one that is not. For example, a forest ecosystem surrounded by commercial forestland will be more viable than a forest surrounded by agricultural fields or housing subdivisions. A reserve will have more integrity if it is adequately buffered from intensive land use, alien and domesticated plants and animals, pollution, and, in the case of forested ecosystems, increased wind and insolation.

11. **Appropriate boundaries** - reserve boundaries should follow natural ecological boundaries where possible and, to reduce the potential impacts of surrounding land uses, the amount of edge should be minimized. Legal boundaries should be designed to comprise intact ecosystems and maintain ecological processes.

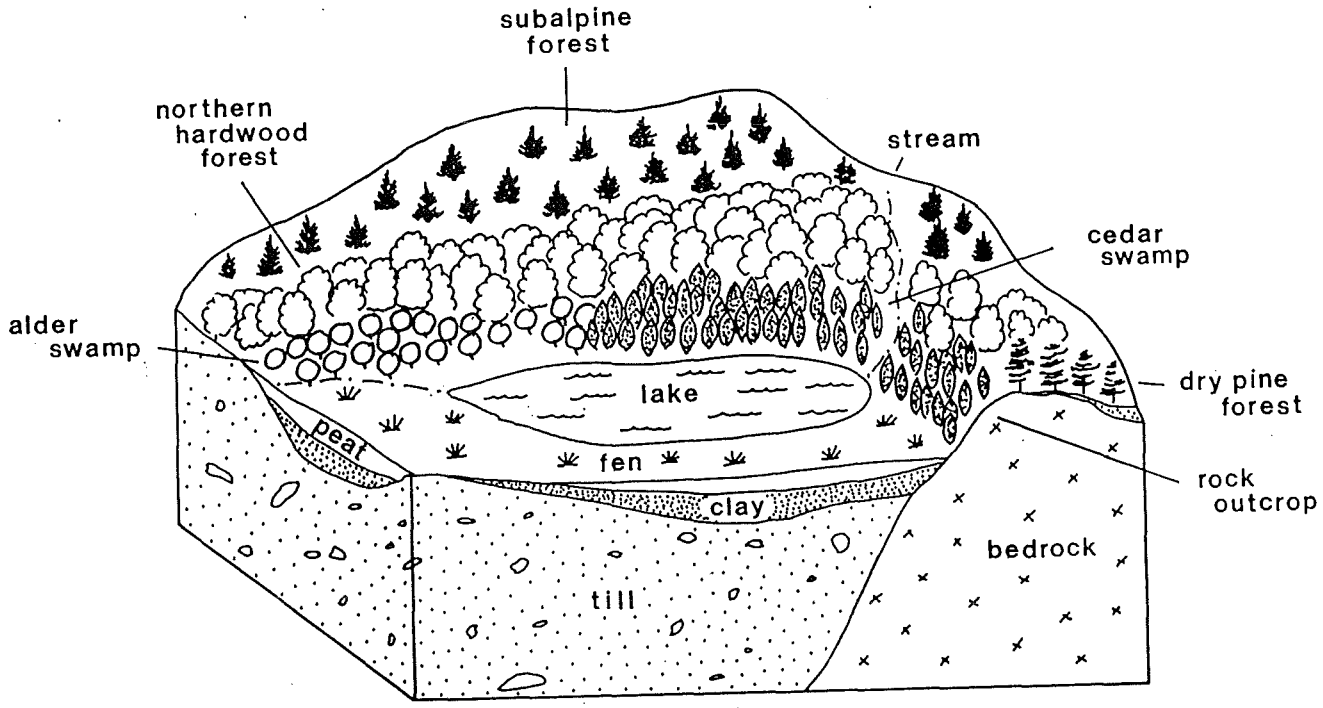


Figure 2. A reserve can be viewed as a piece of the landscape designed to contain a high degree of ecological and physiographic diversity. This hypothetical reserve has eight different ecosystem types. It is designed to include the watershed surrounding the lake and wetland at its center.

LITTLE CONCORD POND - A CASE STUDY

In Maine, where the landscape varies considerably from north to south, a case by case approach to reserve design is appropriate. In most cases, it would be possible to design reserves so that their constituent ecosystems can remain intact over time. In other cases, the best examples of an ecosystem may be small, relatively disturbed, and affected by surrounding land uses. Nevertheless, these remnant ecosystems are important components of the state's biological diversity, and examples could be considered for inclusion in a reserve system even if other design criteria can not be met. In these cases, reserve design will, of necessity, focus on what is inside the reserve boundaries. On large landholdings that contain intact ecosystems, reserve design can be more flexible and it should be possible to integrate many of the recommendations discussed in the preceding pages. Little Concord Pond is used as a case study because it lies somewhere between these two scenarios. Of the sites with potential to be ecological reserves, it is intermediate in both size and diversity. In addition, the amount of survey information collected reflects the level of detail achieved during the inventory. The purpose of this section of the report is to paint a picture of what an ecological reserve might look like using actual inventory data and design criteria. The survey forms for Little Concord Pond were used as examples in Chapter 3 (pages 36-44). They contain specific information on the ecosystem types and species composition of the parcel and were used as the basis for the following analysis.

General Description

Little Concord Pond is a 561 acre parcel owned by the Bureau of Parks and Recreation. It is located in Oxford County in biophysical region 5 (Western Mountains). The pond, and at least parts of all of the hills surrounding it, are included within the Bureau's ownership. From a topographic perspective, the area is diverse. The pond lies at an elevation of 1082 feet. The surrounding uplands rise up to 600 feet above it and a dramatic 200 foot cliff occurs to the southeast. This topographic diversity is reflected in the ecological diversity of the area. The mosaic of ecosystems comprising the Little Concord Pond watershed include the pond itself, several forest and woodland types ranging in age from 30 to more than 80 years, a red maple swamp, intermittent streams, and bare ledges and cliffs. In all, at least ten different ecosystem types occur on the parcel. The varied terrain results in the juxtaposition of forest types typical of the southern half of the state (oak and pine) with those characteristic of northern Maine (northern hardwoods). Together the forests and woodlands provide an excellent example of the effects of elevation, exposure, and aspect.

The parcel is remote and, as a result, human disturbance is minimal. Access is limited to an old haul road now used as a trail. A cabin that once stood at the southern end of the pond has been removed. Many of the lower elevation forest stands were selectively cut between 30 and 60 years ago and less disturbed examples of several forest ecosystem types exist in other portions of Region 5. The higher elevation stands and hemlock ravines are excellent examples of their types. The current boundaries of the parcel encompass almost the entire watershed of Little Concord Pond. The pond has been stocked with brook trout (a native species) in the past.

Design Considerations

From the standpoint of ecosystem and physiographic diversity, the Little Concord Pond parcel would make an excellent ecological reserve. The ten ecosystem types identified during the inventory include the only examples of a dry oak-pine forest and oak-pine woodland in Region 5. Most of the parcel's ecosystems are relatively undisturbed. The forest stands that have been harvested were done so selectively and no permanent roads were constructed. The current boundaries include most of the Little Concord Pond watershed, and as a result, the pond and surrounding slopes are well buffered from external land uses. To completely enclose the watershed, the boundaries would need to be extended to the summit of the hill that flanks the western edge of the pond. The piece of land separating the Little Concord Pond parcel from a lot on Speckled Mountain, which was recently acquired by the Bureau of Parks and Recreation (see Fig. 3a), would provide further protection to the pond and surrounding ecosystems.

Management Considerations

Little Concord Pond has remained relatively unchanged since it was acquired by the Bureau of Parks and Recreation in the mid-1970's. A timber stand improvement plan was prepared in 1978 in compliance with a deed restriction that requires such a plan to be developed on a regular basis for a 105 acre parcel in the northeastern portion of BPR's ownership. No timber harvesting has occurred since the parcel was acquired by the Bureau. It may be necessary to exclude this tract if timber harvesting is feasible since it would not be consistent with a functioning ecological reserve. Or perhaps, timber rights in the 105 acre tract could be exchanged for rights to cut outside of the core reserve area (see Fig. 3a). In either case, the land could be managed in a way that would buffer the adjacent ecosystems.

Most of the adjacent land is commercial forest land. Management to date has not been intensive (for example, clearcuts and herbicides have not been used). If current silvicultural methods continue, the abutting lands would provide further buffering of the Little Concord Pond parcel.

The area is not heavily used. Maintaining a single access point (the old haul road) for foot access would keep maintenance costs low and minimize disturbance to forest and pond ecosystems. There is currently no other access to the interior of the tract.

Three Scenarios for a Reserve Design

1) In the short term, the current Bureau of Parks and Recreation boundaries (Fig. 3a) would adequately protect most of the ecosystems within the Little Concord Pond parcel. Existing land use (timber management) in remaining portions of the watershed has not been intensive and at the current time acts as a buffer to the pond and lower elevation forest ecosystems. However, this protection is not ensured over the long term. If timber harvesting in the hatched area shown in Fig. 3a is economically feasible, a harvest plan could be designed to buffer the ecosystems immediately adjacent to the pond.

2) Fig. 3b shows the natural boundary of the Little Concord Pond watershed with the current boundaries of the Bureau of Parks and Recreation ownerships overlaid. This is the core

of a viable reserve. The watershed boundaries follow natural contours and ecosystem boundaries, and, as a result, are convoluted. This produces a longer boundary that results in a large amount of edge habitat. This would be a handicap if the surrounding lands were developed into an incompatible land use.

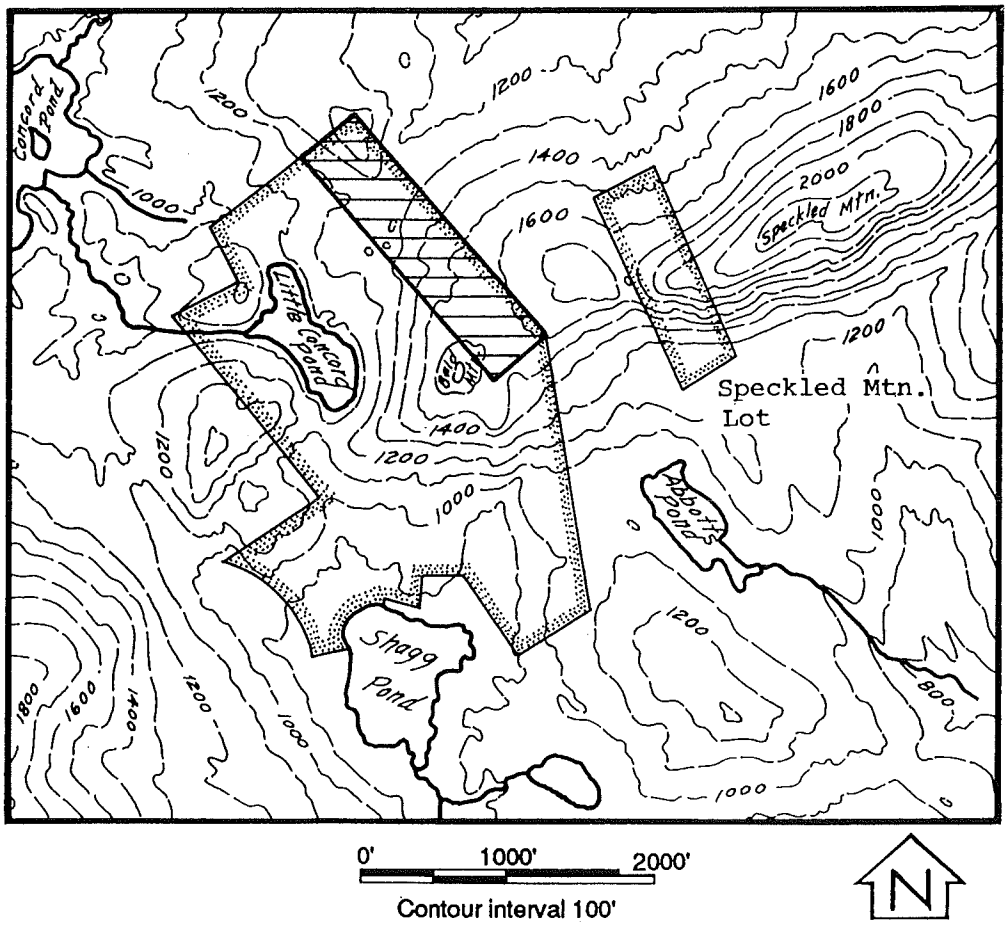
3) The third figure shows a more realistic boundary design that would encompass the entire core area shown in Fig. 3b. The lines are straight and easily identified. They tend to connect or extend existing BPR boundaries. The final design would need to hinge on the actual boundaries of the abutting landowners.

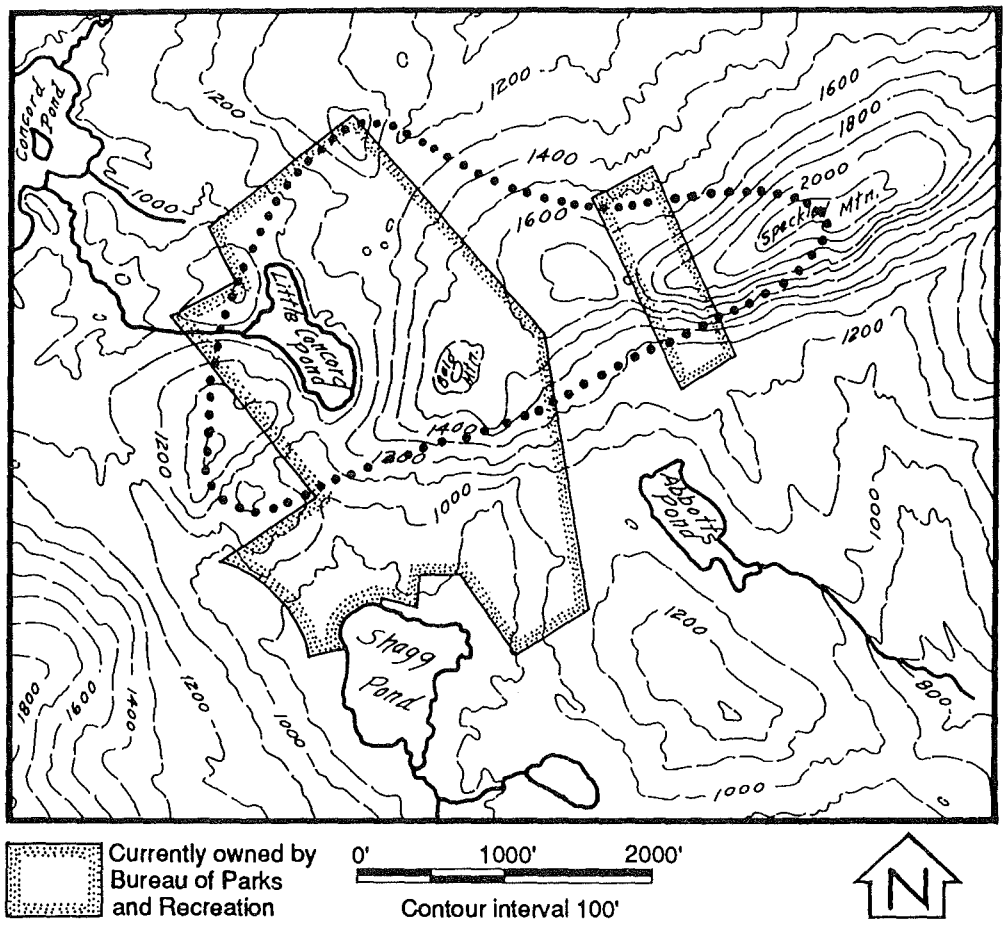
Figure 3A

Legend

Currently owned by Bureau of Parks and Recreation

Timber management deed restriction





Currently owned by Bureau of Parks and Recreation

0' 1000' 2000'

Contour interval 100'

N

Figure 3B

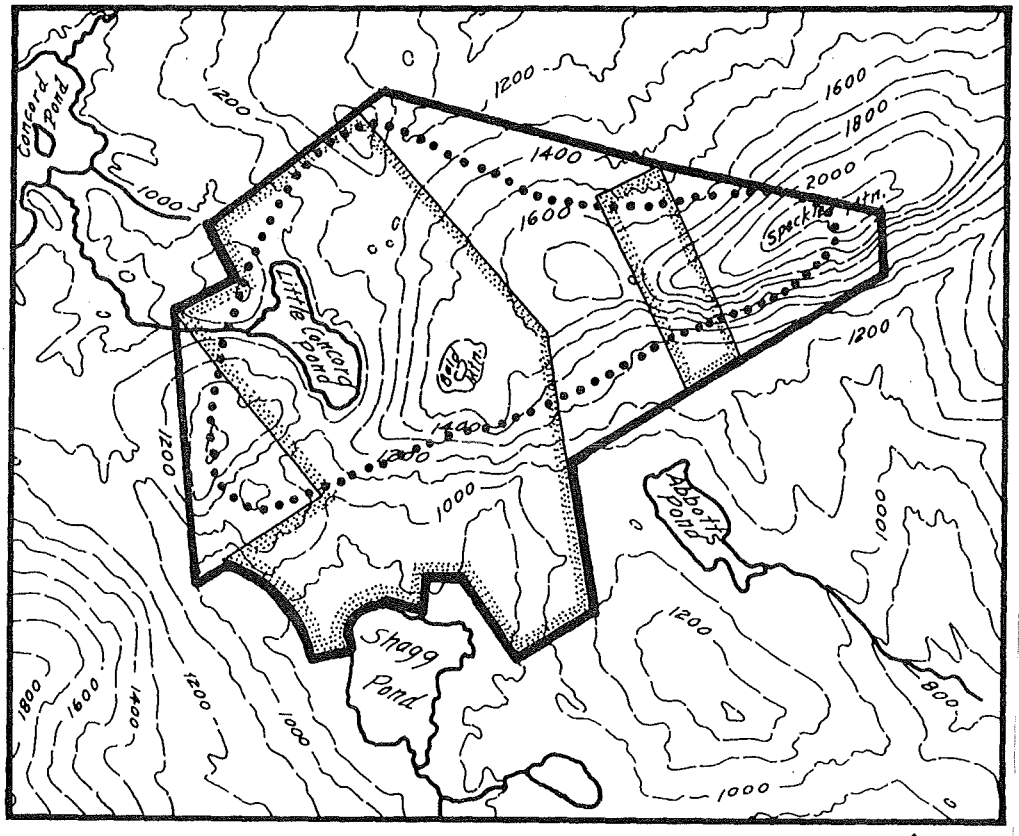
Legend

Little Concord Pond watershed

Figure 3C

Legend

Hypothetical boundary of idealized cological reserve



Currently owned by Bureau of Parks and Recreation

0' 1000' 2000'

Contour interval 100'

N

Remaining Questions

A number of steps would be needed before a reserve design for Little Concord Pond could be finalized. First, the portions of the parcel that were not visited in the field would need to be ground-truthed to determine if other ecosystem types are present, their boundaries, and their condition. Second, the deed restriction requiring regular timber stand improvement for the northeastern portion of the parcel needs to be carefully evaluated to determine whether harvesting is feasible. Portions of this tract are steep and unproductive. Third, boundaries of surrounding ownerships would need to be determined. Their location would guide any future acquisition efforts to complete the Little Concord Pond watershed. These first three pieces of information would be used to delineate the core reserve, the buffer zones needed to protect it, and the optimal boundaries for the Little Concord Pond tract. Finally, ecological reserves staff would need to work closely with Bureau of Parks and Recreation staff to develop management guidelines and incorporate these into an instrument of dedication that would provide appropriate long-term protection to the site.

CHAPTER 5: IMPLEMENTING THE SYSTEM

Establishing an ecological reserves system will involve several steps. Once areas with potential as ecological reserves have been identified and actual reserve boundaries have been delineated, protection and management strategies will need to be developed. Ecological reserves staff will need to work with the appropriate managing agency or organization to determine the best way to actually protect, monitor, and use each reserve. A second important component of protection is stewardship -- actually taking care of the reserve. This usually involves the preparation of a management plan that spells out in detail what is in the reserve, how it should be used, and how it should be managed.

Obviously, there will be a large amount of work involved in establishing even one reserve. Along with the chapters on inventory and design, the information in the following two sections of this chapter should provide a good indication of the work that would be needed to design and establish an ecological reserves system. The second half of the chapter focuses on the resources that would be needed to actually carry this work out (i.e., how many people, what programs could help, and so on).

STRATEGIES FOR PROTECTING ECOLOGICAL RESERVES

A variety of techniques have been used to establish reserves in the United States. The most widely used include (1) landowner notification and registration, (2) management agreements and leases, (3) designation by public agencies, (4) public agency regulations, (5) conservation easements, (6) fee acquisition, and (7) dedication (Cochrane 1986). Each of these strategies is described below. Dedication is described last, and in greater detail, because of its widespread use as an enduring, legally binding protection technique on publicly owned land. Because ecological reserves will generally be larger than the areas typically protected in state natural area systems, and because an important goal is to use representative ecosystems for long-term monitoring and research, strategies that offer permanent legal protection would make the most sense for ecological reserves in Maine.

1. **Notification and registration**. Notification and registration are protection tools that typically occur together. Landowners are told that an important natural feature occurs on their property. The intent is that once a landowner becomes aware of such an occurrence, a personal interest will develop that may result in landowner protection of the feature. Registration is accomplished by placing the location of the feature on a registry or list. The National Register of Historic Places and the National Register of Natural Landmarks are examples of formal registers on which both public and private property may be listed. The Maine Critical Areas Program combines notification and registration. However, unlike registries in many other states, registration does not require a written protection agreement between the Critical Areas Program and the landowner. Any protection that may result is obviously tenuous and temporary in nature. Landowner education and routine monitoring of critical areas or any other natural area is essential to ensure that they are in fact being protected.

2. **Management agreements and leases.** Management agreements are contracts with landowners that obligate the landowner to manage the property in a mutually agreeable manner for a fixed period of time. Leases essentially describe rental agreements. Under a lease, a rent is paid and temporary possession of property is legally conveyed in a deed. Exclusive rights of access to the property for a specific period of time are generally conveyed. These two forms of protection require a commitment from a landowner, but do not permanently restrict the deed to the property. As a result, they can not be used to permanently protect a reserve. However, they could be useful in the short term because their preparation involves less time and effort than more permanent forms of protection such as conservation easements and dedications.

3. **Designation by public agencies.** Most lands held by public agencies in Maine are used for recreation, forestry, and wildlife management. Agencies with jurisdiction over these public lands can designate or set aside acreage for specific purposes through their own administrative processes. Since designation is created administratively, it has no force of law, although it can provide significant protection to an area. For example, sites designated as special protection by the Bureau of Public Lands are usually withdrawn from uses that would conflict with natural area protection. The administering agency has the power to withdraw a specific designation.

4. **Public agency regulations.** State and federal agencies operate under regulatory powers embodied in acts of Congress, executive orders, statewide gubernatorial and legislative orders, permit processes, and condemnation procedures. These regulations can ensure that certain conservation objectives are met before permits for development are given. For example, the Endangered Species Act requires direct protection of listed species on federal lands. Some states have their own acts that require similar protection of state endangered species or natural areas on state lands. In Maine, for example, the habitat of the bald eagle and other endangered animals can be legally protected. Similar legislation does not exist for the state's endangered plants.

5. **Conservation easements.** Conservation easements are restrictions that landowners (or managing agencies) place on their property voluntarily or for a price. These restrictions are legally binding on present and future owners (Hoose 1981). Conservation agencies or private organizations can ensure protection of natural areas by acquiring the rights of an owner or agency that are incompatible with protection of the site. Donating privately owned land for conservation easements can freeze a property's tax classification, reduce taxable value of the gross estate, and entitle the donor to an income tax deduction equal to the fair market value of the easement. The most common arrangement in Maine is for a conservation organization or state agency to hold a conservation easement on privately owned land.

6. **Fee acquisition.** Fee acquisition is the purchase of an area in fee simple, which includes all the rights that come with the maximum degree of ownership permitted in the area in which the property is located. Acquisition by an entity that could hold land as an ecological reserve would be an effective protection method, as it assures the greatest degree of control over the property. In Maine, however, no state agency currently holds land to preserve the integrity of entire ecosystems.

7. **Dedication.** Dedication is the placement of a natural area into a legally established system of reserves whose member properties are protected by strong statutory language against condemnation or conversion to a different use. Enabling legislation that authorizes a program to

develop articles of dedication usually occurs in tandem with the establishment of a statewide reserves system. These reserves systems are usually administered and managed by a state agency. To date, at least 14 states use dedication as a land protection tool. The concept is especially well established in the Midwest, where there are several comprehensive nature reserves systems.

How dedication works

According to common law, a dedication is the deliberate commitment of land to a specified public use by the owner or managing agency (Pearsall 1984). Landowners can dedicate specific interests in property as well as full fee title into a reserve system. As with a conservation easement, specific terms of the arrangement can be tailored to the needs of individual reserves and landowners. These terms are described in "articles" or "instruments" of dedication, which are recorded with the clerk of the county in which the land is located (Hoose 1981). It is considered by many to be the most powerful of the protection strategies described because it gives any member of the public legal standing to take the state to court if the provisions written into an instrument of dedication are not upheld (Hoose 1981).

Dedications can be created in the three ways. (1) Private landowners may sell or donate land or an easement to a public agency with language in the deed specifying that the land is to be used now and in the future for the dedicated purpose. (2) Public agencies which hold land may attach articles of dedication to their deeds. (3) A statutory dedication can be made that conforms to conditions and follows a method established through legislation. Most states have acts that create a statutory framework which allows and encourages dedication of public reserves. Other states (such as Illinois) go one step further by incorporating the public trust concept, in which a public agency acts as a trustee for the dedicated land, thus guarding the public interest.

To date, more than 300 dedicated reserves have been established in the United States. As of 1983, no reserve or dedication statute had been challenged or weakened in the courts (Pearsall 1984). Dedication is used primarily to enhance protection of publicly owned land. The vast majority of dedicated reserves are held by state agencies and most were dedicated as protected natural areas some time after acquisition. Some states have reported administrative difficulties with the dedication concept. Public officials in state agencies may be reluctant to dedicate lands under their jurisdiction because the action could reduce their own management options. Even so, more than 200 reserves have been dedicated by state agencies. On private land, dedication is voluntary and usually involves some sort of landowner compensation. In Illinois and Ohio, for example, property taxes are eliminated on dedicated reserves. Some states have formally extended dedications into the private, non-corporate sector. In Oregon, for example, approximately 50% of the natural areas proposed for dedication are privately owned.

Most states rely on a council or commission to provide public involvement in the dedication process and to ensure political continuity and stability. In the majority of cases, members have expertise in the fields of ecology and conservation. Such a agency can also create an institutional identity for a dedicated reserves program.

A Hypothetical Procedure for Dedicating Ecological Reserves

The following procedure for dedicating ecological reserves is modeled after the standard approach used in Illinois (Illinois Nature Preserves Commission 1990). Illinois has had a Nature Preserves Commission in place since the early 1960's. It is the Commission's responsibility along with the director of the Department which houses the Illinois Nature Preserves System, and the Governor to approve nature preserves dedication. If such a commission were not established in Maine, this responsibility could be transferred to the director of the department housing an ecological reserves program.

- Each area proposed for dedication as an ecological reserve would be examined and reported on in writing to the commission by the staff or by a member, advisor, or consultant, designated by the commission.

- Generally the staff would be responsible for initiating and processing an ecological reserve dedication, with the participation and cooperation of the owner. Ecological reserve staff would determine the interest of the owner in dedication, define boundaries, prepare a legal description of the proposed reserve and a dedication proposal, and submit the dedication proposal to the commission for preliminary approval.

- The dedication proposal for an area would include information on its location, approximate legal description, ownership, provision for custody and management, general character, natural ecosystem types, degree of past disturbance, relation to adjoining lands, and potential as an ecological reserve.

- If, after receipt of such a report, the commission found that dedication of the area as an ecological reserve appeared to be appropriate and feasible, it could adopt a resolution giving preliminary approval to the dedication. Such a resolution would usually include a definite or approximate legal description of the area but need not refer to proposed conditions of dedication. Adoption of such a resolution would not bind the commission to any further action.

- The staff could prepare the instrument of dedication following the standard form on page 58 with modifications as appropriate, and then would negotiate final approval of the dedication by the owner, and submit the dedication to the commission for final approval.

- The commission could give final approval of the dedication provided that either (a) the legal description of the area and the conditions of dedication, if any, are identical in form to those set forth in the resolution of preliminary approval of dedication, or (b) the proposed instrument of dedication in final form was made available at the preceding commission meeting or sent to commission members and other recipients of complete agendas of commission meetings at least seven days before the date of the meeting at which final approval of the dedication is considered.

- The staff would then submit the instrument of dedication to the Governor for approval, together with appropriate documentation including any comments by the department which administers the ecological reserves system.

Finally, the staff would submit the executed instrument of dedication to the county recorder of deeds for recording, provide copies of the recorded dedication to the owner and the department in which the ecological reserves program is housed, and file the original instrument of dedication with the state archives.

A Sample Instrument of Dedication

The form of an instrument of dedication could be as follows, with modification as specific circumstances warrant:

DEDICATION OF AN ECOLOGICAL RESERVE
(Name)

KNOW ALL PEOPLE BY THESE PRESENTS, that _____, being the owner thereof, does hereby dedicate the following described land as an ecological reserve:

(legal description)

The land hereinabove described is dedicated for the purposes, and shall be held, maintained, and used, as provided for Ecological Reserves in the Maine Ecological Reserves Act, approved _____. Said land is further dedicated for the purposes, and shall be held, maintained, and used, as provided for Ecological Reserves in any amendment to said Act enacted hereafter, but no such amendment shall alter the exclusive commitment of said land to the preservation of natural conditions for the purposes specified in said Act as of the date of this dedication.

_____ (owner), its successors or assigns, shall have custody of the ecological reserve herein dedicated, subject to the Rules for Management of Ecological Reserves, as amended, and any approved master plan.

IN WITNESS WHEREOF, we have hereunto set our hands and seals this _____ day of _____, 19___.

_____ (owner)

Attest:

_____

APPROVED:

_____ _____
Manager, Ecological Reserves Program Date

APPROVED:

_____ _____
Director, department housing Ecological Reserves Program Date

APPROVED:

_____ _____
Governor Date

The standard form of an instrument of dedication includes a provision to protect the owner's dedication commitment. Dedication of an ecological reserve constitutes a voluntary relinquishment by the owner of certain ownership rights as specified in the instrument of dedication. The owner retains all ownership rights not specifically relinquished in the dedication. Dedication of an ecological reserve under the terms of a Maine ecological reserves act would not necessarily give the Legislature the right to alter the owner's exclusive commitment of the land to preservation by amendment of that Act. The standard dedication wording is intended to make it clear that if the Legislature alters an ecological reserves act, it would not thereby undo the landowner's dedication commitment.

APPROPRIATE USES OF ECOLOGICAL RESERVES

Two fundamental and complementary objectives of an ecological reserves system are (1) to develop a comprehensive and permanent system of ecological reserves representing all of Maine's ecosystems and (2) to encourage their use for learning about the ecology of natural ecosystems, and, on a larger scale, the overall environment. A third objective, which follows from the first two, is to interpret and disseminate the scientific data gathered and, ideally, to integrate this information into planning efforts at the state level. Implicit in the ecological reserves concept is the notion that research, education, and other uses should not alter the intrinsic quality of the ecosystems in a reserve or in any way interfere with their dynamic evolution.

Two important steps need to be taken to adequately protect and manage ecological reserves. First, a basic policy that outlines uses consistent with the objectives for ecological reserves in general needs to be developed. It should include a list of appropriate uses and guidelines for management and research. Second, a management plan should be developed for each reserve that includes accurate boundary information, baseline inventory information, a specific outline of permitted uses, and a log of research activities and their results.

General Uses of Ecological Reserves

Certain uses such as nonmanipulative research and monitoring are clearly consistent with ecological reserve objectives, while other uses, such as commercial timber harvesting and campgrounds, are not. Between these extremes are a host of activities that may or may not be appropriate.

In Canada, most arguments for preserving natural areas have emphasized their scientific or educational value (Leman 1983). Most provinces set aside ecological reserves for scientific research only. Reserves are often designed and managed to discourage general public use, and access usually requires written permission. Such restrictive policies are politically unpopular and have hindered the completion of ecological reserves systems in many provinces.

In the United States, scientific arguments for establishing reserves are nearly always secondary to those favoring other uses (Leman 1983). Public use is generally encouraged, especially when it is in the form of passive recreation. A number of states also allow consumptive uses such as fishing and hunting. The University of California's Natural Reserves

System and the U.S. Forest Service Research Natural Area Program are exceptions. In California, reserves are set aside specifically for scientific and educational purposes. Access is by permit only. On Research Natural Areas, public use is discouraged by leaving boundaries and access routes unmarked.

Recommended uses and activities on ecological reserves in Maine are discussed below. To some extent, a case by case approach will need to be taken to determine how each reserve should be used and managed. In many states, these uses are specified in the instrument of dedication for a given reserve.

1. **Scientific research and baseline monitoring.** These uses should be encouraged. Research guidelines that outline the types of scientific activities permitted on reserves would need to be developed. Because an objective of reserves is to preserve the opportunity for research, research proposals would be reviewed to ensure that they would not degrade the ecosystems being studied. In addition, individual reserves would need to be evaluated on a case by case basis to determine where and what types of research are appropriate. Researchers would need to demonstrate appropriate expertise in the proposed topic.

2. **Education.** Public participation in research and monitoring efforts would be encouraged. Reserves offer excellent opportunities to generate public support and involvement. Monitoring a variety of parameters could be integrated into educational programs and school curricula (programs could be modeled after successful local efforts such as the Damariscotta River Monitoring Program and Presumpscot Riverwatch). Reserves could also serve as outdoor classrooms for all levels of education. Educational facilities, such as trail systems and interpretive centers, should not be allowed within the core of the reserve, but could be located on adjacent land.

3. **Hunting and fishing.** Hunting and fishing should be permitted except in designated research areas and if those activities did not have a negative effect on reserve ecosystems.

4. **Timber harvesting.** Commercial timber harvesting should not be permitted on reserves. In addition, there should be no cutting of grass, brush, or other vegetation, thinning of trees, removal of dead wood, or planting except for permitted experimental purposes.

5. **Oil and mineral exploration and mining.** Exploration and mining of surface and subsurface materials (e.g., peat, topsoil, sand, gravel, minerals) should be prohibited on reserves. This might require the purchase of mineral rights in some instances.

6. **Camping and campfires.** These activities should be prohibited except in preexisting official campsites. In general, traditional uses should be allowed to continue if they do not degrade the reserve.

7. **Motorized and nonmotorized vehicles.** Motorized vehicles (including motors on boats) and nonmotorized vehicles such as mountain bikes should be prohibited on reserves. Variances should be considered if motorized vehicles were required for research or management.

8. **Day use and passive recreation.** These uses (e.g., hiking, bird watching, canoeing) should be permitted on reserves.

9. **Construction of trails, roads, service areas, parking lots, and other permanent structures.** New trails could be constructed and existing trails could be improved to prevent erosion, trampling of vegetation, and other deterioration, but otherwise should be kept to a minimum. Necessary signs, trash receptacles, and minor structures required to house research instruments or hand tools should be permitted if provided for in the reserve management plan or a permit for research activities. New roads, parking lots, and permanent structures such as research and educational facilities could be located in service areas outside the reserve.

Management Guidelines

The overriding management guideline for ecological reserves is that natural processes be allowed to proceed without human interference. However, there could be instances where lack of human intervention would threaten abutting lands. In other cases, it might be appropriate to substitute artificial disturbance for natural disturbances that are being suppressed (e.g., prescribed burns for fire-dependent ecosystems). Management issues that would need to be addressed for the ecological reserves system as a whole and in individual management plans follow.

1. **Fire control.** The optimum situation would be to let a fire burn if it started from a natural cause. However, because of the risk to adjacent landowners, a fire containment policy would need to be developed for reserves. This policy should spell out the types of control that would least impact the reserve and also address experimental prescribed burns. The latter should be considered only where fire is a natural and essential process in an ecosystem (e.g., pine barrens). In these situations, prescribed burns should be restricted to a small portion of the ecosystem.

2. **Erosion and water level control.** Natural water levels should not be altered. If there is no major impact downstream, removal of existing water control structures should be considered.

3. **Vegetation and wildlife management.** Introduction, removal, and management in favor of one or a group of species should occur by permit only. In general, no attempts should be made to (1) increase or reduce populations of native plants and animals or (2) eradicate exotic species that have become a stable part of the biotic community.

4. **Access.** To keep management costs down and to enhance protection of reserve ecosystems, access should be limited to as few points as possible.

Research Guidelines

Research guidelines should be developed with input from the scientific community. Some of the questions to be addressed include:

1. What types of research should be permitted on reserves? Should manipulative research be allowed, or should scientific activities be limited to observational and comparative research and long-term monitoring?

2. Should research zones be established?

3. What are the research and monitoring needs and tolerances of different ecosystem types (aquatic, terrestrial, wetlands)?

4. What do towns and state agencies need to know? What types of environmental parameters should be monitored?

5. Should reserves be managed to maintain certain successional states or populations of rare or endangered species?

6. What should the general policy be on collections of voucher specimens and materials for classroom or laboratory observation?

7. How should experiment locations and research results be recorded?

8. How can information generated from ecological reserves be integrated into planning at local and state levels?

PROGRAM NEEDS

To make an ecological reserves system a reality, a variety of specific tasks must be accomplished. Some apply to individual reserves while others apply to the coordination of the reserves system as a whole. Some will require a sustained effort, while others will occur once for each reserve. To operate smoothly, the program will need to integrate the expertise and resources of other agencies and programs. Some of the many tasks that an effective ecological reserves program will involve are outlined below.

Short-term needs

1. Authorize an ecological reserves program. Although state government funding of the program does not appear to be a possibility in the short term, authorization could make it easier to generate financial support from other sources.

2. Identify how an ecological reserves program can be integrated with agencies and programs that have complementary goals, such as the Natural Heritage Program, Critical Areas Program, Department of Inland Fisheries and Wildlife conservation programs, Land for Maine's Future program, and the agencies that hold title to the lands that contain potential ecological reserves.

3. Work with each landholding agency to prepare articles of dedication or management agreements for at least one tract per agency. These can then be used as models for additional dedications or management agreements under an ecological reserves program. They can also be used to determine what, if any, additional costs an agency might incur through dedication and management of ecological reserves on their land.

4. Refine criteria and complete inventory work on sites identified during the 1990 inventory to determine their eligibility as ecological reserves. Information on the ecosystem types within each area, as well as land use on adjacent land, will be needed to determine appropriate reserve boundaries.

5. Mark the reserve boundaries on the ground. Surveying expenses should be included within the ecological reserves program budget.

6. Develop guidelines for general use, reserve management, scientific research, and environmental monitoring.

7. Develop management plans for each ecological reserve.

Ongoing needs

1. Conduct inventories to identify representative examples of the ecosystems needed to complete the ecological reserves system.

2. Enter data on inventoried ecosystem and community types into the Natural Heritage Program's Biological and Conservation Database. This information will then be available for planning efforts at the state and local levels.

3. Develop a volunteer stewardship program with the goal of training one steward to regularly monitor the condition of each reserve.

4. Prepare a biennial summary of the accomplishments and priorities of the ecological reserves program. This report should provide a blueprint for future work (e.g., what ecosystem types have been protected, which are most threatened, what research is in progress, what research or monitoring is needed).

5. Prepare a short bulletin on each ecological reserve that can be sent to scientists, students, and others interested in using the areas. This bulletin could provide a brief description of the reserve's climate, flora, and fauna, opportunities for research, the location of the nearest research facilities and housing, and the name of a person to contact for more information.

Long-term needs

1. Prepare a brochure describing the ecological reserves system as a whole that is updated regularly as new reserves are added to the system.

2. Promote research and monitoring activities on ecological reserves. Staff could work with primary and secondary schools, colleges, and universities to integrate monitoring activities and results into science curricula. Staff could also work with towns to develop monitoring programs that are relevant to land use and planning at the local level.

3. Establish a central clearinghouse that will allow information from different regions to be compared and trends to be identified.

4. Incorporate the ecological reserves effort into an overall conservation strategy for Maine. This strategy could include an analysis of how well existing public and private conservation initiatives are representing and protecting the state's natural diversity.

Staffing needs

The tasks outlined above will require a full-time ecological reserves program coordinator with specific expertise in conservation biology and natural resource management. This position will be crucial to the success of the program and would provide a critical link between natural areas conservation efforts and programs that manage land for other purposes. In addition to a full-time coordinator, inventory, survey, and design work could be accomplished on a contractual basis. The ecological reserves program coordinator would work with the land-holding agencies to develop management plans, draft articles of dedication, and establish reserve boundaries.

RELATIONSHIP TO OTHER STATE PROGRAMS

Maine has several programs that focus on different aspects of natural diversity. These include the Critical Areas Program, the Natural Heritage Program, and the conservation programs of the Department of Inland Fisheries and Wildlife. They employ many of the essential tools for identifying, evaluating, and protecting natural diversity in Maine -- from inventories and voluntary protection to species recovery and management plans to legislation and habitat acquisition. The elements of diversity that are monitored include rare and endangered plants and animals, exemplary natural communities, and unusual hydrologic, geologic, and scenic features. To help the reader understand how these programs complement and differ from the ecological reserves effort, the major differences and strengths of each are described here.

Critical Areas Program

The Critical Areas Program, which is housed in the State Planning Office in Hallowell, is essentially a nonregulatory notification and registration program. Critical areas contain plant and animal life or geological features worthy of preservation in their natural condition or other natural features of significant scenic, scientific, or historical value. It is the only state program that focuses on unusual hydrologic, geologic, and scenic features. Like the Heritage Program and the Endangered and Nongame Wildlife Project of the Department of Inland Fisheries and Wildlife, the emphasis is on rare and unusual rather than representative features. The Critical Areas Program also has the responsibility of establishing and updating an endangered plant list and monitoring plant species that are endangered at the federal level. Perhaps the greatest strength of the program is its use of landowner contact and voluntary conservation agreements as natural area protection tools. However, the small staff (two positions, with one currently frozen) make these techniques less effective than they could be. It is not always possible to establish and maintain personal contact with landowners. In addition, most critical areas are not monitored in the field. As a result, the status of a significant percentage of areas is unknown.

The Natural Heritage Program

The Natural Heritage Program's three staff are housed in the Department of Economic and Community Development's Office of Comprehensive Planning in Augusta. The program was designed by The Nature Conservancy to provide a systematic inventory approach and central database for collecting and analyzing information about the state's rare flora and fauna (including vertebrates, invertebrates, and plants) as well as natural communities. A ranking scheme based primarily on state, federal, and global rarity is used to set conservation priorities. The program's standardized approach to collecting and tracking information could easily meet the needs of the Critical Areas Program and Department of Inland Fisheries and Wildlife, but lack of coordination between the three programs has made this a difficult process. A memorandum of agreement establishing the Heritage Program in State government has served to improve this situation. Although the Heritage Program is designed to track the status of natural features statewide, recent activities have focused on organized towns to provide data for their comprehensive planning efforts.

The Department of Inland Fisheries and Wildlife

The Department of Inland Fisheries and Wildlife has several conservation programs designed to assess the status, problems, and needs of the state's inland fisheries and wildlife resources. The Nongame and Endangered Wildlife Project, whose four staff are based in Bangor, is probably the most familiar of these. The primary goals of the Department's conservation programs are to develop long-range management plans, monitoring programs, and habitat protection strategies for a variety of vertebrate species. The Natural Heritage Program's database is used to manage information on sensitive species and their habitats. In addition, the Department administers (or helps administer) a variety of laws aimed at protecting the state's wildlife. These include the Maine Endangered Species Act, Natural Resources Protection Act, Site Location and Development Law, and a variety of laws and regulations that govern the taking of birds and mammals.

A Unified Approach to Conserving Natural Diversity

An ecological reserves system would complement these efforts in several ways. First, examples of the state's representative natural ecosystems are considered along with unusual ecosystem types. Second, reserve design would be based on natural ecosystem processes rather than individual species, thus enhancing the long-term viability of all species in a given ecosystem (the only group of species currently protected under state law is endangered vertebrates). Third, the scale is broader than other natural areas efforts in Maine. The size of a reserve reflects units of landscape such as a small watershed rather than a stand of trees or single population of plants or animals. Fourth, with the ecological reserves concept, a new protection tool -- dedication -- could be introduced. Dedication affords long-term legal protection to ecological reserves. Finally, the system would be designed to provide a framework for monitoring environmental change and, as such, would shed light on the effectiveness of conservation efforts at a variety of scales.

Although the existing programs at the State Planning Office, Department of Inland Fisheries and Wildlife, and the Department of Economic and Community Development are

obviously complementary, the distance between offices, differing mandates of the administering agencies, and small overworked staffs create barriers to working effectively together. There is no formal link to provide coordination, set priorities, or make sure species and habitats are not falling through the cracks -- in short, there is no overall strategy for protecting natural diversity in Maine. For example, there is currently no legal mechanism for protecting plants, invertebrates, or exemplary examples of natural ecosystems. In addition, there is often duplication -- each program has its own inventory methodology, for example. Overlapping program mandates make it difficult for the public to understand which program focuses on which facets of the state's natural diversity.

From the outset, the Ecological Reserves Study Steering Committee advised against creating yet another independent natural areas program housed in yet another agency. It makes more sense to define how an ecological reserves program would complement existing efforts to protect natural diversity and to look for ways to formally link the various programs. In short, this would allow Maine's natural area conservation needs to be met through a unified conservation strategy instead of the fragmented, uncoordinated approach that has characterized natural areas conservation efforts in Maine to date.

An ideal situation might be to place the programs described within a single agency and to clearly define their roles, with each program focusing on what it does best. For example, the Critical Areas Program could focus on voluntary protection through landowner contact and regular site monitoring (additional staff would be necessary to make this an effective approach). The Natural Heritage Program's standardized inventory methods could be adopted by the various programs and the central database could be used as a basis for setting priorities. The Department of Inland Fisheries and Wildlife, under an amended Endangered Species Law that includes both animals and plants, could take the lead on developing conservation plans for all endangered species. Finally, an ecological reserves program could focus at the landscape level by developing management plans for reserves, establishing local and regional monitoring programs, and looking for ways to connect smaller sites. The end result would be a more efficient and effective approach to conservation in Maine.

CHAPTER 6: RECOMMENDATIONS

Maine lacks several of the key ingredients necessary to establish an ecological reserves system. Although a variety of private organizations and government agencies are involved with natural areas protection efforts, there is at present, no single strategy for protecting natural areas or ensuring representation of Maine's ecosystems in a comprehensive and permanent system. For example, if northern hardwood forests are not adequately represented in the array of natural areas that have been protected, there is no generally adopted natural area policy that makes it imperative that this ecosystem type be added. In addition, Maine does not have a state agency that holds or dedicates land specifically for its broader ecological values, e.g., the diversity of the ecosystem as a whole. Some agencies and programs focus primarily on fish and game species or rare and unusual features, while other programs recognize natural area values in a multiple-use management context that may or may not be compatible with the long-term viability of the ecosystems of interest. With the exception of Acadia National Park and most state parks, all existing public lands in Maine can be, and for the most part are, managed for consumptive uses.

The inventory results of the Ecological Reserves Study show that approximately 45 percent of Maine's characteristic ecosystems are currently represented on public and private conservation lands. However, the ecological reserve potential in many of these areas may soon be compromised by other types of management. These facts lend a sense of urgency to the ecological reserves initiative. The sooner an ecological reserves system is established, the higher the quality of the ecosystems contained within it and the greater their value as ecological benchmarks. Once established, the system as a whole would improve our ability to anticipate future environmental problems and design solutions before irreversible consequences occur.

An important lesson gleaned from other states and provinces is that an ecological reserves system in Maine will require a coordinated effort among the various public and private agencies involved with conservation in the state. Only by wedding their differing goals and procedures into a cohesive overall strategy can a permanent network of areas representing all of Maine's natural ecosystems be established. The recommendations on the following pages can be viewed as pieces of this overall strategy. They are designed not only to provide the framework needed for an ecological reserves system, but to ensure that an ecological reserves program is closely linked with other efforts to protect natural diversity in Maine.

The Ecological Reserves Steering Committee clearly recognized that a number of the concepts outlined on the following pages deserve further consideration and refinement. The committee also fully recognizes that the current budget situation precludes these recommendations from being made as a complete package to the Legislature. Authorization of an ecological reserves program and dedication as a protection tool are the first components of the package that could be recommended for implementation. The other concepts presented here represent mechanisms for fully realizing protection of Maine's natural areas through consolidation of programs and development of overarching strategies.

1. AUTHORIZE AN ECOLOGICAL RESERVES PROGRAM

Problem: There are no existing programs in Maine that seek to protect representative natural ecosystems as benchmarks against which changes in the state's environment can be measured.

Goal: To establish a carefully selected and permanently protected system of ecological reserves to be used for scientific research, long-term environmental monitoring, and education. This ecological reserves system would be designed to represent all of Maine's natural ecosystem types.

Recommendation: Authorize an ecological reserves program through legislation. The primary function of this program would be to establish, manage, and oversee the protection of a system of ecological reserves in Maine. This would be accomplished by (1) working with public land-holding agencies to protect sites already owned by the public, (2) identifying sites that should be acquired by the state to complete the ecological reserves system, and (3) promoting research and monitoring on reserves to increase our understanding of both natural and managed systems. Any newly acquired areas would be held by either the Bureau of Public Lands, Bureau of Parks and Recreation, or the Department of Inland Fisheries and Wildlife.

2. ESTABLISH DEDICATION AS A PROTECTION TOOL

Problem: An important function of an ecological reserve system is to provide sites for long-term monitoring and research and to preserve the opportunity for these and other activities. There is currently no legal means to permanently protect ecosystems in their natural state in Maine.

Goal: To afford enduring, legally-binding protection to sites included in the ecological reserves system.

Recommendation: Establish dedication as a tool for protecting ecological reserves. Dedication, which is discussed in detail in Chapter 5, is the voluntary placement of a natural area into a legally established statewide system of ecological reserves, whose member properties are protected by strong statutory language against condemnation or conversion to a different use. Ecological reserves program staff would assist public and private landowners in protecting high quality natural ecosystems in perpetuity through voluntary dedication of their lands into the ecological reserves system. Once dedicated, the program would oversee their management and protection.

Interim Recommendations: Although dedication has been used effectively in other states to protect reserves on publicly owned lands, it has not been tested as a protection tool in Maine. The Steering Committee recommends that (a) ecological reserves staff work through the dedication process with each land-holding agency by selecting one site per agency as a case study, and (b) interim management agreements be developed for areas that may qualify as ecological reserves to provide temporary protection while instruments of dedication are being developed.

3. CONSOLIDATE OR LINK PROGRAMS INVOLVED WITH THE PROTECTION OF NATURAL DIVERSITY

Problem: A variety of programs that focus on different aspects of natural diversity currently exist in Maine (they are the Critical Areas Program, Natural Heritage Program, and several programs of the Department of Inland Fisheries and Wildlife). Although these programs are complementary, they are located in different state agencies and all are small and understaffed. Creating a separate ecological reserves program without formally linking it to existing programs

would amplify the fragmented and often uncoordinated approach that has characterized natural areas conservation efforts in the state.

Goal: To house state programs that address different aspects of natural diversity within a single agency or establish a mechanism for common oversight and coordination that would clearly define their roles, with each program focusing on what it does best.

Recommendation: Formally link the ecological reserves program with other programs that are involved with the protection of natural diversity in Maine by either housing them within one agency or through oversight of all four programs to achieve a consistent, integrated focus. In either case, the agency (or consolidated program) would have the responsibilities of (1) inventorying and maintaining a central database on rare, endangered, and characteristic species and ecosystems, (2) establishing and maintaining official lists of endangered and threatened plants and animals, (3) encouraging voluntary protection of natural areas through landowner contact, regular site monitoring, and the Register of Critical Areas, (4) developing conservation plans for endangered and threatened species, (5) establishing and maintaining a statewide ecological reserves system, and (6) establishing local and regional monitoring programs.

4. DEVELOP A NATURAL DIVERSITY CONSERVATION STRATEGY FOR MAINE

Problem: There is no long-range plan guiding efforts to assess, monitor, and protect natural diversity in Maine. The absence of a clear set of priorities makes it difficult to assess the effectiveness of existing protection efforts and policies.

Goal: To develop a regularly updated long-range plan for protecting natural diversity in Maine.

Recommendation: Develop a natural diversity conservation strategy for Maine. An integrated conservation strategy is needed that seeks to (1) identify and acquire essential habitat for rare and endangered species, and representative examples of characteristic ecosystems, (2) identify gaps in current legislation and evaluate the effectiveness of various protection strategies in conserving the state's natural diversity, including more protective management of these areas on public lands, (3) determine the appropriate protection tool (i.e., registration, dedication, or acquisition) for sites identified by staff of the various programs, (4) develop a system of broad habitat corridors and buffer zones surrounding and connecting reserves, and (5) tie natural areas protection and management into planning efforts at local and regional scales. The plan should be regularly updated to reflect changes in our knowledge of the distribution, condition, and protection status of the elements of diversity being tracked. It should also incorporate current scientific information relevant to the protection of natural diversity in Maine. Representatives of the staffs of The Natural Heritage Program, Critical Areas Program, ecological reserves program, and Department of Inland Fisheries and Wildlife, with the assistance of a scientific advisory council, could be charged with the responsibility of developing and promoting this strategy.

APPENDIX I

STATE OF MAINE

IN THE YEAR OF OUR LORD
NINETEEN HUNDRED AND EIGHTY-NINE

S.P. 456 - L.D. 1241

Resolve, to Study the Development of a System of Ecological Reserves in the State

Legislative findings. Resolved: That the Legislature finds that:

1. Rapid changes are occurring in our environment, including the land, water, atmosphere and climate, as a result of human activities;

2. In order to identify and understand the impacts of these changes it is necessary to study and monitor undisturbed ecosystems;

3. The State has a vital interest in maintaining examples of the State's characteristic ecosystems in their natural state to provide ecological benchmarks in a changing world;

4. These undisturbed ecosystems also are critical to preserving the State's natural heritage and diversity;

5. These areas can provide important opportunities for the public to learn about the State's natural heritage; and

6. An effort to protect examples of characteristic state ecosystems will complement existing state conservation programs, such as the Critical Areas Program, the Land for Maine's Future Fund and the Natural Heritage Data System; and be it further

Study of Ecological Reserves. Resolved: That the State Planning Office shall coordinate a study effort to design a system of ecological reserves in the State. For the purposes of this resolve, "ecological reserves" means areas established to maintain representative examples of the State's characteristic natural ecosystems. The study should consider, but not be limited to:

1. How many reserves should be established;

2. What ecosystem types should be represented;

3. How large the reserves should be;

4. Distribution of reserves around the State;

5. Appropriate uses for the reserves;

6. The potential impact of a reserve system on the State's natural resource-based industries; and

7. Options for implementing the reserve system; and be it further

Inventory. Resolved: That the study effort shall also include an inventory of potential ecological reserve sites on public or conservation ownerships. This inventory shall also identify ecosystem types that are not currently represented on these ownerships; and be it further

Steering committee. Resolved: That the State Planning Office shall establish a steering committee to provide advice to the study effort. The steering committee shall include representatives from the Department of Conservation, the Department of Inland Fisheries and Wildlife, conservation interests, landowners and the university system; and be it further

Report. Resolved: That the State Planning Office shall report its findings, together with any legislative recommendations, to the joint standing committee of the Legislature having jurisdiction over energy and natural resources by February 1, 1991; and be it further

APPENDIX II

Ecological Reserves Steering Committee

Meeting Dates and Agenda Topics

Meeting Date	Agenda Topics
March 29, 1990	• Ecological Reserves legislation and concept paper • Workplan • Biophysical regions approach • Aquatic communities in the proposed system
April 24, 1990	• Classification approach • Lessons from other states and provinces • Ecosystem descriptions
May 17, 1990	• Financial/Staffing situation • Ecosystem classification • Preliminary criteria for identifying ecological reserves
July 19, 1990	• Inventory methodology and progress report • Ecological reserve design: factors to consider
September 20, 1990	• Inventory update • Appropriate uses of ecological reserves • Summary of literature review
October 11, 1990	• An institutional framework for an ecological reserves system
November 16, 1990	• Summary of inventory results • Dedication as a long-term protection tool • Institutional framework
December 13, 1990	• Review of outline for Ecological Reserves Study Report • Draft legislation
January 17, 1991	• Review completed chapter of draft report • Draft legislation
February 6, 1991	• Draft legislation • Were to go from here

APPENDIX III

MAINE ECOSYSTEM CLASSIFICATION

Preliminary Descriptions

* Indicates ecosystem types that are rare (with few occurrences) in Maine.
° Indicates ecosystems that are locally abundant but have a restricted range (three or fewer biophysical regions) in Maine.

NOTE: This classification is being revised by the Natural Heritage Program using information collected during the 1990 field season.

I. TERRESTRIAL ECOSYSTEMS

Upland ecosystems on soils that are dry to mesic (never hydric), and vegetative cover that is never predominantly hydrophytic, even if the soil surface is occasionally or seasonally flooded or saturated.

A. Open -- Upland ecosystems with less than 25% canopy cover of trees that are not associated with water bodies.

1. **Serpentine outcrop/bald*** - Bedrock outcrops, ledges, and summits composed of ultramafic rocks such as serpentine and dunite. Species diversity is low. Magnesium-tolerant plants such as *Adiantum pedatum* v. *calderii* and *Cerastium arvense* are characteristic.

2. **Acidic/circumneutral outcrop/bald** - Bedrock outcrops, ledges, and summits composed of igneous and high-grade metamorphic rocks. Rock such as granite and quartzite weather to soils with a pronounced acid reaction, while base-rich outcrops such as syenite, basalt, and diorite, yield more enriched soils. Vegetation is typically sparse or patchy. On acidic outcrops of cool northern or high elevation sites, *Potentilla tridentata*, *Deschampsia flexuosa*, and *Oryzopsis pungens* are characteristic herbs. *Abies balsamea*, *Picea rubens*, *Betula cordifolia*, and *Sorbus americana* may occur where soil has accumulated. Low elevation and southern outcrops are characterized by *Vaccinium angustifolium*, *Gaylussacia baccata*, *Arctostaphylos uva-ursi*, *Carex lucorum*, hair-cap mosses, and lichens. *Asplenium platyneuron* and *Ranunculus fasicularis* may be present on base-rich rock outcrops in southern Maine. Different plant communities may

3. **Calcareous outcrop/bald*** - Bedrock outcrops of limestone, dolomite limestone, and other calcium-rich formations which, upon weathering, yield calcium-rich soils. These outcrops are often on ridgetops and are typically dry and sparsely vegetated. Characteristic species include *Potentilla fruticosa* and *Aster ptarmicoides*. Rare species that may be associated with this ecosystem type are *Carex eburnea* and *Polygala senega*.

4. **Acidic/circumneutral cliff** - Vertical or near vertical outcrops of resistant non-calcareous rocks often moistened by surface runoff from higher elevations. These cliff ecosystems may include ledges and small areas of talus. Soil development is minimal and vegetation sparse. Species characteristic of shaded cliffs at lower elevations include *Polypodium virginianum* and *Dryopteris marginalis*. On cliffs at higher elevations, *Potentilla tridentata* and *Alnus viridis* are typical. A rare plant, *Dryopteris fragrans* may occur on acidic cliffs. Rare species that may be associated with circumneutral cliffs are *Cryptogramma stelleri*, *Draba lanceolata*, and *Minuartia rubella*. More information is needed on the effects of moisture, aspect, and exposure on the species diversity of cliff ecosystems.

5. **Calcareous cliff*** - Vertical or near vertical outcrops of limestone, dolomite, calcareous schist, or other calcareous rocks. Wet and dry variants exist, but need further study. Rare plants associated with this ecosystem include *Primula mistassinica*, *Saxifraga aizoides*, *Woodsia glabella*, and *Erigeron hyssopifolius*. *Carex scirpoidea* and *Scirpus cespitosus* may occur at higher elevations.

6. **Acidic/circumneutral talus slope/boulderfield** - Ecosystems of loose granitic, mafic, or high-grade metamorphic rocks that have accumulated at the base of cliffs or of boulderfields deposited on level terrain. Vegetation is restricted to isolated pockets of soil. Vines and twining herbs may be abundant. On acidic talus, *Epilobium hornemannii* may occur. *Geranium robertianum*, *Hepatica americana*, *Ranunculus abortivus*, and *Adiantum pedatum* may occur on richer circumneutral talus slopes.

7. **Calcareous talus slope/boulderfield*** - Ecosystems of loose calcareous rocks that have accumulated at the base of cliffs or in boulderfields deposited on level terrain.

8. **Cold-air talus slope/boulderfield*** - An ecosystem that occurs where drainage of cold air to the bottom of steep talus slopes produces a cool microclimate or where ice persists in the crevices of boulderfields well into the summer. Characteristic plants are *Picea mariana*, *Ledum groenlandicum*, *Empetrum nigrum*, and foliose lichens.

9. **Fellfield*** - Exposed mountain summits, tablelands, and slopes where bedrock has become fragmented into scree due to repeated freezing and thawing. Crustose lichens and low herbs such as *Juncus trifidus* and *Carex bigelowii* are characteristic. *Betula glandulosa*, *Salix herbacea*, and stunted *Picea mariana* and *Abies balsamea* may also survive here.

10. **Alpine meadow/snowbank/headwall*** - Open vegetated areas above timberline on Maine's higher mountain summits, exposed ledges, and headwalls. These ecosystems are typically mosaics of small boggy meadows, low heath dominated shrublands, small grassy areas, and exposed bedrock. The flora includes arctic-alpine species that are restricted (in Maine) to these meadows, as well as boreal species that also occur in forests and peatlands at lower

elevations. Soils are composed of peat and nutrient-deficient black muck and are often saturated.

11. **Sand barren/grassland*** - Sand barrens are areas of sandy soil where land use patterns have resulted in xeric sandbarren associations that are nearly devoid of trees. Characteristic species are *Andropogon scoparius* and scattered *Betula populifolia* and *Pinus strobus*. *Lycopodium sabinaefolium*, a rare plant, may also occur. Sandplain grasslands (a successional variant of pitch pine barrens) are mixtures of open grassland and shrubland on excessively drained soils associated with outwash deposits. These ecosystems occur in fire-prone areas and would eventually be replaced by pine-heath woodland or pitch pine barrens. *Andropogon* spp., *Carex lucorum*, and *Liatris borealis* may be characteristic. A number of bird species that are rare in Maine nest in this ecosystem type, including the grasshopper sparrow (*Ammodramus savannarum*), horned lark (*Eremophila alpestris*), Vesper sparrow (*Pooecetes gramineus*), and upland sandpiper (*Bartramia longicauda*), among others.

B. Shrublands and Woodlands -- Shrublands occur in exposed environments that are too harsh for trees to grow to full size. Woodlands are structurally intermediate between forests and open canopy uplands. Trees are typically stunted and/or widely spaced resulting in a sparse canopy. Soils are well-drained to excessively well-drained sands or thin with numerous rock outcrops.

12. **Maritime shrubland/rocky headland** - Shrubland ecosystems of dry seaside bluffs and islands that are exposed to onshore winds and salt spray. This ecosystem is usually dominated by one or more species of shrub, including *Rosa* spp., *Prunus maritima*, *Myrica pensylvanica*, and *Toxicodendron toxicaria*. Stunted *Pinus rigida* and *Betula papyrifera* may be scattered throughout. Seabird nesting islands may be an additional variant.

13. **Boreal shrub-heath headland** - Seaside cliffs and bluffs with a thin organic mat over bedrock where species of northern affinity occur, such as *Empetrum nigrum* and *Sedum rosea*, ans *Euphrasia randii*. *Lomatagonium rotatum*, a rare subarctic species, may also occur here.

14. **Alpine krummholz*** - Low, dense forest of high elevations above the forest zone. Thin cryic soils and constant exposure to wind cause stunted and flagged growth forms. *Abies balsamea* is the dominant species. *Picea mariana* and *Betula cordifolia* are common associates.

15. **Talus slope/boulder field woodland** - Sparse to nearly closed canopy ecosystems on talus slopes. Trees are confined to isolated pockets among boulders where soil has accumulated. Northern and/or high elevation talus woodlands may be dominated by *Betula cordifolia* and lesser amounts of *Picea rubens*. *Ribes glandulosum*, *Sorbus americana*, and *Polypodium virginianum* are common associates. On acidic talus, northern hardwood species are characteristic.

16. **Pitch pine barren*** - Open canopy woodlands on well-drained sandy soils of glacial outwash plains or moraines. Also on thin rocky soils on ridgetops. *Pinus rigida* is the dominant canopy species. The shrub layer is well-developed with a nearly continuous cover of low ericaceous shrubs such as *Vaccinium angustifolium* and *Gaylussacia baccata*. Other

characteristic species are *Kalmia angustifolia, Pteridium aquilinum*, and *Gaultheria procumbens. Quercusilicifolia* may occur in scattered clumps. Grasses, sedges, and lichens are common in the groundlayer. *Hieracium venosum* and *Lycopodium sabinaefolium* may occur in this ecosystem type. Rare, habitat-specific lepidoptera species may also be present.

17. **Pine-heath woodland** - Woodlands dominated by *Vaccinium angustifolium* and other ericaceous shrubs, with scattered *Pinus resinosa* and *Pinus strobus* and early successional species such as *Populus tremuloides* and *Betula populifolia.* Most of these are being managed for blueberries. More information is needed on the vegetation of unmanaged examples.

18. **Red pine woodland** - Relatively open canopy forest of nutrient-poor sandy soils and rocky ridgetops in northern Maine. Soils are excessively well-drained. *Pinus resinosa* is the canopy dominant.

19. **Jack pine woodland*** - Relatively open canopy forest on thin, sandy or gravelly, nutrient-poor soils and on ledgy outcrops and ridges in central and northern Maine and along the eastern coast. Trees growing on outcrops and on coastal sites are typically stunted. *Pinus banksiana* is the dominant canopy species. Common associates include *Pinus resinosa, Pinus strobus, Larix laricina*, and in shoreline situations, *Thuja occidentalis.* A well-developed shrub layer often includes *Kalmia angustifolia, Pteridium aquilinum, Vaccinium angustifolium,* and *Chamaedaphne calyculata.* Maritime jack pine woodlands are often associated with coastal plateau bogs and coastal headland ecosystems.

20. **Pine-oak woodland** - Woodlands of knolls and hilltops where soils are thin and excessively well-drained and bedrock outcrops are abundant. Widely-spaced, often stunted *Quercus rubra* and *Pinus strobus* are canopy dominants. *Juniperus communis* and various ericaceous species are characteristic in the shrub layer. Graminoids (especially *Deschampsia flexuosa* and *Carex lucorum*) and sedges are common in the groundlayer.

21. **Oak-hickory woodland*** - Hardwood forests of well-drained ridgetops and south or west-facing slopes in southern Maine. Moisture availability is low and soil formation is poor or limited to a thick organic mat. Dominant trees include *Quercus alba, Quercus prinus, Quercus rubra, Carya ovata*, and other hardwoods in various mixtures. *Quercus velutina* may occur on lower slopes and the understory may include *Cornus florida.* In dry, sandy coastal areas, *Pinus rigida* is a common associate.

C. Upland forests -- upland ecosystems with tree canopy cover of 60% or more, generally on mesic (moist) soils.

22. **Maritime spruce-fir forest°** - Forests of exposed maritime locations dominated by *Picea rubens, Abies balsamea*, and *Picea glauca.* Soils often have a thick organic mat over a thin mineral layer. On coastal islands and outer peninsulas, where salt spray is a factor, these forests may be reduced in stature with contorted growth forms. Arboreal lichens are abundant.

23. **Spruce-fir flat** - Forests of low to mid-elevations dominated by *Picea rubens* and *Abies balsamea.* Common associates include *Picea glauca, Picea mariana, Betula papyrifera*, and *Betula alleghaniensis.* Soils are typically poorly-drained, but not saturated or peaty. On

better drained sites, *Pinus strobus* may be a codominant. The shrub layer is sparse or patchy. Characteristic shrubs are *Kalmia angustifolia, Aralia nudicaulis, Vaccinium angustifolium,* and *Vaccinium myrtilloides.* Ground cover typically consists of a thick carpet of mosses and herbs, with an abundance of feather mosses. Characteristic herbs are *Maianthemum canadense, Cornus canadensis, Coptis groenlandica, Clintonia borealis,* and *Gaultheria hispidula.*

24. **Spruce-slope forest** - Forests of middle to upper slopes dominated by *Picea rubens, Abies balsamea* and, on sites exposed to wind, *Betula papyrifera* or *Betula cordifolia.* Soils are typically well-drained. Exposed locations experience frequent blowdowns.

25. **Subalpine spruce-fir forest**° - Low diversity coniferous forest of high elevations (generally greater than 800 meters). Occurs on level ridgetops and on steep, stony, upper slopes. The dominant tree is *Abies balsamea.* Common associates are *Picea rubens, Betula cordifolia,* and *Sorbus americana.* Wind damage from severe storms is common and often widespread, resulting in a patchy but dense shrub layer of young *Sorbus americana, Viburnum alnifolium,* and *Rubus* spp.

26. **Mixed hardwood-spruce-fir forest** - A mixed forest that occurs on lower mountain slopes and upper margins of flats on glacial till. In northern Maine, this ecosystem is typically found on southerly facing slopes. Shares dominant tree species and characteristics of both the northern hardwood and spruce-fir forests except that *Acer saccharum* is generally absent and *Acer rubrum* may be a codominant. *Pinus strobus, Tsuga canadensis, Ostrya virginiana,* and *Betula papyrifera* may be locally abundant. *Acer pensylvanicum* and *Acer spicatum* are common subcanopy trees. Characteristic groundlayer plants are *Dryopteris intermedia, Lycopodium lucidulum, Oxalis acetosella, Aralia nudicaulis, Clintonia borealis, Streptopus roseus, Medeola virginiana, Trientalis borealis, Trillium erectum, Viola renifolia, Cornus canadensis,* and *Coptis groenlandicum.*

27. **Northern hardwood forest** - Forests of cool, mid-elevation slopes and the lower slopes of ravines that are dominated by *Acer saccharum, Fagus grandifolia,* and *Betula alleghaniensis* in various mixtures. *Tsuga canadensis, Pinus strobus,* and *Picea rubens* are common associates and *Acer pensylvanicum* is often a prominent understory species. *Quercus rubra* may be a codominant in the southern half of the state. The canopy is often dense resulting in a sparse shrub layer. Characteristic shrubs are *Viburnum alnifolium, Viburnum acerifolium,* and *Rubus* spp. Characteristic herbs are *Medeola virginiana, Maianthemum canadense, Lycopodium lucidulum, Dryopteris intermedia, Trientalis borealis, Uvularia sessilifolia, Mitchella repens, Tiarella cordifolia, Viola rotundifolia, Streptopus roseus,* and *Trillium erectum.*

28. **Cove forest** - Rich northern hardwood forest of sheltered, low to moderate elevation sites, primarily on broad coves and slopes above them. Steep slopes and/or bedrock with calcium result in soils that are enriched in nutrients, organic matter, and supplemental water from runoff and seeps. Indicators are *Tilia americana* in the canopy and *Caulophyllum thalictroides, Carex platyphylla,* and *Carex plantaginea.* Rare species that may occur here include *Panax quinquefolia, Hepatica americana, Impatiens pallida,* and *Dryopteris goldiana.*

29. **Hemlock forest** - Microsites (gorges, steep cool slopes, seepage areas) within northern hardwood and mixed hardwood-spruce-fir forests dominated by *Tsuga canadensis,* with

other northern hardwood species present. The understory and ground layers are very depauperate due to dense shade.

30. **Red oak/mixed hardwood-hemlock-pine forest** - A mixed forest of relatively flat terrain and moderately drained, acidic soils in midcoastal, central, and western Maine. Dominant canopy species include *Pinus strobus*, *Tsuga canadensis*, and *Quercus rubra*, with scattered *Acer rubrum*, *Picea rubens*, *Abies balsamea*, *Fraxinus americana*, and *Betula papyrifera*. *Acer pensylvanicum*, *Viburnum recognitum*, *Viburnum cassinoides*, *Viburnum acerifolium*, and *Corylus cornuta* are common understory species. Characteristic species of the ground layer are *Maianthemum canadense*, *Aralia nudicaulis*, *Aster macrophyllus*, *Cypripedium acaule*, and *Trientalis borealis*.

31. **Dry oak-pine forest** - Forest of sandy soils or well-drained rocky slopes in central and southern Maine. The canopy is dominated by a mixture of *Quercus rubra*, *Quercus alba*, *Pinus strobus*, and *Pinus rigida*. The shrub layer, which is predominantly ericaceous, is not as diverse as that of the dry oak-hickory forest.

32. **Central hardwood forest*** - Closed canopy forest dominated by *Quercus alba*, *Carya ovata* or both. *Betula lenta* and *Quercus rubra* are common associates.

33. **Birch-aspen successional forest** - A hardwood forest associated with recent disturbance (i.e., blowdowns, clearcuts, recently abandoned farmland). The forest is typically dominated by two or more of the following species: *Populus tremuloides*, *Populus grandidentata*, *Populus balsamifera*, *Betula papyrifera*, *Betula populifolia*, *Acer rubrum*, or *Pinus strobus*. This is a broadly defined ecosystem dominated by light-requiring, wind-dispersed species that are well-adapted to establishment following disturbance. A characteristic feature of successional forests is the lack of reproduction of the canopy species. Most of the tree seedlings and saplings are more shade-tolerant than the canopy species.

II. PALUSTRINE ECOSYSTEMS

Perennial freshwater wetlands characterized by emergent vegetation and hydric soils. Includes wetlands that are permanently saturated by seepage, permanently flooded, or seasonally or intermittently flooded (these may be seasonally dry).

A. Swamps -- Wetlands dominated by trees or shrubs, generally without significant accumulation of peat.

34. **Coniferous seepage forest** - Forests dominated by *Thuja occidentalis*, *Picea rubens*, and *Abies balsamea* on gentle slopes where soils are enriched by seepage of cold, minerotrophic groundwater; these soils are often enriched with calcium. Seepage water may be visible at the ground surface as rivulets or small spring-fed brooks. *Calypso bulbosa* has been found on the dry hummocks of some undisturbed, cedar-dominated sites in northern Maine.

35. **Outwash seepage forest** - Seepage forests that occur where springs discharge from the sides of outwash plains that are composed of interbedded clays in sand and gravel. *Acer rubrum* is characteristic, along with *Viburnum cassinoides*, *Alnus incana*, and occasionally *Sphagnum* spp. In eastern Maine, *Picea rubens* and *Abies balsamea* are common associates.

36. **Hardwood floodplain forest** - Hardwood forests that occur on mineral soils of river floodplains. Low areas are annually flooded in the spring, and higher areas are flooded irregularly. Some sites may be quite dry by late summer. Other sites may be flooded again in late summer or early fall (due to heavy precipitation associated with tropical storms). Characteristic canopy trees are *Acer saccharinum*, *Acer rubrum*, *Fraxinus nigra*, and *Fraxinus pennsylvanica*. *Onoclea sensibilis*, *Matteuccia struthiopteris*, and *Impatiens capensis* are good herbaceous indicators. Richer floodplains may have *Allium tricoccum*, *Caulophyllum thalictroides*, and other species that require fertile soils. *Nyssa sylvatica* and *Salix nigra* may occur in southern floodplain forests.

37. **Coniferous floodplain forest** - Forests of *Picea rubens*, *Abies balsamea*, and *Thuja occidentalis* that occur in the floodplains of small streams. Alluvial deposits are not significant.

38. **Black willow-alder swamp** - Swamps of small, often ephemeral watercourses and swales that are dominated by *Salix nigra* and *Alnus incana*. *Acer rubrum* is a common associate. This ecosystem type occurs only in the southern half of the state.

39. **Shrub swamp** - Shrub-dominated ecosystems typically associated with streams, rivers, or the upland edges of open wetlands. The substrate is usually mineral soil or muck. Little is known about this ecosystem type which is quite variable in Maine. Species that are characteristic (in various combinations) are *Alnus incana* ssp. *rugosa*, *Salix* spp., *Cornus sericea*, *Cornus ammomum*, *Myrica gale*, and other shrubs. In southern Maine, *Vaccinium corymbosum* and *Cephalanthus occidentalis* may be common associates in shrub swamps dominated by *Alnus incana* and *Salix* ssp. Shrub swamps may grade into shrub meadows and forested wetlands.

40. **High elevation shrub swamp** - Shrub swamps along steep, fast-flowing mountain streams that are dominated by *Alnus viridis* ssp. *crispa* and *Salix* spp.

41. **Acidic shrub swamp** - Shrub swamps along nutrient-poor streams or ponds that often grade into fens or bogs. These are typically dominated by *Myrica gale*, *Ilex verticillata*, *Nemopanthus mucronata*, *Aronia melanocarpa*, and a variety of ericaceous species.

42. **Red maple-hardwood swamp** - Hardwood swamps that occur in poorly drained depressions throughout Maine, usually on inorganic soils. These swamps are often flooded in spring. Small pools and channels may persist through the growing season. Dominant canopy trees are *Acer rubrum*, *Fraxinus nigra*, *Fraxinus pennsylvanica*, and occasionally, *Ulmus americana*. The shrub layer is often well-developed and typically includes *Ilex verticillata*, *Nemopanthus mucronata*, *Aronia melanocarpa*, *Cornus sericia*, *Viburnum recognitum*, *Viburnum cassinoides*, and *Vaccinium corymbosum*. The herbaceous layer is often dominated by ferns, including *Osmunda cinnamomea*, *Osmunda regalis*, *Osmunda claytoniana*, and *Onoclea sensibilis*.

Other characteristic herbs include *Symplocarpus foetidus*, *Impatiens capensis*, and *Thalictrum polygamum.*

43. **Tupelo swamp*** - Hardwood swamps in basins with stagnant or slow-moving water on peats and mucks in southern Maine. *Nyssa sylvatica* is characteristic. *Acer rubrum* and *Ilex verticillata* are common associates. *Lindera benzoin* may occur in the understory. More information is needed to describe this ecosystem type.

44. **Atlantic white cedar swamp*** - Coniferous or mixed swamps on peaty soils along streams, in poorly drained depressions, and along the edges of peatlands. *Chamaecyparis thyoides* is characteristic and typically makes up more than 50% of the canopy. *Acer rubrum* is a codominant.

45. **Northern white cedar swamp** - Coniferous or mixed swamps on organic soils in poorly drained depressions. The characteristic tree is *Thuja occidentalis*, which may form nearly pure stands, or it may be mixed with various mixtures of *Acer rubrum*, *Tsuga canadensis*, *Abies balsamea*, *Larix laricina*, *Picea mariana*, and *Fraxinus nigra*. The shrub layer is often sparse. The groundlayer may also be sparsely vegetated, but diversity is typically high, with may bryophytes and boreal herbs.

B. Marshes -- Wetlands that are periodically inundated by standing or slowly moving, mineral-enriched water. Surface water levels may fluctuate seasonally, with declining levels exposing zones of matted vegetation or mud. The substrate consists of mineral soil, or occasionally well-decomposed peat. Marshes characteristically show zonal vegetation patterns of emergent sedges, grasses, rushes, and reeds bordering grass and sedge meadows with peripheral bands of shrubs and trees. Submerged and floating aquatics flourish where open water occurs.

46. **Deep emergent marsh** - Wetlands that occur on mineral soils or fine-grained organic soils (muck or well-decomposed peat). The substrate is flooded by waters that are not subject to violent wave action. Water depths can range from 15 cm to 2 meters. Water levels may fluctuate seasonally, but the substrate is rarely dry and there is usually standing water in the fall. Characteristic vegetation includes emergent aquatics such as *Nuphar luteum*, *Nymphaea odorata*, *Typha latifolia*, *Typha angustifolia*, *Scirpus tabernaemontanii*, *Scirpus acutus*, *Sparganium eurycarpum*, *Zizania aquatica*, and *Iris versicolor*. Marshes that have been disturbed may be dominated by aggressive species such as *Lythrum salicaria* and *Phragmites australis.*

47. **Shallow emergent marsh** - Wetlands that occur on mineral soil or muck soils that are seasonally flooded and permanently saturated. These marshes are better drained than deep emergent marshes. Water depths may range from 15 cm to 1 meter during flood stages, but the water level usually drops by mid to late summer and the substrate is exposed. Deep and shallow emergent marshes often intergrade and they may occur together as a complex mosaic in a large wetland. Characteristic species include *Calamagrostis canadensis*, *Phalaris arundinacea*, *Dulichium arundianceum*, *Scirpus cyperinus*, *Scirpus atrovirens*, and *Carex* spp., including *Carex stricta.* Shallow emergent marshes typically occur in lake basins.

48. **Sedge meadow** - A marsh or wet meadow that occurs on mineral soil or muck substrates that are permanently saturated and may be seasonally flooded; there is usually little peat accumulation in the substrate. The dominant species are sedges *Carex* ssp., with *Carex stricta* often the most abundant species. Sedge meadows typically occur along streams and near the inlets and outlets of lakes and ponds. They also occur in basins as zones on the shoreward sides of shallow marshes. A sedge meadow does not form a floating mat, instead it is covered with water during flooding. When water levels are low, there is little or no open water. Sedge meadows may contain as much as 25% shrub, forming an ecosystem sometimes refered to as a shrub meadow.

49. **Beaver flowage and meadow** - Marshes created by beaver dams on small streams. Impoundments may have floating-leaved and emergent aquatics, and there may be many standing dead trees if the site was forested prior to flooding. On gentle slopes bordering beaver ponds, there is usually a wet meadow similar in composition to a shallow basin marsh. The extent of wet meadow is variable through time depending on the condition and elevation of the dam.

50. **Tidal fresh marsh and flats** - Marshes and mud shores located upstream from estuarine and coastal wetlands that are characterized by fresh water conditions (less than 0.5 ppt ocean-derived salts), plant and animal communities dominated by freshwater species, and daily, lunar tidal fluctuations. *Limosella subulata* and *Scirpus pungens* are characteristic species. *Zizania aquatica* may also occur. These marshes may form a continuum with inland freshwater marshes.

C. Bogs -- Ombrotrophic peatlands with a water table at or near the surface. The bog surface, which may be raised or level with the surrounding terrain, is virtually unaffected by groundwater from surrounding mineral soils and is therefore generally acidic and low in nutrients. Surface peat is typically poorly decomposed sphagnum. Bogs are usually covered with *Sphagnum* spp. and ericaceous shrubs, and may be treed or treeless. They typically include a variety of vegetation types, i.e., lagg, mud bottom, moss lawn, shrub heath, shrub thicket, wooded shrub heath, and forested bog.

51. **Maritime slope bog*** - Coastal bogs on peninsulas and islands with frequent fog and relatively high precipitation on appreciably sloping terrain. Peats are typically shallow and may not remain saturated throughout the year. *Empetrum nigrum* and *Rubus chamaemorus* are typical.

52. **Subalpine/alpine slope bog*** - High elevation bogs on appreciably sloping terrain that are fed by frequent fog, precipitation, and water draining from alpine meadows. Peats are shallow and occasionally dry out.

53. **Kettlehole bog** - Flat peatlands in kettles (circular or elliptical depressions formed in morainal or glaciofluvial deposits by the melting of buried ice blocks). The centers of peatlands in these gently sloping, bowl-shaped basins may be floating mats of peat or open water. The surface of the floating mat is sufficiently elevated to be free from contact with mineral-enriched pond water. Characteristic plants of northern kettleholes are *Eriophorum spissum*, *Ledum groenlandicum*, and *Carex pauciflora*. Southern kettleholes may include *Chamaecyparis thyoides*, *Clethra alnifolia*, and *Peltandra virginica*.

54. **Raised (domed) bog** - Large (usually more than 500 m in diameter) peatlands with convex surfaces that rise several meters above the surrounding terrain. The peatland surface is characterized by hummocks and hollows. Peat accumulations are sufficient to maintain a raised (perched) water table. The center of the peatland usually drains in all directions. Raised bogs may be patterned or unpatterned.

a: **Patterned bog** - Peatlands with small crescent-shaped pools usually occurring near the highest point. If the highest point is in the center, the pools tend to form a concentric pattern. If the highest point is off center, an eccentric (to one side) pattern occurs.

b: **Unpatterned bog** - Raised peatlands without pools.

55. **Coastal plateau bog** - Peatlands with flat to undulating surfaces that rise above their surroundings with the bog perimeters often sloping steeply down to mineral soil terrain. Surface vegetation usually lacks trees and contains extensive lawns of *Scirpus cespitosus*. *Empetrum nigrum* and *Rubus chamaemorus* are also characteristic. The crowberry blue butterfly (*Lycaeides argyrognomon empetri*) may occur in this ecosystem type.

56a. **Level bog** - Transitional (in terms of nutrient status) peatlands of basins that have essentially closed drainage, receiving water from precipitation and runoff from the immediate surroundings. The surface of the bog is flat and featureless. These bogs are often treed with *Picea mariana* and *Larix laricina* and ringed with tall shrub or coniferous swamp margins, giving them a bowl-shaped appearance.

56b. **Semi-bog** - A variant of level bog similar to peatlands in the taiga of Canada. Peat is generally shallow and as a result, tree roots may penetrate into mineral soil. The Klondike is the only known example in Maine.

D. Fens -- Minerotrophic peatlands with the water table at or just above the surface. The waters are relatively nutrient-rich, resulting in a more diverse flora than on bogs. Peat is typically moderately to well-decomposed and of variable thickness. The vegetation consists predominantly of sedges, grasses, reeds, and sphagnum, with some shrubs, and occasionally a sparse tree layer.

57. **Rich fen** - Fens that are enriched with calcium and relatively rich in nutrients. These may be patterned or unpatterned.

a: **Patterned (ribbed)*** - Rich fens with parallel, low peat ridges (strings) alternating with wet hollows or shallow pools (flarks) that are oriented across the major slope of the peatland at right angles to water movement. Vegetation is characterized by the presence of *Scirpus hudsonianus*, *Carex diandra*, *Carex exilis*, *Carex livida*, *Juncus stygius*, and a variety of herbaceous calciphiles.

b: **Unpatterned*** - Rich fens without noticeable pattern. Vegetation is similar to that of rich patterned fens.

58. **Poor fen** - Acidic fens that may be patterned or unpatterned. Poor fens are transitional peatlands - their nutrient status is intermediate between ombrotrophic and minerotrophic.

a: **Patterned (ribbed)** - Acidic fens with the ribbed pattern described above. The vegetation on flarks frequently includes *Scheuchzeria palustris*, *Rhynchospora alba*, *Carex lasiocarpa*, *Carex limosa*, *Carex rostrata*, *Xyris montana*, *Juncus brevicaudatus*, *Menyanthes trifoliata*, *Utricularia intermedia*, and *Utricularia minor*. The vegetation on ridges depends on their height above the water table. *Eriophorum spissum*, *Eriophorum angustifolium*, *Carex trisperma*, *Carex stricta*, *Carex pauciflora*, and *Carex michauxiana* are characteristic. A variety of *Sphagnum* spp. occur throughout.

b: **Unpatterned** - Poor fens without noticeable pattern.

III. LACUSTRINE ECOSYSTEMS

Waters situated in topographic depressions and old river channels that lack persistent emergent vegetation, but may include submerged or floating aquatic plants. Shorelines that are affected by lake water level fluctuations are included in this category. Very little is known about the range of biological diversity in lake ecosystems.

A. Shorelines -- Ecosystems on the shores of lakes that are often disturbed by ice scour, flooding, and waves. Fluctuations in water level over the course of the growing season may produce a predictable suite of species. This phenomenon needs further study.

59a. **Acidic/circumneutral rocky shore** - Dry outcrops with vegetation growing in crevices where soil has collected. *Campanula rotundifolia*, *Solidago* ssp., *Aster* ssp., grasses, and small shrubs are characteristic.

59b. **Calcareous rocky shore*** - Dry calcareous outcrops. *Carex eburnea* is an indicator of calcareous riverbanks. There is, however, no known occurrence of a calcareous rocky shore in Maine.

60. **Mud shore/nonpersistent marsh** - Muddy, mucky relatively protected shores that are moist during the growing season and sparsely vegetated.

61. **Sand/gravel beach** - Low sand areas that are characterized by *Cyperus* ssp. and, often, *Potentilla anserina.*

62. **Lakeside seep** - Shorelines where the water level may drop considerably over the course of the growing season but remain moist due to groundwater recharge. *Dulichium arundinaceum* and a variety of rushes are typical.

63. **Cobble shore** - Cobble or shingle shores that are typically in exposed locations with a lot of fetch. Characteristic plants are *Apocynum cannabinum*, *Melilotus alba*, and *Stachys palustris*. Vegetation is sparse.

B. Lakes -- The diversity of benthic invertebrates varies considerably in the lake types described below. Alkalinity and pH are also important. Acidic and circumneutral variants may exist for all except dystrophic lake ecosystems, and can be expected to be reflected in the lake flora and fauna.

64. **Monomictic oligotrophic lake** - Shallow (generally less than 5 meters), low productivity lakes that are typically unstratified. These lakes are characterized by high transparency and few rooted aquatic plants and algae.

65. **Monomictic dystrophic lake** - Shallow, unstratified, low productivity lakes that are darkly colored with tannic and humic acids. These are typically associated with peatlands and are acidic.

66. **Monomictic mesotrophic lake** - Shallow (generally less than 5 meters), medium productivity lakes that are typically unstratified. Rooted aquatic plants and algae are present in moderate numbers.

67. **Dimictic oligotrophic lake** - Low productivity lakes that turn over twice a year. These are typically greater than 12 meters in depth. Rooted aquatic plants and algae are absent or sparse.

68. **Dimictic mesotrophic lake** - Medium productivity lakes that turn over twice a year. These are typically greater than 12 meters in depth. Rooted aquatic plants and algae occur in moderate numbers.

69. **Meromictic lake*** - Permanently stratified lakes that are small, but deep. The only known example in Maine is a kettlehole. The deep water is anoxic and, as a result, has a depauperate biota.

IV. RIVERINE ECOSYSTEMS

Deepwater habitats contained within a channel in which water is flowing. Shoreline ecosystems which are influenced by fluctuating river water levels are included in this category. Our understanding of riverine ecosystems is limited. These ecosystems are broadly defined and may include a number of finer scale habitats, such as riffles, runs, springs, pools, and waterfalls.

A. Riverbanks -- Flood-washed and ice-scoured zone of the immediate river's edge. Includes bedrock ledges that extend into the river channel.

70a. **Acidic/circumneutral rocky shore** - Low or steep bedrock outcrops with alluvial soil in cracks in the rock. Typical plants are *Campanula rotundifolia, Aquilegea canadensis, Solidago* ssp., and *Poa compressa.*

70b. **Calcareous rocky shore*** - Rocky shores characterized by *Carex eburnea, Erigeron hyssopifolius, Hedyotus longifolia*, and, occasionally, *Viola novae-angliae.*

71. **Riverside seep** - Ecosystems on the shores of larger rivers where flood scouring maintains open groundwater discharge sites. Seepage flowing over bedrock or through sands, gravels, and cobbles creates a fen-like environment that can support a number of rare hardy plant species. *Tofieldia glutinosa*, *Spiranthes lucida*, and *Carex garberi* are typical. Rare species of seeps along the Saint John, Allagash, and Aroostook Rivers and their larger tributaries are *Oxytropis campestris* v. *johannensis*, *Pedicularis furbishiae*, *Salix glaucophylloides*, *Hedysarum alpinum* v. *americanum*, *Astragalus alpinus* v. *brunetiana*, and many others.

72. **High energy riverbank** - Sandy, gravelly or cobbly riverbanks that are scoured by high-velocity floodwaters. In eroded areas, these riverbanks are sparsely vegetated with disturbance colonizers.

73. **Low energy riverbank** - Low, regularly flooded areas in backwaters or flat water sections with alluvial mud or clay. Mudflats are sparsely vegetated with low, mat-forming plants.

74a. **Sand and gravel bar** - Meadow ecosystems on sand and gravel bars deposited within a river channel. These ecosystems may be very sparsely vegetated, depending on the rates of deposition and erosion of the sand or gravel.

74b. **Riverwash barrens*** - Sandy to gravelly river deposits with a sand barren floral community including *Hudsonia tomentosa.*

B. Rivers and streams -- Flowing, non-tidal waters that lack persistant emergent vegetation, but may include areas with submerged or floating-leaved aquatic vegetation. Because the biota associated with rivers and streams is poorly understood, river ecosystems are distinguished primarily by watershed position.

75. **Rocky headwater stream** - Small, first and second order, rocky streams with moderate to steep gradients and cold water that flow over eroded bedrock in the areas where the streams originate. Most of the erosion is headward and deposition is minimal. Gorges, waterfalls, and springs may be present.

76. **Wetland headwater stream** - Small, first and second order, marshy brooks with low gradients, slow flow rates, and cool to cold water that flow through marshes, bogs, fens, or swamps. The substrate is gravel or sand, with silt, muck, or peat deposits along the shore.

77. **Midreach stream** - Third and fourth order streams with a well-defined pattern of alternating pools, riffles, and runs. Most of the erosion is lateral. Small waterfalls and springs may be present.

78. **Main channel** - Large, quiet, base level (fifth order or greater) sections of rivers where there are no distinct riffles. Main channel streams may have meanders and are characterized by considerable deposition, with relatively minor amounts of erosion.

79. **Deadwater** - Wide, flat water sections in which aquatic vegetation is usually abundant. These may occur on headwater and midreach streams where natural dams (often constrictions in the river channel) have caused partial impoundments.

80. **Intermittent stream** - Small, ephemeral streams with a moderate to steep gradient, where water flows only in the spring or after heavy rain.

81. **Peatland outlet stream** - Small, cold, strongly-colored streams that are high in tannic and humic acids. The biota of these streams is diagnostic. Ericaceous plants are typical along their banks.

V. ESTUARINE AND MARINE ECOSYSTEMS

Aquatic or wetland ecosystems associated with coastal embayments, tidal rivers, and open ocean. Estuarine ecosystems extend upstream and landward to where ocean-derived salts near the water surface measure <0.5 ppt during the period of average annuyal low flow, and downstream or out to sea to where freshwater dilution is minimal. Marine ecosystems encompass all coastal areas not appreciably diluted by freshwater (surface salinities seldom fall below 30 ppt). Because the salinity of Maine coastal waters varies considerably with season and depth, ecosystems are classified using substrate, tidal regime, and a number of other parameters. More information is needed on vegetation and invertebrates before portions of tidal rivers can be classified as marine or estuarine. This classification focuses on nearshore habitats.

A. Coastal Strand Ecosystems -- Ecosystems located at the interface of land and sea that are influenced by salt spray and storm tides.

82. **Coastal dunes*** - Fore and back dunes associated with sand beaches. These ecosystems may include pitch pine woodlands (dune forests) on stabilized dunes and coastal interdunal swamps in depressions that are deep enough to be in contact with groundwater. Characteristic species are *Ammophila breviligulata, Myrica pensylvanica, Prunus maritima, Solidago sempervirens, Rosa virginiana,* and *Hudsonia ericoides. Nyssa sylvatica* and *Acer rubrum* are thought to be characteristic species in interdunal swamps.

83. **Fresh-brackish pond** - Small ponds formed where beach ridges form natural dams at the heads of marshes. Salinity is between 0.5 and 18 parts per thousand.

B. Intertidal

84. **High energy rocky shore** - Bedrock ledge located in exposed areas of the shoreline, where heavy wave action significantly affects intertidal zonation. Four distinct zones, including the splash zone, barnacle zone, rockweed zone, and *Chondrus* zone, are typically present. Characteristic species include *Anurida maritima* in the splash zone, and *Balanus balanoides, Littorina saxatilis, L. obtusata, L. littorina, Thais latillus, Acmaea testudinalis,* and *Mytilus edulus.*

85. **Low energy rocky shore** - Bedrock ledge located in intertidal areas protected from heavy wave action. There is no obvious zonation pattern. Most low energy rocky shores have a layer of silt coating the surface of the rocks and attached seaweeds. The species composition of this ecosystem resembles that of the high energy rocky shore except that it is less diverse.

86. **Back-barrier salt marsh*** - Large, open marshes behind barrier beaches. The remnants that exist in Maine are thousands of years old.

87. **Fluvial-minor salt marsh** - Large, open marshes occurring in old valleys with underfit streams that are also relatively old.

88. **Fluvial-major salt marsh** - Salt marshes that fringe the edges of relatively large tidal streams.

89. **Bluff-fringing salt marsh** - Small, young (generally less than 100 years old) salt marshes that fringe erodible bluffs. Low marsh species are predominant. Species diversity is generally low, apparently because of geologic instability associated with rising sea level.

90. **Transitional salt marsh*** - Salt marshes that have grown over raised bogs as the local sea level has risen.

91. **Brackish tidal marsh and flat** - Marshes located in coastal impoundments where waters maintain a relatively low salinity (less than 18 ppt), or between salt marshes and freshwater tidal marshes along larger tidal rivers. These marshes are subject to occasional tidal flow and submergence during floods. Characteristic species include *Zizania aquatica*, *Sagittaria latifolia*, *Sium suave*, *Limosella subulata*, and *Aster subulatus*.

92a. **Mud flat** - Fine-grained flats found in coves, inlets, and other protected, low energy coastal sites. The sediments, which include various proportions of silt, clay, sandy, and organic material, are relatively stable. These ecosystems are generally very productive, with a species diversity that is higher than that of other intertidal habitats. Characteristic species include a gastropod *Hydrobia truncata*, *Macoma baltica*, two polychaetes, *Streblospio benidicti* and *Nereis virens*, and, from Casco Bay east, the amphipod *Corophium volutator*.

92b. **Mussel bar** - Temporary 'living reefs' on mudflats that consist of dense blue mussel populations. Mussel bar formation is stimulated when water temperatures are warm and wave action is slight. Other characteristic invertebrates include *Polydora ligne*, *Eleone longa*, scaleworms *(Harmothoe* ssp.), and *Carcinus maeans*.

93a. **Sand and gravel flat** - Flats that form in areas with minimal wave exposure that are composed primarily of sand and gravel. They generally have a slight slope and rippled surface. Species richness is relatively high, but productivity is considerably lower than mudflat ecosystems. *Mya arenaria* and three polychaetes, *Nereis virens*, *Pygospio elegans*, and *Scolecolepides viridis* are characteristic invertebrates.

93b. **Cobbleflat** - Flats that form in areas with moderate wave exposure tha are composed primarily of cobbles.

94. **Sand beach** - Beaches consisting entirely of sand which are exposed to high wave energy. They extend from the mean low water mark to uplands or dune fields, where inland vegetation is established. Well-sorted, constantly shifting sand results in a depauperate biota in

the intertidal zone. A variety of polychaetes, including *Scoloplos* ssp., *Nephtys caeca*, *Paraonis fulgens*, and *Ophelia bicornis*, and an amphipod, *Psammonyx nobilis* are characteristic.

95. **Gravel beach** - High energy beaches consisting of sand and gravel derived from offshore or shoreline deposits of glacial till or outwash reworked and transported by high energy waves. Gravel beach faces are usually narrow and steep. High wave action results in relatively low species diversity, although higher than that of sand beach ecosystems. Gravel beaches often grade into either sand or cobble beaches. *Balanus balanoides*, *Littorina littorea*, and *Mytilus edulus* are typical, along with two amphipods, *Orchestia platensis* and *Hyale nilssoni*.

96. **Cobble beach** - High energy beaches consisting solely of cobbles derived from offshore or shoreline deposits of glacial -till or outwash reworked and transported by high-energy waves. Cobble beach faces are usually narrow and steep. The invertebrate fauna resembles that of gravel beach ecosystems.

97. **Boulder beach** - Beaches of boulders derived from glacial till or jointed bedrock ledge exposed to very heavy waves. These are generally located along exposed rocky headlands and offshore island coasts.Tide pools and pockets of finer sediments are common within these habitats. Because of a relatively stable substrate, these are the most diverse of beach ecosystems. Common invertebrates resemble that of the high-energy rocky shore and include *Acmea testudinalis*, *Littorina* ssp., *Thais latillus*, *Balanus balanoides*, and *Carcinus maenas*.

C. Subtidal (more information is needed on the plant and animal species associated with these ecosystems).

98. **Salt pond** - Coastal ponds with euhaline water (>30 ppt) that are flushed twice daily be the tide. These ponds typically occur behind a natural constriction, such as a reversing falls. Virginian species associated with relatively warm water temperatures may be typical.

99a. **Mud bottom** - Mud and fine sand bottoms commonly found in shallow, relatively protected bays and inlets. Diagnostic species include two bivalves, *Nucula annulata* and *Thayasira* ssp., two polychaetes, *Nephtys incisa* and *Sternapsis scutata*, and amphipods in the genus *Haploops*.

99b. **Eelgrass meadow** - An aquatic bed of mud and sand bottoms dominated by *Zostera marina*. An amphipod *Cymadusa compta* is also characteristic.

100. **Sand and gravel bottom** - Mixed sand and shell bottoms, sometimes mixed with gravel or mud. The sand dollar, *Echinarachnius parma*, and amphipod, *Unciola irrorata* are characteristic.

101. **Cobble bottom** - A scoured substratum consisting largely of cobbles that occurs in channels or passes with relatively high currents. *Homarus americanus*, in the early benthic phase, are thought to be restricted to this ecosystem.

102. **Rocky bottom** - Rocky areas with ledge and/or boulders that are characterized by encrusting and erect coralline algae, the sea urchin, *Strongylocentrotus droebachiensis*, and three

crustraceans, *Balanus crenatus*, *Unciola irrorata*, and *Homarus americanus*. Kelp beds typically occur where sea urchin populations are low.

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This document includes a map that is too large to be digitized. To view the map, please contact the Reference Desk at the Maine Law and Legislative Reference Library.