Fundy Model Forest

~Partners in Sustainability~

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The Fundy Model Forest…
…Partners in Sustainability

"The Fundy Model Forest (FMF) is a partnership of 38 organizations that are promoting sustainable forest management practices in the Acadian Forest region."

Atlantic Society of Fish and Wildlife Biologists
Canadian Institute of Forestry
Canadian Forest Service
City of Moncton
Conservation Council of New Brunswick
Fisheries and Oceans Canada
Indian and Northern Affairs Canada
Eel Ground First Nation
Elgin Eco Association
Elmhurst Outdoors
Environment Canada
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Fundy Environmental Action Group
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Gap Analysis
Summary Report
Spring 1994

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GAP ANALYSIS SUMMARY REPORT

FUNDY MODEL FOREST GAP ANALYSIS PROJECT: SPRING 1994

Summary

Gap analysis is a procedure that delineates a landscape into discreet ecological units (e.g. climatic zones, physiographic regions, vegetative communities) and identifies the "gaps" in the existing system of conservation areas for each unit. The extent of the "gap" is determined by comparing the current percentage of protected land (land set aside or managed for specific conservation purposes, such as ecological reserves or special management areas) in each unit with a predetermined standard, typically 10-18 percent. This represents the estimated minimum area necessary to maintain the viability of the unit over time. Ideally, the estimate of minimum area is based on current knowledge regarding the population dynamics of the unit's member species; levels of genetic variation; the areal extent of the unit; the disturbance regime, both regional and local; and other influential ecological processes. The gap analysis methodology is not rigid; the procedure is determined by the geographic scale and the specific goals of the project. The end results of a gap analysis survey have application for regional landscape planning by providing a biogeographic frame of reference upon which ecologically sensitive management decisions can be made.

Introduction: What Is Gap Analysis?

The term "gap analysis" was first coined by Burley (1988). The procedure was originally developed by conservation biologists who sought an alternative to the "one-species-at-a-time" approach to the protection of biodiversity. In the past, attempts to protect endangered species have often occurred at a stage when the species' status was critical, and management options were limited and costly. It also tended to focus on charismatic vertebrate species, such as

special management over sites that lack these attributes in some way. Because the decisions are based on scientifically-based evaluation, rather than vague impressions, the management decisions are more easily justified, hence reducing potential conflict, not to mention environmental impact.

The Gap Analysis Methodology

Overview

Gap analysis is designed to provide a rapid assessment of a regions' ecological inventory in terms of vegetative communities and their member species. It does not replace field surveys, which are more comprehensive, but provides a level of information that would be costly and time consuming to collect by other more direct means, especially at the regional level. Much of the work is done using Geographical Information Systems (GIS), which are computer-based mapping tools that can perform rapid and comprehensive analyses of complex geographical data.

The process of gap analysis is usually described as a series of filters that capture elements of biodiversity at the various levels of ecological organization (Figure 1) (Scott et al., 1993). From a practical standpoint, this usually means a two-tiered approach: a "coarse-filter" analysis and a "fine-filter" analysis that together seek to capture the total biological diversity of the region. The "coarse filter" is usually the first step and seeks to determine the conservation status of the broad-scale habitat

regolith and/or soil data. The data can come from a variety of sources: landsat images, vegetation cover maps, aerial photographs, recent soil and geomorphologic surveys, and existing geological and climatic maps. The boundaries of each unit depicted on the base map are broad estimates of the unit's range; transitions between differing communities or ecosystems in nature are rarely sharp (Austin, 1991).

There is no set methodology for selecting environmental variables to represent the landscape. More detail means greater accuracy in delineating ecological units and greater ability to characterize or describe on-the-ground "reality". It also means more time required to collect, collate, and interpret the data, thus prolonging the classification process. As a result, many gap analysis projects attempt a tradeoff between simplicity and accuracy, with the degree of tradeoff being determined by the goals of the project and the size of the study region. Data availability is also a factor. For example, projects operating at a national or global scale may be best served by a basemap that uses climate or geomorphological/soil data alone or in combination; both are primary forces influencing ecological process. However, neither may be adequate for representing landscape patterns at provincial/state levels. Vegetation data, on the other hand, is a key visible feature defining an ecosystem (Lewis and MacKinnon, 1992), as well as being a potential predictor of biological diversity (Scott et al., 1993). For these reasons, gap analysis projects in many North American provinces and states commonly use vegetation data, supplemented with predicted vertebrate distributions, to create the base map. At a

"How much is enough to ensure adequate protection?" There has been much discussion on this issue in the scientific literature (e.g. Soule and Simberloff, 1986; Soule, 1986) but the solutions are complex and difficult to generalize. Ideally, the decision should be specific to each unit and based on known scientific data regarding the ecological processes. These processes may include the population dynamics of the unit's member species; the disturbance regime, both regional and local; and the changes in genetic variability that occur over time. Areal extent of the unit and its relationship with adjacent units is also important. Unfortunately, the data may not always exist to make these decisions. Or, it dictates a protection target that is unrealistic in terms of size (e.g. "millions of km^2", see Mann and Plummer, 1993). The World Congress on National Parks (1984) suggested that, as a bare minimum, 12% of the global land surface should be protected to ensure adequate representation of the Earth's ecosystems. Despite its limitations, this standard has been adopted by some administrations as the initial target for conservation efforts (e.g. Table 1B).

Once the geographical range and current percentage of protected area have been determined for an ecological community-type, it is necessary to know the status of that community in the remaining unprotected area. If the community is under-represented, some provision will be required to increase its level of protection. On today's landscape, communities can be highly fragmented by land ownership, land use patterns, and variations in successional status. Therefore, information overlays are created which quantify the extent of each of these features on the landscape, either

In the gap analysis literature, little attention has been focused on the methodology for conducting fine-filter analysis. In fact, there is almost no record in the literature of a "fine-filter analysis" that has been done in association with a gap analysis project to date (though some point mapping of rare species has been done at a scale of 1:500 000 [Scott et al., 1993]). This can be explained in part by the recent implementation of most gap analysis projects in North America. The procedure is inherently "top-down" and fine-filter work gets left to the last.

Despite the absence of a formal "fine-filter" methodology, there are several approaches that can be used to inventory special species and/or unique habitats within a landscape. The most general strategy is to compile existing information on species presence, habitat associations, and abundances as reported in the scientific and natural history literature for the area. Information may also be gathered from local naturalists who usually have a good knowledge of rarities in their locale (Fleming, 1991). This approach likely serves as a good first cut though it may not be exhaustive. A second strategy is to design field sampling strategies that survey all major community types in the region, or focus on highly variable areas, such as sharp environmental gradients (e.g. Austin and Heyligers, 1991). This may identify previously unrecorded species in these locations. However, this may be more appropriate for locating areas of species richness, as opposed to rare species (Prendergast et al., 1993). A third approach that may possess the most promise is to design predictive models or algorithms of rare species distribution based on habitat variables. Commonly there are strong

by each state, the procedures presently being used by Idaho, Wyoming, and New Mexico will be reviewed.

Idaho: The first "gap analysis" project was conducted as a pilot study in Idaho beginning in 1987. The goal was to assess the distribution and conservation status of biodiversity at the state-wide level and make management suggestions based on observed gaps in the protection network. The emphasis of the project was vertebrate species, though plant and invertebrate species were considered to some degree. The methodology used in Idaho served as the basis for gap analysis projects conducted at a later date in other states.

A vegetation map delineating the major forest cover types served as the foundation for the Idaho gap analysis. It was composed of a mosaic of existing vegetation maps, primarily timber survey maps from the US Forest Service, that were refined by comparison to satellite imagery (from this experience, all subsequent gap analysis projects have relied strictly on satellite photos to resolve vegetation boundaries). Additional climate, hydrology, wetlands, and potential vegetation data were also used. In total, 117 forest cover types were identified at a scale of 1: 250 000.

To determine vertebrate species distributions, maps of known habitat associations were matched with forest classes to give a hypothetical range within the state. Maps of some butterfly species were also constructed in this manner. When possible, these predicted distributions were ground-truthed. For species associated with wetlands or water courses, a larger-scale analysis at 1:100 000 was conducted (many aquatic habitat patches were not visible at the

the gap analysis (Driese, 1993).

New Mexico: New Mexico is in the process of creating a base map that is based entirely on dominant cover species data extracted from Landsat data. In cases where wide ranging species dominate the landscape, co-dominant species are used to further distinguish variations in the forest community (Figure 2). New Mexico maintains a minimum sampling unit of 0.08 ha, the smallest possible polygon available from satellite imagery. This fine-scale resolution is considerably smaller than the 100 ha minimum required by the national gap analysis program. It will allow the New Mexico program to conduct a more extensive fine-filter analysis than occurs in most states (Crist, 1993).

(ii) British Columbia

In British Columbia, gap analysis is the working tool of the province's "Protected Area Strategy" or PAS (Province of British Columbia, 1993a). The goal of PAS is to protect 12% of the total land mass by the year 2000. At present, approximately 6% has been set aside in some form of protected area, with some habitats (e.g. arctic tundra) being better represented than others (e.g. lowland coastal Douglas-Fir forest). The gap analysis project seeks to identify gaps in not only the biological resources but also the cultural and recreational resources. In terms of conserving biological resources, the goals include: 1) to enable a systematic approach to protected area planning and assessment 2) to provide a technical rationale for recommending one area over another for study

Gap analysis provides important information on the biological and physical features of the landscape that have obvious applications for broad-scale management planning (Pressey, 1992). However, as a specific tool for biological inventory and conservation planning, gap analysis can only serve as a first step (Scott et al., 1993). The survey of species presence or absence, species range, and species-habitat associations conducted by the gap analysis procedure cannot be considered exhaustive; gap analysis does not substitute for more detailed scientific evaluation. As well, there are limitations in using the land classes (a.k.a. ecological units) identified on the base map to locate ecological reserves and determine their level of representation. For example, relationships between the land classes and the variations in the abundance and distribution of species may be unclear. Also, preserving a piece of one or even several land classes may miss patchily-distributed species (Pressey, 1992). Manipulation of scale may also influence the adequacy of a proposed reserve to represent landscape features; as map scale becomes finer, landscape and biotic diversity increases thus requiring a greater reserve area (Pressey, 1992). These limitations can only be minimized with research projects designed specifically to address these questions. The value of gap analysis is to make these information deficiencies apparent.

Gap Analysis and the Fundy Model Forest

The traditional method for large-scale conservation of lands in

sharp contrast between the forested park, and the plantations and other managed areas that occur up to the park's boundary.

In the Fundy Model Forest, almost 90% of the 420 000 hectares is owned privately (small woodlot owners: 65%, J.D. Irving: 17%) or in crown lease (17%). The remainder is in some form of protected or specially managed area (Fundy Park: 5%, Mature Coniferous Habitat, Deer Wintering areas, and Ducks Unlimited Compounds: 1%) or is settled area (4%). With a goal of the project to develop an integrated management strategy, there is an opportunity to break the traditional protection/non-protection dichotomy and develop a more sustainable and sensitively-managed forest that is, at the same time, a working forest. To help meet this goal, the Gap Analysis project, in conjunction with the Ecological Land Classification (ELC) project being conducted by Bruce Matson and Randy Power from the Department of Natural Resources and Energy, seeks to create an ecological data base for the Model Forest area. The ELC will be delineating all the broad-scale forest communities within the region. The Gap Analysis project will supplement this classification system by delineating the remaining non-forested communities in the Model Forest. This will include the wetlands and the smaller, often highly-localized communities such as the fens, coastal habitats, and riverine areas. A "gap analysis" will then be conducted to determine the current status of all ecological communities within the Model Forest, either as over- or under-represented within the existing conservation network. Management recommendations will than be made based on these findings.

It has been stated by the J.D. Irving company that if they knew

planning strategies in the province, as well as other regions with similar ecological and land-management needs.

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Fundy Model Forest Gap Analysis Project

Year End Report

Andrew MacDougall and Judy Loo
February, 1995

Introduction

One of the twelve objectives of the Fundy Model Forest (FMF) is to protect habitats of species and communities of wild life at risk, unique areas, and areas that are representative of the FMF. As with any managed landscape, the challenge is to balance active land use and conservation; to protect species while conducting viable resource-based activities.

A typical approach to achieving this balance is to obtain information on the distribution and abundance of the plants, animals and invertebrates in a region. If sites with concentrations of uncommon or rare species, or areas determined to be representative of broad-scale ecological features, are identified, land use strategies can be designed that that work around such locations.

Unfortunately, detailed information on the distribution and abundance of most of the flora and fauna of the FMF is not available and the time required to gather such detailed information is prohibitive. However, in its absence, a viable alternative is to focus on the different community types in the FMF. If community types containing species or assemblages of species of interest, are specially managed, it is assumed that both the member species and the processes that maintain them will be preserved, though this may depend on the size of the site, in some cases.

The Fundy Model Forest Gap Analysis Project, in cooperation with the Ecological Land Classification project of the Department of Natural Resources and Energy - Hampton, seeks to create an information profile on the diversity of community types within the FMF.

The objectives of the Fundy Model Forest Gap Analysis project are:

1. to identify sensitive species, critical and unique areas, and centres of species richness within the Fundy Model Forest.
2. To identify major community types.
3. To recommend protection and/or management strategies to ensure that the valued features remain in the landscape. Community types currently not represented in any area receiving special management or protection (the "gaps") will be of particular interest.

types of sites receiving special management within the FMF: deer wintering areas and mature forest habitat blocks.

Many of the identified community types are completely unrepresented by any form of special management within the FMF. The implications of this depend largely on the present and future land use within each community type. Areas that are inaccessible (ravines, cliffs) or economically unimportant may be less at risk than readily accessible areas. Because of the historical land use patterns in the area, much of the Fundy Model Forest has been cut over at one time. River valleys were cleared for farmland, lake edges have been developed for housing or cottages, cedar swamps have been cut and drained, and most of the remaining relatively intact forest patches have been selectively cut or high-graded at some point in their history.

Community types requiring representation in a system of specially managed or protected areas are: hemlock slope forest, oak-pine forest, white cedar swamp, rich hardwoods, red spruce forest, cliffs, escarpments, talus slopes, caves, bogs, fens, sedge meadows, freshwater marsh, inland salt springs, quiet-water shoreline, high-energy shoreline, coastal headland, aquatic, and saltmarsh. Identified sites with these community types in the FMF tend to be small, either naturally or as a result of human activities, and many of them contain rare or uncommon plant species.

Vegetation surveys indicate that the species composition of community types varies widely across the FMF landscape, due, in part, to microsite conditions such as soil pH, moisture, or aspect. Even within a particular combination of environmental conditions, the species composition may vary, especially if there are uncommon or rare species in the assemblage. Sites of potential interest can be pinpointed by intersecting GIS layers with digital terrain data, and climate information but this must be followed by site-specific analysis.

Continuing Work to be Completed by March 31, 1995

Boundaries of all of the sites proposed for special management or protection are being digitized. Summary descriptions, including site profiles, vascular plant species lists, land ownership, and size are being written for each area. In addition, summary statistics are being compiled for all the wetlands of the FMF using information from the Maritimes Wetlands Atlas. There are approximately 1500 identified wetlands consisting of marshes, swamps, bogs and fens in the FMF. A report is near completion on the small-scale community types of the FMF, describing their general characteristics and special features. All of these on-going tasks will be completed by March 31, 1995.

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II. Description of the Gap Analysis Procedure: A General Profile Plus Case Studies From Other Regions of North America.

Introduction

The term "gap analysis" was first coined by Burley (1988), though the term has its roots in earlier work done in conservation biology and landscape ecology (e.g. Margules and Usher, 1981; Nature Conservancy, 1982; Noss, 1987). Gap analysis was developed by conservation biologists who sought an alternative to the "one-species-at-a-time" approach to the protection of biodiversity. In the past, attempts to protect endangered species have often occurred at a stage when the species' status was critical, and management options were limited and costly. It also tended to focus on charismatic vertebrate species, such as the California condor or the bald eagle (Csuti et al., 1993). Gap analysis is a proactive approach that seeks to identify sensitive and unprotected natural areas before they become threatened. By focusing on the ecosystem level, it is assumed that not only will the member species be preserved, but also the processes necessary to sustain them. This includes the maintenance of a gene pool that contains sufficient variation to be able to adapt to future environmental change.

Gap analysis is a procedure that delineates a landscape into discreet ecological units (e.g. climatic zones, physiographic regions, vegetative communities) and identifies the "gaps" in the existing system of conservation areas for each unit. The extent of the "gap" is determined by comparing the current percentage of protected land (land set aside or managed for specific conservation purposes, such as ecological reserves or special management areas) in each unit with a predetermined standard, typically 10-18 percent. This represents the estimated minimum area necessary to maintain the viability of the unit over time. Ideally, the estimate of minimum area is based on current knowledge regarding the population dynamics of the unit's member species; levels of genetic variation; the areal extent of the unit; the disturbance regime, both regional and local; and other influential ecological processes. The gap analysis methodology is not rigid; the procedure is determined by the geographic scale and the specific goals of the project. The end result of gap analysis is a clear portrait of the conservation priorities of an area, which in turn serves as an effective communication tool that can be presented to politicians, planners, and the public.

Despite being founded on conservation principles, gap analysis has wider application as a tool in integrated land use planning. Because it identifies the location and extent of ecological units at one or more spatial scales, gap analysis provides a biogeographical frame of reference upon which forest management decisions can be made. For example, rather than maximizing timber supply to the detriment of other biological resources, cutting could be strategically directed toward the most wide-ranging ecosystems of the region. Less common habitats could be targeted for selective cutting, while rare habitats could be protected. Under these circumstances, the goal is to meet timber requirements while at the same time maintaining the ecological integrity of the area.

Gap analysis can also serve as a tool for conflict resolution between interest groups with differing views on regional land management. When it is not possible to set aside all sensitive habitats within a regional landscape, the reslts of gap analysis can be used to prioritize the

There is no set methodology for selecting environmental variables to represent the landscape. More detail means greater accuracy in delineating ecological units and greater ability to characterize or describe on-the-ground "reality". It also means more time required to collect, collate, and interpret the data, thus prolonging the classification process. As a result, many gap analysis projects attempt a tradeoff between simplicity and accuracy, with the degree of tradeoff being determined by the goals of the project and the size of the study region. Data availability is also a factor. For example, projects operating at a national or global scale may be best served by a basemap that uses climate or geomorphological/soil data alone or in combination; both are primary forces influencing ecological process. However, neither may be adequate for representing landscape patterns at provincial/state levels. Vegetation data, on the other hand, is a key visible feature defining an ecosystem (Lewis and MacKinnon, 1992), as well as being a potential predictor of biological diversity (Scott et al., 1993). For these reasons, gap analysis projects in many North American provinces and states commonly use vegetation data, supplemented with predicted vertebrate distributions, to create the base map. At a local scale however, major vegetation patterns do not always reflect variations in environmental variables that are significant for other biotic levels. As well, current vegetation patterns have often been heavily altered since European colonization and may not reflect more historical distribution patterns. In these situations, the combination of climate and geomorphological/soil data with vegetation data likely presents the most accurate portrayal of local landscape features.

Performing the Coarse Filter and Fine Analyses

The coarse filter of gap analysis seeks to identify the level of representation of the broad scale ecological units by the current protection system. An information layer or "overlay" containing the boundaries of existing protected areas (e.g. federal or provincial parks, sensitively managed zones, areas of private stewardship) is superimposed upon the basemap and the percentage of protected or sensitively managed land in each ecological unit is calculated.

To identify the "gaps" at the course filter level, the calculated percentage is compared with a predetermined standard percentage to determine if levels of protection are sufficient. This standard percentage is an estimate of the minimum size of land base necessary to preserve the ecological integrity of the community through time, and allows a quick assessment of a regions current conservation effort. Underlying the decision on a standard percentage to set aside for conservation is the question "How much is enough to ensure adequate protection?" There has been much discussion on this issue in the scientific literature (e.g. Soule and Simberloff, 1986; Soule, 1986) but the solutions are complex and difficult to generalize. Ideally, the decision should be specific to each unit and based on known scientific data regarding the ecological processes. These processes may include the population dynamics of the unit's member species; the disturbance regime, both regional and local; and the changes in genetic variability that occur over time. Areal extent of the unit and its relationship with adjacent units is also important. Unfortunately, the data may not always exist to make these decisions. Or, it dictates a protection target that is unrealistic in terms of size (e.g. "millions of km^2", see Mann and Plummer, 1993). The World Congress on National Parks (1984) suggested that, as a bare minimum, 12% of the global land surface should be protected to ensure adequate representation of the Earth's ecosystems.

1991). This may identify previously unrecorded species in these locations. However, this may be more appropriate for locating areas of species richness, as opposed to rare species (Prendergast et al., 1993). A third approach that may possess the most promise is to design predictive models or algorithms of rare species distribution based on habitat variables. Commonly there are strong associations between the location of rare species and areas that have unique disturbance regimes, drainage patterns, soil chemistry and/or nutrient levels, or possess sharp environmental gradients (Griggs, 1940; Miller, 1986; Keddy and MacLellan, 1990; Wisheu and Keddy, 1992; Hill and Keddy, 1992; Huston, 1994). This may include tidal zones, windswept escarpments, ice-scoured river banks, chalk cliffs, or alkaline soils associated with underlying limestone parent material. By pinpointing these locations using existing data on GIS, working hypotheses regarding the possible locations of rare species are generated. These may aid in locating rarities in areas seldom traveled or heavily disturbed (such as river banks in urban or heavily farmed areas) which have not previously been inventoried.

Working Examples of Gap Analysis

(i) National Biological Survey in the United States

The National Biological Program in the United States is currently using the gap analysis procedure to assemble geographical information from each state to create an integrated ecological data base to be used in conservation planning. The success of this project will depend on the ability to merge all gap analysis data sets from each state. To ensure success, each state is operating under consistent guidelines at the finest resolution possible. However, some states will be more accurate than others, depending largely on data availability as well as existing infrastructure and starting date (some states are almost finished, some have yet to start). To illustrate the typical methodology used by each state, the procedures presently being used by Idaho, Wyoming, and New Mexico will be reviewed.

Idaho: The first "gap analysis" project was conducted as a pilot study in Idaho beginning in 1987. The goal was to assess the distribution and conservation status of biodiversity at the state-wide level and make management suggestions based on observed gaps in the protection network. The emphasis of the project was vertebrate species, though plant and invertebrate species were considered to some degree. The methodology used in Idaho served as the basis for gap analysis projects conducted at a later date in other states.

A vegetation map delineating the major forest cover types served as the foundation for the Idaho gap analysis. It was composed of a mosaic of existing vegetation maps, primarily timber survey maps from the US Forest Service, that were refined by comparison to satellite imagery (from this experience, all subsequent gap analysis projects have relied strictly on satellite photos to resolve vegetation boundaries). Additional climate, hydrology, wetlands, and potential vegetation data were also used. In total, 117 forest cover types were identified at a scale of 1: 250 000.

To determine vertebrate species distributions, maps of known habitat associations were matched with forest classes to give a hypothetical range within the state. Maps of some butterfly species were also constructed in this manner. When possible, these predicted distributions were

ecological areas across the land base (Province of British Columbia, 1993b). The biological resources targeted are areas that contain the full range of biological diversity, not just sites with high vertebrate species richness as appears to be the focus of some gap analysis projects in the US (Rautio, 1992).

To date, the BC gap analysis project has only been conducted at the coarse-filter level (1: 250 000) and only in a few sections of the province. The fine-filter methodology has yet to be determined on a province-wide basis (Rautio, 1992). The project currently operates at the eco-region and eco-section scale, with the major ecological zones being identified by a combination of eco-region data (based on landform and climate) and biogeoclimatic data (based on vegetation, soil, and climate) (Province of BC, 1993b). The procedure operates as follows: A basemap depicting the major ecological zones of the region is created. Information overlays showing the boundaries of the existing protected areas are superimposed upon the basemap. The percentage of protected area within each ecological zone is calculated. This calculation is then compared with standard percentage (12%) to determine the current level of representation. In ecological zones found to be under-represented, all public land is surveyed in attempt to locate potential candidate sites to help fufill the percentage quota (Province of BC, 1993b).

Limitations of the Gap Analysis Procedure

Gap analysis provides important information on the biological and physical features of the landscape that have obvious applications for broad-scale management planning (Pressey, 1992). However, as a specific tool for biological inventory and conservation planning, gap analysis can only serve as a first step (Scott et al., 1993). The survey of species presence or absence, species range, and species-habitat associations conducted by the gap analysis procedure cannot be considered exhaustive; gap analysis does not substitute for more detailed scientific evaluation. As well, there are limitations in using the land classes (a.k.a. ecological units) identified on the base map to locate ecological reserves and determine their level of representation. For example, relationships between the land classes and the variations in the abundance and distribution of species may be unclear. Also, preserving a piece of one or even several land classes may miss patchily-distributed species (Pressey, 1992). Manipulation of scale may also influence the adequacy of a proposed reserve to represent landscape features; as map scale becomes finer, landscape and biotic diversity increases thus requiring a greater reserve area (Pressey, 1992). These limitations can only be minimized with research projects designed specifically to address these questions. The value of gap analysis is to make these information deficiencies apparent.

Natural history information sources provide information on the presence and distribution of a large number of species from most major biotic groups (e.g. birds, plants, mammals, reptiles, and amphibians). The most common and widespread types of natural history data are found in herbaria and museum records, taxonomic keys, and in field guides.

We used a combination of natural history data sources to compile lists of species recorded in the FMF. These sources included herbaria at the New Brunswick Museum, University of New Brunswick, and Fundy National Park; natural history field guides with North American distribution maps that included southeastern New Brunswick (e.g. Whitaker, 1980); research publications (e.g. Hinds 1983, Erskine 1992, Clayden et al. 1984); taxonomic keys (Hinds 1986); plus consultations with local experts and amateur naturalists familiar with the Model Forest area. In total, 150 bird species (species breeding in NB only), 678 plant species (vascular plant species native to NB only), 48 mammal species, 7 reptile species, and 17 amphibian species were identified. Complete species lists from each of these five biotic groups, are provided in Appendix 1 (birds), 2 (plants), 3 (mammals), and 4 (reptiles and amphibians). Information on species abundance found in the natural history data bases was used to identify the uncommon, rare, or threatened species in the FMF area, and served as a means to determine conservation priorities.

Natural history data bases also provide descriptive information on the habitat affinities of species. This descriptive information varies from the specificity of "sandy or muddy calcareous shores, ditches, and other wet areas" to the very general "coniferous or mixed woods". Poor knowledge of some taxa and differences in the level of site specificity among species both contribute to unevenness of habitat descriptions. However, habitat information, at some level of detail, is available for a large number of species within most biotic groups (MacDougall and Loo, in review).

We used the habitat descriptions found in natural history data bases to determine the community-type affiliations of each species believed to occur in the FMF. Species sharing similar habitats were grouped, forming hypothetical species assemblages as well as providing criteria for identifying community-types that may be species-rich. Once all community-types were determined, those known to be small in area with spatially-restricted distributions were selected (Table 1).

In total, 24 fine-scale community-types were identified using the habitat affinity information provided by the compiled species lists. Complete descriptions of each community-type, including habitat characteristics, dominant species, plus associated uncommon and rare species, are presented in appendix 5 (note: appendix 5 is part of larger document to be published as a Canadian Forest Service Information Report in the summer of 1996 under the title: Fine-scale Community-types of the Fundy Model Forest of Southeastern New Brunswick). Some of the identified fine-scale community-types in the FMF were very specifically described with respect to their physical setting and associated species. Others, such as peatlands or shoreline habitats were more general. The difference was determined by the amount of information available to differentiate community-types found in similar environments. For example, peatlands could only be divided into two community-types: Sphagnum-Ericaceae Bog and Sphagnum-Eriaceae Fen. In contrast, twelve different peatland categories were recognized by the Maine Natural Heritage Program's classification scheme. The differences identified by the Maine program were based on water chemistry, patterns of groundwater flow, drainage, successional status, and

community-types used the species-habitat relationships identified from the natural history data sources. Often there are reliable associations between species or species assemblages and environmental conditions. Knowledge of these associations, plus available data on the spatial distribution of environmental variation from DNRE were exploited to predict the locations of particular community-types within the FMF. This approach was more powerful than occurrence records alone because it allowed the entire FMF area to be systematically surveyed for site locations using the GIS. This habitat-based search methodology was composed of two parts: 1) the use of land resource data to describe target community-types within the study area, and 2) conduct GIS-based searches to identify locations where the described community-type attributes occur.

To conduct computerized searches for potential sites, each of 24 fine-scale community-types were first described by variables available on GIS. The New Brunswick Department of Natural Resources and Energy has a spatially-explicit land resource data base available for a large number of abiotic and biotic attributes, including geologic parent material, soil series, topography, location of water courses, and photo-interpreted forest cover with associated age and size class information (Table 2). To illustrate this procedure, the community-types "calcifilic coastal ravine cliffs" and "non-calcifilic coastal ravine cliffs" were described in terms of geologic parent material (limestone or calcium-enriched sedimentary rock), topography (steeply angled or vertical slopes), and forest cover (areas absent of forest). The community-type "wet cedar forest" was described by soil (rich, often calcareous), forest type (eastern cedar), forest maturity (older stands tend to be more species-rich for most biotic groups), topography (bottomlands), and drainage (poor). The GIS overlays each of these information layers, and identifies locations where all of the identified variables co-occur.

There are land resource data attributes associated with areas typically free from intensive human disturbance, such as sites with infertile and unproductive soils, inundated organic soils, or inaccessible, highly-sloped areas. Remnant patches of mature forest may be found by combining forest cover-type with terrain and soils data. In a study in the southeastern United States, Stahle and Chaney (1994) used combinations of fertility, aspect, and slope to locate potential sites of old oak-dominated forest. Forested sites that were infertile with steep slopes and exposed southerly aspects were selected because of their high probability of escaping forest disturbance and hosting old-growth forest assemblages. In the FMF, black spruce forests growing on organic soils at bog sites can contain mature forest assemblages with trees 100 years old or more. They persist because of their stunted size and the inaccessibility of the sites to heavy forest harvesting equipment.

Combinations of forest cover attributes were also used to identify potentially undisturbed forest patches. Disturbance history strongly influences species composition of the dominant forest cover. For example, a high proportion of intolerant hardwood species generally indicates a recent major disturbance. Pine-dominated stands, particularly jack pine, usually indicates areas disturbed by fire. In working landscapes, large tracts of relatively continuous forest may vary considerably in extant stand features as a result of past land management activities. The presence of undisturbed, older-growth forest fragments within a secondary forest matrix may contain original floristic assemblages, and if large enough, host interior species not found elsewhere.

IV. Management Implications Of FMF Gap Analysis Findings: Conservation Stewardship for Private Landowners

Three principal ownership groups exist within the boundaries of the FMF: private land owners (who own 63% of the FMF area), the New Brunswick provincial government (17%), and J.D. Irving Ltd. (13%). The remaining lands are controlled by Fundy National Park (5%) or municipalities such as Sussex, Hampton, and Petitcodiac.

The fine-scale ecologically significant areas identified by the FMF Gap Analysis project fall on land owned by all the above principal groups. Sites controlled by the crown or by J. D. Irving Ltd. were brought to their attention, and may be considered for special management or even protection by these agencies. Attempts to specially manage or protect sites occurring on private lands presented a much greater challenge. Even the smallest of sites (e.g. several hectares) were often controlled by two or more land owners. Typically, these owners have divergent interests regarding land use, and some owners do not live in the local communities and are thus difficult to contact. To deal with these challenges, the final step of the FMF Gap Analysis project was to plan out a conservation stewardship approach that could be followed in the FMF. This would include contacting owners of ecologically significant sites, informing them of their properties special features, and discussing special management or protection options for those owners interested. The following is an outline of a conservation stewardship approach for the FMF, some of which has already been implemented by the Gap Analysis project.

Objectives, Goals, and Principles of Conservation Stewardship Strategy

A well-defined set of objectives, goals, and principles is necessary for any stewardship program. Together they create the foundation upon which all actions are based. It is essential that all partners are clear about program policies before any landowners are visited. This avoids embarrassing and potentially damaging contradictory statements by the contact person or between participating agencies. Clearly defined objectives makes for a stronger message to the land owner, as well as determining what contact methodology is employed. The following is a proposed list of objectives, goals, and principles:

a) The primary objective is to obtain a verbal commitment from land owners to protect their property to the best of their ability. It will not focus on obtaining legal commitments.

b) The emphasis will be on the positive results of land stewardship, not on negative restrictions.

c) This program seeks to complement existing conservation programs in the FMF, such as formal protection of parkland and special management planning on crown and industrial lands.

d) This programs falls under the mandate of the FMF regarding the protection and maintenance of biodiversity.

e) an objective is to educate land owners by providing information on valued ecological features occurring on their property.

Appendix 1: Listing of bird species found within the Fundy Model Forest.

This compilation is a summary of bird species that occur within the boundaries of the Fundy Model Forest. Four categories are presented: breeding birds, possible breeding birds, non-breeding migrants or visitors, and introduced species. Eventually, required habitat descriptions will be given for each species in all four categories (non-breeding birds have yet to be completed). In general, ten suites of birds have been identified based on habitat preference:

1. Deciduous Forest These species generally are found in the broad-leaf forests associated with the river valleys of southwestern NB (St. John River, Kennebecasis River, upper Petitcodiac River). In some cases, New Brunswick, or the Maritime provinces in general, represents the northern distributional limit of these species.

2. Coniferous Forest These species generally occur in the boreal forests of northern New Brunswick and the Bay of Fundy coast. In some cases, New Brunswick, or the Maritime provinces in general, represents the southern distributional limit of these species.

3. Generalists Found in most areas of the Model Forest with no apparent habitat preference.

4. Old Fields and other Agricultural Areas These species are found in pastures, abandoned fields, forest edges, blueberry barrens, or settled rural areas. Some species in this category have increased in range and/or abundance since European colonization, though trend may have peaked due to the abandonment of some pastures lands over the last fifty years.

5. Disturbed Coniferous Forest Includes habitat that has been created by fires or forestry practices and supports immature forest that may include intolerant hardwood thickets or conifer plantations.

6. Lakes and Ponds

7. Streams, Pond Edges, and Alder/Willow Swales

8. Freshwater Marshes

9. Saltwater Marshes and Riverine Estuaries

10. Sand and Mud Flats Species associated with this habitat generally do not breed within the Model Forest area but are spring and fall shorebird migrants that are stopping off to feed.

Breeding Birds

The following list of birds that have been recorded breeding within the Model Forest area was compiled from the Atlas of Breeding Birds of the Maritime Provinces (Erskine, 1992). For each species, the general habitat preference is given, along with details on current status in NB and locations of confirmed breeding within the Model Forest if available. Most of these species winter to the south; if a species is a year-round resident, it will be noted.

Gaviidae (Loons)

1. Common Loon (Gavia immer) Found in forested lakes and rivers, generally breeding in lakes larger than 40 Ha in area; in winter, occurs in oceans and bays (1,2).

Colymbidae (Grebes)

2. Pied-billed Grebe (Podilymbus podiceps) Habitat is marshes and ponds. Breeding records mostly from southern NB except in northern coastal areas; includes Hampton Marsh area and possibly Belleisle Bay (1,2).

Ardeidae (Herons and Bitterns)

3. American Bittern (Botaurus lentiginosus) Occurs in fresh water and brackish marshes and marshy lake shores. Scattered throughout NB, though scarcer in northwest and northcentral NB (1,2).

4. Great Blue Heron (Ardea herodias) Can be observed in lakes, ponds, marshes, and rivers throughout most of NB (1,2).

5. Green-backed Heron (Butorides striatus) Found in streams, ponds, marshes, and lake margins. **Uncommon** in NB, occurring mostly in the western part of the province in the St. John River valley. One breeding record comes from the Lake Washademoak area (1,2).

Anatidae (Surface Feeding Ducks, Geese, and Swans)

6. Wood Duck (Aix sponsa) A tree cavity nester, its habitat is primarily river flood-plain forests, though also found in ponds, and wooded swamps. **Uncommonly** scattered throughout southern and central NB (1,2).

7. Green-winged Teal (Anas crecca) Occurs in marshes (sometimes brackish), ponds, and marshy lakes. Scattered throughout most of NB, though concentrated in the central and lower St. John River valley area (1,2).
8. American Black Duck (Anas rubripes) Habitat is varied: marshes, streams, lakes, river backwaters, coastal mud flats, and estuaries. Found throughout NB (2).
10. Northern Pintail (Anas acuta) Found in freshwater marshes, extensive bogs, coastal grasslands, and also salt marshes. **Not common** in NB with most breeding records coming from the east and south of the province, including the Washademoak and Belleisle Bay areas (1,2).
11. Blue-winged Teal (Anas discors) Occurs in marshes, shallow ponds, and lakes. Found mostly in the central and lower St. John River valley and associated feeder rivers, and near the coastal regions of the province (1,2).
12. Northern Shoveler (Anas clypeata) Found primarily in marshes or marshy ponds; sometimes in salt or brackish marshes. **Uncommon** in NB, with a few breeding records in the lower St. John River valley and some coastal locations (1,2).
13. American Widgeon (Anas americana) Occurs in marshes, ponds, and shallow lakes associated with generally open areas. **Uncommon** in NB, and restrcited mostly to the lower St. John River valley and some coastal locations (1,2).

14. Ring-necked Duck (Aythya collaris) Seen in wooded lakes, ponds, stillwaters, sedge or shrub marshes, and rivers. Scattered and locally common throughout most regions of NB (1,2).

15. Common Goldeneye (Bucephala clangula) A cavity nester that can be seen year-round; in summer nests on lakes and ponds, in winter occurs mostly

28. Merlin (Falco columbarius) Associated mostly with coniferous forests. **Infrequent** in NB, with a scattered distribution of recorded breeding sites (1,2).
29. Peregrine Falcon (Falco peregrinus) Generally found in open country, both coastal and interior, in association with cliffs, buildings, or other elevated structures. Introduced in several areas near the Bay of Fundy, though likely occurred here naturally at one time. **Rare** in NB (1,2).

Tetraonidae (Grouse)

30. Spruce Grouse (Dendragapus canadensis) Occurs in coniferous forests, especially those with a mixture of spruce and pine; also occurs at the edges of bogs, and regenerating second-growth areas. Absent from hardwood-dominated areas. Scattered throughout NB where appropriate habitat exists (1,2).

31. Ruffed Grouse (Bonasa umbellus) Most commonly found in deciduous forests, especially those with open clearings; also occurs in mixed woods, abandoned farmlands, and overgrown pasture. Found throughout NB (1,2).

Rallidae (Rails and Coots)

32. Virginia Rail (Rallus limicola) Found in fertile freshwater and brackish marshes. Probably **scare or absent** in many regions of the Maritime provinces, including parts of NB. Most NB recordings come from wetland areas of the lower St. John River valley (1,2).

33. Sora (Porzana carolina) Occurs mostly in freshwater marshes and marshy ponds. Breeding records found throughout a wider range in NB than the Virginia range, though restricted primarily to the east coast region of the province and the lower and central St. John River valley. The most common rail in the Maritimes (1,2).

Charadriidae (Plovers)

34. Killdeer (Charadrius vociferus) Generally found in open country such as plowed fields or golf courses. Found throughout most of NB (1,2).

Scolopacidae (Sandpipers, Woodcock, Snipe)

35. Spotted Sandpiper (Actitis macularia) Found almost anywhere near open water, both open and wooded areas. Found throughout NB (1,2).

36. Common Snipe (Gallinago gallinago) Occurs in association with freshwater marshes, ponds, flooded meadows and fields, bogs, and occasionally salt marshes. Scattered throughout most of NB except the northwest highlands (1,2).

37. American Woodcock (Scolopax minor) Found in moist woodlands, mostly deciduous or mixed, and in thickets near open fields. Scattered throughout most of NB (1,2).

Laridae (Gulls and Terns)

38. Herring Gull (Larus argentatus) Common in all aquatic habitats: lakes, rivers, estuaries, and beaches. Breeds along coastal NB; seen throughout most areas of the province (1,2).
39. Great Black-backed Gull (Larus marinus) Occurs on coastal beaches,

chimneys, though originally bred in hollow trees. **Infrequent** in NB, though may be locally common. Distribution is scattered throughout most of the province (1,2).

Trochilidae (Hummingbirds)

51. Ruby-throated Hummingbird (Archilocus colubris) Occurs in suburban gardens, parks, and open woodlands. Scattered throughout most of NB (1,2).

Alcedinidae (Kingfisher)

52. Belted Kingfisher (Megaceryle alcyon) Habitat is rivers, lakes, and salt-water estuaries. Occurs throughout NB (1,2).

Picidae (Woodpeckers)

53. Yellow-bellied Sapsucker (Sphyrapicus varius) Primarily found in younger, open deciduous or mixed forests. Found throughout NB (1,2).

54. Downey Woodpecker (Picoides pubescens) Varied habitat: mostly broad-leaved forests, woodlots, parks, and gardens. Occurs throughout NB. Overwinters in the province (1,2)
55. Hairy Woodpecker (Picoides villosus) Seen most commonly in open deciduous and mixed forests. Scattered throughout NB. Overwinters in the province (1,2).
56. Three-toed Woodpecker (Picoides tridactylus) Found in coniferous forests, especially areas that are burned over, logged or swampy. **Infrequent** in NB, occuring mostly in the higher-elevated northwestern areas of the province (1,2).
57. Black-backed Woodpecker (Picoides arcticus) Occurs in coniferous forests, especially areas that have been burned, logged, damaged by forest insects, or are swampy. **Infrequent** in NB, though more abundant than the more northerly-distributed Three-toed Woodpecker. Scattered throughout most of NB (1,2).

58. Northern Flicker (Colaptes auratus) Generally found in open country with trees; also seen in parks and rural areas. Found throughout most of NB (1,2).

59. Pileated Woodpecker (Dryocopus pileatus) Occurs in dense forests and forest borders; nesting is restricted to larger-diameter trees. Scattered throughout NB where suitable breeding habitat exists (1,2).

Tyrannidae (Flycatchers)

60. Olive-sided Flycatcher (Nuttallornis borealis) Occurs in boreal spruce and fir forests, usually near openings, burns, bogs, and ponds (2). Scattered throughout most of NB (1,2)
61. Eastern Wood-Pewee (Contopus virens) Occurs in forested areas, open woodlands; less common in closed forests. Scattered throughout most of NB (1,2).

62. Yellow-bellied Flycatcher (Empidonax flaviventris) Habitat is primarily coniferous forest where spruce predominates; not found in deciduous forest. Occurs in both mature and successional habitat. Scattered throughout most of NB, though breeding records are most abundant along the Fundy uplands (1,2).
63. Alder or Traill's Flycatcher (Empidonax alnorum) This species is the

mostly coniferous. Found throughout most of NB; occurs here year-round (1,2).

76. Blue Jay (Cyanocitta cristata) Varied habitat: forested, rural, and suburban areas. Common throughout most of NB; over-winters here (1,2).

77. American Crow (Corvus brachyrhynchos) Varied habitat: woodlands, farmlands, and suburban areas. Found throughout NB; many individuals over-winter within the province, though some do migrate south (1,2).
78. Common Raven (Corvus corax) Varied habitat, though primarily in coniferous forest areas. Common in NB; over-winters here (1,2).

Paridae (Chickadees)

79. Black-capped Chickadee (Parus atricapillus) Varied habitat: mixed, coniferous, and deciduous forests; open woodlands; suburban areas. Common in most areas of NB (1,2).
80. Boreal Chickadee (Parus hudsonicus) Habitat is coniferous forests, especially spruce-fir forests. Scattered throughout NB where habitat is suitable (1,2).

Sittidae (Nuthatches)

81. Red-breasted Nuthatch (Sitta canadensis) Found primarily in coniferous forests. Found throughout most of NB (1,2).
82. White-breasted Nuthatch (Sitta carolinensis) Habitat is open deciduous or mixed forest; may over-winter here, especially in urban and suburban areas where feeders are available. **Infrequent but not uncommon** in NB, with most recordings in the western half of the province (1,2).

Certhiidae (Creepers)

83. Brown Creeper (Certhia americana) Breeds in conifer and mixed forests; apparently prefers mature forest stands for both nesting and feeding. Scattered throughout parts of NB. Some individuals are year-round residents, but many migrate south (1,2).

Troglodytidae (Wrens)

84. Winter Wren (Troglodytes troglodytes) Found in dense tangles and thickets in coniferous and mixed forests. Scattered throughout NB (1,2).

Sylviidae (Old World Warblers)

85. Golden-crowned Kinglet (Regulus satrapa) Habitat is dense, older conifer stands, primarily spruce and fir. Found throughout most of NB (1,2).
86. Ruby-crowned Kinglet (Regulus calendula) Found in coniferous and deciduous forests. Common in most areas of NB (1,2).

87. Eastern Bluebird (Sialia sialis) Habitat is most often open farmlands with scattered trees. North American distribuiton associated with eastern broad-leaf forest thus **uncommon** in New Brunswick. It may have increased following colonization, though recently numbers have been reduced due to starling competition for breeding sites. Has been found breeding in clear-cuts amid forests (1,2).

Turdidae (Thrushes)

trees in suburban areas. Common throughout most of NB (1,2).

Parulidae (Wood Warblers)

100. Tennessee Warbler (Vermivora peregrina) Occurs in open mixed woodlands. Abundance in the Maritimes can increase during times of budworm infestation. Widespread and probably common throughout most of NB (1,2).
101. Nashville Warbler (Vermivora ruficapilla) Found at woodland edges, thickets in open conifer and mixed forests, or brushy borders of swamps. Found throughout most of NB (1,2).

102. Northern Parula Warbler (Parula americana) Habitat is mostly mature coniferous forests, especially in wet swampy areas. Common in NB (1,2).

103. Yellow Warbler (Dendroica petechia) Found in moist thickets, open deciduous forests, and suburban and rural areas. Found throughout most of NB, especially in the south and central regions of the province (1,2).
104. Chestnut-sided Warbler (Dendroica pensylvanica) Habitat is young, open, second-growth, predominantly deciduous, woodland and scrub. Found throughout most of NB (1,2)
105. Magnolia Warbler (Dendroica magnolia) Primarily occurs in coniferous forests, especially stands of spruce or fir. Common in NB (1,2).
106. Cape May Warbler (Dendroica tigrina) Found mostly in open spruce forests. May attain high densities during spruce-budworm breakouts. Breeding records come mostly from northern NB, with few sightings in the hardwood dominated St. John River valley (1,2).
107. Black-throated Blue Warbler (Dendroica caerulescens) Seen primarily in broad-leafed or mixed forests. **Widespread but infrequent** in most of NB, possibly due to restricted habitat (1,2).
108. Blackpoll Warbler (Dendroica striata) Occurs in boreal coniferous forests, primarily spruce (2). NB is near the southern distribution limit of this species; most breeding records come from the northern half of the province. No breeding records from within the Model Forest area have occurred, though this likely reflects sampling effort (1).
108. Yellow-rumped or Myrtle Warbler (Dendroica coronata) Occurs in coniferous or mixed forests. Common in NB (2).
109. Black-throated Green Warbler (Dendroica virens) Found primarily in coniferous forests. May increase during budworm outbreaks, but not as much asother conifer-dependant warblers. Occurs throughout most of NB (1,2).
110. Blackburnian Warbler (Dendroica fusca) Found in upper reaches of trees in mostly mid-aged and mature coniferous forests. May be especially abundant in mature hemlock or spruce stands, and during budworm outbreaks (1,2).
111. Palm Warbler (Dendroica palmarum) Found mainly in bogs where scattered low conifers are interdispersed with low shrub cover. Because bogs are limited in number and range in the model forest, and New Brunswick in general, this species is **infrequent** (1).
112. Bay-breated Warbler (Dendroica castanea) Breeds in open spruce forests, though in also seen in deciduous stands. Recorded throughout NB; especially abundant during times of budworm outbreaks (1,2).
112. Pine warbler (Dendroica pinus) Habitat is pine forests, both open stands and small groves (1,2). Has a limited breeding area in NB; mostly the southwest section of the province (1).

113. Black-and-White Warbler (Mniotilta varia) Found chiefly in deciduous or mixed forests. Scattered throughout most of NB, though less common in northern regions of the province (1,2).

127. Sharp-tailed Sparrow (Ammodramus caudacutus) Associated with drier, grassier portions of salt marshes and freshwater marshes. Has likely decreased in the Maritimes in recent decades due to drainage, followed by farming. Recorded breeding records come from the Hampton Marsh/ Belleisle Bay/ Washademoak Lake areas (1,2).

128. Fox Sparrow (Passerella iliaca) Found in a variety of habitats: dense damp shrubbery of alder or willow, weedy pastures, coniferous forest undergrowth, or in brushy roadside areas; though generally prefering higher, cooler areas. Has a **disjunct boreal distribution**; breeds mostly in northern NB, though may nest along the Fundy coast (1,2).

129. Song Sparrow (Melospiza melodia) Found in thickets, pastures, younger forests, and suburban abd rural areas. Common in NB (1,2).
130. Lincoln's Sparrow (Melospiza lincolnii) Found in brushy bogs, willow or alder thickets, or woodland thickets. Scattered throughout most of NB, though scarcer in the hardwood-dominated areas of the St. John River valley (1,2).
131. Swamp Sparrow (Melospiza georgiana) Occurs in association with freshwater marshes with tall or shrubby vegetation, and open wooded swamps. Scattered throughout most of NB where suitable habitat occurs (1,2).

132. White-throated Sparrow (Zonotrichia albicollis) Found mostly in coniferous woodlands in brushy undergrowth areas. Common throughout most of NB (1,2).

133. Dark-eyed or Slate-colored Junco (Junco hyemalis) Occurs in coniferous or mixed forests, usually near opening or forest edges. Scattered but common throughout most of NB (1,2).

141. Pine Grosbeak (Pinicola enucleator) Occurs primarily in coniferous forests, though in winter can be found in mixed woods if fruiting trees are present. The Maritimes are near the southern distributional limit, which is reflected by most breeding records coming from the northern boreal region of the province (1,2).

142. Purple Finch (Carpodacus purpureus) Occurs in mixed and coniferous woodlands. Found throughout most of NB (1,2).

123. Rose-breasted Grosbeak (Pheucticus ludovicianus) Found in moist woodland adjacent to open fields with tall shrubs. Scattered throughout most of NB (1,2).

144. Red Crossbill (Loxia curvirostra) Experienced large declines late last century-early this century, the effect of their primary habitat, mature white pine and hemlock, being removed in great numbers. Signs of recovery may be associated with re-emergence of mature pine and hemlock, though still **uncommon** in NB (1,2).
145. White-winged Crossbill (Loxia leucoptera) A boreal forest species that feeds on spruce, larch, and fir cones. Scattered throughout most of NB, though scarce in hardwood dominated areas of southern New Brunswick. Local abundance dependant on availability of cones (1,2).

146. Pine Siskin (Carduelis pinus) Occurs in predominantly mature coniferous woodlands. Unevenly scattered throughout NB where suitable habitat exists; absent from hardwood-dominated areas such as the St. John River valley (1,2).
147. American Goldfinch (Carduelis tristis) Seen in brushy thickets, weedy

4. Sedge Wren or Short-billed Marsh Wren (Cistothorus platensis) Found in damp meadows and sedge marshes with low bushes. **Rare** in NB. Draining of habitat for farming has reduced potential habitat, though it was probably never common. No recent reports of breeding have been confirmed. Sighting made on near Penobsquis in 1989 (1).

5. Canada Goose (Branta canadensis) Most wild Canada Geese breed further to the north; records of breeding pairs in the Maritimes aree believed to be descendents from introduced birds or escaped captives (1).

6. Indigo Bunting (Passerina cyanea) Occurs primarily in deciduous forest areas at woodland borders, thickets, and shrubbery. Most breeding records in NB occur in the southwest third of the province, though they are scarely established at present (1).

Non-Breeding Birds (migrants and visitors)

There are many species of birds that do not breed in the Model Forest area but occur here on occasion. Most important are migrants that use the area to feed on their way to northern breeding grounds in the spring, or when migrating south in the fall. This is especially true of shorebirds which feed on sand and mud flats, and in saltwater and/or freshwater marshes. Other non-breeding species include accidentals which are outside of their normal breeding range, but may none-the-less be seen here on occasion, or have been seen in other parts of southern NB.

A. Birds of Marshes and Open Freshwater

1. American Coot
2. Black-crowned Night Heron
3. Common Moorhen
4. Long-billed Marshwren
5. Gadwall
6. Snow Goose
7. Brant
8. Ruddy Duck

B. Coastal Birds

1. Semi-palmated Plover
2. Semi-palmated Sandpiper
3. Greater Yellowlegs
4. Lesser Yellowlegs
5. Willet
6. Sanderling
7. Piping Plover
8. Whimbrel
9. Ruddy Turnstone
10. Least Sandpiper
11. Baird's Sandpiper
12. White-Rumped Sandpiper
13. Pectoral Sandpiper
14. Ring-billed Gull
15. Bonaparte's Gull
16. Iceland Gull
17. Glaucous Gull
18. Caspian Tern

eastern North America in the late 1800's and have since spread over most of the continent. They are currently found in most areas of NB, especially near settled urban and rural areas (1).

5. Rock Dove or Pigeon (Columba livia) Introductions of rock doves occurred in the Maritimes as early as 1605, with repeated introductions at later dates. Presently common in most settled areas (1).

6. Ring-necked Pheasant (Phasianus colchicus) Pheasants were first introduced into the Maritmes in the 1850's but did not become established until the early part of this century. In NB, breeding reports come mainly from portions of the Kennebecasis and St. John River valleys (1).

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NB (1).
9. Ground-Cedar (Lycopodium digitatum) Found in wet open woods, clearings and pastures. Common in southern NB (1).
10. Bog Club-moss (Lycopodium inundatum) Found along wet shores, old roadways, and boggy areas. Most common in southern part of NB.
11. Shining Club-moss (Lycopodium lucidulum). Habitat is rich moist woods. Found throughout NB (1)
12. Flat-branch Ground-Pine (Lycopodium obscurum) Occurs in damp open woods, pastures, and clearings. Common throughout NB (1).
13. Juniper Club-moss (Lycopodium sabinifolium) Habitat is open and mostly dry woods and clearings. **Uncommon** within NB. Within Model Forest, found in Fundy Park area and near the St. John River (1).
14. Fir Club-moss (Lycopodium selago) Found on ledges, peatty barrens, and exposed shores and headlands. **Rare** throughout province; occurs along Fundy Coast of Model Forest (1).
15. Ground-cedar (Lycopodium tristachym) Found in dry barrens, open hardwood forest, and clearings. Scattered throughout NB.

Selaginellaceae (Spikemoss Family)

16. Selaginella rupestris Found on dry ledges (1). Very rare in NB. Found on Rockville escarpment within Model Forest; only other NB location is Keswick Ridge. Species is also rare in Nova Scotia; threatened in parts of New England and Ohio (2).

17. Selaginella selaginoides Found on wet calcareous ledges, mossy banks, and calcareous bogs (1, 2). Very rare in NB. Only known southern NB location is at the confluence of the Point Wolfe River in Fundy Park; all other records in north western NB. Listed as rare in Manitoba, Saskatchewan, and Maine; extirpated in Delaware (2).

Isoetaceae (Quillwort Family)

18. Isoetes echinospora Found in shallow water and along wet shores; appears to be common throughout NB. Recorded in Hampton Marsh area of the Model Forest (1).
19. Isoetes X harveyi Habitat is shallow water with muddy bottom. **Uncommon** in NB; recorded from Washademoak Lake. Apparently a recurring hybrid between I. echinospora and I. tuckermanii (1).
20. Isoetes tuckermanii Found in shallow pond margins and along shores. **Uncommon** in southern NB; recorded in Belleisle Bay and Hampton areas (1).

Ophioglossaceae (Adder's-tongue Family)

21. Botrychium matricariaefolium Found in clearings and rich hardwood forests. Recorded in several locations in Model Forest (approximate): near Fundy Park, Peticodiac, Bloomfield Ridge, and area between Washedamoak Lake and Belleisle Bay (1).
22. Grape-fern (Botrychium multifidum) Habitat is sandy thickets, stabilized dunes, clearings, and rich hardwoods. Scattered throughout NB; recorded in Hampton area (1).
23. Botrychium simplex Found on rocky slopes, clearings, and in rich hardwood forests. **Very rare** in NB with scattered distribution; recorded in Peticodiac area (1)
24. Rattlesnake-fern (Botrychium virginiatum) Found mostly in rich hardwood stands. Common throughout NB (1).

Osmundaceae (Flowering Fern Family)

43. Spinulose Shield-Fern (Dryopteris spinulosa) Found in swamps and wet woods. Common throughout NB.
44. Dryopteris X triploidea A hybrid between D. spinulosa and D. intermedia. Found in rich swampy and/or rocky woods. **Uncommon,** but usually found where two parents occur together (1).

45. Oak Fern (Gymnocarpium dryopteris) Occurs in moist woodlands. Common throughout NB (1).

46. Ostrich or Fiddle-Head Fern (Matteuccia struthiopteris) Found in rich woods and meadows, mostly in fine grained alluvial soils. Locally common throughout NB (1).

47. Sensitive Fern (Onoclea sensibilis) Grows in wet open woods and meadows. Common throughout NB (1).

48. Rock Polypody or Polypody Fern (Polypodium virginianum) Habitat is ledges and boulders. Common throughout most of the province (1).

49. Christmas Fern (Polystichum acrosticoides) Occurs in rich woods and on rocky slopes. Abundant in its habitat in west and southern NB (1).
50. Braun's Holly Fern (Polystichum braunii) Occurs in rich woods, mostly on calcareous soils. Has a partial **disjunct boreal distribution** in NB; it is **rare** in NB except for the northern regions where it is uncommon. Recorded in two Model Forest locations including Fundy Park (1).

51. Bracken Fern (Pteridium aquilinum) Grows in open dry deciduous woods, clearings, heaths, and burns. Common throughout NB (1).

52. New York Fern (Thelypteris noveboracensis) Found in moist mixed woods. Common in southern NB; rare or unknown in northern areas (1).
53. Long Beech-Fern (Thelypteris phegopteris) occurs in moist woods. Common throughout NB (1).
54. Marsh Fern (Thelypteris palustris) Found in wet meadows. Scattered throughout province; recorded near Hampton Marsh and in upper Kennebecasis valley (1).

55. Smooth Woodsia (Woodsia glabella) Occurs on moist, calcareous ledges. **Rare** in most of NB; recorded near Hampton and near the southwest corner of Fundy Park (1).
56. Rusty or Fragrent Woodsia (Woodsia ilvensis) Found on dry exposed ledges and talus, often noncalcareous. Locally common in NB (1).

Taxaceae (Yew Family)

57. Canada Yew or Ground-Hemlock (Taxus canadensis) Found in rich woods. Common throughout NB (1).

Pinaceae (Pine Family)

58. Balsam-Fir (Abies balsamea) Varied habitat; may prefer damp woods. Common throughout NB (1,3).

59. Common Juniper (Juniperus communis) Grows on dry exposed ledges, old pastures, rocky slopes, and calcareous bogs. Locally common in southern part of NB (1).
60. Creeping Juniper (Juniperus horizontalis) Found in rocky, sandy, or boggy open areas. Has a **disjunct boreal distribution;** found along Fundy

78. Ditch-Grass or Sea-Gress (Ruppia maritima) Found in saline pools and ditches. Coastal distribution; most common along east coast of NB (1).

Juncaginaceae (Arrow-grass Family)

79. Triglochin gaspense Found in salt marshes below high tide zone. Sometimes forms a "dwarf lawn" around small lagoons in salt marshes. Rare and scattered in NB; has been recorded at the mouth of the Quiddy River at Martin's Head (1, 2).
80. Triglochin maritima Primary habitat is saline or brackish areas of salt marshes; often forms hummocks. Also occurs in inland calcareous bogs, though rarely. Common in NB coastal areas. No inland occurances have been recorded in the Model Forest area (1).

Alismataceae (Water-plantain Family)

81. Alisma plantago-aquatica Occurs in shallow water and along shores. Common in St. John River valley, rare in rest of NB (1)

82. Arrowhead (Sagittaria cuneata) Found in shallow water and along muddy shores. Common throughout NB (1).
83. Grass-like Arrowleaf (Sagittaria graminea) Habitat is muddy and sandy shores. In NB, most common in southern St. John River valley; recorded in Fundy Park area (1).
84. Broad-leaved Arrowleaf (Sagittaria latifolia) Occurs in shallow water and along muddy shores. Common throughout NB (1).

Hydrocharitaceae

85. Canada Waterweed (Elodea canadensis) Usually found in calcareous shallow ponds and streams. In NB, most common in lower St. John River valley (1).

86. Tape-grass or wild celery (Vallisneria americana) Occurs in shallow, calm waters. Locally common in lower St. John River valley (1).

Poaceae (Grass Family)

87. Couch-grass or Witch-grass (Agropyron repens) Found in open mostly fertile soils, and gravelly, sandy shores. Common throughout NB (1).
88. Dog Couch-grass (Agropyron trachycaulum) Two varieties of this species occur in NB. A. trachycaulum var. glaucum is found in rocky woods, thickets, and shores and is common throughout the province. A. trachycaulum var. novae-angliae is found on calcareous gravel strands, ledges, peats, bogs, and coastal beaches and is uncommon. Its presence in the Model Forest is unconfirmed but has been recorded in the upper reaches of the Petitcodiac River valley (1).

89. Upland Bent (Agrostis perennans) Found in moist woodlands and along flooded shores. Listed as uncommon in NB but this may represent collection effort and not actual frequency; recorded in two locations along Fundy coast of Model Forest (1).
90. Fly-away Grass (Agrostis scabra) Occurs in a variety of habitats: lakeshores, roadsides, railroad yards, burnt-over areas. Common throughout NB (1).

91. Short-awned Foxtail (Alopercurus aequalis) Habitat is marshy shores.

109. Red Fescue (Festuca rubra var. juncea) Found in sandy open habitats such as headlands, dunes, and beaches. Recorded along Fundy and eastern coast of NB (1).
110. Red Fescue (Festuca rubra var. megastachys) Occurs mostly in seashore marshes. Recorded along Fundy and eastern coast of NB (1).

111. Small Floating Manna-Grass (Glyceria borealis) Grows in shallow water Common throughout NB (1).
112. Reed-meadow Grass (Glyceria grandis) Found in wet ditches and similar wet areas. Scattered throughout NB (1).
113. Slender manna-Grass (Glyceria melicaria) Grows in wet open woods. Common in all of NB except extreme northern woods (1).
114. Fowl-Manna Grass (Glyceria striata) Found on damp ground in woods, pastures, ditches, stream margins, and bogs. Common throughout NB (1).

115. Indian Grass or Sweet Grass (Hierochloe odorata) Grows in wet meadows, shores, and the landward edge of saltmarshes. Scattered throughout NB.

116. Squirrel-tail Grass (Hordeum jubatum) Found along coastal beaches and in salt marshes; occasionally on inland roadsides and other open areas. Common along coastal NB (1).

117. Spreading Millet Grass (Milium effesum) Occurs mostly in deciduous upland or rich alluvial lowland woods. **Uncommon** but distributed throughout NB; recorded in several Model Forest locations (1).

118. Leafy Muhlenbergia (Muhlenbergia frondosa) Occurs in alluvial woods, clearings, and similar open areas. Common along lower St. John River; recorded in Belleisle Bay area (1).
119. Muhlenbergia glomerata Found on rocky shores, meadows, and bogs. Scattered throughout NB; recorded in Fundy National Park and Belleisle Bay area (1).
120. Muhlenbergia mexicana Occurs on shores, moist rocky scree slopes, and rocky banks. Scattered throughout NB (1).

121. Rough Mountain-Rice (Oryzopsis asperfolia) Found in open dry woods. Scattered throughout NB (1).
122. Canadian Mountain-Rice (Oryzopsis canadensis) Grows on sandy barrens and rocky clearings. **Uncommon** in NB; recorded in upper Petitcodiac River Valley (1).
123. Slender Mountain-Rice (Oryzopsis pungens) Found on sandy barrens and dry rock crevices. Recorded in four locations in NB, including near the Broad River in Fundy Park. Also listed as rare in Nova Scotia, Newfoundland, Yukon, and parts of New England; endangered in Indiana (1,2).

124. Common Witch Grass (Panicum capillare) Various habitats: beaches, banks, roadsides, gardens, and similar open areas. Locally common in southwest NB, especially in the St. John River valley (1).

125. Grove Meadow-Grass (Poa alsodes) Found in rich deciduous woods. **Uncommon** in NB; recorded in Belleisle Bay, Hampton, and Fundy Park areas (1).
126. Glaucous Poa (Poa glaucantha) Found on calcareous ledges. Recorded in four only four NB locations, including Martin Head and the Pt. Wolfe River in Fundy Park (1,2).
127. Fowl Meadow-Grass (Poa palustris) Grows in wet meadows and similar open areas. Common throughout NB (1).

145. Carex brunnescens var brunnescens Found on heights of land, mountain summits, and headlands. **Uncommonly** scattered in NB; mostly in northern highlands and Fundy coast, including Fundy Park area (1).
146. Carex brunnescens var. sphaerostachya Grows in both lowland and upland forests, and at the borders of bogs and swamps. Common throughout NB (1).
147. Carex canescens Occurs in sphagnum bogs, boggy swamps, and shores. Common throughout NB (1).
148. Carex capillaris Varied habitat: moist ground near edges of woods, rocky shores, roads, clearings, and similar mostly calcareous areas. **Uncommon** in NB; occurs in northern regions and along Fundy coast (1).
149. Carex castanea Found primarily in lime-rich areas in NB; often grows in wet meadows and roadside ditches. Locally common; has been recorded in Belleisle Bay area, Kennebecasis Valley, and the HAvelock area (1).
150. Carex communis Grows in woods and on rocky slopes. Common in suitable habitats throughout NB (1).
151. Carex conoidea Found in damp, grassy areas. **Uncommon** in NB, found mostly in southern regions (1).
152. Carex crawfordii Occurs by roadsides, on sandy shores, and in clearings and other open areas. Common throughout NB (1).
153. Carex crinita Found in wet sandy soils of roadside ditches and open swampy ground. Common throughout NB (1).
154. Carex cumulata Occurs on dry or moist disturbed soils. Common in Grand Lake area, scattered in other areas to NB. Recorded in upper Kennebecasis River valley (1).
155. Carex debilis var. rudgei Found on wet fields, roadside ditches, open bottom land woods, and shores. Common throughout southern NB (1).
156. Carex deflexa Grows in open woodlands. Common throughout NB (1).
157. Carex deweyana Grows in open woods, especially beech-maple stands. Common throughout NB (1).
158. Carex disperma Found in boggy woods and thickets. Common throughout NB (1).
159. Carex eburnea Grows on moist calcareous ledges. **Rare** in NB with a **disjunct boreal** distribution; several recordings in northwestern region and one record on the Pt. Wolfe river (1).
160. Carex echinata Found in acidic wetlands such as sphagnum bogs, peaty or sandy lake or river shores. Common throughout NB with numerous recorded occurances in the Model Forest area (1).
161. Carex flaccidula Grows on rich wooded slopes. **Uncommon** in NB; scattered mostly in St. John River and Kennebecasis River valleys (1).
165. Carex flava Found on shores and wet meadows. Common throughout NB (1).
166. Carex folliculata Found in swampy woods. **Uncommon** in NB; found mostly in southern half of province. Recorded near Hampton (1).
167. Carex granularis var. haleana Found along shores and in grassy meadows, often in calcareous areas. **Uncommon** in NB; recorded in upper Kennebecasis valley (1).
156. Carex gynandra Grows in wet clearings, roadside ditches, and swampy, often coniferous, woods. Common throughout NB (1).
168. Carex hirtifolia Found in dry woods and rocky floodplains. Collected in only a few locations in southern NB, including Hatfield Point and the Petitcodiac area (1,2).
169. Carex hormathodes Found in brackish marshes and sands. Common along the NB coast; also recorded along Kennebecasis Valley (1).
170. Carex hystricina Found in muddy shores and swamps. Fairly common in mid St. John River valley; less common elsewhere. Collections have been recorded in several Model Forest locations (1).
171. Carex interior Occurs in bogs and wet meadows, commonly in calcareous areas. Uncomon in NB; recorded in several Model Forest locations (1).
172. Carex intumescens Grows in alluvial woods and swamps. Common

199. Carex stricta Grows in wet meadows. Two varieties occur in NB, and both may be found in the Model Forest. Var. strictior is uncommon and has more coastal distribution. Var. stricta is scattered throughout NB except rare in coastal and northern regions (1).
200. Carex tenera Found in moist open ground and woodlands. **Uncommonly** scattered in southern NB. Recorded in several locations within the Model Forest (1).
201. Carex tenuiflora Found in sphagnum bogs and boggy meadows in calcareous areas. Rare throughout NB; recorded in upper Petitcodiac River valley (1, 2).
203. Carex tonsa Prefered habitat is dry sandy areas, dunes, railways, and open woods. Locally common in NB (1).
204. Carex torta Grows in rocky stream margins. Common throughout NB (1).
205. Carex tribuloides Found in moist habitat: woodlands, banks, and shores. Probably common in most of NB (1).
206. Carex trisperma Found in boggy woods and clearings. Common throughout NB (1).
207. Carex tuckermanii Found in and at the borders of alluvial woods. **Uncommonly** scattered throughout central and southern NB. Recorded in upper Petitcodiac River valley (1).
208. Carex umbellata Grows in dry sandy fields, roadsides, sandy fields, railways, and other open areas. Scattered throughout NB (1).
209. Carex vesicaria Found along shores and in swamps and wet meadows. An extremely variable species that occurs throughout North America and Eurasia. Has been recorded throughout NB. One recognizable variety has been identified in NB (C. vesicaria var. jejeuna) and has been recorded near Washedamoak Lake (1).
211. Carex viridula Found along shores that are often rocky or calcareous. Scattered throughout most of NB (1).
212. Carex vulpinoidea Grows in ditches, clearings, meadows, and along wet shores. Common throughout NB (1).
213. Carex wiegandii Occurs in sphagnum bogs, boggy thickets, and shores. Originally recorded as rare in NB (1). However, not listed in (2), suggesting that it more common than previously thought. Recorded in upper Petitcodiac River valley in Model Forest (1).

214. Awned Cyperus (Cyperus aristatus) Grows on sandy shores. **Rare** in NB, though locally common in Grand Lake-Belleise Bay area (1).
215. Cyperus dendatus Found on rocky and sandy shores. Locally common in southwest NB (1).
217. Yellow Nut-grass (Cyperus esculentus) Found on sandy shores and occasionally on adjacent fields. Locally common in St. John River valley (1).

218. Needle Spike-rush (Eleocharis acicularis) Grows in shallow water, wet shores, and similar wet areas. Probably common throughout NB (1).
219. Bald Spike-rush (Eleocharis erythropoda) Found along wet shores, stream margins, riverbanks, bogs, and brackish marshes. Scattered throughout NB (1).
220. Small's Spike-rush (Eleocharis smallii) Occurs in wet open areas and shallow water. Common throughout NB (1).
221. Eleocharis tenuis Found in wet sands, gravels, and peats. Two varieties grow in NB, only var. tenuis is found within Model Forest and in general is common in southern NB (1).

222. Eriophorum angustifolium Found in acid bogs, boggy meadows, and shores. Common in southeast NB; rare elsewhere (1).
223. Eriophorum vaginatum var. spissum Grows in peat bogs and boggy

243. Star-duckweed (Lemna trisulca) Grows in quiet waters. Rare in NB; has been collected near Petitcodiac (1,2). Also listed as rare in areas of northeastern US (2).

Eriocalaceae (Pipewort Family)

245. White-buttons (Eriocaulon septangulare) Habitat is shallow water of mostly pond and lakes. Common throughout most of NB (1).

Pontederiaceae (Pickerelweed Family)

246. Pickerelweed (Pontederia cordata) Grows in shallow water and on muddy shores. Common in southwest corner of NB; recorded in Washedamoak Lake and Hampton Marsh area, and along St. John River bordering the Model Forest (1).

Juncaceae (Rush Family)

248. Juncus balticus var. littoralis Grows in meadows, ditches, and brackish marshes. Common in NB, especially on or near the coast (1).
249. Juncus brevicaudatus Found in wet open areas. Common throughout NB (1).
250. Toad Rush (Juncus bufonius) Varied habitat: lagoon beaches, roadside ditches, wet cultivated fields and shores. Scattered throughout most of NB; can be locally common (1).
251. Juncus canadensis Found in shores, ditches, and similar wet areas. Common in southern NB (1).
252. Soft Rush (Juncus effusus) Grows in peaty open areas, ditches, and pond margins. Seven varieties occur in NB, ranging from common to rare. There is **no indication which varieties are found within the Model Forest** (1).
253. Black Grass (Juncus gerardii) Found in brackish or saline sandy areas and marshes. Commonly scattered alond coastal NB (1).
254. Juncus nodosus Habitat requirements not given (1). **Uncommonly** scattered in NB; rarer to south. Recorded in Fundy National Park and in upper Canaan River area near Salisbury (1).
255. Juncus pelocarpus Grows in bog margins and muddy or peaty shores. Mostly common in NB (1).
257. Path Rush (Juncus tenuis) Grows on open often disturbed and compacted soils. Common throughout NB (1).
258. Juncus vaseyi Occurs in rock crevices and wet sandy shores and dune hollows. **Uncommonly** scattered along eastern coast of NB; recorded in several locations in or near Fundy Park (1).

259. Luzula acuminata Found in mixed or hardwood areas, rocky slopes, banks, and clearings. Likely common throughout NB (1).
260. Luzula multiflora Found in open woods, fields, banks, and meadows. Common throughout NB (1).
261. Luzula parviflora ssp. melanocarpa Occurs in damp coniferous or mixed woods, cool ravines, and banks. Has a **disjucnt boreal distribution**; common in north NB and rare southwards. Recorded in Fundy Park area (1).

Liliaceae (Lily Family)

262. Wild Garlic (Allium canadense) Found along banks, wet calcareous rocky shores, and adjacent meadows of St. John River valley. Rare in NB; recorded in Belleisle Bay area (Jenkin's Cove). Also recorded as rare in Quebec and New England (1,2).

281. Arethusa or Swamp-pink (Arethusa bulbosa) Found in sphagnum bogs. **Uncommonly** scattered throughout NB; recorded along Fundy coast in Little Salmon River-Quiddy River area (1).

283. Spotted Coral-root (Corallorhiza maculata) Habitat is mostly dryish coniferous or mixed woods. Scattered throughout NB (1).
284. Early or Pale Coral-root (Corallorhiza trifida) Found in seepage areas in rich coniferous or mixed woods. Scattered throughout most of NB; recorded in Washmadoak Lake area (1).

285. Stemless or Pink Lady's-slipper (Cypripedium acaule) Grows in boggy heathland and acid coniferous or mixed woods. **Uncommon** throughout NB; rare in northern part of province. Recorded in Parkindale and Washmadoak Lake areas (1).
286. Yellow Lady's-slipper (Cypripedium calceolus var. pubsescens) Habitat is subacid, rich, well-drained to moist woods and cedar swamps. **Uncommonly** scattered throughout most of NB (except rare in eastern lowlands); recorded in Salisbury area between upper reaches of the Petitcodiac and Canaan Rivers (1).

288. Helleborine (Epipactis helleborine) Found in rich mostly calcareous deciduous and mixed woods. **Rare** in NB; only three known locations have been recorded in NB; listed as rare in the Poley Mountain area near Sussex (1).

291. Hooker's Orchis (Platanthera hookeri) Grows in deciduous or mixed woods. Scattered throughout NB; recorded in Sussex Uplands area (1).
292. Northern Green Orchis (Platanthera hyperborea) Habitat is mostly coniferous woods, occasionally in calcareous sedge meadows, bogs, and roadside ditches. Common throughout NB (1).
293. Ragged Orchis (Platanthera lacera) Found in moist meadows, roadsides, clearings, and similar grassy, open areas. Scattered in southern third of NB (1).
294. Blunt-leaf Orchis (Platanthera obtusata) Grows in arborvitae bogs, mossy hummocks of coniferous swamps and woods. Scattered throughout NB; recorded in Canaan-Havelock region of Model Forest (1).
295. Large Round-leaved Orchis (Plantanthera orbiculata var. macrophylla) Found in rich woods, usually deciduous or sometimes mixed with hemlock. Rare in NB; recorded in four locations in various areas of the province, including the Fundy Park area (B. Freedman, pers. comm.). Also listed as rare in Connecticut (1,2).
295. Small Purple Fringed Orchis (Platanthera psycodes) Grows along rocky shores, moist meadows, roadsides, and borders of woods. Scattered throughout southern NB (1).

296. Auricled Twayblade (Listera auriculata) Found in alder thickets, banks, and arborvitae swamps. Scattered throughout New Brunswick, but rare in the eastern lowlands (1)
297. Heartleaf Twayblade (Listera cordata) Habitat is moist banks, coniferous swamps, and bogs; likely common throughout NB (1).

299. Northern Slender Ladies'-tresses (Spiranthes lacera) Grows in sandy clearings, alder thickets, and similar dryish open areas. Scattered throughout most of southern NB; recorded in the upper Canaan River area (1).
300. Broad-leaved Ladies'-tresses (Spiranthes lucida) Found along springy shores, meadows, and thickets that are often calcareous. **Uncommonly** scattered throughout southern NB; recorded in the upper Petitcodiac River valley (1).

shores, and dunes near the coast. Has a strict coastal distribution; commo along the easatern shore of NB, rarer along the Bay of Fundy (1).

Betulaceae (Birch Family)

312. Speckled Alder (Alnus incana) Found in areas with moist, mostly acid ground, old fields, or along streambanks. Common throughout NB (1).
312. Green or Mountain Alder (Alnus viridis) Occurs on gravelly or sandy banks, rocky shores, and moist slopes. Probably common throughout NB (1)

312. Yellow Birch (Betula alleghaniensis) Grows mostly in cool moist forests on acid soils. Common in NB (1,3).
312. Betula cordifolia Found mostly in spruce forests. Scattered throughou most of NB; forms a hybrid with B. populifolia (B. X caerulea) which has been confirmed within the Model Forest area (1).
312. White Birch (Betula papyrifera) Found on slopes, ridges, and shores i a variety of soil types. Species is shade-intolerant; thrives on burned-over or cut areas, sometimes forming pure stands in thee areas. Common throughout NB (1,3).
313. Grey Birch (Betula populifolia) Found in dry sandy upland mixed forests, sand plain forests, old fields, and dry peaty clearings. Common i the southeastern half of NB; rarer to the north (1).

314. Beaked Hazelnut (Corylus cornuta) Found in open acid woodlands and along the borders of woods. Common throughout NB (1).

314. American Hop-Hornbeam or Ironwood (Ostrya virginiana) Grows in rich mostly deciduous woodlands. Locally common in southern NB (1).

Fagaceae (Beech Family)

315. American Beech (Fagus grandifolia) Found mostly in mature woods, usually moist well-drained slopes or in rich bottomlands. Common throughou most of NB (1,3).

315. Bur Oak or Mossy-cup Oak (Quercus macrocarpa) Grows in swampy woods and rich bottomlands. Scattered in the lower St. John River valley; rare elsewhere in NB. Recorded in the Washmadoak Lake area and in the Kennebecasis and Petitcodiac River valleys (1,3).
316. Northern Red Oak (Quercus rubra) Found mostly on sandy or gravelly acid woodlands. Scattered throughout NB; less common in the northern counties of the province (1,3).

Ulmaceae (Elm Family)

317. American or White Elm (Ulmus americana) Native habitat is the alluvia soils of river bottoms; has been extensively planted elsewhere. Common throughout most of NB (1).

Urticaceae (Nettle Family)

320. Wood-Nettle (Laportea canadensis) Found in alluvial woods. Common throughout NB (1).

321. Stinging Nettle (Urtica dioica sub-species gracilis var. gracilis) Grows in rich, moist deciduous woods. Scattered throughout most of NB. Other subspecies/varieties exist in NB but are introduced or are uncommon and not found within the Model Forest area (1).

Caryophyllaceae (Pink Family)

342. Field Chickweed (Cerastium arvense) Found on gravelly or rocky expose slopes, and calcareous ledges. Probably scattered throughout NB (1).

343. Birdseye (Sagina procumbens) Found on rocky beaches or seepage areas in fresh or brackish places. Scattered throughout NB (1).

346. Spergularia marina Occurs in salt lagoons, estuaries, and inland salt springs. Scattered along coastal NB; recorded in Sussex Salt Springs (1).

348. Stellaria alsine Found on wet banks and similar springy areas. **Uncommonly** scattered in southern NB; recorded in Hampton Marsh area (1).
349. Stellaria calycantha Grows in wet seepage area. Common throughout NB (1).
350. Stellaria humifusa Found in salt marshes and meadows. **Uncommonly** scattered along coastal NB (1).

Nymphaceae (Water-lily Family)

351. Beaver-Root Yellow Pond-Lily (Nuphar luteum var. variegatum) Found in lakes, ponds, and quiet backwaters. Common throughout NB (1).

352. Fragrant Water-lily (Nymphaea odorata) Occurs in lakes, ponds, and similar still waters. **Uncommonly** scattered in southwestern NB; recorded in Belleisle Bay area (1).

Ranunculaceae (Crowfoot Family)

353. White Baneberry (Actaea pachypoda) Found in rich often calcareous woods. Common in western half of NB in vicinity of St.John River valley; rare elsewhere. Recorded in Fundy Park.
354. Red Baneberry (Actaea rubra) Occurs in mixed or deciduous woods, bottomlands, and thickets. Common throughout much of NB (1).

355. American Wood-Anenome (Anemone quinquefolia) Grows in moist woods and thickets. Scattered throughout southern NB (1).
356. Tall Thimbleweed (Anemone riparia) Found on calcareous ledges and shores. Scattered in the St. John and Restigouche River valleys; rare elsewhere.

358. Purple Clematis (Clematis occidentalis) Occurs on mostly calcareous ledges, rocky slopes, and open woods. Scattered throughout most of NB (1).
359. Virgin's-bower (Clematis virginiana) Found in bottomlands and thickets, borders of woods. Common throughout NB (1).

360. Goldthread (Coptis trifolia) Grows in moist, mossy coniferous or mixed woods. Common throughout NB (1).

360. Round-leaved Hepatica (Hepatica nobilis) Found on dryish hardwood or mixed slopes. **Rare** in NB; one recording in the upper Belleisle Bay area (1).

361. Kidney-leaf Buttercup (Ranunculus abortivus) Found in bottomlands and moist woodlands. Scattered throughout NB (1).
362. Common Buttercup (Ranunculus acris) Habitat is pastures, wet ditches, and waste areas. Common throughout NB (1).
362. White Water-Crowfoot (Ranunculus aquatilis var. capillaceus) Grows in

exposed calcareous ledges. Rare; recorded in three locations in NB, including Martin Head within the Model Forest. NB collections near the southern range of its distribution. Recorded as rare in NS and Maine; endangered or threatened in north-central US (1,2).

383. Yellow Cress (Rorippa palustris) Grows on gravelly or muddy shores; occasionally a weed in fields. Scattered throughout NB (1).

Sarraceniaceae (Pitcher-plant Family)

384. Pitcher-plant (Sarracenia purpurea) Occurs in acid bogs and boggy margins of ponds. Common throughout most of NB (1).

Droseraceae (Sundew Family)

385. Narrow-leaved Sundew (Drosera intermedia) Found in acid bogs and bogg ponds. Scattered throughout most of NB (1).
386. Round-leaved Sundew (Drosera rotundifolia) Grows in acid bogs and moist acid roadside ditches. Common throughout NB (1).

Crassulaceae (Orpine Family)

388. Roseroot (Sedum rosea) Grows in moist ledge crevices. Scattered along the Bay of Fundy coast (1).

Saxifragaceae (Saxifrage Family)

389. Water-mat (Chrysosplenium americanum) Found in swamps, seepage areas, shallow shaded streams, and wet ditches. Widespread throughout NB (1).

390. Mitella nuda Occurs in cool, mossy usually coniferous woods. Scattered throughout NB (1).

391. Wild Black Current (Ribes americanum) Found on rich mostly calcareous soils of moist woodlands and thickets. Scattered throughout southern half of NB; rarer towards the north of province (1).
392. Skunk-current (Ribes glandulosum) Found on rocky slopes, moist woods and thickets. Common throughout NB (1).
392. Canada or Bristly Gooseberry (Ribes hirtellum) Habitat is rocky woods and clearings. Common throughout most of NB (1).
393. Bristly or Swamp Current (Ribes lacustre) Found in moist woods, thickets, and swamps. Common throughout most of NB (1).
394. Wild Red Currant (Ribes triste) Habitat is mostly rocky moist woods and thickets. Scattered throughout most of NB (1).

395. Livelong Saxifrage (Saxifraga paniculata) Found on moist calcareous ledges (1) or dry ledges (2) ???. Rare in NB; four recorded locations including two in Model Forest area: Walker Settlement and Fundy Park. Listed as rare in Nova Scotia, New England, and Northwest Territories (1,2).

396. False Mitrewort (Tiarella cordifolia) Grows in rich woods. Scattered mostly in western part of NB (1).

Hamamelidaceae (Witch-hazel Family)

397. Witch-hazel (Hamamelis virginiana) Found in moist mostly acid woods and shore thickets. Locally common in southwest NB; rare elsewhere (1).

woods, roadsides, and ditches. Common throughout most of NB (1).

416. Geum aleppicum Grows in damp woods and thickets. Common mostly in western NB (1).
417. Geum canadense Occurs in rich woods and thickets. Mostly confined to St. John River system; recorded in Belleisle Bay area and along the Canaan River (1).
418. Geum laciniatum Found on stream banks, and in damp meadows and thickets. Scattered throughout most of NB (1).
419. Geum macrophyllum Grows in rich woods, thickets, and meadows. Scattered over much of NB (1).
420. Water- or Purple-Avens (Geum rivale) Grows in wet meadows and shores. Scattered over much of NB; locally common (1).

423. Silverweed (Potentilla anserina) Grows on sandy or gravelly shores. Common along NB coast; uncommon along inland streams (1).
426. Shrubby Cinquefoil (Potentilla fruticosa) Found in rocky or gravelly, rarely boggy areas, often calcareous. Most common in southern and western NB; rarer in northeast (1).
427. Rough Cinquefoil (Potentilla norvegica) Found in waste areas, fields, and similar open areas. Common throughout NB; possibly both native and introduced (1).
428. Marsh-Five-Finger (Potentilla palustris) Grows at the edges of bogs and both fresh and salt water marshes. Scattered throughout most of NB (1)

429. Old-Field-Cinquefoil (Potentilla simplex) Found mostly in old fields, roadsides, and young mixed woods. Common throughout southern half of NB (1).
430. Three-toothed Cinquefoil (Potentilla tridentata) Found on exposed rocky or sandy headlands, mountain tops, and shores. Scattered throughout much of NB (1).

431. Pin-Cherry (Prunus pensylvanica) Occurs in clearings, burned areas, and young mixed forests. Common throughout much of NB (1).
431. Sand-Cherry (Prunus pumila) Found on sandy beaches and similar open areas. Scattered throughout much of NB except eastern and southeastern parts of province (1).
432. Black-Cherry (Prunus serotina) Grows in dry or moist woods and border thickets. Locally common throughout much of southern NB; rarer northwards (1).
433. Choke-cherry (Prunus virginiana) Found in thickets, borders of dry woods, and on shores. Common throughout much of NB (1).

436. Meadow Rose (Rosa blanda) Found in meadows and on rocky slopes and gravelly shores. Scattered throughout most of NB; locally common along St. John River valley (1).
437. Rosa carolina Found in sandy and rocky open areas. Scattered throughout most of NB; rarer in northwest (1).
438. Bristly Rose (Rosa nitada) Grows in acid bogs and marshes, wet thickets, and stream margins. Scattered throughout most of NB (1).
439. Swamp Rose (Rosa palustris) Occurs along wet shores, and in marshes and swamps. **Uncommon to rare** in southern NB; recorded in two Model Forest locations: northwest of Fundy Park and in the Lake Washmadoak area (1).
441. Rosa virginiana Grows on shores, roadside ditches, meadows, and clearings. Common throughout southeast NB; rarer northwestward (1).

442. Rubus allegheniensis Found in thickets and clearings. Locally common in most of southern NB (1).

Euphorbiaceae (Spurge Family)

470. Acalypha rhomboidea Grows on gravelly shores, roadsides, and waste areas. Locally common along St. John River valley in York, Queens, and King's counties. Recorded in Belleisle Bay area (1).

471. Chamaesyce vermiculata Found along dry sandy and gravelly shores, roadways, and in waste areas. Locally common within St. John River drainag system (1).

Callitricaceae (Water-Starwort Family)

474. Callitriche heterophylla Found in quiet waters and on shores. Common throughout most of NB (1).

Empetraceae (Crowberry Family)

475. Black Crowberry (Empetrum nigrum) Found on exposed headlands, windswept peaty or rocky barrens. Locally common along coastal NB; occasionally found inland (1). The Northern Blue butterfly ( ), a sub-boreal species more common in northern NB and Quebec, feeds exclusivly on this plant species and thus is likely found in this area (T. Thomas, pers. comm.).

Anacardiaceae (Cashew Family)

476. Staghorn-Sumac (Rhus typhina) Found at dry woods edges and on rocky slopes. Common in southwest NB; rarer to the north and east (1).

477. Toxicodendron radicans Grows in swampy woods or thickets. **Uncommon** in NB; populations concentrated on lower St. John River system. Recorded in Belleisle Bay area (1).
478. Toxicodendron rydbergii Found on rocky or sandy woods and shores. Common in the St. John River drainage system; scattered elsewhere in NB. Recorded in several Model Forest locations, including Fundy Park (1).

Aquifoliaceae (Holly Family)

479. Black Alder or Winterberry (Ilex verticillata) Grows in swampy or boggy open woods and thickets. Common in south and east NB; rare elsewhere (1).

479. Mountain-Holly (Nemopanthus mucronata) Grows in damp acid woods, bogs, thickets, and shores. Common throughout most of NB (1).

Aceraceae (Maple Family)

480. Striped Maple (Acer pensylvanicum) Occurs in cool moist woods. Common throughout most of NB (1).
480. Red Maple (Acer rubrum) Prefered habitat is moist soils around the borders of swamps as well as alluvial lowlands and moist uplands (1,3). Common throughout NB (1).
480. Silver Maple (Acer saccharinum) Found in rich and moist alluvial bottomlands; rarely at higher elevations (1,3). Common along St. John River valley; rare elsewhere in NB. Recorded in Kennebecasis, Petitcodiac, and Canaan River valleys as well as Belleisle Bay area (1).
480. Sugar Maple (Acer saccharum) Found in rich, often rocky upland woods. Common in most regions of NB (1).

505. Viola nephrophylla Habitat is gravelly shores. **Uncommon** in NB; scattered in southcentral and northern areas of province. Recorded in uppe Petitcodiac River valley and Belleisle Bay area (1).
506. Blue Marsh Violet (Violoa obligua) Occurs in wet meadows and swamps. Common throughout most of NB (1).
506. Viola obligua X Viola septentrionalis Hybrid occurs occasionally in southern NB. Recorded in one Model Forest location (1).
507. Smooth Yellow Violet (Viola pubescens var. eriocarpa) Grows in moist deciduous woods. Common throughout most of NB except east and central area (1).
508. Kidney-leaved Violet (Viola renifolia) Occurs in moist cool woods and on rocky slopes. Scattered throughout most of NB (1).
509. Great-spurred Violet (Viola selkirkii) Found in rich deciduous woods and on rocky slopes. **Uncommon** in NB; mostly scattered in south and western areas of province (1).
510. Northern Blue Violet (Viola septentrionalis) Found in moist clearings and open woods. Common in southern half of NB (1).

Onagraceae (Evening-primrose Family)

511. Circaea alpina Grows in cool moist woods. Common throughout most of NI (1).
512. Circaea lutetiana ssp. canadensis Found in rich usually deciduous woods and thickets. Scattered mostly in southern half of NB (1).
513. Circaea X intermedia A fertile hybrid between C. alpina and C. lutetiana found in rich often alluvial woods. Scattered throughout most of NB (1).

514. Fireweed (Epilobium angustifolium) Found in clearings, thickets, and open woods, especially in burned over areas. Common throughout most of NB (1).
514. Glandular Willow-herb (Epilobium ciliatum ssp. glandulosum) Found on fresh shores or springy grounds. Common throughout much of NB (1).
515. Hornmann's Willow-herb (Epilobium hormanii) Grows on cool moist slopes, ledges, and shores. **Uncommon** in NB with **disjunct boreal distribution**; scattered in northwest, central highlands, and Bay of Fundy area, including Fundy Park (1).
516. Narrow-leaved Willow-herb (Epilobium leptophyllum) Habitat is wet ditches, seepage areas, and marshes. Scattered throughout much of NB (1).

517. Water-purslane (Ludwigia palustris) Found in shallow water and on wet shores. Common in southwest third of NB; uncommon or not found elsewhere i province.

518. Evening-Primrose (Oenothera biennis) Found on roadsides, waste areas, sandy and gravelly shores, and old fields. **Uncommon** in NB with a scattered and restricted distribution, including the lower St. John River vallety (1).
518. Oenothera parviflora Grows on sandy or gravelly shores, headlands, talus, and waste areas. Common throughout most of NB (1).
519. Sundrops (Oenothera perennis) Found in moist to dry open areas. Commo throughout most of NB (1).

Haloragaceae (Water-Milfoil Family)

520. Myriophyllum alterniflorum Found in shallow water of lakes and rivers Scattered throughout much of NB (1).

533. Pinesap (Monotropa hypopitys) Grows in coniferous forests. **Uncommon** i NB; scattered in southern half of province and rare northwards. Recorded i Fundy Park area (1).
534. Indian-pipe (Monotropa uniflora) Found in shaded mostly deciduous woods. Common throughout most of NB (1).

535. One-sided Pyrolia or Wintergreen (Orthilia secunda) Grows in mostly mixed woods. Common throughout most of NB though rare along Bay of Fundy. Recorded in Fundy Park area (1).

536. Pink Pyrola or Wintergreen (Pyrola asarifolia) Found in mostly coniferous woods. Scattered throughout most of NB though rarer in south an east portions; recorded in Belleisle Bay area and possibly near Parkindale (1).
537. Pyrola chlorantha Occurs in mostly coniferous woods. **Uncommon** in NB; scattered throughout much of province but rarer in the south. Recorded in the upper Kennebecasis River valley (1).
538. Shinleaf (Pyrola elliptica) Found in dry to moist mostly mixed woods. Common throughout most of NB (1).
539. Pyrola minor Grows in cool moist woods. **Rare** in NB with a **disjucnt boreal distribution**: recorded along the Bay of Fundy, central highlands, and in the northwest of the province. Collected in Fundy Park area (1).

Ericaceae (Heath Family)

540. Bog-rosemary (Andromeda polifolia) Found in peat bogs and on boogy shores. Common throughout much of NB (1).

540. Bearberry (Arctostaphylos uva-ursi) Grows on dry ledges and on sands. **Uncommon** in NB; scattered in southcentral and eastern portions of province Recorded in Kennebecasis River valley in two locations (1).

541. Leather-leaf (Chamaedaphne calyculata) Grows in peat bogs and margins of acid bog ponds. Common throughout much of NB (1).

541. Mayflower (Epigaea repens) Occurs in cool moist peaty woods. Common throughout much of NB except rarer in western regions (1).

542. Creeping Snowberry (Gaultheria hispidula) Found in cool moist coniferous forests. Scattered throughout most of NB (1).
543. Checkerberry of Teaberry (Gaultheria procumbens) Grows mostly in dry mixed or coniferous woods. Common in eastern lowlands; uncommon to rare elsewhere (1).

544. Black Huckleberry (Gaylussacia baccata) Found at the edges of dry woods, sandy shores, and clearings. Common in south and east of NB; rare elsewhere (1).
545. Dwarf Huckleberry (Gaylussacia dumosa) Occurs in sphagnous bogs and wet barrens. **Uncommon or overlooked** in NB; scattered in south and east of provinve mostly near the coast (1).

546. Lambkill or Sheep-Laurel (Kalmia angustifolia) Found in rocky barrens, clearings, and old pastures. Common throughout much of NB (1).

546. Labrador-tea (Ledum groenlandicum) Habitat is peat bogs and peaty lowlands. Scattered throughout much of NB (1).

561. Screw-stem (Bartonia paniculata) Found in wet peaty or sandy lowlands Very rare in NB; recorded in Charlotte County and in the Little Salmon River gorge. listed as rare or endangered in parts of eastern and central Canada and the US (1,2).

Apocynaceae (Dogbane Family)

563. Spreading Dogbane (Apocynum androsaemifolium var. incanum) Found in dry fields, roadsides, and ditches. Scattered throughout most of NB (1).
564. Indian Hemp (Apocynum sibiricum) Grows on gravelly shores. Scattered throughout most of NB though rare in eastern lowlands (1).

Asclepiadaceae (Milkweed Family)

565. Swamp-Milkweed (Asclepias incarnata) Occurs on shores and wet meadows Locally common in southwest third of NB (1).
566. Common Milkweed (Asclepias syriaca) Grows in fields, roadsides, waste areas, and thickets. Scattered in southern NB; rarer northwards (1).

Convolvulaceae (Morning-glory Family)

567. Hedge-Bindweed or Wild Morning GLory (Convolvulus sepium or Calystegia sepium) Found at the edges of salt marshes, and in thickets, woods, and waste areas. Scattered throughout much of NB; common on east coast (1).

Menyanthaceae (Buckbean Family)

569. Buckbean (Menyanthes trifoliata) Grows in bogs and shallow ponds. Scattered throughout most of NB (1).

570. Floating-heart (Nymphoides cordata) Occurs in the shallow water of lakes, ponds, and slow streams. Scattered in southern NB (1).

Polemoniaceae (Polemonium family)

571. Collomia (Collomia linearis) Found on railway tracks and disturbed ground. Rare in NB, with recordings in several locations including the Hampton area. Was last collected in 1945 and may have been introduced from further west. Listed as rare in Quebec, Ontario, and the NWT (1,2).

Boraginaceae (Borage Family)

573. Sea-Lungwort (Mertensia maritima) Grows on sandy or gravelly sea beaches. Scattered along NB coasts (1).

575. Myosotis laxa Occurs on seepage areas and shores. Scattered throughout much of NB (1).

Verbenaceae (Vervain family)

580. Blue Vervain (Verbena hastata) Found on shores, river bottoms, and in meadows. Uncommonly scattered throughout most of NB (1).

Lamiaceae (Mint Family)

581. Wild Basil (Clinopodium vulgare) Grows in open woods, slopes, and waste areas. Scattered mostly in western half of NB; rare in the eastern

606. Utricularia intermedia Found in ponds and slow streams. Common throughout most of NB (1).
607. Utricularia vulgaris Grows in quiet waters. Common in south of province; rare elsewhere (1).

Plantaginaceae (Plantain Family)

608. Seaside-Plantain (Plantago maritima) Found in coastal salt marshes, sands, and ledges. Common in coastal areas (1).

Rubiaceae (Madder Family)

609. Northern Bedstraw (Galium boreale) Found in open woods, thickets, and meadows. **Uncommon** in NB; scattered in south- and west-central parts of province (1).
611. Galium obtusum Found on shores and similar wet places. **Uncommon** in NB; mostly along east coast. Recorded in several Model Forest locations (1).
612. Marsh Bedstraw (Galium palustre) Occurs on wet open shores, meadows, and similar open areas. Common throughout most of NB (1).
613. Clayton's Bedstraw (Galium tinctorium) Grows in wet depressions and bottomlands. Scattered over most of NB (1).
614. Dyer's Cleavers (Galium trifidium) Three subspecies are found in NB; two could occur within the Model Forest area: G. trifidium ssp. halophilum grows in salt marshes and along brackish shores, and is scattered primarily along the east coast. G. trifidium ssp. trifidium grows on wet shores, marshes, and meadows, and is common throughout the province (1).
615. Sweet-scented Bedstraw (Galium triflorum) Occurs in bottomlands and in mixed or hardwood forests. Common throughout most of NB (1).

615. Bluets (Hedyotis caerulea) Found in open areas, lawns, and meadows. Locally common in southwest NB (1).

616. Partridge Berry (Mitchella repens) Grows in coniferous or mixed woods. Scattered mostly in southern NB; rarer northwards. Recorded in Canaan and Kennebecasis River valleys (1).

Caprifoliaceae (Honeysuckle Family)

617. Bush-Honeysuckle (Diervilla lonicera) Found at roadsides, field margins, mixed woods, and rocky slopes. Common throughout much of NB (1).

617. Twinflower (Linnaea borealis) Occurs in mixed or deciduous woods and clearings. Common throughout much of NB (1).

617. Fly-Honeysuckle (Lonicera canadensis) Found in damp coniferous or mixed woodlands. Common throughout most of NB (1).
617. Swamp Fly-Honeysuckle (Lonicera oblongifolia) Occurs in calcareous swamps and bogs. Rare in NB; recorded mostly in western regions of the province plus in the central Kennebecasis River Valley. Listed as rare in Maine; extirpated in Ohio (1,2).
617. Mountain Fly-Honeysuckle (Lonicera villosa) Grows in peaty or rocky barrens, swamps and bogs. Common throughout NB (1).

618. Elderberry (Sambucus canadensis) Found on shores and in swamps and damp thickets. Common in southern half of NB; uncommon northwards (1).
618. Red-berried Elder (Sambucus racemosa) Found in mixed woodland, clearings and shores, and thickets. Common throughout much of NB (1).

reported from several localities including the upper Petitcodiac River valley (1).

635. Fireweed (Erechtites hieracifolia) Found on disturbed soils, burned areas, clearcuts, fields, and waste areas. Common in southern NB; rarer elsewhere (1).

636. Daisy-Fleabane (Erigeron annuus) Occurs in open grassy areas, disturbed soils, and waste areas. Scattered throughout most of NB (1).
636. Hyssop-leaved Fleabane (Erigeron hyssopifolius) Occurs on calcareous ledges and shores. Has a **disjunct boreal distribution**, with locally-common populations occuring in southeast and northern NB. Recorded in the Fundy Park area (1).
637. Erigeron philadelphicus Grows in moist meadows and similar open areas. Scattered throughout most of NB though uncommon in the eastern lowlands (1).
637. White-top (sometimes also called Daisy-Fleabane) (Erigeron strigosus) Found in cultivated areas, roadsides, and waste places. Common throughout most of NB (1).

638. Joe-Pye-Weed (Eupatorium maculatum) Found in damp meadows, thickets, and shores. Common throughout most of NB (1).
638. White Snakeroot (Eupatorium rugosum) Grows in moist, cool woods and clearings. **Semi-disjunct boreal distribution; rare** along eastern coast of NB and Bay of Fundy; **uncommon** in northwest of province. Recorded in three locations in Fundy Park area (1; B.Freedman, pers. comm.).

639. Gnaphalium sylvaticum Grows on dirt roadways, and in clearings and fields. Scattered throughout most of NB (1).

640. Hieracium X dutillyanum A hybrid between H. canadense and H. umbellatum. Grows in thickets, clearings, and fields. Locally common in southern NB (1).
641. Hieracium kalmii Found at roadsides, railways, clearings, and borders of woods. **Rare** in NB; occurring in southwest corner of the province. Recorded in Fundy Park area (1).
641. Hieracium paniculatum Found in open rocky woods and thickets. **Very rare** in NB; reported from Fredericton and Hatfield Point on Belleisle Bay (1).
641. Robinson's Hawkweed (Hieracium robinsonii) Occurs in ledge crevices along streams. **Very rare** in NB; recorded in Albert and St. John counties and in Fundy National Park (1).

643. Lactuca biennis Occurs in clearings, old fields, and waste areas. Common throughout most of NB (1).

643. Petasites frigidus var. palmatus Grows in cool moist woods. Scattered throughout most of NB (1).

644. White Lettuce (Prenanthes altissima) Found in moist mixed or hardwood forests. Scattered throughout most of NB (1).
645. Glaucous Lettuce (Prenanthes racemosa) Found along shores, and in meadows and thickets. **Uncommon** in NB; scattered along St. John and Restigouche River drainage systems. Recorded on Washmadoak Lake (1).
646. Gall-of-the-Earth (Prenanthes trifoliata) Found in open woods, clearings, and thickets. Scattered throughout most of NB (1).

647. Golden Ragwort (Senecio aureus) Found in damp meadows, thickets,

Appendix 3: Species list of mammals occurring within the Fundy Model Forest.

Descriptions of animal distribution within the FMF based on available information, mostly from Fundy National Park and DNRE records.

(Deer Family)

1. Moose (Alces alces) Primary habitat is spruce forest and swamps (1). Common but not overly numerous in Fundy National Park.

2. White-tailed Deer (Odocoileus virginianus) Prefers habitat of farmlands, woods, brushy areas (1). Common in Fundy National Park.

Felidae (Cat Family)

1. Bobcat (Felis rufus) Primary habitat is broken forest, scrubby country, but adapts to farmlands or swamps (1). Common in Fundy National Park (2).

2. Lynx (Felis lynx) Deep forest habitat is prefered (1). Rare in Fundy National Park; has not been observed for many years and thus may be extirpated in that area (2).

3. Cougar (Felis concolor) Habitat is varied; adults may have wide ranges (1). In Fundy National Park, 28 observations and two sets of tracks have been recorded between 1949 and 1977. However, no conclusive evidence, such as photographs or scat specimens, have been found (2).

Mustelidae (Weasels, Skunks, and Otters)

1. River Otter (Lutra canadensis) Habitat is primarily along rivers, ponds, and lakes in wooded areas, but will roam far from water (1). Uncommon in Fundy National Park (2).

2. Striped Skunk (Mephitis mephitis) Wide habitat range; can be found in woodlands, rural and suburban areas (1). Uncommon in Fundy National Park (2).

3. Mink (Mustela vison) Habitat is along rivers, creeks, lakes, ponds, and marshes (1). Uncommon in Fundy National Park.

4. Long-tailed Weasel (Mustela frenata) Varied habitat: forested, brushy, and open areas, including farmlands, preferably near water (1).

5. Short-tailed Weasel or Ermine (Mustela erminea) Varied habitat: open woodlands, brushy areas, grasslands, wetlands, farmlands (1). Recorded as uncommon in Fundy National Park (2).

6. Fisher (Martes pennanti) Habitat is mature and/or regenerating forest (1). Uncommon in Fundy National Park (2).

7. Marten (Martes americana) Habitat is forests areas, especially coniferous forests (1). Introduced to Fundy National Park in 1984; current status unknown (2).

5. Big Brown Bat (Eptesicus fuscus) In summer, roosts in buildings or hollow trees. In winter, hibernates in buildings, mines, and other protected places (1). Listed as common in New England (4).

6. Silver-haired Bat (Lasionycteris noctivagans) Habitat is forested areas near lakes or streams (4). In summer, roosts in protected spots (e.g. hollow trees). Hibernates in tree crevices, buildings and other protected areas in winter (1). Presence in Fundy National Park suspected but not confirmed (2). Recorded as rare to uncommon in New England (4).

7. Eastern Pipistrelle (Pipistrellus subflavus) Usually hangs in vegetation by day; hibernates in caves, mines, or crevices (1). Identified as uncommon for New Brunswick in general; though may be more common than records indicate (3). Species is uncommon to rare in New England (4). Hibernacula containing this species has been found in Hampton/Noton area (3).

Leporidae (Hare Family)

1. Snowshoe Hare (Lepus americanus) Found in most northern forests in areas with dense brushy cover (1,4). Abundant in Fundy National Park (2).

Sciuridae (Squirrels, Chipmunks, and Woodchuck)

1. Eastern Chipmunk (Tamias striatus) Habitat is open woodland, forest edges, brushy areas (1) Recorded as uncommon in Fundy National Park (2)

2. Northern Flying Squirrel (Glaucomys sabrinus) Habitat is coniferous forests, mixed forests; sometimes in hardwoods forests with numerous woodpecker holes, especially in stumps (1). Uncommon in Fundy National Park (2); recorded as common to uncommon in New England (4).

3. Red Squirrel (Tamiasciurius hudsonicus) Found in most forest types, including plantations, and in suburban areas (1). Recorded as abundant in Fundy National Park (2).

4. Gray Squirrel (Sciurus carolinensis) Hardwood or mixed forests; suburban areas if food source available (nut trees, feeders) (1). Recorded as rare in Fundy National Park (2).

5. Woodchuck (Marmota monax) Found in pastures, meadows, old fields, woods (1). Uncommon in Fundy National Park (2).

Castoridae (Beaver Family)

1. Beaver (Castor canadensis) Found in rivers, streams, marshes, lakes, and ponds (1). Uncommon in Fundy National Park (2).

Cricetidae (New World Rats and Mice: Muskrat, Mice, Voles, and Lemmings)

Muskrat:

1. Muskrat (Ondatra zibethicus) Fresh, brackish, or saltwater marshes, ponds, lakes, and rivers (1). Recorded as rare in Fundy National Park, though distribution not well known. May be limited due to lack of good

Recorded as common in Fundy National Park (2).

4. Arctic Shrew (Sorex arcticus) Habitat is swamps, bogs, marshes, grass-sedge meadows (1). Presence in Fundy National Park suspected but has not been confirmed (2).

5. Pygmy Shrew (Microsorex hoyi) Habitat is most commonly wet or wet-dry areas located in deep woods, open and brushy fields, moist sphagnum bogs (1). Recorded as uncommon in Fundy National Park (2). Little is known about the life history of this species (4).

6. Short-tailed Shrew (Blarina brevicauda) Found in most wooded areas (1). Common in Fundy National Park (2).

Moles:

1. Star-nosed Mole (Condylura cristata) Prefers wet woods, fields, or swamps; sometimes lawns, other dry areas (1). Rare in Fundy National Park due to lack of suitable habitat (2).

2. Hairy-tailed Mole (Parascalops breweri) Found in woods with well drained light soils; also brushy areas, lawns adjacent to woods (1).

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night to chorus or breed. Both are identical in appearance; Cope's Treefro has a faster trill and half the number of chromosomes (1).

3. American Toad (Bufo americanus) Common in many habitats from mowed lawn to heavily forested woodlands, wherever moisture and insects are abundant (1). Abundant in Fundy National Park (2).

4. Wood Frog (Rana sylvatica) Habitat primarily moist woodlands. May venture far from water during summer; hibernates in forest debris during the winter (1). Widespread in Fundy National Park (2).

5. Mink Frog (Rana septentrionalis) Appears to prefer habitat with cold water where vegetation, especially water lilies, are abundant. Also found near edges of ponds or lakes with peatty bottoms or emergent vegetation (1). Uncommon in Fundy National Park; found only in Caribou and Laverty lakes (2).

6. Northern Leopard Frog (Rana pipiens) Habitat ranges from freshwater sites with profuse vegetation to brackish marshes and moist fields (1). Rare in Fundy National Park; only two sightings (2).

7. Pickerel Frog (Rana palustris) Slow moving water and other damp areas, preferably with low,dense vegetation; streams, swamps, and meadows (1). Common in Fundy National Park (2).

8. Green Frog (Rana clamitans) Lives close to shallow water, springs, swamps, brooks, edges of ponds and lakes. May be found among rotting debris of fallen trees (1). Widespread in Fundy National Park (2).

9. Bullfrog (Rana catesbeina) Prefers ponds, lakes, and slow-moving streams with sufficient vegetation to provide cover (1) Uncommon in Fundy National Parks; seen in Marven and Chambers lakes (2).

Caudata (Salamanders)

1. Red-backed Salamander (Plethodon cinereus) Habitat is cool, moist coniferous, mixed, and hardwood forests; completely terrestrial. Feeds in moist leaf litter (1). Common in Fundy National Park (2). Recorded as abundant in Hayward Brook research area (Parker, pers. comm.).

2. Four-toed Salamander (Hemidactylium scutatum) Habitat is bogs, boggy streams, and floodplains; usually associated with sphagnum moss. Adults live under stones and leaf litter in hardwood forests surronding boggy areas; the need for this special habitat accounts for irregular distribution (1). Rare in Fundy National Park; one found in 1983 (2).

3. Two-lined Salamander (Eurycea bislineata) Habitat is rock-bottomed brooks, springs, seepages, river swamps, and floodplain bottoms in coastal plain (1). Appears especially common at brooksides. Common in Fundy National Park (2).

4. Dusky Salamander (Desmognathus fuscus) Found in rock-strewn woodland creeks, seepages, and springs. Rare in Fundy National Park; may be extirpated (2).

5. Tremblay's Salamander (Ambystoma tremblayi) Found in deciduous forests (1). A hybrid species found in southeastern New Brunswick; may not occur in

similar species, pine-drops, a very rare New Brunswick plant, occurs exclusively in mature pine forests, though it has yet to be recorded in the FMF area.

The pine-oak forest community-type is scattered and uncommon in New Brunswick in general; today it is more common in central and southern Maine. Pollen records indicate that pine-oak forests were more abundant in New Brunswick around 6000 years ago, when climatic conditions were warmer and drier (Livingstone, 1968). With predicted climate change, this forest assemblage may become more common in the future.

Pine-oak forest can be seen in the Rockville area along Big Bluff, Urney, and Waterford. These forests range from almost pure white pine to pure red oak.

3. **Hardwood Talus Slope Forest Community-type**

Talus, also known as scree, is an accumulation of rock debris that forms at the base of cliffs and escarpments and includes loose boulders, cobble, and sometimes gravels and finer sediment. The type of talus depends primarily on the underlying parent material of the area. Boulder talus is characteristic of harder, granitic rock material while smaller cobble and gravel talus is derived from softer sedimentary rock or highly fractured slates. Within the FMF, talus slopes are known to occur in four areas: Hampton, Mt Zachy-Jonah, Waterford, and Parlee Brook.

Talus is an unstable substrate, prone to land slides and new rock falls from above. The stability of talus slopes varies. Steeper slopes often experience more rock slides, though larger talus material tends to lodge together and increase stability. Talus rapidly drains, especially in the upper slopes. Among the larger boulders and rocks, soil formation is limited to small pockets and water retention is poor. Lower slope areas tend to accumulate soil and moisture. The nutrient status of talus areas is dependent on whether the parent material is acidic or circumneutral/basic. Circumneutral or basic sites generally support a richer community of plant species than acidic sites. Aspect and proximity to coastal areas also have an influence on species composition. Both northern aspect and coastal proximity create cool and moist conditions that enhance the development of lichens and some vascular flora.

In the highly xeric boulder and rock talus with limited soil formation, vegetative growth is often restricted to lower vascular plants, such as reindeer lichen, crustose and foliose lichens, and the mosses Rhacomitrium canescens and Polytrichum spp. These species are less likely to occur in small-substrate talus which is less stable than boulder and rock talus thus continually disrupts establishment.

In downslope areas, or on upper talus fields where moisture is not limiting, a forest community may establish. Talus forests are typically composed of mixed assemblages of tree species such as sugar maple, yellow birch, balsam fir, white birch, beech, white pine, and red spruce, and on occasion green alder. At two gravel-talus sites within the FMF, pure ironwood or ironwood-red oak stands occur.

The ground flora in forested talus often includes several fern species: marginal shield-fern, glandular wood-fern, rock polypody, bracken

nutrient-poor. They are influenced by the coastal climate of the Bay of Fundy, with cool temperatures and frequent fogs. This creates humid conditions that, in combination with shading from the dense forest overstory, result in thick moss beds on the forest floor and abundant arboreal lichens.

There are ten red spruce-dominated coastal ravines within the Fundy Model Forest, running from Fundy National Park down to the Little Salmon River gorge. They range in length from just under one kilometer to almost twenty kilometers. The age and physical structure of these forests are not all identical. Some ravines contain mature forest; others have uneven-aged forest, likely the result of spruce budworm. Effects of logging from last century also remain. Logs from the upland plateau were collected at ravine edges and dumped into the ravines for river transportation. These log "avalanches" scoured away all soil and can still be seen along the sides of some ravines.

Although dominated by red spruce, these forests include mixtures of balsam fir, black spruce, red maple, white birch, and yellow birch. Where soils are especially thin due to surficial bedrock, white pine occurs infrequently. Vascular understory vegetation is sparse, possibly because of the shade and the dense mats of moss limiting establishment of vascular flora. The dominant moss species are Pleurozium schreberi and Bazzania trilobata; with the plume moss occurring in moist seepy locations (Hirvonen and Madill, 1978). The vascular ground flora species includes bunchberry, wild-lily-of-the-valley, goldthread, creeping snowberry, and bluebead lily. Moccasin-flower and indian pipe are also seen occasionally.

The red spruce forests of the FMF coastal ravines are known breeding sites for the rare bicknell's thrush, a species largely restricted to cool remote upland forests. Other known breeding locations of this species in the Maritimes include the Cape Breton Highlands, the northwestern New Brunswick uplands, and several other coastal locations, including Grand Manan island (Erskine, 1992). Until recently it had been classified as a subspecies of the grey-cheeked thrush but it is now considered a separate species (Ouellet, 1993).

Red spruce trees of the coastal ravine forests often reach larger sizes than trees in the adjacent upland plateau forests. This reflects both the suitable growing conditions in the ravines and the age of the trees, a result of the inaccessibility of the slopes, which has prevented harvesting. Some of these untouched forests include trees greater than 300 years old.

6. Sugar Maple-White Pine Inland Cove Forest Community-type

The inland cove forest community-type occurs in broad sheltered coves, both along the shores of lakes and bays, and on the low to mid-elevation slopes above them. The cove habitat is characterized by mesic soils with a climate ameliorated by the influence of the adjacent water bodies and protection by the cove headlands.

In the FMF, cove forests occur along Washademoak Lake and Belleisle Bay. They have rich and diverse vegetative assemblages, with mixes of species typical of both rich northern hardwood community-types and coniferous community-types. Dominant tree species are sugar maple, white

Dominant trees and shrubs of this community-type include silver maple, black ash, red ash, red maple, and black willow. American elm was once very common in this forest-type but has been reduced by dutch elm disease. Less-common tree species are butternut, white cedar, basswood, and bur oak. Typical ground flora includes jack-in-the-pulpit, dutchman's breeches, indian cucumber-root, spring beauty, nodding trillium, carrion-flower, and trout lily. Species listed as scattered, uncommon, or rare include golden alexanders, maidenhair fern, canada lily, and the lance-leaved grape-fern. Maidenhair fern has not been recorded for some time and may now be extirpated. It had originally been observed in the Belleisle Bay area.

Both rich northern hardwood community-types provide suitable habitat for many breeding bird species. Most common are the red-eyed vireo, northern oriole, ovenbird, and american redstart. Uncommon or rare species include scarlet tanager, wood thrush, and the warbling vireo. These species were likely never abundant within New Brunswick, which is the northern limit of their natural range. However, they may have been more prevalent before colonization when mature broad-leaved forest was more widespread (Erskine, 1992).

Because of the fertile nature of areas supporting the two northern hardwood forest community-types, they were typically the first lands to be cleared following European colonization. Today very little remains forested, or if it is forested, the successional stage and age distribution are characteristic of abandoned farmland reverting to forest. Distribution of both community-types was likely always restricted in the FMF because suitable habitat was limited. However, habitat alteration has further reduced and fragmented sites to the point that species may no longer be able to persist, especially those requiring the shady moist conditions provided by mature closed-canopy forest. Opening up the forest increases light levels, allowing the penetration of weedy species that may outcompete native flora. It also may increase parasitism of neotropical migrant bird nests by cowbirds. For many plant species, fragmentation and habitat conversion may also affect migration along river valleys, with inter-patch distance often greater than the distance the seeds or pollen can naturally travel.

Rock Outcrop Community-types: Escarpments, Cliffs, Headlands, and Caves

Rock outcrop community-types occur on exposed rock faces or in subterranean caves. Soil formation is limited (where applicable) and the member species have adapted to tolerate the specialized conditions of the habitat. Seven rock outcrop community-types have been recognized within the FMF occurring on escarpments, cliffs, headlands, and caves.

9. Dry Lichen-Blueberry Escarpment Community-type

Escarpments are barren and windswept rock outcrops occurring on exposed ledges or at the summit of hills or mountains ("balds"). Bedrock dominates the ground surface, though thin pockets of soil may develop. The formation and maintenance of escarpments is the result of constant exposure from wind and sun, and low moisture availability. In some cases, fire also

plays a role, burning off organic soil and killing plants whose root systems support the soil layer. Low-elevation escarpments usually face south and west, the aspect most exposed to the sun. North-facing escarpments are less common, possibly because sun exposure is reduced, resulting in cooler temperatures and reduced moisture loss, allowing forest vegetation to develop.

Escarpments are sparsely vegetated with few trees. Typical tree species include grey birch, balsam fir, and white pine; they are restricted to the soil pockets and often stunted. Various lichen species and small-statured drought-tolerant herbs and shrubs are dominant. Characteristic shrubs and ground flora species include mountain-ash, green alder, low-bush and velvet-leaf blueberry, three-toothed cinquefoil, and pussytoes. Less-abundant are pale corydalis with its distinctive yellow and pink flowers, and rusty woodsia. The preponderance of berry-producing plants creates feeding grounds for bears and coyotes in late summer.

Exposed escarpments sometimes support uncommon and rare species. Rock spikemoss, a lower vascular plant that grows on cliffs and escarpments (Lellinger, 1985), is considered very rare in New Brunswick. One of its two known New Brunswick locations is an escarpment near Sussex Corner. Bearberry is considered uncommon in New Brunswick but may be found in large patches on some escarpments in the FMF.

In the FMF, the dry lichen-blueberry escarpment community-type is confined to ledges. In New Brunswick, balds occur mostly in the higher elevation areas of central and northern New Brunswick (Big Bald Mountain, Mount Carleton). Escarpment ledges are long and narrow, extending up to 750 m in length, with a typical width of 10-30 m. Inward from the edge of the escarpment, exposure diminishes, soil formation is more common, and vegetation increases in abundance and diversity. Woodland strawberry, bush honeysuckle, rough mountain-rice, silverrod, common juniper, and sweet-fern commonly occur in in this transtion area. The early blue violet or hooked-spur violet, listed as uncommon in New Brunswick, has also been observed here. The transition areas grade into forest composed of white pine, red spruce, jack pine, balsam fir, red oak, and beech.

The escarpments of the FMF occur within the Rockville-Parlee Brook-Waterford area. Despite the apparent similarity in physical setting among these sites, they do not all contain the same groupings of plant species. The rock spikemoss has been recorded at only one site; bearberry and pale corydalis at only two sites. The occurrence and abundance of some of the more common species may also vary. There may be several reasons for these differences. Larger escarpments have a higher probability of receiving wind-born propagules. There are also microsite differences in moisture availability and substrate fertility that may limit the species establishemnt. Some escarpments have more turbulent disturbance histories then others (fire, human disturbance), possibly resulting in extirpations at the more disturbed sites.

It is possible that escarpments are remnants from the immediate post-glacial period when windswept barrenlands were prevalent in New Brunswick. As this community-type shrank in size due to forest expansion, escarpments became refugia for species adapted to these conditions. Due to their small size and disjunct distribution, populations at each site are limited in size. If these small populations are extirpated at a site due to an intense disturbance event, such as fire, there is often no immediate seed source for re-colonization.

1983), are all restricted to the Point Wolfe River Gorge in Fundy National Park. Livelong saxifrage also occurs at this location. Smooth woodsia, a rare New Brunswick species; clinton's club-rush, an uncommon provincial species; and hyssop-leaved fleabane, a species restricted in distribution to the Fundy Coast and northern New Brunswick, are all found in several of the ravines near Fundy Park but appear to be absent in ravines farther west. All are known to prefer calcium-rich ledges (Hinds, 1986). The fleabane may also occur on rocky shorelines in this area.

In the Little Salmon River gorge, two additional species typical of calcareous ledges are found. The tufted club-rush has a unique and rare variety (var. delicatulus) that is found on calcium-enriched cliff ledges. The Little Salmon River ravine is its only known location. Its more common variety (var. callosus) is found in upland coastal peat bogs (Hinds, 1986). The very rare alpine woodsia has also been recorded once within the Little Salmon River gorge (Clayden, pers. comm.). This species has been reported mostly from calcareous ledges (Hinds, 1986).

11. Coastal Ravine Non-Calcifilic Plant Community-type

The non-calcifilic plant assemblage shares many of the common plant species that are found in the calcium-enriched sites., including bellflower, poverty oat-grass, fragile fern, wavy hair grass, and fir club-moss, which is listed as rare in most of New Brunswick and uncommon along the Fundy coast. The fragrant fern, a rare New Brunswick species located mostly along the Bay of Fundy and in northern New Brunswick, also occurs at these sites. In Maine this species is described as characteristic of cool acidic cliffs (Maine Natural Heritage Program, 1991).

Inland Cliffs

Inland cliffs are generally more moisture-stressed than coastal ravine cliffs and as a result, support different species assemblages. Two different inland cliff community-types are recognized, with the differences determined primarily by aspect: the shady fern cliff community-type and the dry lichen cliff community-type. Most of the inland rock faces of the FMF occur on Mount Zachy-Jonah and in the Rockville-Cedar Camp-Waterford-Parlee Brook area.

12. Shady Fern Cliff Community-type

The shady fern cliff community-type typically occurs on east and north facing cliffs where exposure to sun and wind is limited. If small enough, they may be partially shaded by the surrounding forest, further reducing exposure. On occasion, this assemblage can be found on less sheltered rock faces in association with seepage zones.

Plant species commonly seen on shady fern cliffs include rock fern, bellflower, rusty woodsia, fragile fern, common blueberry, marginal shield-fern, and the woodland strawberry. Numerous uncommon and rare plant species also occur. Hairy rock-cress has been recorded at Mount Zachy-Jonah and in the Cedar Camp area; it is considered uncommon in New Brunswick. Carex backii, a sedge species that occurs in shaded ledges and rocky soils, has been recorded on Mount Zachy-Jonah. Though it has a very broad geographic range, this species is considered very rare in New Brunswick, having been recorded in only two locations (Hinds, 1986), as well as being

listed as rare or endangered in parts of the northeastern United States and British Columbia (Hinds, 1983). The maidenhair-spleenwort, a member of the fern family and also considered very rare in New Brunswick, has been recorded on Mount Zachy-Jonah as well. The laurentian bladder fern, a fertile hybrid between the fragile fern and the bulblet bladder-fern is found on wet seepy rock faces and has also been recorded in the Walker Settlement area (Hinds, 1986). This species is considered rare throughout its entire distribution in North America (Lellinger, 1985).

13. Dry Lichen Cliff Community-type

South and west facing rock faces are the most extreme of the cliff habitats. They have limited moisture availability and are often fully exposed to sun and wind. As a result, they are the most species-poor of the cliff community-types. The dominant species are typically lichens, mosses, and liverworts which can withstand the aridity and exposure and can grow directly on the rock face. Little or no survey work has been conducted on the cryptogramic species found on the dry cliffs of the FMF. However, survey work on similar habitat in Nova Scotia found typical species to include Lecanora spp. and Lecidia spp. (crustose lichens); Parmelia spp. and Gyrophora spp. (foliose lichens); Cladonia spp. and Stereocaulon spp. (fruticose lichens); as well as Bartramia pomiformi, Hedwigia ciliata, Radula complanata, Porella platyphylloides, Plagiochila asplenioides, and Plagiopus oederiana (mosses and liverworts) (Simmons et al., 1984). Colonization by vascular plants is sporadic. Common species include rusty woodsia, bellflower, and rock fern. Three uncommon or rare vascular plant species occur on this habitat-type within the FMF: hairy rock-cress and drummond's rock-cress, both uncommon species in NB, and livelong saxifrage, a very rare species found near Walker Settlement and also listed as rare in Nova Scotia, Maine, New Hampshire, and Vermont (Hinds, 1983).

Most of the dry lichen rock face community-type within the FMF occurs in the Sussex upland area, especially around Parlee Brook, Waterford, Walker Settlement, Picadilly Mountain, and Chambers Settlement.

Cliffs are likely the least threatened of all community-types within the FMF because of their inaccessibility. In the past, many of the coastal ravine rivers were used to drive logs from the upland plateau to the coast. As the logs floated down river, they undoubtedly scraped off riverside cliff vegetation. It is unclear how this affected current distribution patterns of the cliff species. Some species may have been lost; others with slow rates of dispersal may still be recovering lost habitat. Today, threats to cliff community-types include disturbance from hiking or climbing, and alteration of surrounding forest. Deforestation around a shady fern rock face assemblage could alter micro-habitat conditions to a point that member species may no longer persist.

14. Coastal Headland Deschampsia-Danthonia Community-type

Coastal headlands are large, sparsely vegetated outcrops of bedrock that occur along coastlines. They are found above the high-tide line but are buffeted by salt spray and occasional storms. The absence of soil, except in small pockets, means moisture retention is limited. This is somewhat offset by the higher relative humidity and greater frequency of rainfall in these coastal areas. Much of the coast of the FMF is lined with coastal headlands that rise up from at or below the high-tide line, some as

high as 400 m

Many of the plant species that establish on coastal headlands are small-statured and herbaceous and are able to withstand the unique environmental conditions. Common species include hemlock- parsley, roseroot, sagewort wormwood, seaside-plantain, silverweed, bellflower, and wavy hair grass. At least three rare plant species are known to occur on the coastal headlands within the FMF: rand's eyebright, a very rare New Brunswick species known from only four locations (Hinds, 1986); glaucous poa, a rare grass species known from only five localities in the province (Hinds, 1986); and the rock-cress draba, a rare provincial species recorded from only three sites (Hinds, 1986).

The peregrine falcon likely occurred along the Fundy coastal headlands until pesticides and other pollutants decimated the populations in North America in the 1950's and 1960's. Banning of DDT, which caused reproductive failure in the species, and the reintroduction of birds by Fundy National Park beginning in 1982, has enabled the re-establishment of this species along the Fundy Coast. The Peregrine falcon nests amongst the headland cliffs and feeds primarily on shorebirds and waterfowl from nearby areas (Clayden et al., 1984).

15. <u>Bat Cave Community-type</u>

Caves are subterranean habitats formed by the erosion of bedrock by flowing or percolating water. Soft bedrock types, such as limestone, are more apt to contain caves than harder bedrock.

Caves can host an abundance of roosting and hibernating bats composed of one or several species. Data on the distribution and abundance of bats within the FMF area is limited primarily to Fundy National Park where at least three species are believed to occur (Corbett, 1985). There may be as many as seven bat species found in New Brunswick (Whitaker, 1980), all of which roost and some of which hibernate in caves.

Many New Brunswick caves occur in the Albert county limestone formation that lies to the east of the Fundy Model Forest. Others occur just to the west of the FMF near St. John. The FMF itself contains at least four recognized caves, occurring in the Havelock area, near Hammond River, and near Waterford (Arsenault, unpublished). Kitts Cave, found along the Hammond River, is one of only six sites in NB to have a record of the eastern pipistrelle, a rare bat species (McAlpine, NB Museum, pers. comm.). One of the better known NB caves, Archie's Hole, occurs in the FMF near Havelock. It has been sealed off and is used as a drainage site by a local limestone mining company.

Caves are important bat habitat, either as nightly roosts or for winter hibernation. Bats have specific temperature and humidity hibernation requirements. These variables are products of cave architecture, air and water circulation. Forest canopy cover at cave openings may also be important. As a result, bat caves, and hibernating bat colonies, may be highly vulnerable to disturbance (Clayden et al., 1984).

Peatland Community-types

Peatlands are saturated areas where the decomposition of vegetative

matter is limited and thus outpaced by accumulation. These features are scattered throughout most of the FMF area, with concentrations occurring along the Fundy Coast and in the Canaan River area (figure 1: map of wetlands areas within the FMF).

Several peatland types are recognized within the FMF: bogs, fens, and sedge meadows. However, classification of the location, abundance, and identification of peatlands has been limited. The Maritime Wetland Atlas indicates the location of most peatlands. However, it classes them all as "bogs". This work was done primarily by photo-interpretation and emphasized breeding wetland bird habitat. While most of peatlands undoubtedly are bogs, some fens and sedge meadows have been misclassified because they are visually similar. Examination of the water chemistry, vegetation assemblage, or water flow patterns is required to classify peatlands. Bogs can grade into fens if a portion of a peatland comes in contact with moving water, such as at the margins of raised bogs or areas adjacent to alluvial marshes.

For each peatland type are there can be one or more specific community-types with distinct environmental conditions and associated biotic assemblages. Environmental parameters such as water level, seasonal water variation, source of water input (atmospheric vs ground water), fertility (acidic vs circumneutral), amount of standing water (ponds, puddles), and location (coastal, interior) provide conditions for different biotic assemblages. Though many of the species overlap, the relative abundance of sedges and sphagnum, for example, vary among community-types. For this report, general descriptions of three broad peatland community-types are presented: sphagnum-ericaceae bogs, sphagnum-ericaceae fens, and sedge meadows. A listing of the plant species generally associated with either sphagnum-ericaceae bogs, sphagnum-ericaceae fens, or sedge meadows are provided, though most of these species do occur on one or both of the other peatland types.

16. Sphagnum-Ericaceae Bog Community-type

A bog is a peat-covered or peat-filled wetland formed either in depressions underlain by impermeable or slow-draining substratum, usually hard igneous or metamorphic rocks, or by the infilling of a lake or pond. Bogs are wet saturated areas with the water table always at or near the surface. They are not influenced by nutrient-rich ground water from surrounding forest areas; the source of their moisture is almost completely from precipitation. As a result the bog environment is low in nutrients and highly acidic.

The dominant material in the formation of a bog is sphagnum moss. Decomposition rates in bogs are very slow due to the high acidity and anaerobic conditions created by the high water table levels. As a result, the rate of organic matter production, mostly from sphagnum, greatly exceeds the rate of decomposition. Partially-decomposed sphagnum ("peat") builds up, layer by layer, forming the bog.

There are several types of bogs that likely occur within the FMF. The type of bog that forms is influenced by topography, location (coastal vs inland), age of the bog, size, pattern of peat accumulation, and quantity of water input. Coastal plateau bogs are influenced by maritime climatic conditions: cool temperatures, high levels of precipitation, and high air

humidity. Raised or "domed" bogs are large inland bogs, typically greater than 500 m in diameter, that possess a central elevated area several meters above the surrounding terrain. Peat accumulation in the raised area may be sufficient to support a perched water table, creating a pond or at least saturated substrate conditions. Level bogs, in contrast to raised bogs, are flat featureless peatlands; the pattern of peat accumulation is more spatially uniform than raised bogs. Kettlehole bogs form in and around old kettleholes, which are circular or elliptically-shaped depressions that are usually deeper than wide. They were formed in sediment deposits created by the melting of buried ice blocks.

Bogs are often species-poor compared to other peatland-types due to the infertility and acidity of the substrate. They may be treeless or support scattered and mostly stunted black spruce and tamarack. Despite being dwarfed, these trees sometimes reach ages greater than 200 years. The ground cover of bogs is variable, both within a bog and between bogs, though typically the vegetation is dominated by mixtures sphagnum moss, heath (ericaceous) species, and often members of the sedge family. The most common heath species are labrador tea, sheep laurel, bog laurel, leather-leaf, bog-rosemary, rhodora, and large cranberry. Sedge species often include Carex disperma, Carex echinata, and Carex trisperma. Other members of the sedge family, such as white cotton-grass, tawny cotton-grass, and tufted club-rush are also typical. The bog goldenrod, bog aster, three-leaved false solomon's-seal, and the well-known insectivorous species, pitcher plant, sundew and narrow-leaved sundew, are also common.

Drier sections within bogs support Cladina lichens and Polytrichum mosses may occur. Crowberry, a coastal bog species, may also occur in these drier areas. This species is host to the rare Crowberry Blue Butterfly.

Within the Fundy Model Forest area, several rare vascular plant species are known to occur in bogs. All are coastal species, possibly reflecting more thorough surveys in coastal bogs than in the interior. The curly-grass fern is a recently discovered (1986) species that is very rare in New Brunswick, Nova Scotia, Newfoundland, and the eastern seaboard of northeastern United States. It is found on raised peat ridges ("hummocks") at one FMF location near the Little Salmon River gorge. Another very rare New Brunswick bog species, screw-stem, can be found in association with curly-grass fern, as well as several other coastal bogs. Because of the very small size of both curly-grass fern and screw-stem (6-10 cm height), they are difficult to locate and may be vulnerable to trampling. Peat mining, a common human disturbance of bogs, would probably eliminate this species from New Brunswick if conducted in these coastal areas.

The four-toed salamander is a rare amphibian species that occurs in boggy areas, including bog ponds, sphagnum beds, and adjacent peaty woodlands. It requires these various elements to complete its life cycle. Its only known location in New Brunswick is within Fundy National Park, though it may occur in similar bogs along the Fundy Coast (McAlpine, pers. comm.). It has a scattered distribution in eastern and central North America, extending from the Gulf of Mexico, up to Ontario, and over to Nova Scotia where it occurs in Cape Breton (Conant 1975; cited in Clayden et al., 1984).

17. Sphagnum-Ericaceae Fen Community-type

Fens, like bogs, are peatlands. Unlike bogs however, fens receive water from sources other than just rainfall, either groundwater or overflow from adjacent forested habitats. As a result, fens are generally more nutrient-rich than bogs and support a more diverse vegetative community. The fertility of fens is dependent on the groundwater chemistry of the flow inputs. Fens may be acidic (though likely less acidic than bogs) or circumneutral, the result of underlying calcium-rich parent material. The circumneutral fens tend to be floristically richest and contain rare species.

Fens have been classified into two structural categories. Patterned or ribbed fens are usually found on gentle slopes and possess low, parallel peat ridges alternating with wet depressions or shallow pools. The wet trough areas are distributed across the slopes of the peatland at right angles to the direction of water movement. Unpatterned fens are those areas that are not ribbed, usually occurring on flatlands. Of the two, unpatterned fens are likely the most common in the FMF.

The vegetative community of fens is typically dominated by mixtures of sedges, grasses, and sphagnum moss; there may be a lower proportion of sphagnum than found in bogs. Many of the heath and other ground flora species found in bogs also occur in fens. Fens are more likely to support several uncommon orchid species, including pogonia, swamp-pink, and grass-pink. More abundant orchid species, green woodland orchis and moccasin flower are also found in these areas. In nutrient-rich peatlands, several uncommon or rare sedge species may be found, including Carex diandra and Carex interior. Carex michauxiana, also an uncommon species, sometimes occurs in nutrient-rich fens, though it may not be restricted to fertile peatlands. Carex exilis, a species considered rare in New Brunswick with only four recorded locations (Hinds, 1986), is found in abundance in at least one site within the FMF near the Little Salmon River Gorge. Carex tenuiflora is also a rare species found in calcareous peaty areas. It has been recorded in the Petiticodiac area (Hinds, 1986).

18. Sedge Meadow Community-type

Sedge meadows are areas predominated by sedge, with lesser quantities of sphagnum mosses and grasses. They occur on permanently or seasonally saturated peat or muck soils. They are usually more nutrient-rich and less inundated than bogs which allows the sedges to thrive while reducing sphagnum accumulation. Sedge meadows may be circumneutral or acidic, depending on underlying parent material. Ground water inputs may occur but the volume of flow-through is minimal or seasonal, thus differentiating them from fens. The calcium-rich sedge meadows often contain many uncommon or rare sedge species. Uncommon or rare orchid species also occur here.

Sedge meadows appear to be uncommon in the Fundy Model Forest. They are usually located on the edges of fens, bogs, or even swamp forests. Typical species are Carex stricta, Carex pallescens, Carex canescens, Carex trisperma, and Carex echinata. Other common species often observed include the grass Calamagrostis canadensis, rhodora, steeple-bush, and blue flag. Several scattered or uncommon orchid species occasionally seen in sedge meadows include green adder's-tongue, bog-candle, large purple-fringed orchis, and the ragged orchis.

Marshlands Community-types

Wetland habitat occurs in poorly drained basins where exposure to wind and lake wave-action is limited. Seasonal flooding is typical. Wetland substrate is mineral soil or muck, with little or no peat formation (Maine Natural Heritage Program, 1991). Standiong water is present most or all of the year, usually over 15 cm in depth. Wetlands may have fresh, brackish, or salt water. Within the FMF. three marshland community-types are recognized: spartina coastal salt marsh, Juncus inland salt springs, and cat tail-sagittaria freshwater marsh.

19. Spartina Coastal Salt Marsh Community-type

Coastal salt marshes occur in areas that are regularly inundated with salt water from tides, and sometimes storms, but are sufficiently sheltered by sand bars and spits to allow the development of a marsh plant community. Unsheltered areas are too unstable to support a permanent salt marsh. Coastal salt marshes can be classified according to tidal influence: the inter-tidal marsh and the littoral zone, the area above the influence of daily high tides.

The environmental conditions found in a salt marsh, including high levels of salinity and permanent or daily inundation, result in an assemblage of plants and animals that are uniquely adapted to this habitat. Salt marshes often are highly productive areas that serve as feeding areas for large numbers of migrating shore birds or as breeding sites for numerous marsh birds.

Two salt marshes occur within the boundaries of the Fundy Model Forest, the Martin Head Marsh at the mouth of the Quiddy River and the marsh at the mouth of the Alma River in Fundy National Park. They contain small areas of open water and semi-stagnent tidal run-off pools (Hirvonen and Madill, 1978), with soils in the inter-tidal zones composed of a combination of alluvial silts and tidal deposits. Typical vegetation includes saltwater cord-grass or spartina, ditch-grass, Triglochin maritima, Atriplex prostrata, sea lavender, and Puccinellia americana. A very rare sedge, Carex glareosa, occurs in brackish areas of the Alma Salt Marsh (Richard and Clay, 1993). Its presence at Martin Head has not been confirmed

The littoral zone of the Martin Head Marsh contains exposed and protected areas. Much of the protected area is the zone immediately above the average high tide line. This is the beginning of the transition area from the marsh and to the adjacent forest. The exposed areas are the spits and beaches between the marsh and the ocean. The vegetation of the littoral zone is quite distinct from the inter-tidal marsh. it includes scotch loveage, Spartina alterniflora, seaside goldenrod, sea lyme-grass, beach pea, and beachgrass. The exposed littoral zone usually contains a greater proportion of species that can withstand the environmental instability, including deep-rooted perennial grasses such as sea lyme-grass, beachgrass, and Poa palustris and species that tolerate the high sun exposure and low moisture availability such as beach pea).

Coastal salt marshes are not common along Fundy coast of the FMF. In many areas, the steep coastal headlands of the coast make marsh formation impossible. Because of their infrequency, biotic diversity, importance as

feeding and nesting sites for both migratory and resident bird species, as well as being nurseries for marine aquatic species, salt marshes are valuable habitats within the FMF.

20. Juncus Inland Salt Spring Community-type

The inland salt springs within the FMF occur in association with the potash deposits found in the Plumsweep area near Sussex. The high concentration of mineral salts restricts plant species to those that are salt-tolerant. As a result, the vegetation is characteristic of a coastal salt marsh. Plants recorded here include at least two Juncus species, the toad rush and Juncus balticus. Spike-grass Distichlis spicata, a species listed as rare in New Brunswick; chickenclaws; Spergularia marina; and the alkali-grass Puccinellia langeana also occur. One species, Atriplex prostrata, was recorded at this site in 1927 but has not been recorded since (Dionne et al., 1988).

The best known salt spring occurs along the Trans-Canada highway near Plumsweep and has been heavily disturbed. It was dredged and had its banks altered for a tourist paddle-boat operation no longer in business. Despite this disturbance, the above listed species remain. Other smaller salt springs occur in the Plumsweep area, though the total number is unknown and their species composition unsurveyed.

21. Cat tail-Sagittaria Freshwater Marshes Community-type

Cat tail-Sagittaria freshwater marshes typically contain diverse vegetative assemblages. Common species include cat-tail, several species of arrowhead (Sagittaria spp.), yellow pond-lily, pickerelweed, water plantain, marsh-five-finger, wild calla, a bur-reed (Sparganium eurycarpum), and sweetflag. These freshwater marshes also support numerous grass, sedge, and rush species, such as northern wild rice, small's spike-rush, Carex stricta, reed-meadow grass, black-girded wool-grass, freshwater cord-grass, and reed canary-grass. The grass species serve as valuable feed for resident and migrant waterfowl.

Freshwater marshes provide breeding habitat for many species of waterfowl such as the black duck, green-winged teal, blue-winged teal, ring-necked duck, and the mallard. Less-common species in the FMF region of NB include the northern pintail, northern shoveler, and the pied-billed grebe. It also serves as valuable breeding and feeding habitat for other bird species such as the american bittern, great blue heron, northern harrier, red-winged blackbird, swamp sparrow, and sora rail. The virginia rail, sedge wren, and black tern are considered uncommon or rare in New Brunswick yet occasionally breed in freshwater marshes within the FMF (Clayden et al., 1984; Erskine, 1992).

Cat tail-sagittaria marshes have been the target of special-management activities in recent decades, in particular by the Ducks Unlimited (DU) organization. Within the FMF, there are eleven DU compounds covering 235.7 hectares. The largest compound (46.4 hectares) is located in the Hampton area. Most compounds are associated with the St John River or the Kennebecasis River, with the remainder located on watersheds of the Anagance and Pollett Rivers, and on Belleisle Bay.

DU compounds are effectively managed to promote the breeding of

waterfowl and other marsh birds. However, by raising water levels through damming, these sites become less suitable for other floral and faunal groups that occur in freshwater marshes. It has been demonstrated that increased standing water is directly associated with reduced species richness of plant species in wetlands (Johnson and Leopold, 1994). In addition, adjacent forested areas typically dominated by cedar or black spruce are adversely affected by raised water levels. As a result, it is important that some marsh habitat be left in its natural state to promote the full compliment of its flora and fauna.

Inland Shoreline Community-types

Inland shorelines occur along open bodies of water, such as lakes and ponds, and along rivers. They also include gravel bars which surface within rivers when vernal water levels drop. Shorelines are exposed to a range of disturbances that shape the composition and number of species that persist there. Many experience ice scouring and seasonal flooding. Lake and pond shores are especially prone to wave action, with wave intensity determined by the size of the water body and the position of the shore relative toprevailing winds. River shore flooding during spring run-off can be severe. The high intensity flow of water and scouring action of suspended sediments may kill exposed vegetation and wash away bank substrate.

The frequency and intensity of shoreline disturbance influences substrate composition. Heavy wave action or exposure to fast-running water results in gravel and cobble shores. High-energy water flow suspends and carries away the finer sediments. Quiet water shorelines are areas of deposition, accumulating silts, sands, and organic material.

Type of substrate and disturbance regime of a shoreline influence the composition of vegetation assemblages. As with other disturbance-prone community-types, shorelines possess numerous species adapted to the specific environmental conditions. Some can withstand frequent inundation while others are adapted to survive the scouring of ice and heavy wave action. Typically these species are less able to compete in other habitats, and require these stresses to persist.

The composition of inland shoreline vegetative assemblages depend on the frequency and intensity of disturbance and two community-types are recognized accordingly: low-energy alder shorelines and high-energy ruderal shorelines.

22. Low-energy Speckled Alder Shoreline Community-type

Infrequently disturbed low-energy shorelines occur along slow moving rivers and streams, small lakes, or sheltered shores of large lakes. Flooding is limited to spring when water levels are highest. Soils are often silty or muddy and saturated, though well-drained sand and gravel beaches and rock ledges are found along these shorelines.

The low-energy shoreline community-type is typically thickly vegetated and dominated by patches of speckled alder. Common understory flora include bulrushes, such as black-girded wool-grass and Scirpus macrocarpus, sedges such as Carex canescens, Carex crinita, and Carex flava, rushes (Juncus brevicaudatus and Juncus effusus), spike-rushes (Eleocharis spp.) and

horsetails, such as the water-horsetail and the common field-horsetail. Willow species such as Salix pyrifolia, Salix petiolaris, and Salix pellita also occur. Eleocharis intermedia, a very rare New Brunswick spike-rush, is found in a quiet stream alder thicket near Petitcodiac.

Well-drained sandy and gravel shorelines host several uncommon or rare species in addition to the species commonly associated with this community-type. This includes beggar-ticks and nodding beggar-ticks; Bidens discoidea, a very rare New Brunswick species reported only from Lake Washademoak (Hinds, 1986); yellow loosestrife; the rare whorled loosestrife found at several locations on Belleisle Bay; glaucous lettuce, an uncommon provincial species; and Aster vimineus, a rare species that can be found along parts of Lake Washademoak (Hinds, 1986). Rocky ledge shoreline is known to support the mountain-mint known provincially only on Belleisle Bay.

23. High-energy Ruderal Shorelines

High-energy shorelines exhibit a gradient of vegetation density that is sparsest at the water's edge where disturbance is most frequent and intense. Shrub and forest vegetation persist above the limit of flooding and ice. Water edge species are usually herbaceous ruderals that can tolerate the unstable conditions. Some of these ruderals are prolific seeders, continually re-establishing each year, while others have deep tap roots.

As disturbance decreases on high-energy shorelines, perennial plant species become more abundant. Typical species include tall meadow rue, flat-topped white aster, joe-pye-weed, white mandarin, wavy hair grass, northern white violet, false hellebore, northern green orchis, bog-candle, northern blue violet, and blue-joint grass. White snakeroot occurs along some of the Fundy Coastal Ravine rivers; it is considered rare in the Fundy Coastal area and uncommon in northwestern New Brunswick (Hinds, 1986). Carex capillaris occurs in circumneutral shorelines along the Point Wolfe River in Fundy National Park (Richard and Clay, 1993); it is considered uncommon in New Brunswick, occurring rarely along the Fundy coast and more commonly in the northern section of the province (Hinds, 1986). Scirpus hudsonianus, an uncommon bulrush of New Brunswick (Hinds, 1986), occurs on the shorelines of Goose Creek near Fundy National Park.

Shorelines have been highly disturbed in areas of the FMF due to agriculture (cattle grazing, shore-side cultivation); flooding by dams; log running; and the establishment of cottages along lakes, bays and rivers. Invasion by non-native weedy species has altered the vegetation community now found in many of these areas. Today, cottage development is the most prevalent form of shoreline disturbance. If these land use trends continue, the uncommon and rare native plant species of these community-types will certainly be threatened.

Aquatic Community-type

24. Juncus-Pondweed Stillwater Community-type

The juncus-pondweed lacustrine community-type occurs at the quiet margins of lakeshores, ponds, and slow moving rivers. The community-type occupies submerged habitat permanently inundated yet shallow enough for

light to penetrate through the entire water column. Such shallow-water habitat is productive for vegetative growth, serves as nurseries for the development of fish and insect offspring, and provides habitat for freshwater snails and mussels.

Shallow-water areas do not all have similar groupings of vascular plant species, with differences in species composition explained by water chemistry (alkaline vs acidic), water depth, disturbance (either natural or human), and substrate-type (sand/gravel vs silt/mud). Certain groups of species are found in most shallow-water areas, such as the pondweeds (Potamogeton spp.), rushes (Juncus spp.), and bulrushes (Scirpus spp.). Other common shallow-water species include pickerelweed, duckweed, yellow pond-lily, white-buttons, broad-leaved arrowhead, and cat tails (Typha latifolia and Typha angustifolia).

Within the FMF, the shallow water lacustrine habitat also supports numerous plant uncommon and rare species. Most occur in Lake Washademoak, Belleisle Bay, or Hampton Marsh, each part of the St. John River drainage corridor. A list of uncommon and rare shallow-water plant species includes two quillwort species (Isoetes harveyi and Isoetes tuckermanii), two pondweed species (Potamogeton zosteriformis and Potamogeton oakesianus), a bladderwort species (Utricularia geminiscarpa), Star-duckweed, the rare yellow water-crowfoot, a water-starwort (Callitriche hermaphroditica), a waterwort (Elatine americana), water-shield, and the fragrant water-lily. Myriophyllum heterophyllum, a very rare water-milfoil species with only two known occurrences in New Brunswick, has been recorded in Belleisle Bay near Hatfield Point (Hinds, 1986).

Little is known about the distribution of many of the invertebrate species that are associated with this habitat within the FMF. However, two rare mussel species have been identified. The dwarf wedge-mussel is considered an endangered species in Canada. Its only known Canadian location is the Petiticodiac River and a tributary of the Petitcodiac, the North River, which flows through the Intervale area of the FMF. Its habitat is the gravel, sandy or muddy bottom of medium to slow-flowing rivers and it is often found among submerged aquatic plants. In 1981 it was reported as common in its New Brunswick habitat, its most northerly known location. It is also found discontinuously in rivers of the Atlantic drainage south to North Carolina. A similar species,the swollen wedge-mussel, is also found in the Petitcodiac River system, its only known New Brunswick location. It has also been observed in Nova Scotia and south to North Carolina. It requires fast running water, residing in sand or among gravels and rocks of the river bottom. The current status of both of these mussel species is unknown. They are likely vulnerable to pollution or habitat alteration (Clarke, 1981; cited in Clayden et al., 1984).

Site #01: Airplane Bog

Location: on east side of Little Salmon River road approximately two km north of ATV trail leading down into the river gorge.

Size: 137.63 ha

Site Description: A large relatively continuous bog dominanted by sedge meadows, but also containing bog ponds, heath meadows of labrador tea and bog laurel, and small stands of stunted black spruce. Coring of black spruce trees at bog center indicate ages of 100-150 years.

Disturbance History: No sign of human disturbance

Conservation Siginificance:

1) One of the largest bogs and sedge meadow areas observed along the Fundy Coastal Plateau.

2) Numerous well-used game trails indicate that site is heavily utilized by moose.

3) Two very rare plant species in NB, Carex exilis and screw-stem, are abundant in this bog.

Conservation Priority Ranking: The size and special features of this bog make it **very significant**. Future land management plans are unknown for this area. However, the site is likely not threatened.

Recommended Management Strategy: Full protection, except for existing land use activity (seasonal moose hunting).

Land Ownership: Province of NB.

Site #02: Dowdall Lake

Location: source of one of three major branches of Wolf Creek along Fundy Coast.

Size: 49.16 ha

Site Description: A small lake surrounded by treeless bog and sedge meadow shoreline. Immediately adjacent to the bog and sedge meadow is a black spruce forest with sphagnum moss and sedge understory. A series of sedge meadows extending to the northwest drains into the lake, and has been dissected by a logging road.

Disturbance History: Unknown, but no signs of recent disturbance within the identified site boundaries except for the logging road. A large clearcut is found immediately outside site limits to the southwest.

Conservation Significance:

1) A small but habitat-diverse area that includes sedge meadows, bogs, shallow pondweed-dominated stillwaters, quiet streams, and treed bog.

2) Well-used game trails, and the presence of an elevated hunting blind, suggest that the site is commonly utilized by moose.

3) A number of provincially uncommon and rare plants are found at this site, including screw-stem, the pondweed Potamogeton oakesianus, the beakrush Rhyncospora capitellata, and the folliculate sedge.

Conservation Priority Ranking: The diversity of habitat and associated species at this site, including the presence of uncommon and rare species, makes this bog **significant**. Future land management plans are unknown for this area. However, the site is likely not threatened.

Recommended Management Strategy: Full protection, except for existing land use activity (seasonal moose hunting).

Land Ownership: Province of NB.

Site #03: Little Salmon River Curly-Grass Fen

Location: near junction of the northside Little Salmon River road and the ATV trail leading down into the river ravine.

Size: 24.3 ha

Site Description: A series of peatland sedge meadows, pools, black spruce meadows, and surrounding black spruce-red maple forest. Appears to be a fen, with ground water draining towards the river ravine. The sedge meadows are dominated by Carex exilis, Carex trisperma, and Carex echinata and also host a rich array of associated species including pitcher-plants, sundew, bog cranberry, four orchid species, horned bladderwort, and numerous heath species. This site contains several uncommon and rare plant species.

Disturbance History: No sign of disturbance in the fen itself. Parts of the surrounding forest shows signs of past cutting, including the presence of old logging roads.

Conservation Significance:

1) A species-rich peatland compared to other peatlands along the Fundy Coast. Appears to be ground water fed, which would increase fertility and explain the rich assemblage of species.

2) Contains small populations of two species considered very rare in New Brunswick- the curly-grass fern and the screw-stem.

3) Contains a large population of Carex exilis, a species considered uncommon to rare in New Brunswick and only occurs in peatlands along the Fundy coast uplands.

Conservation Priority Rating: Due to the rich species assemblage that includes several uncommon, rare, and very rare plant species, this site is considered **highly significant**. Many of the rare plants are small and likely vulnerable to any form of mechanical disturbance, including human trampling from interested botanists. The sensitivity of this site makes it **threatened**.

Recommended Management Strategy: Full protection. Any form of intrusion, including excessive trampling, could significantly damage this site.

Land Ownership: Province of New Brunswick

Site #04: Little Salmon River Gorge

Location: occurs at boundary of Fundy Model Forest approximately 20 km southwest from the western edge of Fundy National Park.

Size: 369.76 ha (only includes the eastern half of the gorge, the western section falls outside the Fundy Model Forest).

Site Description: A large steep-sloped river gorge extending approximately 15 km inland from the Fundy coast. Much of the valley slopes are covered with mature red spruce forest. Other areas have steep to vertical cliff faces and are covered with wet seep zones in places. Several of the stream tributaries (Dustin Brook, Walton Glen Brook [not in FMF-see map]) contain wet, fern-covered cliff faces and numerous waterfalls.

Disturbance History: Many of the steep valley slopes appear uncut. Other sections show signs of harvest, or were used as log chutes to send logged from the plateau above down into the river. Log driving on the river severely disrupted salmonid gravel spawning beds and scoured bankside and low-lying cliff faces of vegetation. The upper reaches of the river are not steeply sloped, thus immediately adjacent forested areas have been intensely cut in places.

Conservation Significance:

1) Hosts extensive mature red spruce forest on the gorge slopes, including numerous large-sized trees.

2) Seepy cliff faces host uncommon, rare, and very rare plant species: braun's holly fern, fragrant fern, alpine woodsia, smooth woodsia, and the club moss Lycopodium selago.

3) The uncommon plant species, white snakeroot, recorded on gravel shores along lower reaches of the river.

4) Hosts a portion of the Fundy Hiking Trail.

Conservation Priority Ranking: The presence of the numerous uncommon to very rare plant species, and the extensive red spruce forests make this site **very significant**. The lower reaches of the river gorge are currently designated as "mature coniferous forest habitat" by DNRE's Forest Land habitat Management Program. As a result, it is not threatened, though this protection is not permanent. The upper reaches of the river have not received this level of protection.

Recommended Management Strategy: Full protection of river, forested ravine slopes, and immediate area beyond the ridgetop to serve as a buffer.

Land Ownership: Portions of the river gorge owned by J D Irving Ltd. and by Province of NB.

Site #05: Rapidy Brook

Location: first ravine north of Little Salmon River gorge along Bay of Fundy coast.

Size: 119.02 ha

Site Description: Narrow but, in places, very steep river gorge extending approximately 8 km from Fundy coast. Numerous waterfalls and high, moist, and fern-covered rock faces occur along the lower portions of the gorge.

Disturbance History: Lower section of the river was used for transporting logs cut on the plateau above during late 18800's or early 1900's.

Conservation Significance: Mature red spruce forest along the ravine slope. Numerous, and in some places, extensive cliffs and ledges provides potential habitat for arctic-alpine plant species. Contains a portion of the Fundy Coast hiking trail.

Conservation Priority Rating: Future management plans for this area are unknown, but the Rapidy Brook gorge is likely not threatened. The value of this site as potential habitat for the many rare plant species typical of these coastal ravines, plus its potential for salmon breeding makes classifies this site as **important.**

Recommended Management Strategy: Full protection of gorge and immediately surrounding area.

Land Ownership: Province of NB.

Site #08: Quiddy River

Location: Large river ravine intersecting the Crawford Lake-Goose River Road approximately 5 km east of Crawford Lake.

Size: 589.37 ha

Site Description: Twenty-km long river system beginning in the Fundy Plateau and draining into the Bay of Fundy at Martin Head. Upper reaches of the river small and slow-moving. A four kilometer stretch of river beginning just below the Crawford Lake-Goose River road contains a series of waterfalls and high steep cliff faces. Many of the cliffs receive steady seepage from the plateau above and thus host a rich plant assemblage. The lower portion of the river is steeply-sloped forest dominated by red spruce, with cobble/gravel shorelines. Quiddy River contains part of the Fundy Hiking Trail.

Disturbance History: During the late 1800's, all river ravines along the Fundy Coast were heavily disturbed, including Quiddy River. Most of the adjacent ridge tops were cut, some of the slopes were harvested where accessible, and logs were dumped over the ravine side and floated down river. Only the steepest areas of the ravine remained uncut.

Conservation Significance:

1) Portions of the Quiddy River ravine are forested with mature red spruce forest, including many large individual trees likely at least 100-200 years old.

2) The fast and clear running waters, deep pools, and numerous gravel and cobble beds on the river bottom provide ideal habitat for salmonid species, including the atlantic salmon.

3) the wet seepy cliff faces contain unusual assemblages of plant species, including the rare Lycopodium selago. They also host several species normally associated with bog habitat, such as bladderwort Utricularia cornuta, Narrow-leaved sundew, and the very rare Scirpus caespitosus variety delicatulus.

Conservation Priority Rating: The mature red spruce forests, cliff face floral assemblages, and potential salmon habitat make this site **very significant**. Existing and future management plans for this area are unknown, so threats can not be assessed.

Recommended Management Strategy: Full protection, with allowances for current recreational activities (swimming, hiking, fishing).

Land Ownership: Owned almost entirely by J D Irving Ltd., with the remainder owned by the Province of New Brunswick.

Site #09: Brandy Brook

Location: Small river gorge between Quiddy river gorge and Goose Creek gorge.

Size: 59.89 ha

Site Description: A small 1.5 km long river gorge. Due to its short length, the stream quickly drops to Bay of Fundy and contains numerous small waterfalls, cliffs, and rock ledges. The gorge slopes are steep and contain many large-sized red spruce.

Disturbance History: All the forest up to the edge of the ravine has been cut. The inaccessibility of the steep slopes apparently limited logging at the turn of the century, though some logs from the plateau above may have been driven down stream during high water.

Conservation Significance: Sections of the ravine slope contain mature red spruce forest, including large individual trees. Potential habitat for rare arctic-alpine species. Contains part of the Fundy Coast hiking trail.

Conservation Priority Rating: Future management plans for this area are unknown, but the Brandy Brook gorge is likely not threatened. The value of this site as potential habitat for the many rare plant species found in these coastal ravines classifies this site as **important.**

Recommended Management Strategy: Full protection of gorge and immediately surrounding area.

Land Ownership: J D Irving Ltd.

Site #10: Telegraph Brook

Location: located between Wolf Brook and Quiddy River along the Fundy Coast.

Size: 100.69 ha

Site Description: Small river gorge approximately 2.5 km in length. Much of the ravine is steeply sloped and covered in red spruce forest. Numerous cliff faces and, in places, small waterfalls, occur.

Disturbance History: Unknown in the gorge itself. Much of the surrounding plateau has been clearcut and are now in plantations.

Conservation Significance: Mature red spruce forest along the ravine slopes, including large individual trees. Potential habitat for rare arctic-alpine species. Contains part of the Fundy Coast hiking trail.

Conservation Priority Rating: Future management plans for this area are unknown, but the Telegraph gorge is likely not threatened. The value of this site as potential habitat for the many rare plant species of these coastal ravines, plus its potential for salmon breeding classifies this site as **important.**

Recommended Management Strategy: Full protection of gorge and immediately surrounding area.

Land Ownership: Mostly owned by J D Irving Ltd.

Site #11 : Wolf Brook

Location: third river gorge east of the Little Salmon River gorge along the Bay of Fundy Coast.

Size: 287.73 ha

Site Description: River gorge approximately 10 km in length. The upper half of this ravine branches into three tributaries. Much of the site is steeply sloped and covered in mature red spruce forest. Numerous cliff faces and ledges occur, as well as small waterfalls in places.

Disturbance History: Lower section of the river apparently was used for transporting logs cut on the plateau above during late 1800's or early 1900's.

Conservation Significance: One of the larger coastal ravines in the FMF. Mature red spruce forest along the ravine slopes, including many large individual trees. Potential habitat for rare arctic-alpine species. Contains part of the Fundy Coast hiking trail.

Conservation Priority Rating: Future management plans for this area are unknown, but the Wolf Brook gorge is likely not threatened. The value of this site as potential habitat for the many rare plant species typical of these coastal ravines, plus its potential for salmon breeding makes classifies this site as **important.**

Recommended Management Strategy: Full protection of gorge and immediately surrounding area.

Land Ownership: Province of NB and J D Irving Ltd.

Site #12: Goose Creek Gorge

Location: First large river gorge west of Goose River gorge in Fundy National Park

Size: 769.41 ha

Site Description: A 15-km long river system draining parts of the Fundy Plateau into the Bay of Fundy. Upper reaches of the system are small, slow-moving streams. The mid and lower stretches of the river flow through an extensive and steep river gorge. Most of the gorge slopes are forested with stands of mature red spruce. The valley bottom is narrow, comprised of gravel and cobble shorelines, rock ledges, vertical riverside cliff faces, or bottomland forest of yellow birch and red spruce. Several uncommon rare plant species are found along the river, either on the shore or on the cliff faces. Goose Creek contains part of the Fundy Hiking Trail.

Disturbance History: During the late 1800's, most river ravines along the Fundy Coast, including Goose Creek, were used to drive logs. Many of the adjacent ridge top areas were cut, some of the slopes were harvested if accessible, logs were dumped down the sides of the ravines, and dams were built in the river to control water flow. Signs of all these practices remain today: the dams still exist, signs of the dumping sites are still very evident on the ravine slopes, and few fish now reside in the rivers, reflecting in part disturbance of the gravel spawning beds by log running.

Conservation Significance:

1) Much of the ravine steep slopes are covered with extensive stands of mature red spruce forest, including trees that may be 200 or more years old.

2) The fast and clear running waters, numerous deep pools, and existing cobble and gravel beds of Goose Creek provide adequate habitat for reintroduction of salmon.

3) several uncommon and rare species occur at Goose Creek: *Lycopodium selago*, hyssop-leaved fleabane, *Luzula parviflora* (rare in southern NB only; more common in north of province), and smooth woodsia.

Conservation Priority Rating: Due to the presence of the mature red spruce forest, several uncommon and rare plant species, and its potential for salmon management, this site is considered **very significant.** It is considered **not threatened** due to the inaccessibility of the standing timber of the ravine slopes and the low volume of visitation by hikers at present. However, increased hiker traffic could threaten both the stability of the affected slope areas plus the rare vegetation, which may be sensitive to disturbance.

Recommended Protection Strategy: Full protection

Land Ownership: Owned by DNRE and J D Irving Co.

Site #13: Point Wolfe River Gorge

Location: Includes the north and west branch of the river. The north branch forms the boundary of Fundy National Park near Wolfe Lake. The west branch begins at the boundary and extends westward away from the park.

Site: 496.61 ha

Site Description: A steep forested river gorge with cliffs, ledges, and numerous waterfalls and rapids.

Disturbance History: Forested valley slopes apparently disturbed by spruce budworm infestation in the late 1970's or early 1980's; the spruce canopy not as intact as seen in other river gorges occurring down the western coast of the bay of Fundy. The river likely was used to transport logs in late 1800's or early 1900's.

Conservation Significance:

1) Captures the remainder of the Point Wolfe River gorge not already protected within Fundy National Park.

2. Contains the following rare species: fragrant fern, smooth woodsia, Lycopodium selago, hudsonian club-rush, white snakeroot, and hyssop-leaved fleabane.

Conservation Priority Rating: This site is considered **very significant.** Future management plans for this area are unknown, but the steep-sloped valley sides and river are likely not threatened.

Recommended Management Strategy; Full protection of ravine and immediate area beyond the gorge ridge to serve as a buffer.

Land Ownership: almost all controlled by the province of NB, with a very small section on the west branch owned by J D Irving Ltd.

Site #14: Walton Lake

Location: Approximately 10 km south of Waterford on road to Little Salmon River.

Size: 66.98 ha

Site Description: A small lake with a naturally occurring population of arctic char.

Disturbance History: A small number of buildings have been constructed along the lakeshore. Several non-native fish species have inadvertently been introduced via escaped live bait from fishermen.

Conservation Significance: One of only two native populations of landlocked arctic char in New Brunswick. The other population is at Upsalquitch Lake.

Conservation Priority Rating: The rarity of landlocked arctic char in northeastern North America makes site **very significant.** This population may be considered **threatened** due to the introduced non-native fish species, and clearcutting and road construction in adjacent areas which may disrupt or block access to required spawning beds in adjoining rivers.

Recommended Management Strategy: This population is currently being privately managed to ensure persistence for fishing. Steps may be required to protect spawning areas and reduce or eliminate non-native fish species.

Land Ownership: primarily provincial government.

Site #16: Rose Brook

Location: first river gorge to the west of the Fundy Park boundary at Goose River

Size: 63.71 ha

Site Description: River gorge approximately 3 km in length consisting of a series of small waterfalls, numerous cliffs and ledges, and a mature red spruce forest with numerous large individual trees.

Disturbance History: Lower section of the river apparently used for transporting logs cut on the plateau above during late 18800's or early 1900's.

Conservation Significance: Mature red spruce forest along the ravine slopes, including many large individual trees. Potential habitat for rare arctic-alpine species. Contains part of the Fundy Coast hiking trail.

Conservation Priority Rating: Future management plans for this area are unknown, but the Rose Brook gorge is likely not threatened. The value of this site as potential habitat for the many rare plant species typical of these coastal ravines, plus its potential for salmon breeding makes classifies this site as **important.**

Recommended Management Strategy: Full protection of gorge and immediately surrounding area.

Land Ownership: Province of NB and J D Irving Ltd.

Site #17: McManus Hill

Location: Near northwest corner of Fundy National Park behind Wolf Lake

Size: 146.97 ha

Site Description: A stand of tolerant hardwood forest dominated by sugar maple, yellow birch, and beech. Stand age could not be determined, though most trees are small to medium sized. Several fern-covered rock outcrops and a large seepage zone are found on the forest floor. Understory flora contains species typical of this forest type, including spring beauty, trout lily, beechdrops, soloman's-seal, and false soloman's-seal.

Disturbance History: Appears not to have been heavily disturbed in the past. Areas immediately adjacent to the hardwood stand have been recently clearcut.

Conservation Significance: An intact representative sample of the upland tolerant hardwood forest community-type found within the Fundy Plateau ecodistrict. This stand is an isolated patch. All the surrounding forest in this area has been cut and, in most cases, converted to plantations, or is a different forest type. McManus Hill lies across the Fundy Park boundary and overlooks Wolf Lake within the park. Harvesting this stand would destroy the existing viewscape looking west from the Wolf Lake interpretive center.

Conservation Priority Rating: Proposals for increased hardwood consumption in New Brunswick in the near future may put this site at risk, especially since it is predominantly crown-owned. Therefore, this site is considered **threatened** and **significant**.

Recommended Management Strategy: Full protection, or limited extraction in a manner similar to the natural disturbance regime of tolerant hardwood forests.

Land Ownership: Mostly crown, with the remainder owned by J D Irving Ltd.

Site #18: Parlee Brook Valley

Location: southwest corner of Parlee Brook-Walker Settlement loop road.

Size: 603.83 ha

Site Description: Consists of a complex of sites representing a variety of habitat types and vegetation formations, including a) one stand of pure hemlock b) dry exposed south-facing cliffs c) cool moist north facing seepage areas d) ridge-top tolerant hardwood stands e) mature red spruce forest f) stands of mature mixed forest g) forested talus slopes. These features have been delineated as one or a combination of proposed "core" areas, around which a buffer zone has been designated. The combination of core and buffer areas forms one large site.

Disturbance History: A patchwork of disturbances, occurring at different times and at different intensities, has occurred in the Parlee Brook area. The more accessible sites were cleared for farmland (now abandoned), or have been cut for wood fiber. However, a large portion of this area is composed of steep river and stream valleys or cliffs, escarpments, and talus slopes. Some of the valley-side forest was cut, possibly at the turn of the century. At present, much of the land-use is recreational, either fishing or hunting. A waterfall in one of the streams is a popular swimming hole for local people.

Conservation Significance:

1) Contains representative samples of a wide diversity of habitat-types and vegetation formations within a small geographic area. Area has not received significant disturbance in recent decades and has a pristine appearance, especially in the steep valleys where numerous spectacular viewscapes are found.

2) Area has been poorly surveyed for all biotic groups. However, general surveys for vascular plants suggests that beta diversity is high. Most of the tree species native to New Brunswick can be observed here, including butternut, red oak, jack and red pine, hemlock, as well as the more common conifer and hardwood species. The rare large round-leaf orchis (Platanthera macrophylla), laurentian bladder fern (Cystopteris laurentiana), and the livelong saxifrage (Saxifraga paniculata) have also been recorded.

Conservation Priority Rating: The immediate and long term management plans for this area are unknown, so it is impossible to accurately assess if this area is threatened. However, significant timber harvest has occurred in nearby sites within the Parlee Brook valley so it can be assumed that portions of the identified areas are also **threatened**. The conservation values outlined above make this area **significant**.

Land Ownership: Large portions of many of the identified core areas are owned J D Irving Ltd. (see map). The remaining land parcels are owned privately.

Site #21: Vinegar Hill Tolerant Hardwood Forest

Location: located between the communities of Campbell Settlement and Vinegar Hill.

Size: 111.31 ha

Site Description: A tolerant hardwood forest of sugar maple, beech, ash, and ironwood occurring along the sides and at the top of Vinegar Hill. Ground flora is typical of upland hardwood forest, including northern green orchis, green woodland orchis, rose twisted stalk, red trillium, soloman's-seal, and red and white baneberry.

Disturbance History: Not known if hill was previously harvested in full or part. Diversity of ground flora and size of some of the trees suggests past cutting was not extensive. A section of the hill adjacent to this site was recently clearcut.

Conservation Significance: Vinegar Hill is part of the Anagance Ridge Ecodistrict, an extensively settled area where tolerant hardwood occurs on the higher hills. Within this century, many of these hardwood ridges have experienced various levels of human disturbance, including clearcutting and selective logging. Some ridgetops were cleared for pasture that has since been abandoned. As a result, areas still hosting mature tolerant hardwood forest are small and fragmented. Vinegar Hill is one of these mature forest fragments, representing the original forest cover and serving as a valuable source of propagules for adjacent areas.

Conservation Priority Rating: This area is considered **important.** Anticipated increases in demand for hardwood, and the paucity of similar large hardwood stands in the area, classify this site as **threatened.**

Recommended Management Strategy: Full protection if possible. If not fully protected, timber extraction should be limited, with intensity of cutting reflecting natural disturbance regimes of this forest type.

Land Ownership: Controlled by numerous private land owners, including J D Irving Ltd.

Site #22: Upper Salt Spring Hardwoods

Location: approximately 3 km north from route 860 at Salt Springs along Salt Springs-Southfield Road.

Size: 57.4 ha

Site Description: A ridge-top stand of mature tolerant hardwood that includes sugar maple and beech, with some white ash, ironwood, and yellow birch. The ground flora was characteristic of a mature tolerant hardwood forest understory, hosting dutchman's-breeches, spring beauty, trout lily, indian cucumber-root, and red trillium. The only rare plant species observed was wild leek.

Disturbance History: No signs of cutting, past or present, were observed in the area where the wild leek occurred on the ridge top. A baiting station for black bear, and an accompanying tree platform, were seen. Large quantities of scat indicated regular visitation of the site. In the northwest corner of the ridge, a large clearcut was recently made within the tolerant hardwood zone, likely for firewood. All sides of the ridge have been extensively cut and/or cleared for agriculture, and are now covered with white spruce and intolerant hardwood.

Conservation Significance:

1) An extensive population of wild leek (*Allium tricoccum*), probably the largest observed recently in New Brunswick. This species has been officially listed as a rare plant in New Brunswick (Hinds, 1983: The Rare Vascular Plants of NB).

2) This site appears to be a forest remnant from a larger, more continuous expanse of rich tolerant hardwood forest that occurred in this area at one time. The dominant landform in this area, Bloomfield Ridge, has been completely cleared for agriculture or has been cut over in the past 75+ years, and no mature tolerant hardwood, or associated ground flora species can now be found.

Conservation Priority Rating: This site is considered both **significant** and **threatened**. The presence of the clearcut may mean the other sections of this stand are due to be cut, though the land owners have not been contacted to confirm this.

Land Ownership: Six private land owners control this site. One owner, Mr John Cummings of Norton, owns most of the ridge top, including the areas where most of the leek is found. He has not been contacted.

Site #23: Waterford Escarpment

Location: On the north side of Cedar Camp Brook facing the village of Waterford and Poley Mountain.

Size: 141.56 ha

Site Description: A variety of habitat types and associated vegetative formations, including a) an extensive series of cliffs, ledges, and exposed escarpment b) an extensive fine-grained talus slope covered almost exclusively with ironwood occurring at the base of the cliffs c) tolerant hardwood forest on the ridge top that ranges from sugar maple-white ash-ironwood in the more sheltered areas to pure red oak in the drier, more exposed sites along the southwestern face of the ridge. Geological maps indicate seams of exposed limestone in this area.

Disturbance History: Most of the identified area, except the far eastern portion of the forested ridge top, appears to have never been significantly disturbed by human land use practices. On the ridge top, numerous very large ash, maple, and ironwood trees can be observed. Areas immediately outside the identified site all show signs of extensive disturbance from the early part of this century.

Conservation Significance:

1) Old growth tolerant hardwood stand on the ridge top with associated ground flora- spring beauty, dutchman's-breeches, trout lily, indian cucumber-root, and red trillium.

2) Extensive stand of ironwood highly unusual for New Brunswick. The size of some of these trees also much larger than usually observed in New Brunswick forests.

3) Hosts several uncommon plant species in association with the cliffs, ledges, and escarpments: hairy rock cress (Arabis hirsuta), drummond's rock cress (Arabis drummondii), bearberry (Arctostaphylos uva-ursi), and great-spurred violet (Viola selkirkii).

Conservation Priority Rating: Due to unusual vegetative formations, both forested and the non-forested escarpment, and the presence of several uncommon plant species, this site is considered **significant**. The talus and cliff are inaccessible and are likely not threatened. However, the escarpment area may be susceptible to hikers seeking the spectacular viewscape offered along the ridge top. The tolerant hardwood forest is likely under the greatest threat via logging, though the landowners have not been contacted and future land-use plans are unknown.

Recommended Protection Strategy: full protection

Land Ownership: Seven private land owners have been identified; all live in the Sussex area.

Site #24: Picadilly Mountain

Location: on north side of Picadilly Road near Urney

Size: 319.61 ha

Site Description: a relatively large ridge-top forest dominated by tolerant hardwood tree species (sugar maple and beech), with white pine growing on some of the dry south-facing ridge crests. The tolerant hardwood forest begins approximately 2/3 up the mountain slope. Below this, large tracts of white spruce indicate that the land was cleared at one time, likely for pasture. Similarly, portions of the ridge top show signs of past land clearance, being dominated by white spruce and white birch, or host small-statured tolerant hardwood stands.

Disturbance History: Portions of the slope and ridge top of Picadilly Mountain appear to have been cut earlier this century. Many of the trees are small-statured and ground flora diversity is low.

Conservation Significance: Picadilly Mountain is typical of upland tolerant hardwood forests found in the Anagance Ridge Ecodistrict of New Brunswick. Much of the original forest cover was cleared or selectively cut following settlement, resulting in species-poor forests with small statured trees. However, many of these upland forests, including Picadilly Mountain, have not been significantly disturbed in several decades. As a result, there is potential to develop into mature forest. Given time, ground flora and other species associated with established tolerant hardwood forest may recolonize if nearby sources of migrants are available. At present, the greatest asset of Picadilly Mountain is its ownership. It is largest crown-owned upland tolerant hardwood forests in the Fundy Model Forest.

Conservation Priority Rating: The expected increase in hardwood consumption in the future may put this site at risk. Long-term plans for Picadilly Mountain are unknown so its vulnerability can not be assessed at present. It has been recognized as a potential ecological reserve since biological surveys were first conducted there in the early 1970's.

Recommended Management Strategy: Full protection would ensure the continued development of tolerant hardwood forest found on this site. If cutting is deemed necessary, a low intensity harvest regime that resembles natural disturbance patterns of this forest type is recommended.

Land Ownership: Mostly controlled by the Province of NB, with some private land ownership.

Site #25: Urney Red Oak Ridge

Location: Directly across from Picadilly Mountain along Picadilly Mountain Road.

Size: 19.33 ha

Site Description: An exposed south-facing ridge forested almost completely in red oak (*Quercus rubra*). Numerous small rock ledges occur along the edges of the ridge and are covered by lichens and vascular plants tolerant of the dry, predominantly soil-less conditions. This includes large numbers of berry-producing plants (blueberry, bearberry) which attract both bear and coyote in the late summer and fall. Fine-grained talus slope exists below ridge cliffs, and is covered in red oak, ironwood, and beech.

Disturbance History: Past disturbance likely but intensity difficult to determine. Most of the slope behind the ridge shows signs of land clearance, either by farming or logging. At the top, very few large oaks exist, and signs of stump sprouting are not uncommon. However, small size could also be a result of slow growth rates due to exposed conditions.

Conservation Significance:

1) Large continuous red oak stands are uncommon in most of New Brunswick due to habitat restrictions and human disturbance.

2) Acorn and berry crops likely valuable food sources for local populations of various animal and bird species.

Conservation Priority Rating: At present this site is likely **not threatened**. The size of the red oak stand makes this site **significant.**

Recommended Protection Strategy: The red oak is successfully regenerating at this site. Selective cutting that did not significantly alter the existing forest canopy would likely not alter the composition or extent of the existing stand.

Land Ownership: Five private land owners were identified.

Site #26: Chambers Settlement Cliffs and Escarpment

Location: On north side of Chambers Settlement Road near its intersection with Sussex Corner-Walton Lake Road.

Size: 8.69 ha

Site Description: A small escarpment with associated cliffs and underlying talus slope. The escarpment and cliffs are sparsely covered with a variety of lichen and vascular plant species tolerant of the dry rock face conditions. The talus slope is composed mostly of ironwood.

Disturbance History: The cliff and associated talus forest do not show obvious signs of disturbance. The escarpment is accessible to cattle and has been grazed for some time.

Conservation Significance:

1) Cliff ledges host the drummond's rock-cress, a species listed as uncommon in New Brunswick.

2) The stand of almost pure ironwood is an uncommon occurrence in New Brunswick.

Conservation Priority Rating: The presence of the drummond's rock-cress and the stand of ironwood makes this site **significant**. Due to the inaccessibility of the cliffs and talus, it is **unlikely that this site is threatened**.

Recommended Management Strategy: Though disturbance is unlikely, landowners should be made aware of the site's significance. Removal of cattle from the escarpment may encourage re-establishment of ground flora species, both common and uncommon, typically found on escarpments in this part of NB.

Land Ownership:

Site #32: Hatfield Point Bald Eagle Nest and Hardwood Forest

Location: Near the intersection of Grant Brook and the transmission line approximately 2 km north of Hatfield Point.

Size: 21.08 ha

Site Description: A very steep north-facing ridge covered in mature tolerant hardwood forest. Many small fern-covered rock outcrops are scattered throughout the forest understory. Grant Brook runs at the base of this ridge. On the opposite side of the stream is a very large solitary white pine that hosted an active bald eagle nest in 1994.

Disturbance History: Tolerant hardwood slope may not have been significantly disturbed in the past, though a recent clearcut of the hardwoods occurred along the top of the ridge. The nesting tree is the only remaining large tree on the north side of the brook; the remaining area was clearcut within the last two decades.

Conservation Significance:

1) A representative sample of sugar maple-beech-white ash tolerant hardwood forest assemblage that was, at one time, much more abundant along the valley slopes surrounding Belleisle Bay. Today, only small isolated pockets of this forest type remain in this area. The very steep incline of this site near Hatfield Point spared it from logging.

2) Bald eagle nesting site in 1994, though ospreys occupied site in 1995.

Conservation Priority Rating: Future management plans for this area are unknown. With anticipated demand for hardwood fiber in the near future, it **may be threatened.** The nesting tree was intentionally left and does not appear to be threatened. Overall, the site rates as **significant.**

Recommended Management Strategy: Full protection of nesting tree for the duration of its use, with limited or no extraction of timber on the adjacent hardwood slope.

Land Ownership: Small woodlot owners and J D Irving Ltd.

Site #37: Babcock Brook Sedge Meadow and Jack Pine Stand

Location: first major logging road north of bridge crossing Babcock Brook along highway between Pollett River and The Glades. Site is several kilometers east from the highway (see map for exact location).

Size: 15.23 ha

Site Description: A large sedge meadow surrounded by a jack pine stand. Small pockets of the sedge meadow also occur amongst the jack pine in the southwest corner of the site.

Disturbance History: No signs of past human disturbance observed. However, during time of site visit (July 1994), portions of the jack pine to the north and east of the meadow were being clearcut. The strong association between jack pine and fire indicates that this site was burned at one time. This burning would likely not significantly affect the moist sedge meadows.

Conservation Significance: The sedge meadow hosts large numbers of two orchid species, Large Purple-Fringed Orchis and Ragged Orchis, plus rare white hybrids of the two species. Pinesap, an uncommon NB plant species, was also recorded in the forest adjacent to the meadows.

Conservation Priority Rating: The large assemblage of orchids at this site, combined with clearcutting some or all of the adjacent forest up to the edge of the meadow makes this site **significant and very threatened.**

Recommended Management Strategy Full protection of the sedge meadow areas. Establishment of a forested buffer strip around the meadow to protect microclimatic and hydrological regimes.

Land Ownership: Province of NB.

Site #38: Hunter's Home Bog and Sedge Meadows.

Location: approximately 3 km from Hunter's Home on the south side of the Canaan River.

Size: 67.69 ha [core areas only; buffers will increase size of site].

Site Description: a large series of sedge meadows, boggy areas, beaver ponds, and treed heath meadows. Surrounding areas composed of plantations, recent cuts, and forest stands of black spruce, red maple, and balsam fir.

Disturbance History: adjacent forested areas cut at various times over last several decades.

Conservation Significance: a large representative sample of the peatlands found within the poorly-drained and black spruce-dominated region south of the Canaan River. This site feeds into Miller Brook, one of the two major creeks that drain this lowland region. The floristic assemblage found at this site is typical of acid bogs and sedge meadows. Well-traveled game trails suggest regular visitation by moose and possibly deer.

Conservation Priority Ranking: this site is considered **important**. Long-term management plans are unknown for the area, but the adjacent forested areas not already cut will likely be harvested in the near future.

Recommended Management Strategy: Full protection of identified core areas with forest buffers of at least 100 m.

Land Ownership: the province of NB.

Site #39: Miller Brook Bog and Sedge Meadows.

Location: approximately four km south of Cherryvale. See map for exact location

Size: 81.99 ha [core areas only; buffers will increase size of site].

Site Description: a large series of barren and treed sedge meadows, boggy areas, bog ponds, and adjacent forest dominated by jack pine and black spruce. The ponds and some of the meadows are remnants from abandoned beaver dams. This site bridges two creek watersheds, Miller Brook and Thornes Brook, both of which flow into the Canaan River.

Disturbance History: portions of the adjacent forest show signs of both recent and past harvesting, including clearcutting. At one recent clearcut, a skidder trail was made through the center of a bog. The presence of several stands of jack pine, including some with large individual trees, suggests that some or all of this area was burned in the past.

Conservation Significance: a large and habitat-diverse peatland complex representing the poorly-drained and black spruce-dominated lowland region south of the Canaan River. Hosts a diverse floral assemblage typical of peatlands, and provides potential habitat for peatland species uncommon and rare in distribution. Well-traveled game trails in portions of this complex suggest regular visitation by moose.

Conservation Priority Ranking: this site is considered **important**. Long-term management plans are unknown for the area, but the adjacent forested areas not already cut will likely be harvested in the future.

Recommended Management Strategy: Full protection of identified core areas. Land use in identified buffer areas should be restricted to selective timber harvest. The construction of permanent roads within the buffer area could threaten existing hydrological patterns that support parts of the wetland.

Land Ownership: the province of NB.

Site #40: Big Cove cove forest

Location: Shoreline and forest along southwest corner of Big Cove, located 8 km south of Cambridge-Narrows on Route 710.

Size: 65.28 ha

Site Description: A forested shoreline and hillside area on the southwest corner of Big Cove. Hosts a wide diversity of tree species: eastern white pine, white cedar, red oak, white ash, ironwood, sugar maple, yellow birch, red maple, silver maple, jack pine, black ash, and hemlock.

Disturbance History: There are no signs of recent disturbance, though the existing forest structure suggests some land clearance has occurred on part of this site in the past.

Conservation Significance:

1) Cove forests occur in sidewaters of large lakes, rivers, and freshwater bays. They are sheltered, have mesic soils, and typically support a rich floristic community. Forested coves are desirable areas for lakeside cottage development and the mesic soils are suitable for agriculture. As a result, undisturbed cove forests have become uncommon in the Washademoak Lake and Belleisle Bay area, and New Brunswick in general.

2) Supports a rich floristic community that includes a large assemblage of tree species.

3) The checkered rattlesnake plantain (Goodyera tesselata), an uncommon NB orchid, was recorded on the hillside forest of this site.

Conservation Priority Rating: Due to the uncommon occurrence of relatively undisturbed cove forest communities, this site is considered **significant**. Cottage development along the northwest shore of Big Cove is slowly migrating towards this site and plans undoubtedly exist to develop this site. Therefore, it is considered **very threatened**.

Recommended Management Strategy: It is likely that the integrity of this site could be maintained with low-intensity, selected forest harvest. If cottage development is inevitable, an education program could alert developers and cottage owners to the importance of this site and encourage maintaining connected patches of original forest and associated ground flora. The usual tendency is to convert most of the property to lawn, leaving only a few ornamental shade trees.

Land Ownership:

Site #43: Morgan Hill Tolerant Hardwood Forest

Location: located between Snider Mountain and Head of Millstream on the north side of route 880.

Size: 464.35 ha

Site Description: A tolerant hardwood forest of sugar maple, beech, ironwood, and ash occurring along the sides and top of Morgan Hill. In some areas, large patches of ironwood are found. Ground flora is typical of upland hardwood forest and includes christmas fern, soloman's-seal, red baneberry, and red trillium.

Disturbance History: Unknown.

Conservation Significance: The DNRE forest inventory database indicates that Morgan Hill is one of the largest continuous tolerant hardwood stands presently existing within the FMF. The upland hardwood forest assemblage represented by this site has been reduced in total area due to human activities, including clearcutting, selective logging, and clearance for pasture. Many hillside and ridgetop pastures have been abandoned and now host intolerant hardwood and white spruce. Large remnant patches such as Morgan Hill maintain pre-settlement forest conditions and serve as seed sources for adjacent areas now regenerating back into forest.

Conservation Priority Rating: This area is considered **important.** Anticipated increases in demand for hardwood, and the paucity of similar large hardwood stands in the area, classify this site as **threatened.**

Recommended Management Strategy: Limited extraction of timber, with intensity of cutting reflecting natural disturbance regimes of this forest type.

Land Ownership: Controlled by numerous private land owners, including J D Irving Ltd.

Site #44: Head of Millstream Bog Complex

Location: approximately 3 km north of Head of Millstream.

Size: 198.19 ha [core areas only; buffer will increase size of site].

Site Description: a series of bogs, sedge meadows, alder thickets, stream stillwaters, and occasional bog ponds. The largest patch of peatland is the 69.6 ha Head of Millstream bog, one of the largest continuous bog formations within the FMF. This complex bridges the headwaters of Morgan Brook and Thornes Brook drainage basins, both of which feed into Canaan River.

Disturbance History: Much of the adjacent forest has been recently harvested; in some cases plantations have been established. Some of the bog areas have been heavily disturbed by skidders or cutting of black spruce. No forest buffer was left around the Head of Millstream bog.

Conservation Significance: The largest identified bog complex in the FMF representing the poorly-drained lowland region south of the Canaan River. The size and habitat diversity of this site hosts, or has the potential to host, a large assemblage of flora and fauna typically associated with wetlands.

Conservation Priority Ranking: This site is considered **important**. Long term land management plans for this site are unknown. However, it appears that parts of this site are **threatened**, either by direct harvest or by alteration of hydrological pattern as a result of road construction and the absence of forest buffers.

Recommended Management Strategy: Full protection, including a buffer zone of at least 100 m that surrounds and connects all identified core areas.

Land Ownership: Most of site is owned by J D Irving Ltd.

Site #45: Lower Kars Creekside and Shoreline Forest

Location: Occurs along small stream that runs under Lower Kars Road and into the western shore of Jenkins Cove.

Size: 2.72 ha

Site Descriiption: A small but rich forested site that includes both streamside and shoreline habitat. The streamside area is dominated by eastern cedar with occasional thick patches of speckled alder. The shoreline area is dominated by black ash and cedar. Ground flora included hellebore, northern green orchis, jack-in-the-pulpit, nodding trillium, dutchmans-breeches, canada lily,

Site #47: Cherryvale Bogs, Sedge Meadows, and Connecting Streams.

Location: approximately 1 km north of Cherryvale-Salem road near powerlines.

Size: 62.67 ha [core areas only; buffer will increase size of site].

Site Description: a large complex of treed and barren sedge meadows, bogs, beaver ponds, and small marshes that form the upper reaches of Ben Keith Brook, which drains into the Canaan River. The southern third of the site is dissected by a set of powerlines.

Disturbance History: The adjacent forest has been cut within the last several decades and is dominated by small to medium sized red maple, poplar, balsam fir. A power line dissects the southern third of the site.

Conservation Significance: The easternmost wetland complex in the poorly-drained black spruce-dominated lowland region south of the Canaan River. The vegetative assemblage at this site is more diverse than other wetland sites in this region of the FMF. Included is a very large population of the rose pogonia orchid (Pogonia ophioglossoides), a species scattered in pockets throughout southern New Brunswick. Other observed orchids are the large purple-fringed orchis (Platanthera grandifolia) and the ragged orchis (Plantanthera lacera). The marshes at this site offer some suitable breeding habitat for waterfowl and other wetland birds.

Conservation Priority Ranking: This site is considered **important**. Long term land management plans for this site are unknown so threats cannot be assessed at present.

Recommended Management Strategy: Full protection, including a buffer zone of at least 100 m surrounding and connecting all identified core areas.

Land Ownership: province of NB.

Site #48: Anagance Marsh

Location: Anagance River and surrounding marsh from the King's county line to Dunsinane

Size: 208.37 ha

Site Description: An extensive series of marshes and ponds occurring in or adjacent to the Anagance River. In some sections of the river, numerous beaver dams have created large ponds. Extensive areas are heavily vegetated by marsh grasses and cattails, providing cover for resident fauna. Some sections of shoreline host large stands of eastern white cedar.

Disturbance History: Unknown.

Conservation Significance: A large continuous area of marsh habitat that supports numerous species of waterfowl and other marshland birds. Cedar forests support a rich array of ground flora species, including several orchids. Large, relatively continuous stands of eastern cedar such as this one are now uncommon in the FMF area due to logging.

Conservation Priority Rating: The size and suitability of this habitat for ducks and other bird species, plus the presence of cedar forest and associated rich ground flora, classifies this site as **significant**. The wetlands are likely not immediately threatened by land management activity. One section of the river is being managed by Ducks Unlimited. The cedar stands are considered **very threatened** due to heavy demand for cedar wood and by artificially high water levels caused by damming. Clearcutting of cedar has occurred near the DU compound.

Recommended Management Strategy: Full protection of site. DU compound only captures a small percentage of this site's total area. Damming to maintain high water levels should be discouraged in areas not already dammed. High water favors duck activity but is detrimental to some marsh vegetation. Extensive mortality of shoreside eastern white cedar has resulted from damming at the DU compound.

Land Ownership: J D Irving Ltd. and numerous small woodlot owners.

Site #49: Gibson Creek and Pollett River Gorge

Location: approximately 2.5 km south of Elgin where the Pollett River crosses under the Elgin-Churchs Corner road.

Site: 159.11 ha

Site Description: a high narrow creek valley that contains a variety of forest assemblages. Stands of mature hemlock occur along the Elgin River gorge and the lower reaches of Gibson Creek. Large numbers of white pine are found along the ridge top of the south-facing slope, with spruce and fir on the valley side below. The upper reaches of the valley bottom, and sections of the south facing slopes, contain tolerant hardwood. The tolerant hardwood understory has a diverse ground flora. Streamside rock ledges are inhabited by numerous fern, moss, and liverwort species.

Disturbance History: An old road along the south side of the valley indicates past human disturbance. However, many of the stands have large individual trees, suggesting that harvesting was selective, minimal, and/or during the last century and early half of this century. Some recent clearcutting has occurred along the southern ridge top, including one cut that extends at least halfway down the valley slope.

Conservation Significance:

1) A diverse assemblage of forest stand types within a relatively small topographic area.

2) Contains the largest stand of hemlock observed in the Fundy Model Forest, including several large individuals.

3) The rare frog-orchis (Coeloglossum viride) and uncommon lesser wintergreen (Pyrola minor) have been recorded in this valley.

Conservation Priority Rating: This site is considered **significant.** Future management plans for this area are unknown, but recent clearcutting in stands adjacent and in this valley suggest that it is **threatened.**

Recommended Management Strategy; Full protection, or limited fine-scale forest management, of ravine and immediate area beyond the gorge ridge to serve as a buffer. Current land use activities (hunting and fishing, hiking and swimming by people in the Pollett River gorge) are acceptable.

Land Ownership: Almost completely owned by small woodlot owners, with small parcels of land owned by J D Irving ltd. and the province of NB.

Site #50: Tommy Long Hollow Hemlocks

Location: small stream valley located on the northwest side of road between Upper Goshen and Goshen.

Size: 41.83 ha

Site Description: Stand of pure hemlock on the west-facing slope of a small but sheltered stream valley. Numerous large white and red pine occur on the ridge top. The adjacent forested areas are tolerant hardwood.

Disturbance History: No sign of recent disturbance, though small size of hemlocks suggests site may have been cleared at one time.

Conservation Significance: One of only four small stands of hemlock observed within the FMF boundaries.

Conservation Priority Ranking: The rarity of hemlock within the FMF makes this site **significant.** This site is scheduled to be cut during the 1997 management period and is therefore **highly threatened.**

Recommended Management Strategy: Full protection, including maintenance of immediate surrounding forest (pines and hardwood) to buffer against alteration of microclimate conditions in hemlock understory. Increased light and temperature and reduced humidity in the understory may negatively affect hemlock regeneration.

Land Ownership: Several owners, including the province of NB.

Site #51: Morrison Brook Bog, Sedge Meadows, and Connecting Streams.

Location: occurs at top of several small stream tributaries, including Morrison Brook, that run south into the Northeast branch Long Creek.

Size: 46.82 ha [core areas only; buffer will increase size of site].

Site Description: The westernmost bog complex within the Long Creek watershed. The Long Creek watershed is part of a larger region of poorly-drained infertile soils dominated by black spruce that occur within the FMF immediately south of the Canaan River. This site includes a complex of sedge meadows, beaver ponds, and bogs all connected by a series of alder-lined streams.

Disturbance History: adjacent forested areas cut at various times over last several decades.

Conservation Significance: a representative sample of peatlands found within the Long Creek watershed. This site is located between several large bog complexes on the upper reaches of the Long Creek watershed, and an extensive marsh found at the mouth of Long Creek at Lake Washademoak. The maintenance of this site in its existing condition, including the presence of alder-lined stream corridors, will not only maintain existing species assemblages within, but also may facilitate migration of wetland-dependent species between these two areas.

Conservation Priority Ranking: this site is considered **important.** Long-term management plans are unknown for the area, but the adjacent forested areas will likely be harvested in the future.

Recommended Management Strategy: Full protection of identified core areas, including the connecting streams and a buffer strip of at least 100 m surrounding each feature.

Land Ownership: the province of NB.

Site #53: North River Wet Cedar Forest

Location: approximately 1.5 km up river from North River bridge on the Scott Road

Size: 80.78 ha

Site Description: Extensive stand of eastern white cedar (Thuja occidentalis) and black spruce (Picea mariana) found around a large stillwater pond off the North River. Most of the cedar is found in the wetter areas near the stillwater, with black spruce increasing in abundance away from the pond. In the understory of the pure cedar stands are sparsely vegetated mats of sphagnum moss that support a variety of ground flora species, including many orchids. In the relatively drier black spruce areas, the ground cover is denser, dominated mostly by Ericaceous species such as sheep laurel, labrador tea, and rhodora.

Disturbance History: There is no evidence of past disturbance at this site in the forest itself. However, a large clearcut, likely targeting cedar, has recently occurred at the perimeter of this stand.

Conservation Significance:

1) Contains large undisturbed stand of eastern white cedar.

2) Contains numerous rare or otherwise significant ground flora species, including:
   (a) showy lady's-slipper (Cypripedium reginae) rare and possibly endangered in NB.
   (b) boreal aster (Aster borealis) very rare in NB.
   (c) yellow lady's-slipper (Cypripedium calceolus variety parviflorum) uncommon in NB.
   (d) hooker's orchis (Platanthera hookeri) scattered in parts of NB.
   (e) Carex limosa uncommon sedge species in NB.
   (f) small yellow water-crowfoot (Ranunculus gmelinii) rare in NB.

Conservation Priority Rating: Due to the high price and subsequent heavy demand for cedar in New Brunswick, this site can be considered **highly threatened.** Evidence from historical studies suggests that the percentage of cedar forest was originally considerably higher than occurs today in southeastern New Brunswick. Stands such as this North River site are very uncommon, especially stands that support such a rich and rare assemblage of ground flora species. As a result, this site is also considered **highly significant.**

Recommended Protection Strategy: Full protection

Land Ownership: Six different land owners, five of which are private and one appears to be government (NB Agricultural Board).

Site #54: Mount Zachy-Jonah

Location: On west side of road between Pleasantvale and Meadow in Albert county.

Size: 79.59 hectares

Site Description: An extensive north and east facing talus slope forest, with associated cliffs and ledges in the understory below the ridge crest. Several uncommon and rare understory plant species are found on the talus and rock faces.

Disturbance History: No sign of disturbance in the talus forest, except for naturally-occurring rock slides on the unstable talus substrate. The forested ridge top of Zachy-Jonah consists mostly of regenerating forest from previous human disturbances. The least-disturbed ridge-top forests are sugar maple stands used for syrup production.

Conservation Significance:

1) Extensive talus and shaded cliff face habitats support rich vegetative assemblages.

2) The following uncommon, rare, and very rare plant species have been recorded on Mount Zachy-Jonah: Carex backii, maidenhair-spleenwort (Asplenium trichomanes), the albino spotted coralroot (Corallorhiza maculata forma flavida), hairy rock cress (Arabis hirsuta), and maple-leaved goosefoot (Chenopodium gigantospermum).

Conservation Priority Rating: The size of the identified section of Mount Zachy-Jonah and the number of uncommon and rare species makes this site **very significant.** The inaccessibility of the steep talus and cliff area reduces the threat of human disturbance; this site is likely **not threatened.**

Recommended Management Strategy: Full protection. The unstable slope substrate would be seriously affected by cutting. Many of the understory plant species likely require forest canopy shading to offset the dry conditions of the talus and cliff substrate.

Land Ownership: Five land owners have been identified, as listed on the site map.

Site #55: Havelock Tolerant Hardwood Ridge

Location: Approximately 3 km north of the town of Havelock on route 885. Occurs 750 m off highway behind the barn of Dykstra's diary farm.

Size: 29.04 ha

Site Description: A rich forest site on a ridge of pure limestone. Ridge-top canopy is composed of pure tolerant hardwood: sugar maple, beech, white ash, yellow birch, ironwood, and butternut. Population of mature butternut limited to approximately ten trees, all small-sized, though regeneration is occurring. Hemlock found sporadically below ridge. Ground flora species include yellow lady's-slipper, true soloman's-seal, common sweet cicely, blue cohosh, Carex limosa, red baneberry, and nodding trillium.

Disturbance History: This site can be classified as moderately to highly disturbed. Many of the beech trees are dying, likely due to beech-bark disease. There has been occasional firewood extraction. The ground flora at this site is surprisingly depauperate for such a rich substrate, likely reflecting cattle intrusion. The only place were the rarities occur is the rocky and, in places, steep ridge crest that runs through the forest.

Conservation Significance:

1) The town of Havelock was once called Butternut Ridge. However, very few trees remain except for some ornamentals, likely due to land clearance and use of this species as a cabinet wood. This site represents the last known stand of butternut in the area.

2) This site is a rare remnant of a forest-type that was likely more common at one time. Dry exposed ridges of limestone occur sporadically across southeastern New Brunswick. In pre-European times, these sites probably supported rich tolerant hardwood or cedar forests with diverse ground flora assemblages. However, most of these ridges occur in association with rich agricultural areas and are now highly disturbed, either completely cut, quarried for limestone, or abandoned but supporting young intolerant hardwood species. The Havelock site is the only known dry limestone ridge that still supports remnants of its original canopy and ground flora.

3) This site contains the easternmost record of blue cohosh in the province. The next closest citation has been in the St John River valley west of Fredericton.

Conservation Priority Rating: Due to the beech bark disease, one of the landowners has contemplated cutting the front of the stand that occurs on his property. Alternatively, he has also thought of tapping the sugar maple trees. The back of the property, which includes all the butternut trees, is owned by Havelock Limestone Co. and will likely be quarried at some future date. As a result, this site can be considered **highly threatened**. Due to the rarity of the assemblage, it is considered **highly significant**.

Recommended Management Strategy: Full protection, possibly with some active management to encourage butternut establishment and reintroduce

ground flora species that would be expected to be associated with this habitat type.

Land Ownership: Six different land owners, all private or industrial, as listed on the site map.

Site #56: Kitts Cave

Location: near Hammondvale. If more specific information on the location of this site is required, contact Dr Don McAlpine at the New Brunswick Museum or Sam Arsenault at University de Moncton.

Size: above ground: 0.8 ha
below ground: 154 m long and approximately 8 m deep

Site Description: An active stream cave know to host several bat species. Parent material is Mississipian limestone.

Conservation Significance: Roosting site for small populations of bats, including the species Pipistrellus subflavus, one of only four known sites containing this species in NB (McAlpine, 1983).

Conservation Priority Rating: Due to the small number of caves in this region of New Brunswick, this site is considered **very significant**. Like most caves, it is highly vulnerable to human disturbance, which disturbs roosting bat colonies and may affect fragile habitat conditions. Without preventative measures to restrict visitation, this site is considered **threatened**.

Recommended Management Strategy: Full protection of cave and area immediately surrounding the cave.

Land Ownership: Province of New Brunswick.

Site #61: Beulah Great Blue Herring Nesting Colony

Location: One km north on logging road found immediately west of Jones Brook off of Route 705.

Size: Core area containing heron colony several hectares in size.

Site Description: Several large white pine trees each hosting multiple nests/roosts. A nearby tree contains an active osprey nest.

Disturbance History: Extensive clearcutting has occurred in the nearby area. The white pine trees occur at the edge of one clearing and may have been intentionally left. The colony shows no negative signs of this intrusion.

Conservation Significance: Only known heron nesting colony in FMF area.

Conservation Priority Rating: This site is considered **significant.**

Recommended Management Strategy: Heron colonies tend not to be permanent. Build-up of guano eventually kills the host trees. However, until this happens, trees should be identified and protected. Human visitation disturbs the entire colony and should be minimized, especially during the nesting period.

Land Ownership: J D Irving Ltd.

Site #62: Mannhurst Road Scirpus lineatus site

Location: near the intersection of a tributary of Bennett Brook and Mannhurst Road (see map for exact location).

Size: 4.52 ha [includes the core area where species occurs plus a surrounding buffer area].

Site Description: a small wet swampy area adjacent to the road and hosting populations of several sedge and bulrush species. Site fertility is apparently enriched by the influence of the nearby Havelock limestone formations.

Disturbance History: Unknown. Wet area may have formed when road construction impeded regular drainage paterns in the area. Site likely susceptible to salt pollution from winter road maintanence.

Conservation Significance: Only known location of Scirpus lineatus in NB. This species requires lime-rich wet areas, and may have been more abundant in the Havelock area before conversion of local habitat to agriculture.

Conservation Priority Rating: The rarity of this species, and the small size of the population, classifies this site as **significant** and **threatened**.

Recommended Management Strategy: Full protection of site. Introducing this species to similar habitat in the Havelock area could reduce the threat of extirpation.

Land Ownership: J D Irving Ltd and two local owners.

Site #63: Paper Mill Hill Eleocharis site

Location: Off route 114 just below Springdale

Size: 52.97 ha

Site Description: Narrow alder-lined stream occurring south of Springdale.

Disturbance History: Route 114 crosses stream nears its intersection with Dove Hollow Brook.

Conservation Significance: Contains the spike-rush Eleocharis intermedia, a very rare plant only recorded in three other NB locations.

Conservation Priority Rating: This site may be affected by the continuing construction of the Trans Canada highway near Springdale. It is considered **significant** and potentially **very threatened.**

Recommended Management Strategy: Full Protection of entire stream to ensure that existing levels of water flow through are maintained and to prevent disturbance of the spike-rush population.

Land Ownership: Several owners, including province of NB.

Site #65: Fundy Coastal Headlands

Location:

Size: 134.81 ha

Site Description:

Conservation Significance:

1) Rare Plants

2) Peregrine Falcon

Conservation Priority Rating:

Recommended Management Strategy: All species dependant on coastal headland habitat are sensitive to disturbance. Education towards climbers, hikers best means to make people aware of actions.

Land Ownership: DNRE and J D Irving Ltd.

Site #66: Northeast Branch Long Creek and Beatty Brook

Location: several km northeast of Marrtown on King's County line.

Size: 146.72 [core areas only; buffer will increase size of site].

Site Description: a large series of barren bogs, alder thickets, bog ponds, stream stillwaters, and treed peatlands dominated by black spruce and larch. This peatland complex bridges two watersheds. Northeast Branch Long Creek flows into the Canaan River, while Beatty Brook flows south into the Kennebecasis River.

Disturbance History: The adjacent forest has been cut within the last several decades, including a large clearcut at the northwest corner of the site.

Conservation Significance: The most habitat-diverse peatland complex in the poorly-drained lowland area south of the Canaan River. The northern section of this site feeds into Northeast Branch Long Creek, one of two major creek watersheds that drains this lowland area of the FMF. Large tracts of bog and alder thickets host a wide array of flora and fauna dependent on peatland habitat conditions for persistence.

Conservation Priority Ranking: The size, habitat diversity, and potential to host large numbers of peatland species makes this site **important**. Long term land management plans for this site are unknown. It is likely not directly threatened at present.

Recommended Management Strategy: Full protection, including a buffer zone of at least 100 m that surrounds and connects all identified core areas.

Land Ownership: Most of site is owned by J D Irving Ltd.

Site #67: Goose River Gorge

Location: Forms the lower western boundary of Fundy National Park.

Site: 193.13 ha

Site Description: A steep forested river gorge with cliffs, ledges, and numerous waterfalls and rapids.

Disturbance History: Goose river likely was used to transport logs in late 1800's or early 1900's.

Conservation Significance: One of the larger coastal ravines in the FMF. Contains tracts of mature red spruce forest, including large individual trees. Captures the remainder of the Goose River gorge not already protected within Fundy National Park.

Conservation Priority Rating: The forested slopes, potential habitat for arctic-alpine species, and presence of only one side of this ravine within Fundy Park makes this site **significant.** Future management plans for this area are unknown, but the steep-sloped valley sides and river are likely not threatened.

Recommended Management Strategy; Full protection of ravine and immediate area beyond the gorge ridge to serve as a buffer.

Land Ownership: almost all controlled by the Province of NB, with a very small section owned by J D Irving Ltd.

Sites #68 and 69: Miller Brook Fringed Polygala Sites

Location: Two sites approximately 1 km upstream from the junction of Miller Brook and Canaan River (see map for exact locations).

Size: Both sites have core areas several hectares in size.

Site Description: Both sites are dominated by stands of jack pine, black spruce, balsam fir, and red maple. The soils are poor and support a ground flora dominated by heath species (rhodora, sheep laurel) and bracken fern. Both sites border plantations and recent clearcuts.

Disturbance History: Unknown, though presence of large numbers of jack pine suggests that site was burned at one time. Areas immediately adjacent to this site were clearcut and are now plantations.

Conservation Significance: Host populations (approximately 20-100+ individuals) of fringed polygala (Polygala paucifolia), a very rare NB species recorded in only three other locations in the province.

Conservation Priority Rating: The presence of the very rare populations make these sites **very significant.** This area is heavily managed for timber harvest. Long-term management plands show that the northern site is scheduled to be cut. As a result, these populations are considered **very threatened.**

Recommended Management Strategy: Full protection of the core areas. A buffer zone of 100 meters would help protect the core area, and allow for population expansion.

Land Ownership: Province of NB.

Site : Parleeville White Ash Stand

Location: Located between Route 875 and the Case Settlement-Lower Millstream Road near Parleeville.

Size: unknown

Site Description: Mature tolerant hardwood stand at the base of an extensive series of cliffs and very steep wooded slopes. Many large emergent white ash and sugar maple trees, as well as ironwood, beech, and yellow birch. Understory flora is rich, containing plant species typical of this forest type, such as bloodroot, false-solomon seal, helleborine orchid, indian cucumber root, hooked buttercup, nodding trillium, and christmas fern. Cliffs are mostly shaded and fern covered, hosting large populations of bulblet-bladder fern, fragile fern, rock polypody, and several Dryopteris species. The uncommon sweet cicely species Osmorhiza longistylis was observed on the shady moss-covered ledges. Numerous caves show evidence of occupation by black bear and porcupine.

Disturbance History: No signs of human disturbance. Occasionally, large boulders dislodge from the cliffs above, likely creating extensive damage in the forest below. No recent signs of rock fall are evident.

Conservation Significance:

1) Old growth tolerant hardwood stand, including several very large, and likely very old, white ash and sugar maple trees. This site was the most extensive mature tolerant stand observed in the FMF by the Gap Analysis project.

2) While only one uncommon plant species was observed, the understory and rock ledge plant communities were species-rich, with many of the populations being large and extensive.

Conservation Priority Rating: This site is rated as **very significant** due to the size of some of the trees and of the stand itself. The land owners have not been contacted so the future plans for this site is unknown. However, due to the general inaccessibility of the area, it is **probably not threatened** at present.

Recommended Protection Strategy: The forest understory is heavily shaded and as a result, sparsely vegetated relative to better illuminated sites. Significantly altering the existing canopy would increase understory light and undoubtedly encourage the invasion of light-loving, weedy species currently absent from this site. Therefore, full protection is the preferred approach, though limited selective cutting is possible.

Land Ownership: private

Site # : Wickham Purple Martin Colony

Location: Several hundred meters south of the intersection between Route 705 and the Wickham-London Settlement Road.

Size: NA

Site Description: A local property owner has a several martin boxes set up that hosted a colony of 20-30 birds in the summer of 1995.

Conservation Significance:

Purple Martin colonies occur in the warm river valley interiors throughout southern New Brunswick and are probably sporadically scattered in the St John, Kennebecasis, and Petitcodiac River valleys of the FMF. The overall population of martins in the Maritimes is considered small (Erskine, 1992) and on occasion may be threatened by invading starlings.

Conservation Priority Rating: Due to the infrequent occurrence of purple martin colonies in southern NB in general, this site is considered **significant**.

Recommended Management Strategy: Alert owner of significance of site if she or he is not already aware. Inquire if houses are cleaned each spring??

Land Ownership:

1997

Landscape-level (1:12,500) Gap Analysis in the Fundy Model Forest of Southeastern New Brunswick, Canada.

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Abstract

A gap analysis was conducted in the Fundy Model Forest (FMF) of southeastern New Brunswick, Canada, to assess representation at the ecosite (1:12,500) level by existing protected areas and to determine the potential contribution of two sets of recently identified ecologically significant sites for offsetting protection deficiencies. The analysis was intended to provide information for the development of an integrated land management program within the FMF. Ecosites units were delineated using GIS-based abiotic data (soil, drainage, elevation, slope, climate), supplemented with forest cover information. In total, 29 ecosites were identified from three major climatic regions (Coastal, Upland, and Interior Valley). Because ecosites were derived from finely resolved environmental and biotic variations, we assumed that they captured variations in biodiversity more accurately than other surrogates used by gap analysis, such as forest cover. A minimum representational standard of 12% was used to assess coverage provided by existing reserves and the recently identified sites in each ecosite. Priority rankings were assigned to each ecosite using the gap analysis results combined with information on habitat conversion and land ownership. Levels of existing protection were skewed towards the Coastal and Upland regions where settlement and permanent land clearance have been historically limited. In these regions, existing protected areas met minimum protection targets. Conversely, all ecosites in heavily settled Interior Valley region had no protection, have experienced the greatest levels of habitat conversion, and are dominated by small private land holdings. All very high and high priority ecosites occurred in this region. The two sets of supplemental sites captured portions of all but four ecosite units, but met minimum representational targets in only three ecosites that were not already protected. These programs were not designed to represent landscape-level environmental variation and as a result, additional ecosite-specific sites will be required if minimum protection targets are to be met for these units.

Introduction

Gap analysis is a simple yet effective procedure that serves as a valuable first step towards systematically identifying conservation priorities at continental, regional, or local levels. The success of gap analysis in assessing existing biodiversity protection and directing conservation planning has led to its implementation by management agencies in Canada (Lewis & MacKinnon 1992, Iacobelli *et al.* 1993), the United States (Scott *et al.* 1993, Wright *et al.* 1994), and other countries such as Mexico (Bojorquez-Tapia *et al.* 1994) and Brazil (Fernside & Ferraz 1995).

To implement gap analysis, an ecological land classification (ELC) system is required that delineates the area of interest into relatively homogeneous units using patterns of existing vegetation cover or environmental variation represented by climatic, edaphic, geologic, and topographic divisions. Once these units are identified, gap analysis compares the level of existing protection in each unit with a predetermined representational standard, typically a percentage ranging from 5% to 50% (e.g. Noss 1992, Wright *et al.* 1993, Scott *et al.* 1993, Strittholt & Boerner 1995), which estimates the minimum land base required to sustain existing levels of biological diversity.

To date, most gap analysis programs have been conducted at national and regional scales, reflecting administrative priorities to first define broad conservation needs. However, the land classification procedures used by these programs, typically applied at a scale of 1:100,000 or smaller, are not suitable for conducting gap analysis at finer spatial resolutions, nor can they provide spatially explicit landscape-level information needed by land managers (MacDougall & Loo *unpublished*). Coarse-scale ecological delineations broadly classify landscape pattern, but achieve predictive consistency at the expense of spatial accuracy (Costanza & Maxwell 1994). Coarse-scale resolution is also insufficient to detect small, spatially-restricted ecological units that may have considerable conservation significance, such as wetlands and isolated forest remnants in highly fragmented landscapes.

Several recent gap analyses have been conducted at fine spatial scales (Strittholt & Boerner

1995, Slaymaker *et al.* 199-, Stohlgren *et al. in press*). Each has adapted a multiple-variable ELC as a means to resolve the complex level of detail that occurs at high levels of resolution, with greatest emphasis on vegetation-based pattern provided by remote-sensed imagery. For our study, we adapted a fine-scale ELC primarily delineated using abiotic land resource data, with photo-interpreted vegetation data used only to validate the landscape unit boundaries. The use of physical feature data to construct an ELC has several advantages. Patterns of environmental variation are considered more enduring than vegetation pattern, especially in heavily disturbed landscapes (Rowe 1993, Noss 1995). In poorly surveyed areas, distribution of physical feature variables can be used as a proxy for the distribution of species or species assemblages known to be associated with particular habitat features (Scott *et al.* 1993). Environmental variation serves as a more accurate surrogate for overall patterns of biodiversity distribution than vegetation cover, as many species are distributed independently of dominant forest cover species (Hunter *et al.* 1988, Currie 1991, Lapin & Barnes 1994, Price *et al.* 1995). Finally, a conservation strategy that captures environmental variation can allow for shifts in species distribution in response to climatic changes (Noss & Cooperrider 1994).

Using a physical feature-based ELC system, a fine-scale gap analysis was conducted in the FMF, a 420,000 ha study area in southeastern New Brunswick. The study area was established in 1992 as part of Canada's Model Forest program, which has a mandate to develop integrated and sustainable land management strategies that consider economic, social, and environmental values, including the maintenance and preservation of existing levels of biological diversity. The gap analysis was used to assess the level of representation by established reserves throughout the entire area, and to determine the degree of coverage provided by two recently completed programs that systematically identified representative landform features, species rich hotspots, and sites hosting rare populations. The conservation status of each classified landscape unit was prioritised using gap size, percentage of each unit permanently converted for human land use, and ownership status.

Establishing conservation priority rankings of forest assemblages will only serve as a preliminary step in the development a protected areas strategy for our study area. The main

purpose of this project was to use gap analysis to create an information base on the identity and location of landscape-level units within the study area, and prioritize the conservation needs of each. Decisions on reserve selection, plus the location, configuration, abundance, and connectivity of reserves will presumably follow.

Study Area and Methods

Study area

The Fundy Model Forest occurs in southeastern New Brunswick, Canada (Fig. 1). Much of the area has been utilized for forestry, farming, or settlement since the onset of European colonization over 300 years ago. Evidence suggests that the proportions of forest tree species have changed since land clearance began, likely the result of habitat alteration and the interruption of naturally-occurring disturbance patterns. Some species, such as *Abies balsamea*, have increased considerably (Lutz 1997), mirroring similar changes in the nearby state of Maine (Irland 1993). Others tree species, such as *Picea rubens*, *Juglans cinerea*, *Thuja occidentalis*, *Tsuga canadensis*, and *Quercus rubra*, appear to have decreased in abundance compared to historic accounts from the area (Perley 1843, Lutz 1997).

Just over 5% of the FMF is currently protected (Fig. 1). Fundy National Park, formed in 1950 and covering 20,500 ha, accounts for 5% of this total. Three new Conservation Areas were established in 1996 immediately west of Fundy Park and range in size from 151 ha to 695 ha. They cover 0.3% of the study area and are classified as Category 1b protected areas (IUCN 1994), as the traditional practices of recreational hunting and fishing are permitted.

Supplementing the existing protected areas are two independently-derived sets of ecologically significant sites (Fig. 1). These sites were identified in a geographically systematic manner by programs seeking to represent elements of biotic or environmental variation. One program was conducted on a province-wide basis and identified coarse-scale (1:500,000) representative areas capturing landform variation (Gorman *unpublished*). Three of these representative areas,

ranging in size from 1724 ha to 5409 ha, occurred in the study area and covered 3% of the land base. The second program was specific to the FMF and identified community-level sites hosting populations of provincially-uncommon or rare species, local hotspots of species diversity, or small and spatially-discrete forest assemblage types resulting from either natural or human causes (MacDougall & Loo 1996, MacDougall *et al.* unpublished). Sixty-seven fine-scale sites were identified, covering 1.8% of the FMF and ranging in size from 0.18 ha (an inland salt spring) to 797 ha (an upland complex of escarpment, cliffs, and mature ridgetop forest). Neither of the two sets of supplemental sites are presently protected but, if it can be demonstrated that they offset deficiencies in existing protection, they could be used as the starting point for achieving minimum conservation objectives in the study area.

The physiography of the FMF is highly diverse, and is described in detail elsewhere (Power & Matson 1995, MacDougall *et al. unpublished*). While only encompassing 5% of the total land area of New Brunswick, the FMF contains parts of three of the provinces four climatic regions (Power & Matson 1995) and seven of the province's 34 macro-scale landform districts (NBDNRE 1996). All of New Brunswick's thirty-three tree species occur in forest assemblages ranging from conifer-dominated boreal forest in the cool, moist regions to "Alleghanian" (*sensu* Roland & Smith 1969) broadleaf forest associated with the warmer continental climate of the major inland river valleys. Floristically, the area hosts at least 65% of the province's vascular plant species, including 182 provincially-classified uncommon, rare, and very rare species (MacDougall & Loo 1996). Land ownership is divided among three major ownership groups. Private woodlot owners with small land holdings occupy 65% of the study area. The remaining land is owned by either the province of New Brunswick (18%) or by local forest companies (17%).

Ecological land classification

background

The ecological land classification (ELC) used for this gap analysis was developed independently by the New Brunswick Department of Natural Resources and Energy

(NBDNRE). The origins of ELC in New Brunswick begin with programs developed for Canada as a whole (Halliday 1937, Rowe 1959) and for Canada's Maritime provinces: New Brunswick, Prince Edward Island, and Nova Scotia (Loucks 1962). The recent development of geographical information systems (GIS) and the availability of a detailed land resource data base in New Brunswick has facilitated the creation of a multi-level, hierarchical province-wide ELC (NBDNRE 1996). This new classification system integrates data on soil series, geologic parent material, climate, elevation, slope, landform, coastal proximity, hydrology, and forest cover data, which includes age- and size-class information, plus dominant forest cover species. The New Brunswick ELC is organized in a top-down manner, with fine scale units nested within higher-order levels defined at coarser scales (Table 1).

The development of ELC in New Brunswick was primarily based on environmental variation, as opposed to patterns of existing forest cover used by other ELC programs (e.g. Scott *et al.* 1993). Vegetation data obtained from low-level aerial photographs were used, but only to validate the placement of boundaries defined by the physical landscape, not to delineate boundaries *per se.*

The gap analysis was conducted at the ecosite level within the provincial ELC system (Table 1). Ecosites are unique combinations of environmental parameters, resolved at the landscape level (1:12,500), to which a specific group of late-successional forest cover species are probabilistically associated. The species composition of these forest cover assemblages is estimated using knowledge of tree silvics, historical records, and forest cover data on the distribution of mature age classes interpreted from aerial photos, and from over 10,000 sample plots surveyed by NBDNRE across New Brunswick. The level of resolution at which the ecosites are identified created two advantages for our ELC system. First, it captured variations in landscape pattern at a much finer scale than existing land classifications within New Brunswick, or for regional gap analysis programs in general. Second, it provided information at the level of resolution required by land managers to implement landscape-level conservation objectives. As well, the estimated late-successional assemblage composition of each ecosite serves as surrogate for presettlement vegetation pattern, allowing an estimate of the level of forest cover conversion, either by permanent clearance or alteration of dominant

Table 1: *Hierarchical land classification categories within New Brunswick (DNRE 1996).*

Category	Scale	Description
Ecoprovince	1 :1,000,000	Broad-scale macroclimate from national climate maps.
Ecoregion	1 : 500,000	Macroclimate conferred from elevation, broad-scale aspect, and coastal proximity.
Ecodistrict	1 : 500, 000	Macro-scale landform from elevation, slope, and aspect; general terrain features; plus age and lithology of rock formations.
Ecosection	1 : 250,000	Meso-scale landform based on pattern and density of streams, plus mode of deposition, texture, and lithology of soils
Ecosite	1 : 12,500	Topoclimate conferred by slope, aspect, and slope position; broad-scale soil moisture and fertility from mode of deposition, texture, and lithology of soils.
Ecoelement	ground level	Microclimate conferred by soil moisture and nutrient regime, as well as discontinuous and unique physical elements such as rock outcrops and seeps.

forest cover species. Such information is vital for identifying forest assemblages most at risk, and for designing strategies for re-establishment when mature forest cover on certain ecosites has been drastically reduced in distribution relative to presettlement times.

classification

Ecosite classification used a rule-based algorithmic model incorporating in total six data themes: (1) coarse-scale climatic and geomorphologic variation, (2) elevation, (3) slope, (4) soil, (5) drainage, and (6) percent cover of late-successional forest stand types. Each of the six data themes were derivable from GIS data.

Regional variation in climate and geomorphology were approximated using the previously established boundaries of ecoregions and ecodistricts, respectively, for the province of New Brunswick (NBDNRE 1996). These boundaries had been determined using regional-source climatic data, coarse-scale topographic maps (1:500,000), marine water temperature data, and geology maps. It was assumed that environmental differences represented by these boundaries were sufficient to influence the species composition and relative proportion of forest species among these units, as well as factors such as site productivity and the distribution of other biotic groups (Zelazny *et al.* 1995).

Elevation and slope data were obtained using fine-scale digitized terrain mapping (DTM). Point elevation data (1:10,000) for the Province of New Brunswick are registered on a series of north-south lines running at 200 m intervals, with an average of 70 m separating points on the same line. These points were used to create a triangular irregular network (TIN), which was converted to raster-based DTM's with 100 m cell resolution. The DTM's were interpreted for slope, aspect, and elevation. Twenty elevation classes were created at 20 m intervals up to 400 m ASL, the maximum elevation in the study area. Ten slope classes were created, incorporating percent sloped area per polygon up to 50%, the maximum slope value that occurs. Preliminary assessment of vegetation change in relation to aspect revealed no consistent trends (V. Zelazny, *pers. comm.*), and aspect was removed from this analysis.

Soil and drainage data were compiled from The Forest Soils of New Brunswick (Colpitts *et al.* 1995). Forty-four provincial forest soil units occurred in the study area, with each unit connoting homogeneity in the geological origin of the soil parent material, profile characteristics, and mode of deposition. Drainage values for each soil unit were available in six different classes ranging from rapidly draining to very poorly drained.

Percent cover of late-successional forest stand types were obtained from the NBDNRE forest inventory, a 1:12,500 photo-interpreted database available across the province (NBDNRE Timber Management Branch 1986). In total, six stand types were employed, representing the dominant tree species assemblages associated with mature stages of forest development in New Brunswick. Early successional tree species assemblages indicative of anthropogenic disturbance were not used in the analysis.

Ecosite classification involved a series a step-wise incremental groupings that progressively simplified the environmental variation represented by the six data phases. First, to minimize macroclimatic variation, ecosite classification was conducted separately in each of the regions. Next, the categories within the soil, slope, elevation, and drainage data themes were broadened, thereby reducing the number of categories in each. The forty-four soil types were reduced to a maximum of six categories per ecodistrict, with the number of categories determined by the environmental diversity of the region. Four of the categories were based on fertility levels, ranging from fertile soils derived from weatherable calcareous sedimentary parent materials to infertile coarse-textured glacial-fluvial deposits composed of igneous coarse fragments. The two remaining two soil classes were intervale soils or peat-based organic soils. Elevation, drainage, and slope were reduced by grouping each into three broad categories. Vegetation information was used in some cases to assist in the delineation of these categories. For example, a sharp consistent transition from *Picea rubens-Abies balsamea* forest to deciduous-dominated forest occurred at an elevation of 160 m within the Upland district (Power & Matson 1995), and this transitional boundary was used to define one of the elevational divisions. The end result of these reductions was a maximum of 162 (6x3x3x3) hypothetical combinations of environmental variation per district. The GIS data was then used to determine which of these combinations actually occurred. The final step assigned the late-

successional forest cover data to each combination. This information; plus the soil, drainage, slope, and elevation data; was then used to designate each of the combinations into one of twenty-seven possible ecosites using an aspatial tabular analysis developed by Zelazny *et al.* (1989, 1995).

Assignment of conservation priority rankings

Three different data sets were used to assign conservation priority rankings for each identified ecosite: the size of the "gap"; the percentage of area converted to settlement, agriculture or plantation; and the pattern of land ownership.

Gap size was calculated by comparing total ecosite area with the area of reserves and supplemental sites found within each ecosite. A twelve percent standard was used to assess if ecosite protection, in the form of reserves or the supplemental sites, met minimum representational requirements. The twelve percent standard was based on recommendations by the IUCN and the World Commission of Environment and Development (WCED) to protect at least 12% of each nation's land base in a representative manner (WCED 1987, IUCN 19--). It is well recognized that 12% is only a minimum and may not be sufficient to maintain the viability of some ecological systems. It also does not address issues such as reserve size and shape, or spatial orientation relative to other similar reserve types. This standard only serves as a first cut at assessing the degree of existing, as well as proposed, protection for identified ecological units across a region or landscape.

Percentage of permanently converted land per ecosite was calculated using photo-interpreted (1:12,500) data that identified farms, roads, settlements, quarries, and other similar areas. Forest plantations were also classified as permanently converted land for this analysis. Forest plantations represent the conversion of mixed-species mature forest to silvicultural monocultures, and can contain substantial changes in microclimate, levels of coarse woody debris, soil fertility, and species composition compared to non-plantation forests (Freedman *et al.* 1995). As well, some plantations in the study area have been established using trees species not native to Canada, such as Norway spruce (*Picea abies*) and European larch (*Larix*

decidua).

The pattern of land ownership was determined for each of the identified landscape units using an GIS overlay of property boundaries assigned to one of the three ownership groups.

Each ecosite was assigned a conservation priority ranking (Table 2) determined by the combination of gap size, percent habitat conversion, and ownership, with gap size, especially in reference to existing protected areas, being most heavily weighted in importance. For land ownership, it was assumed that private ownership presented the greatest challenge to meeting the minimum representational standard of 12% protection. Within the FMF, most private lands are controlled by multiple owners with highly divergent management objectives. The process of contacting land owners and subsequently designing cooperative management programs that protect and maintain valued conservation features is extremely time intensive. Sites found on government or industrial lands, while still at risk, are at least easier to tackle with only one property owner to approach.

Results

Ecological land classification and gap analysis

Twenty-nine ecosite units were identified within the FMF (Table 3), with seven assemblages each in the Coastal and Upland regions and fifteen in the Interior Valley (Fig. 3) region. Average unit size was 14,187 ha; median unit size was 4662 ha. The largest ecosite type, A6 (Interior Valley *Picea rubens-Abies balsamea* on nutrient poor slopes), covered 98,171 hectares or 23% of the entire study area. The smallest ecosite type, U5 (Upland *Picea mariana-Abies balsamea-Thuja occidentalis* bottomland), covered only 53 hectares.

Sixteen of the ecosites were found to be completely unprotected by existing reserves. All but one occur in the Interior Valley, the region most populated and heavily farmed. The undulating topography and generally poor nutrient status of the Uplands and Coastal region

Table 2: *List of conservation priority categories.*

Code	Category	Description
1	Very high	Little or no existing protection, with >20% clearance and >75% private ownership.
2	High	Existing protection <12%, with >50% private ownership
3	Moderate	Minimum protection standard exceeded by combined existing and proposed protected areas, with moderate-to-low levels of clearance, and <50 private ownership
4	Low	Existing protection >25%, with clearance <25% and private ownership <50%.

Table 3: Ecosite descriptions, including median values of environmental variables used to classify each ecosite unit. Elevation (E) values range from 1 (low) to 3 (high). Soil (S) ranges from 1 (high fertility) to 4 (low fertility), with 5 indicationg intervale soils, and 6 indicating organic peats. Drainage (D) ranges from 1 (well drained) to 3 (poorly drained). Slope (Sl) ranges from 1 (gentle) to 3 (steep).

Region	ES	E	S	D	Sl	Description
Coast	C1	1	4	1	1	*Picea rubens-Abies balsamea* forest on acidic coarse-textured soils.
	C2	2	3	3	1	*Picea rubens-Abies balsamea* forest on wet acidic till plain.
	C3	2	6	3	1	*Picea mariana* forest on coastal bog.
	C4	2	3	1	2	*Picea rubens* forest on well-drained nutrient deficient steep coastal ravine slopes.
	C5	1	2	2	2	*Picea rubens-Betula alleghaniensis* mix on gentle mid and lower slope sites with moderate drainage and fertility.
	C6	3	2	2	1	*Picea rubens* forest on moderately drained coastal plateau.
	C7	2	2	1	2	*Picea rubens-Betula alleghaniensis* forest on moderately fertile and moderate to well drained upper slopes.
Upland	U1	1	3	2	2	*Picea rubens-Abies balsamea* forest on lower slopes with acidic moderately-drained soils.
	U2	2	3	3	2	*Abies balsamea-Picea rubens* forest on wet acidic till plain
	U3	2	3	1	3	*Abies balsamea-Acer saccharum-Picea rubens-Betula alleghaniensis* forest on acidic steep slopes
	U4	2	2	2	2	*Picea rubens-Abies balsamea-Acer rubrum*, with some tolerant hardwood, on gentle mid- and upper-slopes and low relief hilltops with moderately drained soils
	U5	1	5	3	2	*Abies balsamea-Picea mariana-Thuja occidentalis* forest on poor- to moderately-rich and well-drained bottomland soils
	U6	3	2	2	3	*Acer saccharum-Picea rubens-Betula alleghaniensis-Fagus grandifolia* on well-drained and moderately fertile ridges

	U7	3	3	1	3	*Acer saccharum-Picea rubens-Fagus grandifolia* on well-drained nutrient-defiecient steep slopes
Valley	A1	1	4	1	1	*Picea rubens-Abies balsamea-Pinus* spp. on acidic coarse-textured soils.
	A2	1	4	2	1	*Picea rubens-Picea mariana* forest, with *Abies balsamea* and *Acer rubrum*, on low elevation gentle slopes with coarse-textured acidic soils.
	A3	1	3	3	1	*Picea mariana-Picea rubens* forest, with *Acer rubrum*, on wet acidic till plains.
	A4	1	6	3	1	*Picea mariana* bog.
	A5	2	3	1	2	*Picea rubens-Acer rubrum-Abies balsamea-Betula papyifera* forest on well-drained nutrient-poor slopes.
	A6	2	2	2	2	*Picea rubens-Abies balsamea* forest on nutrient-poor slopes.
	A7	2	2	3	1	*Picea rubens-Picea mariana-Abies balsamea*, with some *Pinus banksiana* or *Thuja occidentalis*, on bottomland intervale soils.
	A8	1	5	3	1	*Picea marianan-Abies balsames-Acer rubrum* on mid-elevation bottomland sites with poor drainage
	A9	2	5	3	2	*Thuja occidentalis*, with *Picea mariana*, on calcareous-enriched till plains.
	A10	2	2	2	2	Red spruce-balsam fir-red maple-black spruce on moderately drained upper slopes.
	A11	1	5	2	1	Red spruce-balsam fir-black spruce forest on high-elevation bottomland sites with moderate drainage. Silver maple-green ash-american elm forest occurs on seasonally flooded lands near the St. John River.
	A12	3	1	2	2	Red spruce-balsam fir-eastern cedar, with tolerant hardwood, on calcareous upper slopes.
	A13	2	2	1	2	Tolerant hardwood forest on well-drained mid-elevation slopes and ridges
	A14	3	1	1	2	Sugar maple-beech forest, with red spruce, white ash and hemlock, on calcareous-enriched ridges
	A15	3	3	1	2	Tolerant hardwood-red spruce forest, with some pine and red maple, on dry high elevation ridges with moderately-infertile soils

have limited levels of permanent land clearance. Some of the steep coastal ravines are inaccessible and have never been harvested, with stands of *Picea rubens* occasionally exceeding 300 years of age.

Thirteen ecosite units were captured in part by either Fundy National Park or the three Conservation Areas, and only two, U1 and U7, did not meet or exceed the 12% minimum standard for protection (Table 4). All but one of the units that met minimum protection levels were over 20% protected, with two having over 80% of their total area captured. Most of the protected area was contained within Fundy Park. The Conservation Areas added no more than 6% additional protection to any of the ecosites, reflecting the fact that their size and boundary location were not specifically designed to address protection needs at the ecosite level.

The two sets of supplemental sites captured parts of all but four of the 29 identified landscape units in the FMF. However, only thirteen of these ecosites had greater than 12% of the land base contained within one or the combination of these sites, and ten of these thirteen units were already represented by the existing protected areas at 12% or more.

The boundaries of the three coarse-scale representative areas identified using landform variation straddled multiple ecosites but captured no more than 5% of all but one assemblage. The exception was A15 (Interior Valley high elevation dry hardwood ridge) which had 28% of its total area captured.

The small size of most of the fine-scale proposed sites meant that they covered a very small percentage of most units, except when the ecosite itself was limited in total area. In only two cases, C3 (Coastal *Picea mariana* bog) and A4 (Interior Valley *Picea mariana* bog), did the fine-scale sites contribute over 12% coverage that were not already captured by the other larger conservation areas.

Converted land

The percentage of permanently cleared land and forest plantations per ecosite ranged from

Table 4: *Summary of gap analysis results using the minimum 12% representation target for each ecosite.*

Unit	Area (ha)	Existing Protected (%)			Supplemental Sites (%)		Total Gap	Priority rating
		Fundy Park	Other	Total	fine	1:500,000	(existing + suppl.)	
A12	15,343	0	0	----	0	0	----	1
A14	225	0	0	----	0	0	----	1
A9	222	0	0	----	0	0	----	2
U5	53	0	0	----	0	0	----	1
A8	4,484	0	0	----	0.04%	0	0.04%	1
A1	13,950	0	0	----	0.2%	1.5%	1.7%	1
A6	97,150	0	0	----	0.8%	1.7%	2.5%	1
A5	38,297	0	0	----	0.6%	2%	2.6%	2
A10	32,923	0	0	----	0.3%	3%	3.3%	1
A7	8,542	0	0	----	3%	0.6%	3.6%	2
A13	20,931	0	0	----	4%	0.7%	4.7%	2
A11	1,331	0	0	----	5%	0	5.0%	1
A2	48,965	0	0	----	0.7%	5%	5.7%	2
A3	34,697	0	0	----	1.4%	5%	6.4%	2
U1	1,317	6%	0	6%	2%	0	8%	2
U7	1,596	6%	0.06%	6%	4%	0	10%	2
A4	2,680	0	0	----	19%	0.3%	19.3%	2
U2	2,792	21%	0.1%	21.2%	3%	0	24.3%	3
U6	37,889	23%	0.7%	23.7%	0.8%	0	24.5%	3
C2	563	13%	0	13%	13%	0	26%	3
U4	11,567	25%	1%	26%	0.9%	0	26.9%	4
C6	10,785	23%	2%	25%	5%	0	30%	4
A15	11,390	0	0	----	1.8%	28%	30.6%	2
U3	6,886	41%	5%	46%	4%	0	50%	3
C1	117	23%	0	23%	30%	0	53%	4

C4	4,662	39%	3%	42%	35%	0	77%	4
C3	134	0	0	----	88%	0	88%	3
C5	109	80%	4%	84%	9%	0	93%	4
C7	973	85%	6%	91%	6%	0	97%	4

65% to 4% (Table 5). The most affected units occurred on alluvial bottomlands, calcareous-enriched soils, or coniferous till plains. The ecosite units least affected by permanent clearance or conversion to plantations occurred on slopes and ridges, or poorly-drained acid or organic soils. The ecosites with the highest percentages of habitat conversion were also those with the lowest levels of existing and proposed protection (Fig. 4).

Land ownership

Distinct land ownership trends exist among the three major climatic regions (Fig. 5). The Interior Valley was dominated by private land ownership (73%), with the remainder divided between crown (13%) and industrial (14%). The Coastal region was mostly controlled by either crown (62%) or industrial (28%). The Uplands were divided relatively evenly among private (39%), crown (35%), and industry (25%). These ownership trends reflected settlement history, a function of topography and site productivity. The ecosite units occurring on gentle slopes and edaphically-rich soils were mostly small private land holdings. In general, the non-industrial private land was the least protected by existing reserves or recently identified supplemental sites (Fig. 6). Conversely, the ecosites found on poorly drained and infertile soils or areas with undulating topography tended to be controlled by the crown or industrial interests, and were better protected.

Conservation priority rankings

Eight ecosite types received a very high priority ranking (Table 3), with little or no existing protection, greater than 20% permanent land clearance or conversion to plantations, and predominantly private ownership. Seven of these eight units were found in the Interior Valley region. Eleven ecosites had moderate or low priority rankings, occurred in the Coastal or Upland regions, and were captured in part by Fundy Park and the Conservation Areas.

Table 5: Percentage of permanently cleared land and established forest plantations for each ecosite within the study area.

Unit	Area (ha)	Cleared	Plantation	Total (%)
A8	4618	3015 (65%)	11 (0.2%)	65%
A11	1331	627 (47%)	7 (1%)	48%
A14	225	95 (42%)	1 (0.4%)	43%
A10	31,950	11,617 (36%)	686 (2%)	39%
U5	53	20 (38%)	0	38%
A1	13,949	4127 (30%)	329 (2%)	32%
A12	15,343	3956 (26%)	555 (4%)	29%
U2	2792	69 (2%)	682 (24%)	27%
A3	34,696	7597 (22%)	1101 (3%)	25%
C5	109	24 (22%)	2 (2%)	24%
A6	98,171	17,361 (18%)	5583 (6%)	23%
U4	11,567	430 (4%)	2161 (19%)	22%
C6	10,785	188 (2%)	2227 (21%)	22%
A2	48,964	5382(11%)	3298 (7%)	18%

A7	8707	873 (10%)	544 (6%)	16%
U1	1317	125 (9%)	88 (7%)	16%
U6	37,889	1365 (4%)	4657 (12%)	16%
A5	38,717	4671 (12%)	724 (2%)	14%
A9	222	5 (2%)	27 (12%)	14%
A4	2678	342 (13%)	14 (1%)	13%
C1	117	15 (13%)	0	13%
U7	1596	55 (3%)	136 (9%)	12%
A13	20,931	1509 (7%)	824 (4%)	11%
C2	563	5 (1%)	44 (8%)	9%
C4	4662	118 (3%)	85 (2%)	5%
U3	6886	185 (3%)	174 (3%)	5%
C7	973	48 (5%)	1 (0.1%)	5%
A15	11,390	282 (2%)	155 (1%)	4%
C3	134	0	4 (3%)	3%

Discussion

Gap analysis

Results of the gap analysis clearly demonstrate that in the FMF, existing protection of ecosite-level features is unsystematic and skewed towards less settled areas characterized by poor soils and undulating topography. As well, the two sets of supplementary sites fail to meet minimum protection requirements for ecosite units currently not sufficiently represented by existing reserves.

The lack of systematic conservation protection at regional levels is a common trend, as is the bias towards the protection of lands with relatively limited economic importance (Pressey 1994, Pressey & Tully 1994). While the Coastal and eastern Upland regions of our study area do have considerable timber value, this value exists in part because the land was largely abandoned at the turn of this century. The formation of Fundy National Park occurred following a rapid decline in the lumber industry along the Bay of Fundy coast in the late 1800s . As profits declined and mills closed, tourism was seen as a way to revitalize the region's economy by providing recreational opportunities, such as fishing, golf, and Bay of Fundy viewscapes (Hirvonen & Madill 1978). The three new Conservation Areas were a provincial government initiative and had a combination of objectives, including the protection of rare flora and deer wintering areas, and capture of the upper reaches of a major Fundy Park watershed that was previously unprotected. Unfortunately, the Conservation Areas contribute little towards improving the level of ecosite representation in southeastern New Brunswick, in part reflecting the fact that Conservation Areas can only be established on government-owned land. It is no coincidence that government land in the study area is also restricted to the Coastal and eastern Upland regions.

When regional protected area networks are unsystematic, typically it is the locations most suited for agriculture and permanent settlement that are least protected and have undergone the highest levels of habitat conversion (e.g. Shafer 1994, Rudis 1995, Llewellyn *et al.* 1996). This is also the case in the FMF. While all three regions have experienced considerable human disturbance since the onset of colonization, including the area now contained by Fundy National Park, it is

the Interior Valley region that has had the most persistent and intensive land use. Ecosites in this region have been permanently cleared by as much as 65%, and forest cover data reveals little or no remnant mature canopy. A companion analysis on the distribution and conservation status of rare flora in the study area (MacDougall *et al. unpublished*) indicated that the Interior Valley ecosites host as many as fifteen taxa which now appear to be extirpated, plus numerous other provincially-uncommon, -rare, or -very rare taxa with uncertain futures due to habitat loss.

The combination of high levels of habitat conversion and no existing protection, plus ownership dominated by small-sized private land holdings is a difficult mix for achieving minimum conservation objectives in the Interior Valley region. First, traditional agrarian-based land use practices are firmly established, and developing alternative strategies that create space for a protected areas network will not be easy. Second, given the high levels of habitat conversion and apparent displacement of many ground flora taxa, some ecosites will need to be actively managed to create and maintain protect the late-successional forest assemblages and associated biota that originally occurred in the area. Finally, the ownership diversity of the area represents the greatest challenge for meeting minimum conservation targets. The process of contacting and informing land owners of their properties' significance, and explaining and implementing management options is highly time consuming. This process is further complicated when there are multiple owners with diverse and possibly contrasting property objectives. In the end, a patchwork of strategies may be required to meet the end goal of preserving the existing ecological values for any site. Given these complications for achieving conservation objectives in heavily utilized landscapes, it is evident that the areas most in need of conservation action will also be the most difficult to work with. A gap analysis such as ours can do no more than serve as a guide to where these priority areas occur, which can focus conservation effort on the areas most in need.

The two sets of supplemental sites captured portions of many of the unprotected ecosite units identified in the Interior Valley region, as well as capturing portions of ecosites in the other regions already protected in part by existing reserves. However, in only three cases did the level of coverage provided by these sites in the unprotected ecosites exceed our 12% minimum representational standard. Of the remaining sixteen unprotected ecosites, four were completely missed by the supplemental sites and the others had no more than 10% coverage. Conversely,

in the ten ecosites that were protected by at least 12% by existing reserves, coverage by the supplemental sites was 19% or higher.

The failure of the supplemental sites to meet representational targets has three explanations. First, neither program was established to represent landscape-level environmental variation. The coarse filter program sought landform representivity, seeking out broad environmental gradients that hosted a diverse array of forest assemblages. This analysis was too coarse to capture the full range of landscape-level variations found in the FMF. The fine-scale program was focused at the community level, identifying sites hosting rare or threatened species, as well as local species rich hotspots or habitat-restricted biotic assemblages, such as those found on cliff faces, seep zones, wetlands, and in aquatic habitats. These sites were usually too small to adequately represent the ecosites within which they occur. As well, the distributions of these fine-scale features may be more subject to local-level process such as competition, random distribution events, and micro-habitat features variation, than to environmental variations at the landscape-level. Second, the fine-scale sites focus on only extant features. In the Interior Valley region, the high level of habitat conversion means that where community-level sites do persist, if they persist at all, they are usually small and isolated habitat remnants. Finally, because the coarse-scale sites were identified on a province-wide basis and the Interior Valley region extends greatly beyond the FMF boundary, this region is captured in part at other locations. The problem however, is that this program was largely restricted to crown lands. At the provincial level, crown land covers many major landform divisions. However, this is not the case for the heavily farmed ecosites throughout the Interior Valley region which is currently unprotected and thus the conservation problems identified in our study area extend across its entire range.

The failure of the supplemental programs to meet minimum representational targets supports the notion that any comprehensive plan for biodiversity protection must have a multi-levelled focus for both spatial scale and biological organization (Noss & Cooperrider 1994, Kershaw *et al.* 1995, Kiester *et al.* 1996). The objective of any singular conservation strategy, and the scale at which it is conducted, determines which features are captured and sites identified by one program will not necessarily coincide with sites identified by other programs. For

example, hotspots of species richness and locations of rare species may not be coincident (Prendergast *et a*l. 1993), nor may species-rich areas and sites hosting threatened species (Kershaw *et al.* 1993). As a result, a combination of approaches is necessary to adequately detect the variations in biological diversity that occur across spatial and scalar axes. Once established, reserve selection algorithms can be designed (e.g. many references) to maximize the overlap of various site types in as small an area a possible, a relevant concern given limited availability of land for conservation purposes in working landscapes.

Ecological land classification

The intricacy and spatial explicitness of an ecological land classification is determined by the scale at which the classification is conducted. As resolution improves, the increased level of descriptive information permits detection of pattern not apparent at coarser scales. Coarse-scale ELC tends to average out variation, achieving predictive consistency at the expense of spatial accuracy (Costanza & Maxwell 1994). However, the advantage of improved resolution at finer scales is offset by the heterogeneity of the data, which can make meaningful delineation of ecological boundaries difficult. Data variability is especially prevalent when using forest cover information to classify ecosystems in heavily disturbed landscapes. Under these circumstances, vegetation cover varies widely in species composition and successional status depending on disturbance and stand history. At regional levels, such variability does not obscure the observable relationship between environmental pattern and overstory composition (Host & Pregitzer 1992, Host *et al.* 1996). However, the relationship between habitat and forest cover pattern becomes more complex at local levels, potentially rendering classification of landscape pattern using vegetation alone highly subjective and non-replicable, and saying little about the distribution of presettlement assemblages or how distribution pattern has changed since colonization. Given these considerations, fine-scale ELC must achieve a balance between the spatial accuracy of the classification, the scale at which the classification is conducted, and the types of databases employed.

For our purposes, a hybridization of several data sets, with an emphasis on abiotic information, provided a means for classifying fine-scale ecosystem variation within the FMF.

Having access to multiple data attributes for any given landscape scene reduced uncertainty when attempting to distinguish and delineate ecosystem units within our highly heterogenous landscape. Two particular problems plague the classification of vegetation units at fine scales, apart from transitions caused by human disturbance. First, there is often an absence of sharp, visually-apparent boundaries separating forest units. Instead, zones of transition among assemblages may extend many kilometres in length. Second, some forest units differ in proportion rather than composition of dominant species, and that these proportional differences may not be visually apparent. Even using high resolution vegetation data from satellite images or low-level aerial photographs, it is difficult to identify where breaks occur between interwoven assemblages, or to determine if observed proportional variations are random, disturbance-induced, or the result of underlying environmental change. In our situation, the combination of slope, soil fertility, elevation, and drainage coverages provided an objective criterion for separating visually diffuse landscape units. In many cases, the estimated late-successional canopy composition differed among ecosites in proportion rather than species composition. For example, the seven Coastal ecosites were dominated by unique combinations of *Picea rubens, Abies balsamea, Picea mariana, and Betula alleghensis*, with the differences being determined by slope, coastal proximity, elevation, and drainage (Zelazny, *unpublished*). Proportional shifts in canopy composition among ecosites also occurred due to disturbance, and site factors such as drainage, topography, and slope also influenced the type, frequency, and intensity of disturbances in a predictable fashion. For example, in low elevation, well-drained, and poorly-fertile areas in the Lowlands region (U5), fire frequency is relatively high, and species composition reflects this, with increased levels of jack pine and white pine compared to adjacent, poorly drained areas.

One result of employing an abiotic-based ELC appears to be the creation of a classification system more finely-divided compared to vegetation-based classifications conducted at similar scales (Strittholt & Boerner 1995). Given that dominant forest cover species may be insensitive to certain environmental variations, vegetation-based classifications will tend to underestimate habitat changes that may be significant for the distribution of other biotic groups. If so, this has two implications. First, an abiotic-based ELC that captures fine-scale environmental variability will create a more effective coarse filter for capturing biological

diversity from all biotic groups. The less finely-divided vegetation-based ELC will only capture those biotic groups whose distributional patterns mirror the distributional pattern of the extant forest cover. Second, there may be considerable intraspecific genetic variation in relation to environmental factors in widespread forest tree species, and a finely divided ELC based on abiotic variability will be more effective at capturing this variation. Under hypothesized climate change scenarios, maintaining intraspecific variation will be important for adaptation to future changes.

The limitation of a finely-divided ELC is that, compared to less intricate classification systems, a much larger total reserve area is required to meet minimum conservation standards for each identified landscape unit (Pressey & Bedward 1991). However, we believe that the creation of a more effective coarse-filter plus the capture of a wide range of intraspecific genetic variation necessitates the use of an intricate fine-scale ELC to judge the adequacy of representivity. Rather than reduce conservation targets, efforts should be focused at finding alternative means to achieve conservation objectives. For example, minimum representational targets do not necessarily have to be achieved via strict protection. It may be possible to sustain the ecological integrity of certain landscape level assemblages by specially designed forest management programs, rather than doing nothing because strict protection is impossible.

Conclusion

The FMF has been subject to persistent anthropogenic disturbance since the onset of European colonization, resulting in extensive alteration of forest cover pattern. In our analysis, it was obvious that the location, type, intensity, and duration of this land use activity was strongly influenced by factors such as site productivity and accessibility. Similarly, past conservation efforts have been focused on locations where past utilization has been limited due to these same site factors. This bias reflects in part the higher conservation value of less utilized areas (e.g. less disturbed sites have more mature forest stands). However, it also reflects a relatively lower economic loss involved in removing such areas from production. The Coastal and Upland regions have a low density of permanent land activity compared to

the Interior Valley region, and while these less-settled regions are heavily timbered, protection is easier to attain than if they were farmed or settled. Using our abiotic-based gap analysis, we were able to demonstrate the unsystematic distribution of existing protected areas, and highlight the need for immediate conservation action in landscape-level habitat units found in the Interior Lowlands.

The results of our analysis only represent the first step towards meeting minimum representation of ecosites within our study area. Once conservation priorities are established, the next step is the development of strategies to meet protection targets. However, given past land use trends, continued intensive land utilization, and the ever growing for demand for natural resources at local, national, and global levels, achieving conservation objectives will be challenging. Such difficulties emphasize the need for broad-ranging conservation initiatives that integrate a range of protection strategies, including land stewardship programs, and special management initiatives geared to protect or promote the expansion or re-establishment of particular biotic features. The information provided by our analysis can now serve as the foundation upon which such efforts can be based.

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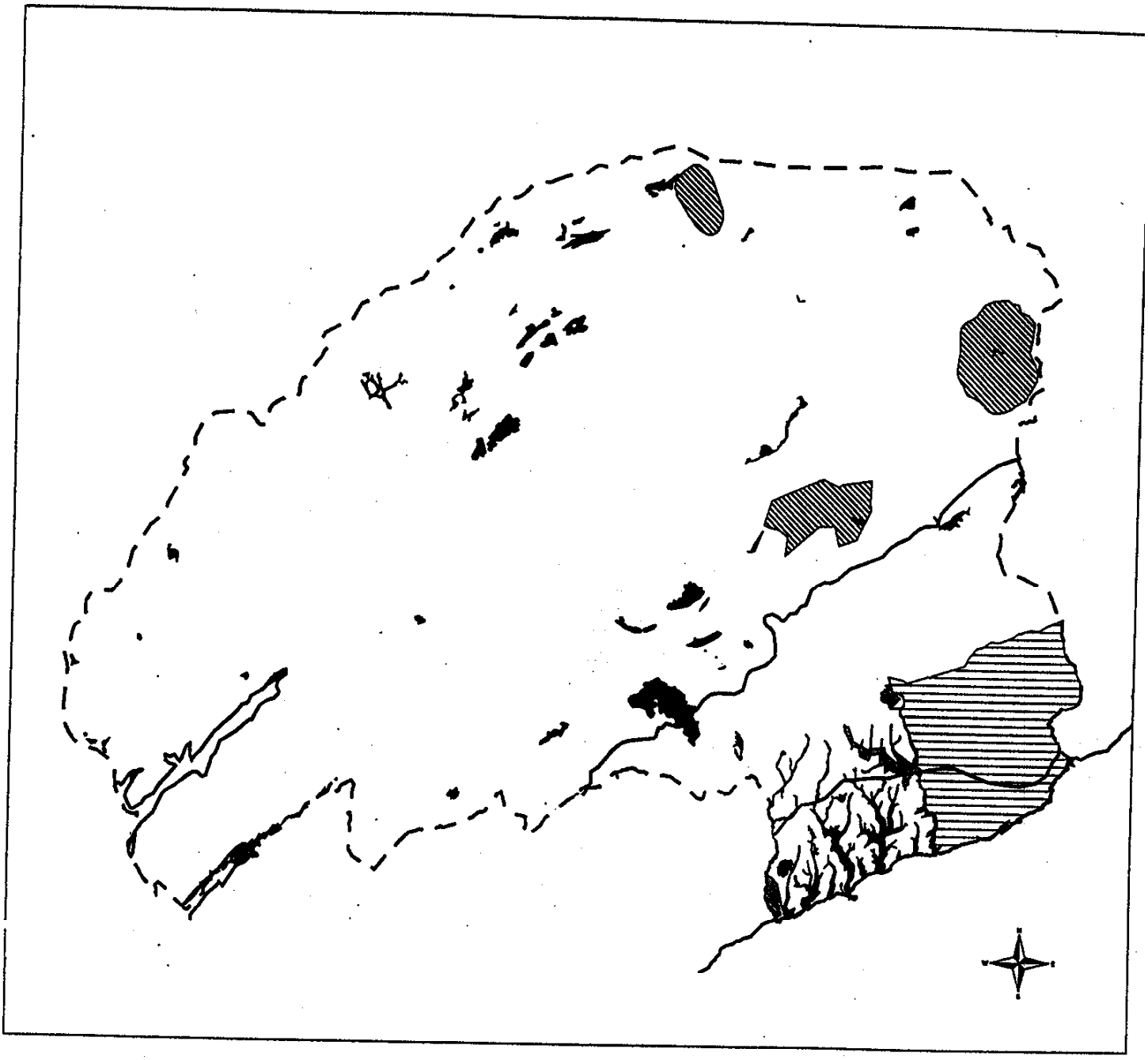
Fig. 1. Map of existing reserves and supplemental sites in the study area.

Fig. 2. Ecosite map for each of the three study area regions.

Fig. 3. Relationship between percentage of permanent land clearance and percentage of protection in each ecosite.

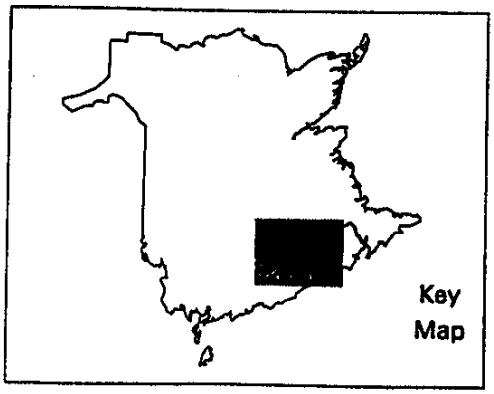
Fig. 4. Relationship between percentage of private ownership and percentage protection in each ecosite.

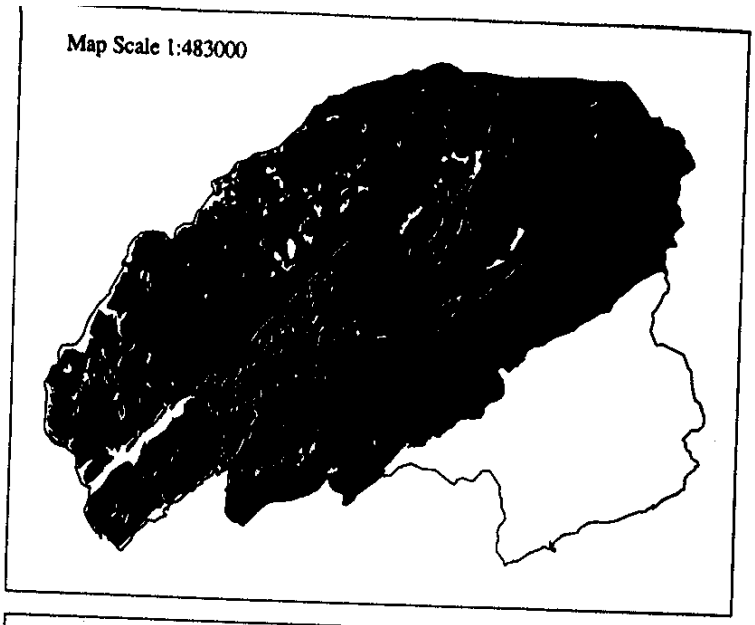


Legend

- FMF Fine Filter Site
- DNRE Conservation Area
- Coarse Filter Site
- Fundy National Park
- Ecoregion Boundary
- FMF Boundary

Map Scale 1:496889
1 cm = 4.97 km





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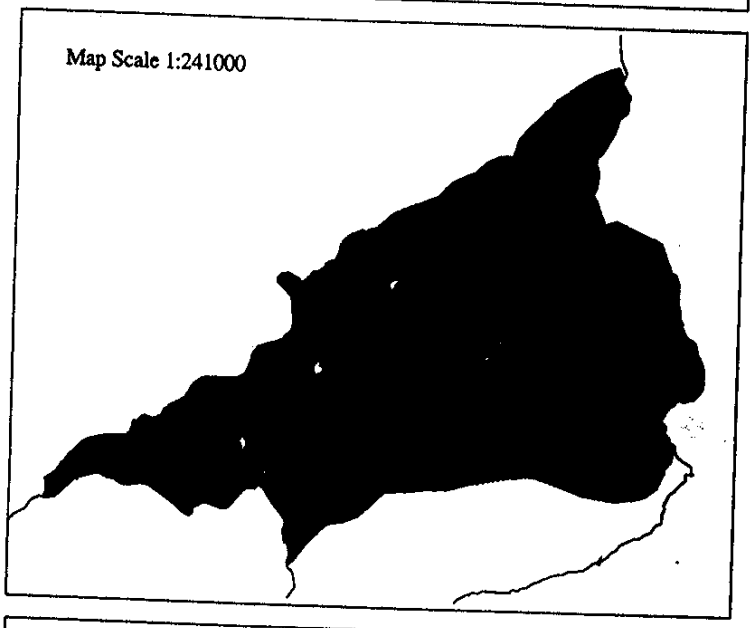

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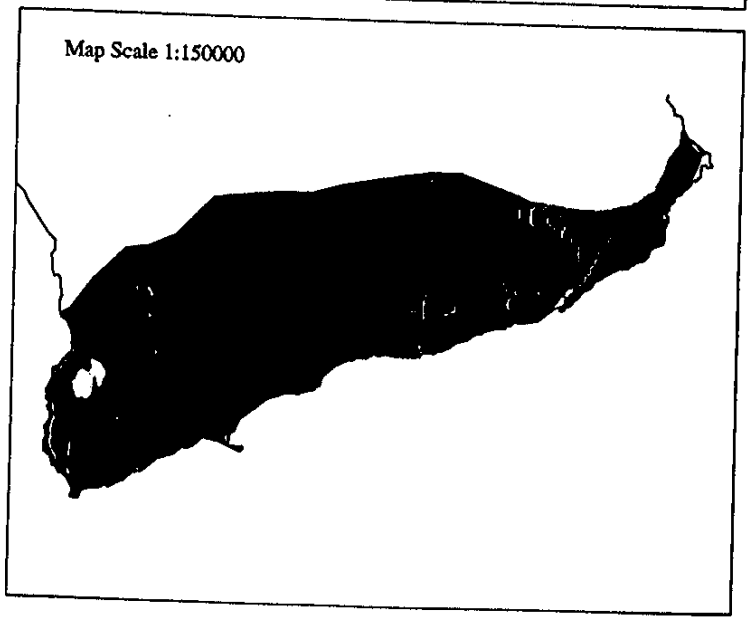

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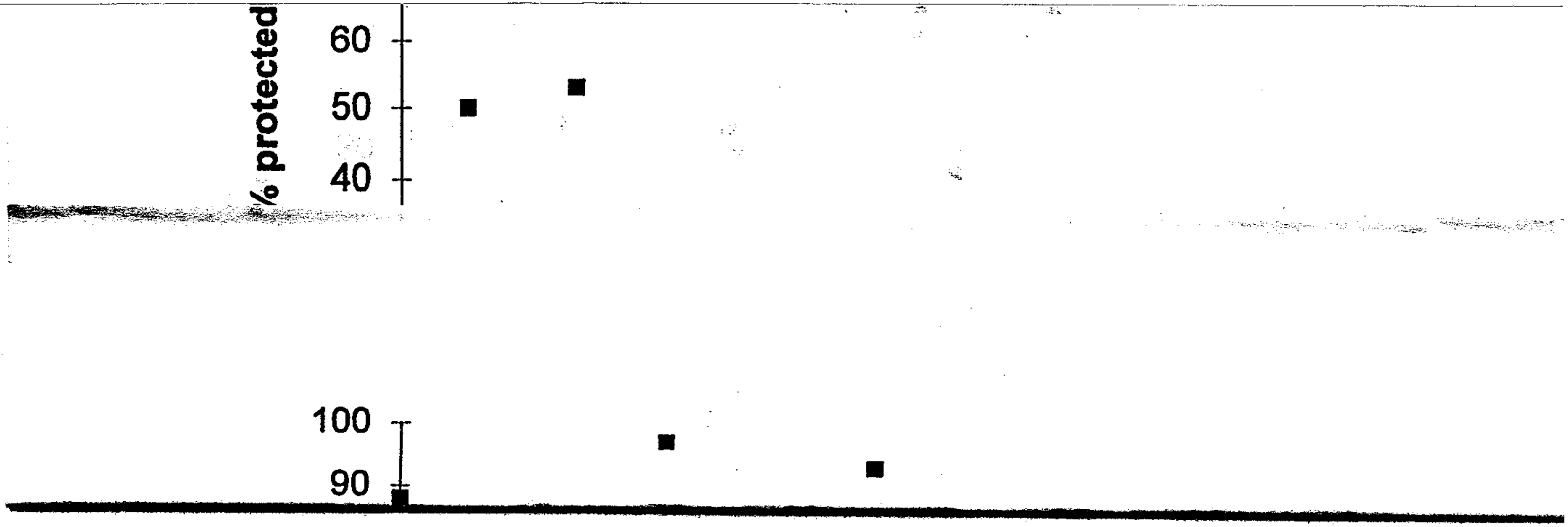
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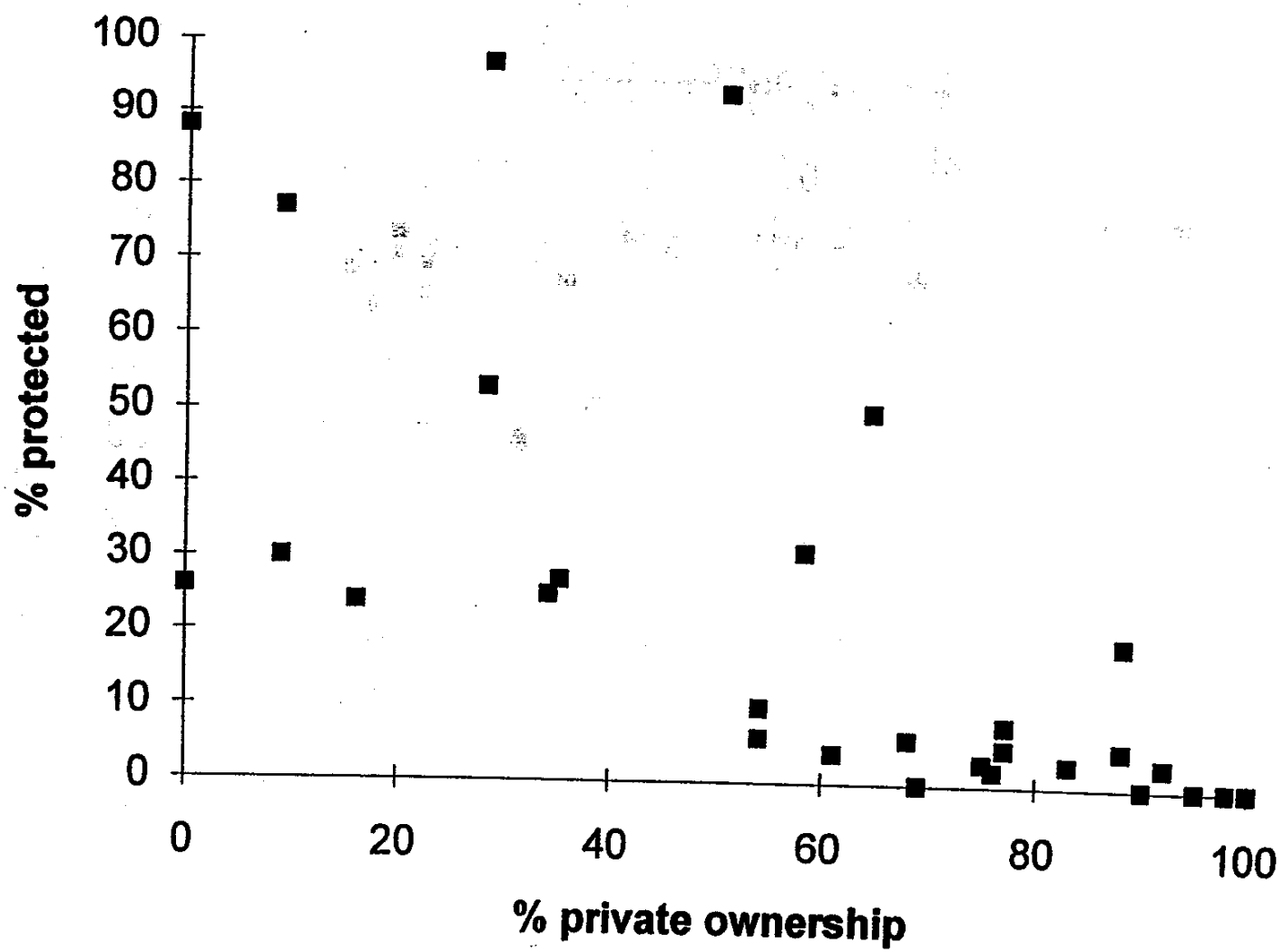
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