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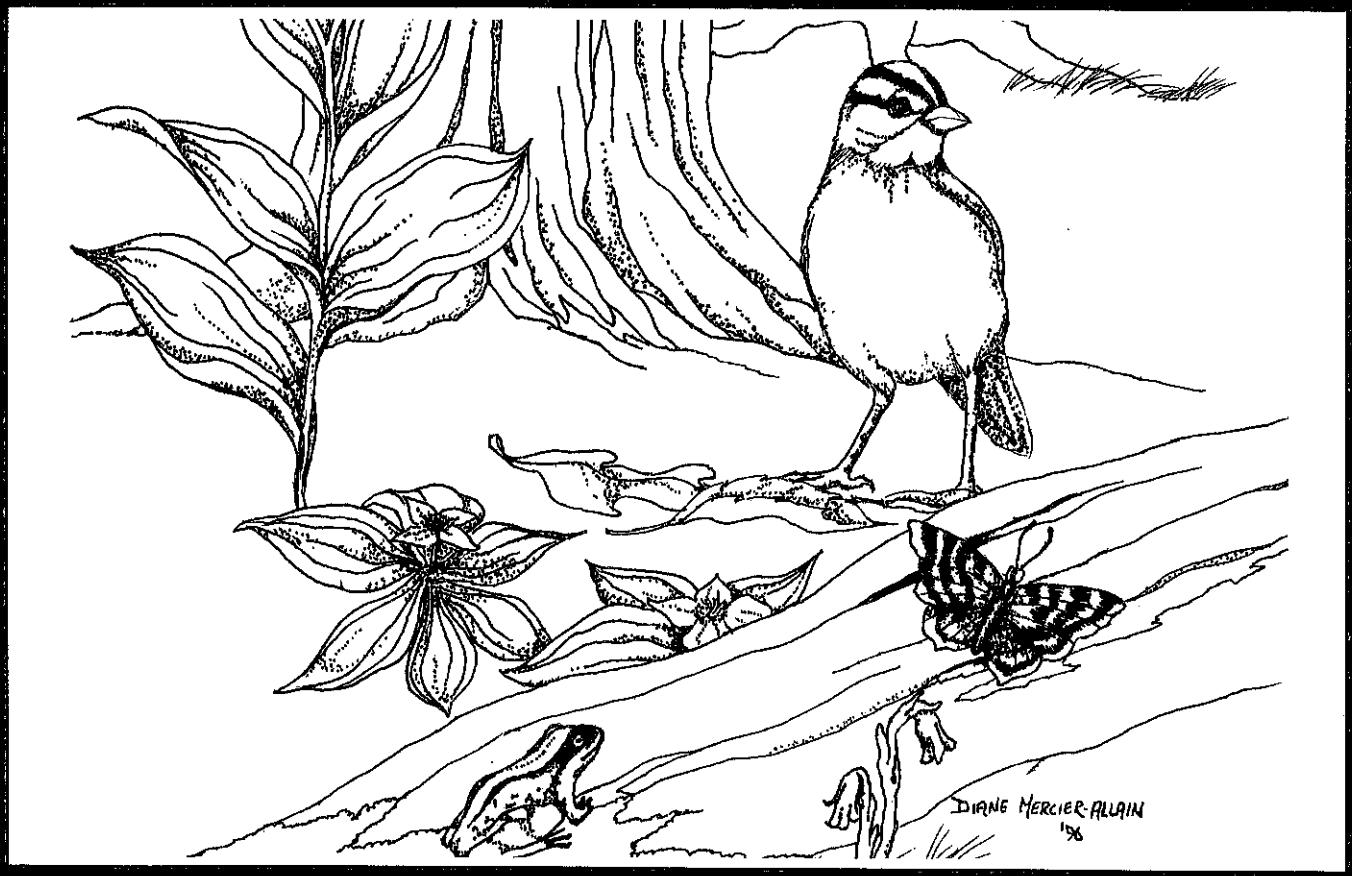
Andrew MacDougall
and
Judy Loo

Canadian Forest Service - Atlantic Forestry Centre
Information Report M-X-198E



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Abstract

This report identifies and describes spatially restricted and ecologically significant community types that occur within the 420 000-ha Fundy Model Forest of southeastern New Brunswick. The purpose of the report is to draw attention to the presence of these biotic features within the Fundy Model Forest, and highlight their contributions to the biological diversity of the area. These small features are often overlooked when designing landscape-level forest management strategies and, without special management, they are vulnerable to species loss. Twenty-four fine-scale community types were identified. They include remnant patches of late successional forest types, various wetland assemblages, and specialized communities inhabiting rock faces, talus slopes, shorelines, and caves. Habitat features, general location within the Fundy Model Forest, characteristic biota, and all known uncommon and rare species are given for each community type. The level of descriptive detail provided for each community type depended in part on the level of existing information on the distribution of the communities, as well as the species they contain. Past human disturbance history, when known, and existing and future threats are also presented.

Résumé

Le présent rapport fait ressortir et décrit les types de communautés à petite échelle de grande importance écologique que renferme la forêt modèle de Fundy, une zone de 420 000 ha située dans le sud-est du Nouveau-Brunswick. Le rapport a pour but d'attirer l'attention sur la présence de ces biotes dans la forêt modèle de Fundy et de souligner leurs contributions à la diversité biologique de la région. On oublie souvent de tenir compte de ces éléments d'envergure restreinte lors de l'élaboration de stratégies d'aménagement forestier visant l'ensemble du paysage et, sans une gestion spéciale, ils sont vulnérables à la disparition d'espèces. Vingt-quatre types de communautés à petite échelle ont été relevés, dont les suivants : petits îlots résiduels de forêts de succession normale avancée, diverses communautés implantées sur les terres humides, ainsi que des communautés adaptées qui habitent les parois rocheuses, les tabliers d'éboulis, les rivages et les grottes. Les caractéristiques des habitats, l'emplacement général de ces derniers dans la Forêt modèle de Fundy, la biote qui les caractérise, et toutes les espèces peu communes et rares connues sont indiqués pour chacun des types de communautés. Le niveau de précision des descriptions fournies en ce qui a trait à chacun des types de communautés dépend en partie de la quantité de renseignements disponibles concernant leur distribution et les espèces qu'on y trouve. Le rapport expose également les antécédents connus relativement aux perturbations provoquées par l'homme, de même que les menaces actuelles et futures.

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Introduction

Explanation of "community type"

Community ecology is the study of relationships between assemblages of plants and animals and their environment. A landscape may consist of a few or many biotic assemblages or "community types". Some community types occupy large areas with relative continuity. Others, hereafter referred to as fine-scale community types, occupy small areas and are spatially discrete. Fine-scale community types can be abundant and widely distributed or limited to one or a few locations. Community ecology seeks to describe patterns of community types on the landscape and to determine the processes that shape their size and distribution.

A community type may be defined as an assemblage of species from all biotic groups (plant, animal, insect) commonly associated with a particular set of environmental conditions (Begon *et al.*, 1986; Maine Natural Heritage Program, 1991; Angelstam, 1992). Habitat is the physical environment within which the assemblage is found, defined by abiotic (*e.g.*, soil, moisture, light) or biotic (*e.g.*, canopy shade) factors, or a combination of the two. Examples of habitats include lime-rich rock faces, bogs, talus slopes, and deep-water marshes.

The characteristics of a physical setting and the group of species associated with those characteristics most strongly differentiate community types. Thus, patterns of community types also reflect the large-scale patterns of biological diversity found within a region. While common species are found in many community types ("generalists"), certain species are restricted to the specialized environmental conditions associated with a particular habitat. Others are adapted to the levels of inter- and intra-specific competition occurring within given communities. Often the physical characteristics of fine-scale community types are extreme, with one or more resource limitations (poor soil fertility, low light level), physical constraints (inundated soil, short growing season, exposed rock), or geographic isolation (mountain top). The species that persist in these areas have adapted to such conditions, usually to escape competition for resources in more moderate environments. Because they often include rare or uncommon species, the fine-scale community types add significant contributions to the overall diversity across a landscape (Whittaker, 1965; Miller, 1986).

Patterns of community types across a landscape are not static. Since the last glacial period for example, some 10-12,000 years ago, forces of erosion, climate change, dropping sea levels, and migration have continually reshaped northeastern North America (Hunter *et al.*, 1988). The rate of these changes has been gradual and they continue. For example, it is believed that some plant species in the Maritime provinces may still be expanding their ranges in this post-glacial period, colonizing new areas where they are able to persist (Holland, 1980).

Other forces act upon landscape patterns in a more immediate and obvious fashion. Insect infestation, disease, and fire can all drastically alter forest structure over large areas. Fire may also cause long-term, local destruction of some species if no sources for recolonization exist. However, many of the changes caused by these forces are temporary and, in fact, their occurrence may characterize certain community types. For example, community types in areas with dry climate, poor soils, good drainage, and flat topography tend to have a higher fire frequency than those in areas without these characteristics. Often, species of fire-prone community types are adapted to exploit, or at least tolerate, the effects of fire.

Land clearance for settlement, agriculture, and forestry has also had obvious influence on the patterns of community-type distribution since European colonization began 300 years ago in southeastern New Brunswick. However, unlike the effects of fire or infestation, the changes affecting the physical structure, species composition, and the size, range, and location of these communities on the landscape have often been lasting. Some community types have been more strongly affected by land clearing than others. For example, areas of nutrient-rich soils, supporting species-rich, tolerant hardwood forest, were often first to

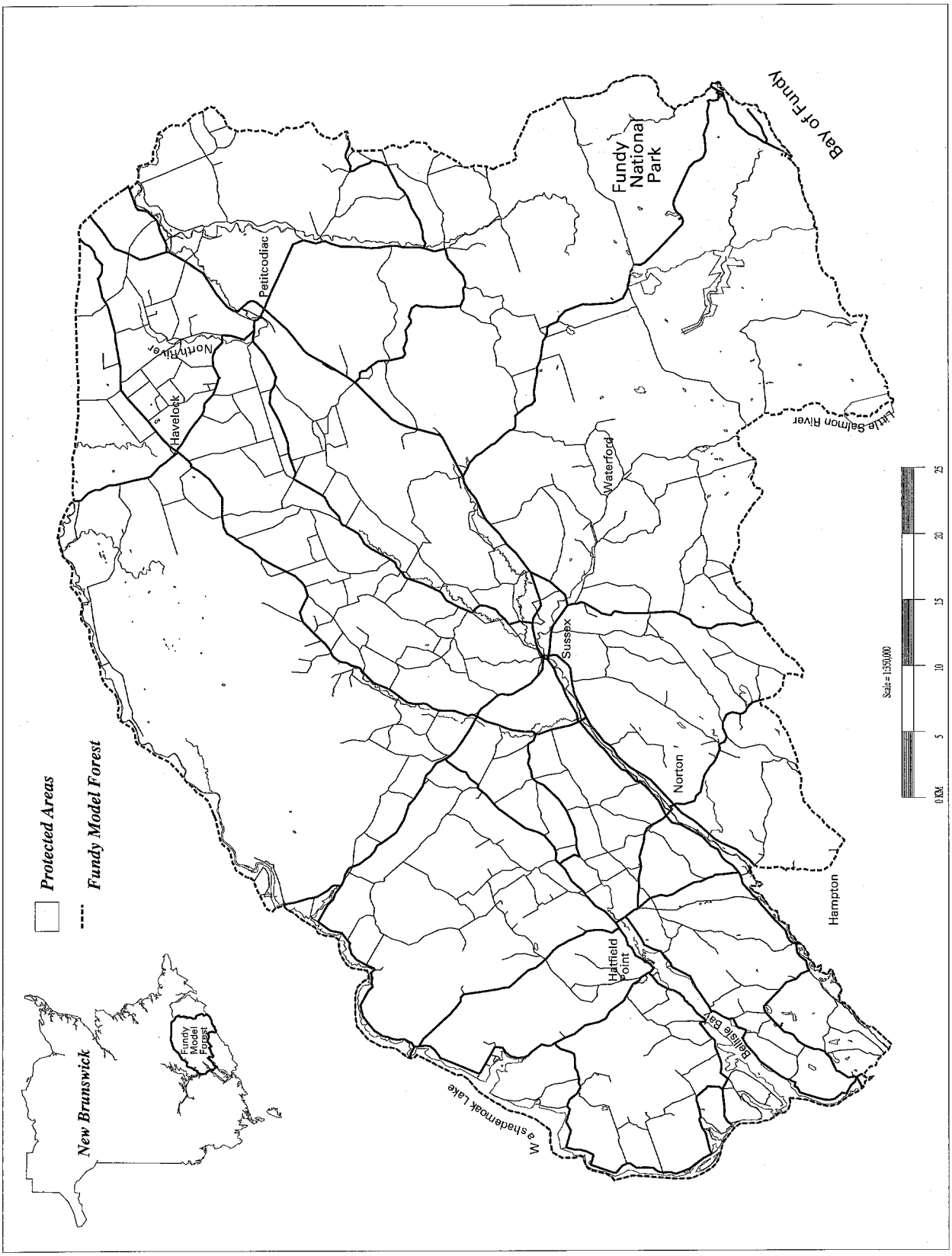
Protected Areas
Fundy Model Forest
New Brunswick
Fundy Model Forest
Bay of Fundy
Fundy National Park
Petitcodiac
North River
Havelock
Little Salmon River
Waterford
Sussex
Norton
Hampton
Hatfield Point
Belliste Bay
Shadagmook Lake
Scale = 1:250,000
0 KM
5
10
15
20
25

Figure 1

be cleared by settlers because these sites often supported valuable cabinet-wood species and were well suited for agriculture. Today, such rich hardwood community types are uncommon (Rudis, 1995), as are numerous species associated with these habitats.

Mature coniferous forests have also been heavily exploited for both timber and fiber production. As a result, their physical and age structure, as well as species composition, have often been significantly altered. Some coniferous forests now have a higher percentage of mature trees than expected under natural conditions because of the suppression of fire and insect infestations. However, the prevalent trend has been the reduction of older stands. Many of the trees are now under 75 years of age and, with the advent of active forest management, including plantation forestry, the occurrence of coarse woody debris and snags has been reduced. In many New Brunswick forests, the proportion of balsam fir has increased significantly, with associated decreased abundance of red spruce, as described by Irland (1993) for the State of Maine. These changes affect species specifically adapted to the compositional, structural, and microclimatic conditions typically found in mature coniferous forest. The pine marten and the northern flying squirrel are oft-cited examples.

Purpose and methodology

This report identifies and describes the fine-scale community types that occur in the Fundy Model Forest (FMF), a 420,000-ha study area in southeastern New Brunswick (Fig. 1). Established in 1992, the mandate of the model forest program is to develop integrated and sustainable land-management strategies that consider economic, social, and environmental values (LaPierre, 1993). This includes the maintenance and preservation of existing levels of biological diversity. The purpose of this report is to draw attention to the presence of the small, localized community types with the FMF, and their contribution to the biological diversity of the area. Some of these community types naturally occur as small, localized patches because of limited availability of suitable habitat. Others are small as a result of human-caused disturbance that has fragmented species assemblages that were once more continuous and wide ranging. In both cases, these community types often include rare species not found elsewhere. Because of their limited area, they may be overlooked when designing a landscape-level forest management plan. Without special management, some of these community types are vulnerable to disturbance and species loss. Identifying and locating such sites are important first steps in planning for their long-term persistence.

Fine-scale community types likely to occur within the FMF were first identified using community-type classification schemes developed in Maine (Maine Natural Heritage Program, 1991) and Nova Scotia (Simmons *et al.*, 1984). These systems were employed because such community types had not been classified to date in New Brunswick. Many of the assemblage types found in these adjacent jurisdictions can be expected to also occur in southeastern New Brunswick, so these systems provided a good starting point. Once a list of potential community types was established, the presence or absence of each within the FMF was confirmed, and distributions were determined by ground surveys and using existing fine-scale site records (*e.g.*, Dionne *et al.*, 1988). The final step identified additional community types specific to this area of New Brunswick by determining habitat affinities of uncommon, rare, and very rare plant species growing in the FMF. By grouping these species by habitat requirements, it was possible to identify habitats supporting assemblages of infrequently occurring species.

For each community type, we describe physical characteristics and general location within the FMF. A list of the dominant flora that characterize each community type is presented, as well as all uncommon, rare, and very rare plant species. Plant species are emphasized for two reasons: they are the best surveyed of all biotic groups within the FMF, and they form the community matrix upon which other biotic groups depend. From a practical perspective, when species characteristics of a community type are unexpectedly infrequent or absent, it suggests that the site may be disturbed or too small or isolated to support its typical vegetation. The site may, therefore, require

some form of special management to maintain or restore its characteristic biological diversity.

In addition to plants, there is considerable information on breeding bird distributions within the FMF. When known, the bird species typical of a given community type are also presented.

All species listed in this report, except where noted, have been observed within the FMF boundaries, either from field surveys conducted by the authors in the summer of 1994, or from records of sightings listed in Hinds (1983, 1986) for plants and Erskine (1992) for birds. The classification of plant species as uncommon, rare, or very rare is based on Hinds (1983, 1986). This classification was based on the frequency of occurrence in the province, not just within the FMF, and refers to those species restricted to only a few populations or to those broadly but very sparsely distributed within New Brunswick. A complete list of the known uncommon, rare, and very rare flora of the FMF is provided in Appendix II. When applicable, mention is also made of those plant species rare in other parts of North America.

Other biotic groups, such as mammals, amphibians, reptiles, insects, and lower vascular plants, are discussed in passing or not at all for some community types. Ground surveys were not conducted for these groups and detailed distributional information does not exist or is incomplete within the FMF region. Information about these groups was included when available, but this should not be considered a comprehensive analysis for all biotic assemblages.

Fine-scale community types of the Fundy Model Forest

Twenty-four fine-scale community types were identified within the FMF. Some community types named and described are very specific with respect to their physical setting and associated species. Others, such as Sphagnum-Ericaceae Bog or Low-Energy Speckled Alder Shoreline, are more general. The difference is based on the amount of information available to distinguish between community types within and among the various recognized habitat types. Peatland habitat, for example, was divided into twelve different community types by the Maine Natural Heritage Program's classification scheme; these differences were based on water chemistry, patterns of groundwater flow, drainage, successional status, and dominant vegetation. Such detailed information has not been collected within the FMF to allow a similar level of classification; therefore, some significant variations in wetland type may be overlooked.

Community Type Descriptions: Physical Setting and Member Species

Forested community types

Forested community types are those assemblages dominated by one or more tree species. All of these community types were once more extensive, but have been reduced in area and, in some cases, have been fragmented, by land clearance and forestry activities. Eight fine-scale, forested community types were identified in the FMF.

Hemlock Slope Forest Community Type

Hemlock forests typically occur in association with shady ravines, streamsides, or north-facing slopes; all areas with cool, moist microclimatic conditions. In addition to eastern hemlock, these forests may include white pine, red spruce, and yellow birch. Pockets of hemlock forest are often found within wider-ranging upland hardwood or mixed forest areas. Hemlock is extremely shade tolerant and is capable of self-perpetuation without disturbance.

The understorey vegetation of hemlock slope forests is sparse because of the dense shade. Common ground flora species include partridge berry, creeping snowberry, bunchberry, wild lily-of-the-valley, pink pyrola, wood sorrel, and twinflower. On occasion, the rare large round-leaved orchis (Fig. 2) has been observed in hemlock understoreys. This species may not be a good competitor in community types with denser understorey vegetation.

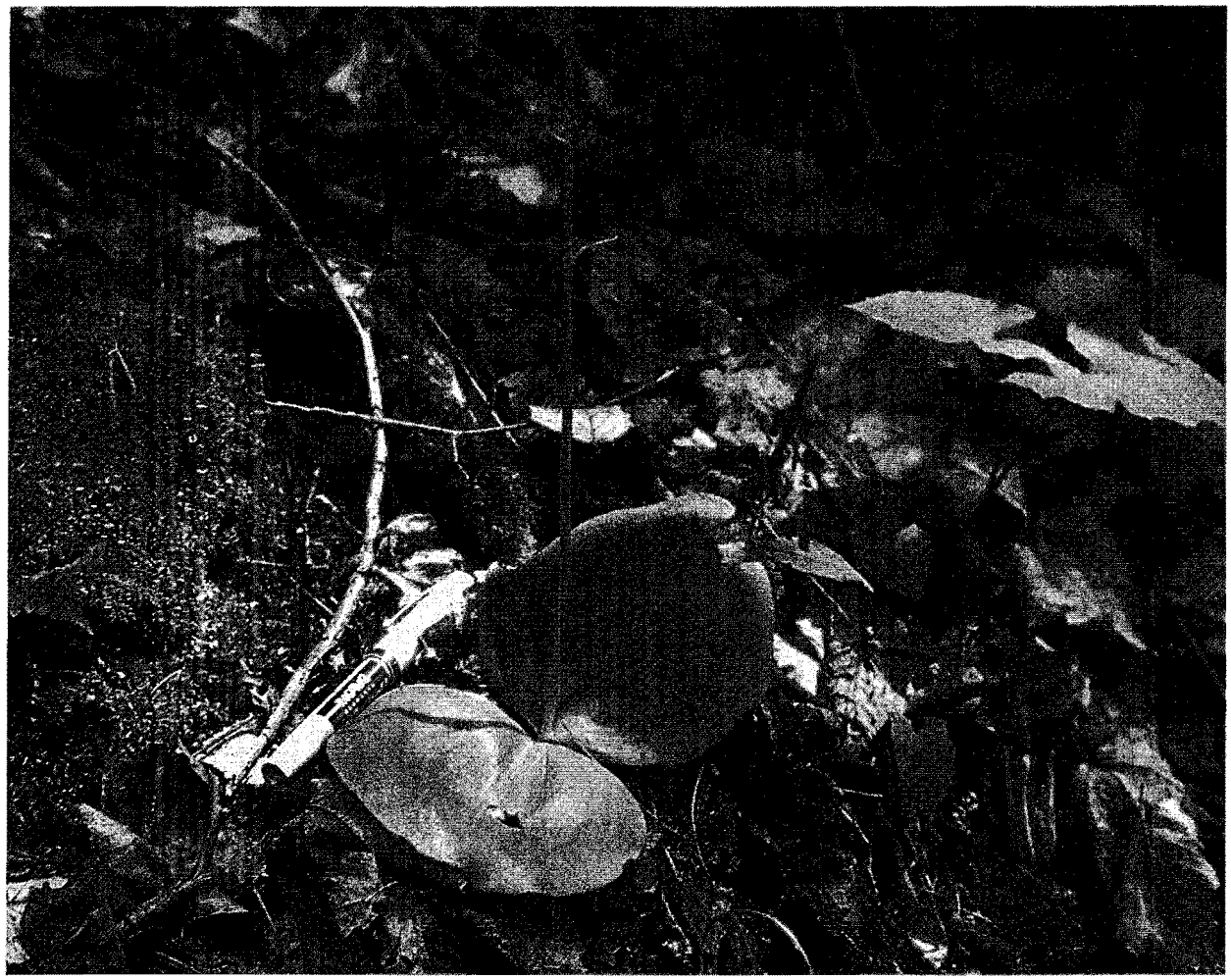

Figure 2 Large round-leaved orchis in a mixed hemlock-rich deciduous forest near Parlee Brook

Hemlock trees can live to a very old age. As they mature, they are often colonized by fungi that cause bole rot, which results in cavities. These cavities are used by faunal species for denning or shelter (DeGraaf *et al.*, 1989). When hemlock stands are disturbed through cutting or wind, the microclimatic conditions of the understorey are altered. Light intensity and temperature increase, while relative humidity decreases. The changes may lead to the loss of species dependent on the understorey conditions of hemlock slope forests, such as the large round-leaved orchis. Hemlock regeneration may be reduced under these changed conditions, as regeneration is most successful under shade (Fowells, 1965).

Hemlock slope forests are uncommon within the Fundy Model Forest (Fig. 3). They occur in small localized patches in only a few locations in the Fundy Highlands from Sussex to Elgin. These stands do not contain large trees. In some stands, very few young hemlock seedlings were seen, indicating they are not successfully regenerating. Because of its limited distribution and possible vulnerability to disturbance, hemlock may require specific management actions to ensure its long-term persistence in the FMF.

Pine-oak forest community type

Pine-oak forests are found on well-drained, sandy soils, rocky slopes, knolls, and hilltops. The overstorey is dominated by mixtures of white pine and red oak; red pine, jack pine, and beech may also occur. The understorey shrub layer is often sparse, especially under the pines, where thick layers of fallen needles reduce establishment of ground flora species. Plant species often found in

Figure 3 Sparsely vegetated hemlock slope forest understorey near Upper Goshen

association with pine-oak forest include sheep laurel, prince's pine, partridge berry, bunchberry, wood sorrel, wild lily-of-the-valley, and indian pipe. Pinesap, an uncommon member of the wintergreen family, also occurs within this community type. A 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.

Talus slope hardwood 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

Figure 4 Moss, lichen, and fern-covered talus near Parlee Brook

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 five areas: Hampton, Mount Zachie Jonah, Waterford, Urney, and Parlee Brook (Fig. 4).

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 drains rapidly, 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 depends 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 fruticose, 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 disrupting 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, red spruce, and, on occasion, green alder. At two gravel-talus sites within the FMF, pure ironwood or ironwood-red oak stands occur.

Figure 5 *Wet cedar-black spruce understorey near Salisbury. The sparsely vegetated sphagnum beds on the forest floor provide ideal habitat for orchids and other rare plant species*

The ground flora in forested talus often includes several fern species: marginal shield-fern, glandular wood-fern, rock polypody, bracken fern, rusty woodsia, and the mountain wood-fern, as well as the woodrush *Luzula acuminata*, mountain-ash, skunk-currant, Canada gooseberry, poison ivy, low-bush blueberry, whorled wood aster, and the large-leaved aster. The ironwood talus sites, enriched by limestone, have bloodroot, false Solomon's seal, and the green woodland orchis. At least two uncommon vascular plant species occur on talus slopes within the FMF: herb-robert, which is considered uncommon in New Brunswick, and the maple-leaved goosefoot, a rare species in the province that occurs in only three known locations, including Mount Zachie Jonah.

Talus slopes are also preferred habitat for two very rare shrew species in New Brunswick, the Gaspé shrew and the rock shrew (Clayden *et al.*, 1984). Both are found in cool, mossy, talus areas, usually near streams. Neither of these species has been observed within the FMF, though thorough surveys have not been done. The rock shrew was observed in nearby Albert County in 1979, thus may occur in the FMF.

Wet cedar forest community type

Wet cedar forests occur in poorly drained areas typically associated with open peatlands and small ponds. They are dominated by eastern white cedar but may also include varying amounts of black spruce, larch, and red maple. These forests are sometimes called "cedar bogs" because of dense mats of sphagnum that form to varying depths in the substratum (Maine Natural Heritage Program, 1991).

Wet cedar forests typically develop on alkaline soils that have a higher pH than is normally found in wet conifer forests dominated by larch or black spruce (Fig. 5). Sites that are especially rich in lime and undisturbed by logging often have a very

Figure 6 Hooker's orchis growing in a wet cedar forest near Salisbury

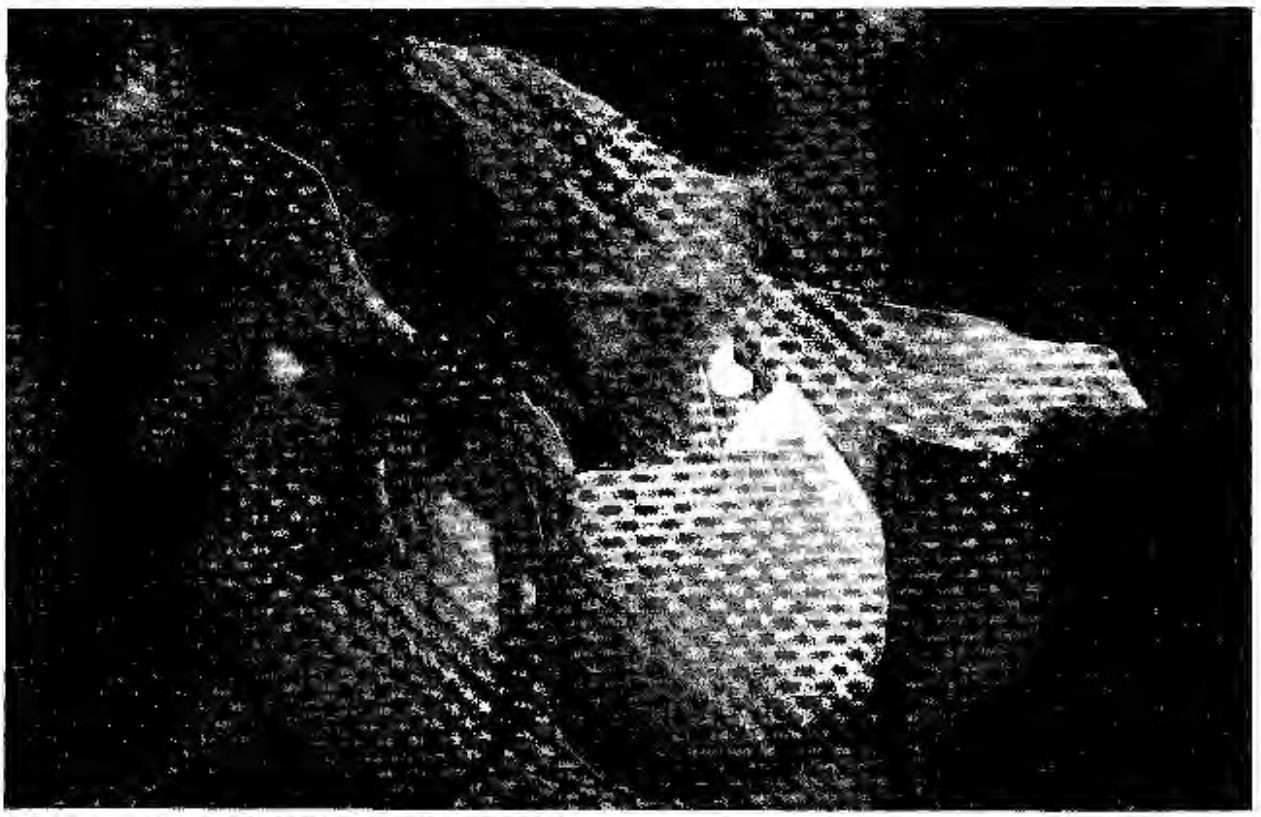

Figure 7 Showy lady's slipper, a threatened New Brunswick species, today found only in wet cedar forests (Photo: H.R. Hinds)

Figure 8 Yellow lady's slipper, another uncommon New Brunswick species of both wet cedar forests and rich hardwoods (Photo: H.R. Hinds)

diverse herbaceous understorey. Commonly observed species include sheep laurel, bog goldenrod, three-leaved false Solomon's seal, bunchberry, and marsh fern. Less common are royal fern, wood anemone, mitrewort, alder-leaved buckthorn, blunt-leaf orchis, and the heartleaf twayblade. A number of rare plant species also occur in these sites, including *Carex castanea, C. folliculata, C. wiegandii*, and hooker's orchis (Fig. 6). Also occurring on these sites are boreal aster, reported as very rare, and showy lady's slipper (Fig. 7), which is listed as rare, and possibly endangered, in New Brunswick. Its numbers have been decimated by habitat loss and by pickers and collectors (Hinds, 1986). Yellow lady's slipper (Fig. 8) is uncommon for similar reasons.

Wet cedar swamps are scattered and uncommon within the FMF, occurring along the St. John River and also near Salisbury. When cedar stands are cut, or flooded by the damming of adjacent wet areas, many or all of the rare species are adversely affected by the disturbance and disappear. While cedar may re-establish at these sites, the rare species are less likely to do so. Their distribution is restricted and the distance of seed movement is limited, so they may not be able to colonize regenerated sites. As a result, remaining undisturbed cedar stands serve as critical habitat for the maintenance of species that may now be considered threatened in New Brunswick.

Coastal ravine red spruce forest community type

This forest community type is found along the sides and at the rims of the FMF coastal ravines. These forests typically occur on well-drained to moderately well-drained, coarse-textured soils which are often thin and poor in nutrients. 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 overstorey, result in thick moss beds on the forest floor and abundant arboreal lichens.

Figure 9 The ravine at Little Salmon River, looking inland from where the river meets the Bay of Fundy

There are ten red spruce-dominated coastal ravines within the FMF. These are found from Fundy National Park to the Little Salmon River gorge. They range in length from just under 1 km to almost 20 km. The age and physical structure of these forests are not all identical. Some ravines contain mature, closed-canopy forest while others have more open-canopy forest, likely as a 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 (Fig. 9).

Although dominated by red spruce, these forests include mixtures of balsam fir, black spruce, red maple, white birch, and yellow birch. At the ridgetops, where the soil is thin over the bedrock, white pine occurs infrequently. Vascular understorey vegetation is sparse, possibly because of the shade and the dense mats of moss, limiting establishment of vascular flora. The dominant non-vascular plant species are Schreber's moss

Figure 10 A small, sheltered cove forest on Lake Washademoak near Thornetown

and the liverwort *Bazzania trilobata*, with plume moss occurring in moist, seepy locations (Hirvonen and Madill, 1978). The vascular ground flora species include bunchberry, wild lily-of-the-valley, goldthread, creeping snowberry, and clintonia. 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 forest patches include trees more than 300 years old.

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 climatic extremes moderated by the influence of the adjacent water bodies and protected by the cove headlands.

In the FMF, cove forests occur along Washademoak Lake and Belleisle Bay (Fig. 10). 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

Figure 11 A typical view of the Fundy Model Forest landscape, with the bottomland area cleared for agriculture and the steep-sloped hillsides forested, near Cornhill

maple, white pine, and yellow birch, with eastern white cedar, ironwood, red maple, white and black ash, red pine, and red spruce also occurring. Ground flora species include bunchberry, sundrops, blue flag, wood sorrel, intermediate wood fern, oak fern, jack-in-the-pulpit, and *C. tribuloides*. At Big Cove along Lake Washademoak, checkered rattlesnake plantain, a member of the orchid family, was recorded. This species is considered uncommon in New Brunswick.

Cove forests only occur in a few locations in the FMF. However, many have been affected by early land clearance for settlement or agriculture, or more recently for cottage development. Remaining sites are threatened by new development.

Rich Northern Hardwood Forest

Rich northern hardwood forest comprises two different community types in the FMF: the sugar maple-white ash-ironwood-beech forest assemblage and the silver maple-American elm alluvial bottomland assemblage. Both exist as small, discrete forest patches within the FMF due to limited habitat availability, exacerbated by land clearance for agriculture (Fig. 11).

Figure 12 A butternut tree near Havelock

Sugar Maple-White Ash-Ironwood-Beech Community Type

The sugar maple-white ash-ironwood-beech community type occurs on mid-slope and rich upland soil sites derived directly from limestone parent material, or sedimentary parent material with a limestone component. Their elevation results in more frost-free days than in the valley bottom. These conditions occur at Havelock and in the Sussex area. This community type differs from the more common sugar maple-yellow birch-beech community type found in less fertile areas of the FMF.

In addition to sugar maple, white ash, ironwood, and beech, basswood and butternut may be components of this forest assemblage. At one time, butternut was much more common in the FMF (Fig. 12). The community of Havelock was once named Butternut Corner and a nearby location was called Butternut Ridge. Today, few butternuts remain in the area, probably less than 50 trees, several of which are ornamentals. With the rapid spread of the butternut canker (*Sirococcus clavigignenti-juglandacearum*) in the United States and central Canada, the future of this species is uncertain. However, the separation of the New Brunswick butternut trees from those in the diseased areas may be sufficient to postpone infection, representing an important interim refuge for the species.

Common ground flora of these forests include dutchman's breeches, indian cucumber-root, spring beauty, rattlesnake fern, red trillium,

Figure 13 Blue cohosh, a species found only in rich hardwood forests and considered uncommon in New Brunswick

Figure 14 An extensive patch of wild leek in a rich hardwood understorey near Bloomfield Ridge

Solomon's seal, and trout lily. Several species are listed as uncommon, rare, or very rare for New Brunswick, including blue cohosh (Fig. 13), wild leek (Fig. 14), grove meadow-grass, and a species of black snakeroot (*Sanicula trifoliata*).

Silver Maple-American Elm Alluvial Bottomland Community Type

The silver maple-American elm alluvial bottomland community type occurs on alluvial deposits found on the low-elevation bottomlands of river and lake valleys. Most plant species of this community type can tolerate occasional seasonal flooding. The locations of alluvial deposition in the FMF are typically small in area and, as a result, this forest assemblage is only found in limited, discrete patches.

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 since the 1950s and may now be extinct in the area. It had originally been observed in the Belleisle Bay area.

Both rich northern hardwood community types identified in the FMF 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 parasitism of neotropical migrant bird nests by the brown-headed cowbird. 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 where soil fomation is limited and the member species have adapted to tolerate the specialized conditions of the habitat. Six rock outcrop community types have been recognized within the FMF occurring on escarpments, cliffs, and headlands. As well, we have included a seventh community type – caves – within this category.

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 to 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 are less common, possibly because

Figure 15 A distant view of Rockville escarpment near Sussex

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. Trees are restricted to the soil pockets and are 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 (Fig. 15). Bearberry is considered uncommon in New Brunswick but is 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 in the FMF. 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 this transition area. The early blue violet, listed as uncommon in New Brunswick, has also been ob-

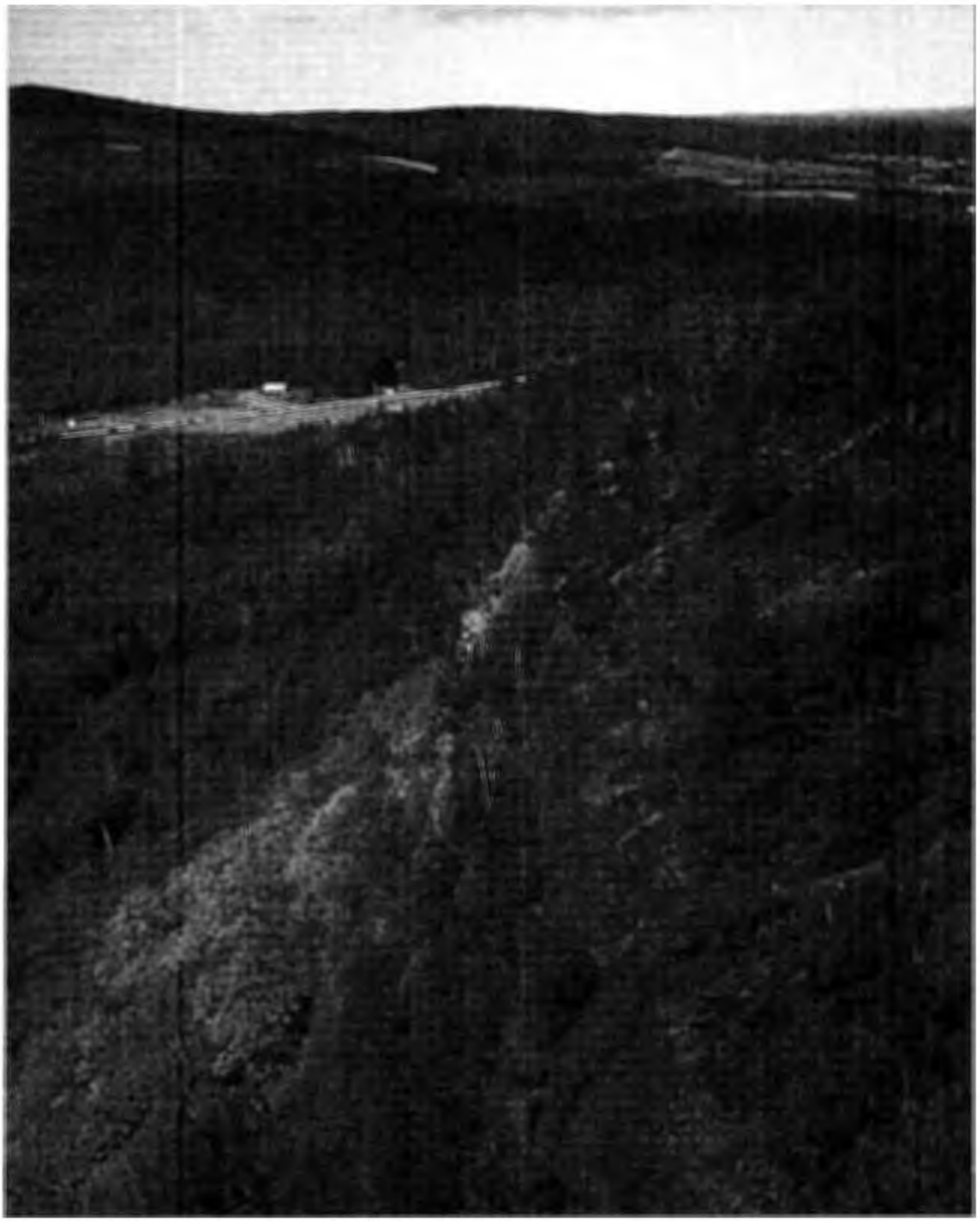

Figure 16 Exposed escarpment and cliffs near Waterford

served here. The transition areas grade into forest often composed of white pine, red spruce, red oak, jack pine, balsam fir, and beech.

The escarpments of the FMF occur within the Rockville-Parlee Brook-Waterford area (Fig. 16). Despite the apparent similarity in physical setting among these sites, they do not all contain the same assemblages 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 also varies. There may be several reasons for these differences. Larger escarpments have a higher probability of receiving wind-borne propagules. There are also microsite differences in moisture availability and substrate fertility that may limit the species establishment. Some escarpments have more turbulent disturbance histories than others, possibly resulting in extinction at the more disturbed sites.

It is possible that escarpments are remnants from the immediate post-glacial period when wind-swept barrenlands were prevalent in New Brunswick. As this community type shrank in size due to forest expansion, escarpments became refuges for species adapted to these conditions. Because of their small size and disjunct distribution, populations at each site are limited in size. If these small populations are destroyed at a site because of an intense disturbance event, such as fire, there is often no close-at-hand seed source for recolonization.

Cliffs

Cliffs are very steep to vertical rock faces. The formation of cliffs is often by geologic faulting and folding. Erosion and glaciation also play a role. They are extreme habitats, characterized by little or no soil formation, except for small ledges and crevices, sometimes heavy exposure to wind and sun, and very dry conditions except in seepage zones or areas exposed to river spray. As a result, cliffs represent one of the most severe habitats for the establishment of both vascular and non-vascular plants. The species that establish themselves on cliffs are strongly influenced by water availability. Wet, seepy, often north-facing areas commonly support an entirely different suite of species than dry rock faces with southern exposure.

Usually, wet cliffs are much richer in species than dry cliffs. As with other community types, vegetation patterns are also influenced by parent material. Cliffs may be acidic granites or other igneous rocks, or circumneutral sedimentary or metamorphic rocks with a limestone component. Lime-rich substrates typically are richer in species than acidic substrates.

Within the FMF, four cliff community types are recognized: the coastal ravine calciphilic plant community type, the coastal ravine non-calciphilic plant community type, and two inland groups, the shady fern cliff community type and the dry lichen cliff community type. The differences between these assemblages are determined by variations in parent material, aspect, and moisture availability.

Coastal Ravine Cliffs

The riverside cliffs found in the FMF coastal ravines generally have less moisture stress than inland cliffs due to the cool foggy climate, shading by the steep ravine sides, and river spray. Seepage zones originating in the upland forest plateau are also frequent. As a result, there are both vascular and non-vascular rock face plant species found only in these FMF sites, particularly "arctic-alpine" species that typically occur in cooler, more northerly locations of New Brunswick and Quebec.

Ten coastal ravines dissecting two parent material types occur within the FMF (Fig. 1). Most of the ravines are on felsic and mafic volcanic rocks, which tend to be acidic and infertile. There are also pockets of sedimentary rock enriched with calcium carbonate. Much of this sedimentary material occurs in or near Fundy National Park, with sporadic patches occurring in ravines further west down the coast. The differences in parent material result in the two different coastal ravine cliff community types.

Coastal Ravine Calciphilic Plant Community Type — Some of the species found on the sedi-

Figure 17 Vertical rock face in the Little Salmon River ravine. An abundant and diverse floral assemblage is found here due to its cool northern aspect, constant groundwater seepage from above, and a calcium-enriched substrate

mentary parent material are calciphilic plants, which are restricted to the calcium-enriched rock faces. All are listed as uncommon to very rare within New Brunswick. Glaucous poa, a rare grass species; *Selaginella selaginoides*, a spikemoss species rare throughout much of its range; and bird's-eye primrose and green spleenwort, both very rare species also listed as rare in Nova Scotia, Maine, and Quebec (Hinds, 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 species in the province; 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 further west. All are known to prefer calcium-rich ledges (Hinds, 1986). The fleabane may also occur on rocky river shorelines in this area.

In the Little Salmon River gorge (Fig. 17), two additional species typical of calcareous ledges are

Figure 18 One of the two fir club-moss species found in the Fundy coastal ravines

Figure 19 The rare fragrant fern growing on a shady rock face in the Little Salmon River ravine

Figure 20 A wet, shady, fern-covered rock face near Dustin Brook

found. A rare variety of tufted club-rush (var. *delicatulus*) is found on calcium-enriched cliff ledges. The Little Salmon River ravine is its only known location. The more common variety (var. *callosus*) is found in upland coastal peat bogs (Hinds, 1986). The provincially very rare alpine woodsia, rare throughout much of its North American range, 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).

Coastal Ravine Non-Calciphilic Plant Community Type — The non-calciphilic 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 one, or possibly two, fir club-moss species, that are listed as rare in most of New Brunswick and uncommon along the Fundy coast (Fig. 18). The fragrant fern, a rare New Brunswick species located mostly along the Bay of Fundy and in northern New Brunswick, is more common at these sites than at more calcareous sites (Fig. 19). 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 Zachie Jonah and in the Rockville-Cedar Camp-Waterford-Parlee Brook area.

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 (Fig. 20). 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 Zachie 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 Zachie 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 Unites 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 Zachie Jonah. This species is also rare, threatened, or endangered in other parts of its range. The Laurentian bladder fern, a recently described species that arises by hybridization 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).

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 that can withstand the aridity and exposure and can grow directly on the rock face. Little or no survey work has been conducted on the cryptogamic 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 spe-

Figure 21 Dry lichen-covered cliffs near Parlee Brook

cies 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 New Brunswick, 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 (Fig. 21).

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. Today, threats to cliff community types include disturbance from hiking or climbing, and alteration of surrounding forest. Deforestation around a shady fern rockface assemblage could alter microhabitat conditions to a point that member species may no longer persist.

Coastal Headland Deschampsia-Danthonia Community Type — Coastal headlands are large, sparsely vegetated outcrops of bedrock that occur

Figure 22 View of coastal headlands taken from the shore near Little Salmon River. The small island in the distance is Martin Head

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 headlands that rise up from at or below the high-tide line, some as high as 400 m (Fig. 22).

Many of the plant species that establish on coastal headlands are small in stature 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 at only three sites (Hinds, 1986).

The peregrine falcon likely occurred along the Fundy coastal headlands until pesticides and other pollutants severely reduced the populations in North America in the 1950s and 1960s. Banning DDT, which caused reproductive failure in the species, combined with 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).

Bat Cave Community Type — 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 one or several species of roosting and hibernating bats. Data on the distribution and abundance of bats within the FMF area are 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. Non-hibernating bat species migrate south in winter.

Many New Brunswick caves occur in the Albert County limestone formation that lies to the east of the FMF. Others occur just to the west of the FMF near Saint 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 New Brunswick to have a record of the eastern pipistrelle, a rare bat species (McAlpine, N.B. Museum, *pers. comm.*). One of the better known New Brunswick caves, Archie's Hole, is located 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 an 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 slow decomposition of vegetative matter is outpaced by accumulation. Peatlands are scattered throughout most of the FMF area, with highest frequency along the Fundy coast and south of the Canaan River between Salisbury and Coles Island.

Three 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 peatlands undoubtedly are bogs, some fens and sedge meadows have been misclassified because superficially they are similar to bogs. 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. Examination of the water chemistry, vegetation assemblage, or water flow patterns is required to classify peatlands.

For each peatland type, 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. groundwater), 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, varies 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 each is provided, though most of these species also occur on one or both of the other peatland types.

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, 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 groundwater from surrounding forest areas; their moisture is obtained 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 because of the high acidity and anaerobic conditions created by high water tables. Thus, 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.

Several types of bogs likely occur within the FMF. The type of bog 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. In these bogs, a central elevated area is 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 are flat featureless peatlands. The pattern of peat accumulation in these bogs is more spatially uniform than in raised bogs. Kettlehole bogs form in and around old kettleholes, which are circular or elliptically shaped depressions that are usually more deep than wide. These depressions were formed in sediment deposits created by the melting of buried ice blocks.

Bogs often have less diversity of species than other peatland types because of the infertility and acidity of the substrate. They may be treeless or may support scattered and mostly stunted black spruce and tamarack. Despite their small size, these trees sometimes reach ages greater than 200 years. Bog ground cover is variable, both within and among bogs, though typically the vegetation is dominated by mixtures of sphagnum moss, heath (ericaceous) species, and members of the sedge family. The most common heath species are labrador tea, sheep laurel, bog laurel, leather-leaf, bog-rosemary, rhodora, and small cranberry. Species in the sedge family often include *Carex disperma, C. echinata, C. trisperma*, white cotton-grass, tawny cotton-grass, and tufted club-rush. Also common are bog goldenrod, bog aster, three-leaved false Solomon's seal, and the well-known insectivorous species: pitcher plant (Fig. 23), and round-leaved and narrow-leaved sundews.

Drier areas in bogs often support *Cladina* lichens and *Polytrichum* mosses. Crowberry, a coastal bog species, may also occur in these drier areas. This species is host to the rare crowberry blue butterfly.

Within the FMF 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 the northeastern United States. It is found on raised peat ridges ("hummocks") at one FMF location near the Little Salmon River gorge. Screw-stem, another bog species very rare in New Brunswick and elsewhere within its range, can be found in association with curly-grass fern, as well as several other coastal bogs (Fig. 24). 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 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 each of these 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

Figure 23 Pitcher plant growing on a sphanum bed near Crawford Lake

Figure 24 Curly-grass fern and screw-stem, both rare in New Brunswick, growing side-by-side in a bog near Crawford Lake

Figure 25 A fen near Little Salmon River

in Cape Breton (Conant, 1975; cited in Clayden *et al.*, 1984).

Sphagnum-Ericaceae Fen Community Type

Fens, like bogs, are peatlands. Unlike bogs, however, fens receive water from other sources in addition to rainfall, either groundwater or overflow from adjacent forested habitats. As a result, fens are generally richer in nutrients than bogs and support a more diverse vegetative community. The fertility of fens depends on the groundwater chemistry of the flow inputs. Fens may be acidic, though they are usually less acidic than bogs, or circumneutral, if the underlying parent material is calcium rich. The circumneutral fens tend to be rich in flora and contain rare species.

Fens have been classified into two structural categories. Patterned or ribbed fens are usually found on gentle slopes and are characterized by 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 not ribbed, usually occurring on flatlands. Of the two, unpatterned fens are thought to be the most common in the FMF (Fig. 25).

Figure 26 Rose pogonia in a small bog on the Fundy Plateau near Quiddy River

Figure 27 Sedge meadow near Babcock Brook

Figure 28 Ragged-fringed orchis (left) and a hybrid between the ragged-fringed orchis and the large purple-fringed orchis (right)

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 (Fig. 26), swamp-pink, and grass-pink. More abundant orchid species, such as the 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 *C. 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 Little Salmon River Gorge. *Carex tenuiflora*, a rare species here and in other parts of its range, is also found in calcareous peaty areas. It has been recorded near Petitcodiac (Hinds, 1986).

Sedge Meadow Community Type

Sedge meadows are areas dominated by species of the sedge family, Cyperaceae, with lesser quantities of sphagnum mosses and grasses. They occur on permanently or seasonally saturated peat or muck soils. They are usually richer in nutrients 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. Groundwater 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 FMF (Fig. 27). They are usually located on the edges of fens, bogs, or even swamp forests. Typical species are *Carex stricta*, *C. pallescens*, *C. trisperma*, and *C. echinata*. Other common species 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-fringed orchis (Fig. 28).

Marshlands Community Types

Marsh habitat occurs in poorly drained basins where exposure to wind and lake wave action is limited. Seasonal flooding is typical. Substrate in marshes is mineral soil or muck, with little or no peat formation (Maine Natural Heritage Program, 1991). Standing water is present most or all of the year, usually over 15 cm in depth. Marshes 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.

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. The environmental conditions within a coastal salt marsh vary according to tidal influence. The inter-tidal zone is the area that is daily inundated. The littoral zone is the area above the influence of regular high tides, and experiences flooding only during storms or exceptionally intense tidal periods.

Environmental conditions 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. These sites are also nurseries for a wide variety of ocean fauna.

Coastal salt marshes are not common along the Fundy coast of the FMF. In many areas, the steep coastal headlands of the coast make marsh formation impossible. As a result, only two salt marshes are found within the boundaries of the FMF, 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-stagnant 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*.

The littoral zone of the Martin Head Marsh contains both exposed and sheltered areas. Much of the sheltered area is the zone immediately above the average high tide line. This is the beginning of the transition area from the marsh 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 lovage, salt-water cord-grass, 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 fowl meadow-grass, and species that tolerate the high sun exposure and low moisture availability such as beach pea.

Juncus Inland Salt Spring Community Type

The inland salt springs within the FMF occur in association with potash deposits found in the Plumweseep area near Sussex. The high concentration of mineral salts restricts plant species to those that are salt tolerant. Thus, 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 Plumweseep and has been heavily disturbed. It was dredged and had its banks altered for a tourist paddle-boat operation that is no longer in business. Despite this disturbance, the above-listed species remain. Other smaller salt springs occur in the

Figure 29 Anagance Marsh

Plumweseep area, though the total number is unknown and their species composition has not been surveyed.

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 New Brunswick 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 ha. The largest compound (46.4 ha) 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 (Fig. 29).

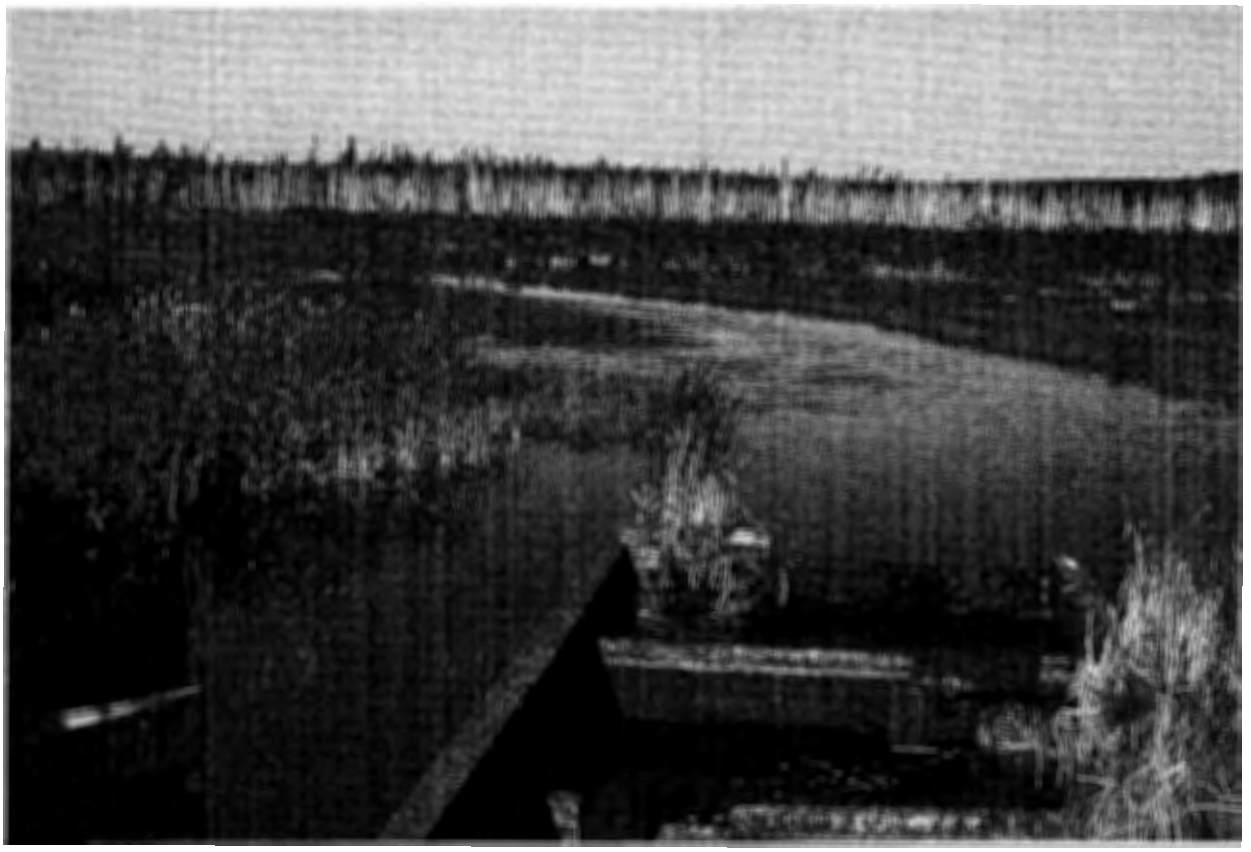

Figure 30 Ducks Unlimited compound at Anagance Marsh. Note the large stand of dead cedars in the background, likely the result of elevated water levels

Ducks Unlimited 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 (Fig. 30). As a result, it is important that some marsh habitat be left in its natural state to promote the full complement 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 to prevailing winds. River shore flooding during spring runoff 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 support 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 depends on the frequency and intensity of disturbance and two community types are recognized accordingly: low-energy alder shorelines and high-energy ruderal shorelines.

Low-Energy Speckled Alder Shoreline Community Type

Slow-moving rivers and streams, small lakes, or sheltered shores of large lakes have low-energy shorelines that are infrequently disturbed. 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 understorey flora include bulrushes, such as black-girded wool-grass and *Scirpus microcarpus*, sedges such as *Carex canescens, C. crinita,* and *C. flava*, rushes (*Juncus brevicaudatus* and *J. effusus*), spike-rushes (*Eleocharis* spp.), and horsetails, such as the water-horsetail and the common field-horsetail. Willow species, such as *Salix pyrifolia, S. petiolaris,* and *S. pellita*, also occur. *Eleocharis intermedia*, a spike-rush very rare in New Brunswick and rare in other parts of its range, is found in a quiet stream alder thicket near Springdale.

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 nodding beggar-ticks; *Bidens discoidea*, a very rare New Brunswick species reported only from Lake Washademoak (Hinds, 1986); 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.

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 persists 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 (Fig. 31).

While shoreline community types depend on the regular disturbance caused by natural forces, both of these community types have also been highly disturbed in areas of the FMF by 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

Figure 31 Shoreline along Goose Creek near the Fundy coast

community now found in many of these areas. Of the human-induced disturbance types, cottage development is most frequent today. If land-use trends continue, the uncommon and rare native plant species of these community types will certainly be threatened.

Aquatic Community Type

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 that is 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 corresponding to 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 cattails (*Typha latifolia* and *Typha angustifolia*).

Within the FMF, the shallow-water lacustrine habitat also supports numerous uncommon and rare plant 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 *I. tuckermanii*), two pondweed species

(*Potamogeton zosteriformis* and *P. oakesianus*), a bladderwort species (*Utricularia geminiscapa*), 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 Petitcodiac 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 in New Brunswick is unknown. They are likely vulnerable to pollution or habitat alteration (Clarke, 1981; cited in Clayden *et al.*, 1984).

Conclusion

The community types described in this report represent the small, discrete, and isolated species assemblages known to occur within the Fundy Model Forest. Despite their small size, most of these community types contain species recognized as uncommon or rare in part or all of their range. Each community type, therefore, contributes to the overall diversity of the FMF. It will be necessary to consider these community types when designing integrated land-management strategies to meet the state FMF objective of maintaining biological diversity. Because these assemblages have narrow distributions and limited population sizes, they may be severely affected by land-use activities that would have less impact on large, wide-ranging community types.

The threat of habitat loss is not the same for each identified small-scale community type. Those assemblages that occur in inaccessible or commercially unimportant habitats, such as rock outcrops or talus slopes, are not at high risk in most cases. Some species assemblages may not currently be at risk, but are vulnerable to future disturbances. For example, the mining of bogs for peat would destroy the associated bog community type. Groundwater pollution through seepage or fertilizers from cottages, settlements, and farms could affect nearby shallow-water aquatic community types by increasing nutrient levels, and encouraging invasion by alien species or causing algal blooms. Finally, areas of suitable habitat for community types such as wet cedar forest, cove forest, and the rich northern hardwood forest have been substantially reduced since European colonization and the few sites left are not secure. Continued cottage development along lakes, bays, and rivers threaten remaining cove and alluvial bottomland forest community types. Conservation of these community types must be given priority to ensure their long-term persistence in this region.

At present, approximately 6% of the FMF is specially managed to protect and maintain community types or individual species. Much of this (5%) is Fundy National Park, and the remainder is Ducks Unlimited compounds, deer wintering areas, and mature forest plots on Crown lands. The latter two special management areas are not permanently protected. If the forest is determined to be overmature, the site may be replaced by another similarly-sized mature forest area in the area under lease. The 6% that is protected or specially managed captures portions of seven of the 24 recognized community types within the FMF. Fundy National Park contains some of the coastal calciphilic plant community type, the sphagnum-ericaceae bog community type, the high-energy ruderal community type, the low-energy speckled alder community type, and the coastal ravine red spruce community type. The Ducks Unlimited

compounds capture some of the cat-tail-sagittaria freshwater marsh community type, though by raising water levels by damming, the integrity of these sites is lost. The remaining community types currently have no formal protection or special management within the FMF.

Community-type classification aids in assessing the distribution, abundance, and present conservation status of existing species assemblages within an area. This report suggests that while broad-scale habitat features appear similar (*e.g.,* rock outcrops, peatlands, wetlands, forested areas), variations in disturbance frequency, parent material composition, moisture availability, and other environmental factors result in very different species assemblages. Therefore, without some form of detailed site analysis, it is not safe to assume that one habitat example represents the species at all sites.

For some of the fine-scale habitats, there is insufficient information to differentiate clearly among species groups. This is true for peatlands and it may also apply to low-energy shorelines, inland cliff faces, and coastal beach community types. To offset these information deficiencies, and more fully analyze the status of small-scale community types within the FMF, more detailed physical feature and species distribution information would be required.

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Appendix I

Common and Scientific Names of Species Listed in Text

Plants

Alder-leaved buckthorn	*Rhamnus alnifolia*
Alkali-grass	*Puccinellia langeana*
Alpine woodsia	*Woodsia alpina*
American beech	*Fagus grandifolia*
American elm	*Ulmus americana*
Aster sp.	*Aster borealis*
Aster sp.	*Aster vimineus*
Atriplex sp.	*Atriplex prostrata*
Balsam fir	*Abies balsamea*
Basswood	*Tilia americana*
Beach pea	*Lathyrus japonicus*
Beachgrass	*Ammophila breviligulata*
Bearberry	*Actocstaphylos uva-ursi*
Beggar-ticks	*Bidens vulgata*
Bellflower	*Campanula rotundifolia*
Bidens sp.	*Bidens discoidea*
Bird's-eye primrose	*Primula farinosa*
Black ash	*Fraxinus nigra*
Black-girded wool-grass	*Scirpus atrocinctus*
Black snakeroot	*Sanicula trifoliata*
Black spruce	*Picea mariana*
Black willow	*Salix nigra*
Bloodroot	*Sanguinaria canadensis*
Blue cohosh	*Caulophyllum thalictroides*
Blue-joint grass	*Calamagrostis canadensis*
Blue flag	*Iris versicolor*
Bluebead lily	*Clintonia borealis*
Blunt-leaf orchis	*Platanthera obtusata*
Butternut	*Juglans cinerea*
Bog aster	*Aster nemoralis*
Bog-candle	*Platanthera dilatata*
Bog goldenrod	*Solidago uliginosa*
Bog laurel	*Kalmia polifolia*
Bog-rosemary	*Andromeda polifolia*
Bracken fern	*Pteridium aquilinum*
Broad-leaved arrowhead	*Sagittaria latifolia*
Bulblet bladder-fern	*Cystopteris bulbifera*
Bunchberry	*Cornus canadensis*
Bur oak or mossy-cup oak	*Quercus macrocarpa*
Bush-honeysuckle	*Diervilla lonicera*
Calamagrostis sp.	*Calamagrostis canadensis*
Callitriche sp.	*Callitriche hermaphroditica*
Canada gooseberry	*Ribes hirtellum*
Canada lily	*Lilium canadense*
Carex sp.	*Carex backii*
Carex sp.	*Carex canescens*
Carex sp.	*Carex capillaris*
Carex sp.	*Carex castanea*
Carex sp.	*Carex crinita*
Carex sp.	*Carex diandra*
Carex sp.	*Carex disperma*
Carex sp.	*Carex echinata*
Carex sp.	*Carex exilis*
Carex sp.	*Carex flava*
Carex sp.	*Carex interior*
Carex sp.	*Carex michauxiana*
Carex sp.	*Carex pallescens*
Carex sp.	*Carex stricta*
Carex sp.	*Carex tenuiflora*
Carex sp.	*Carex torta*
Carex sp.	*Carex tribuloides*
Carex sp.	*Carex trisperma*
Carrion-flower	*Smilax herbacea*
Checkered rattlesnake plantain	*Goodyera tesselata*
Chickenclaws	*Salicornia europaea*
Clinton's club-rush	*Scirpus clintonii*
Coltsfoot	*Tussilago farfara*
Common blueberry	*Vaccinium angustifolium*
Common cat-tail	*Typha latifolia*
Common field-horsetail	*Equisetum arvense*
Common juniper	*Juniperus communis*
Creeping snowberry	*Gaultherla hispidula*
Crested woodfern	*Dryopteris cristata*
Crowberry	*Empetrum nigrum*
Curly-grass fern	*Schizaea pusilla*
Cystopteris sp.	*Cystopteris laurentiana*
Ditch-grass	*Ruppia maritima*
Drummond's rock cress	*Arabis drummondii*
Duckweed	*Lemna minor*
Dutchman's breeches	*Dicentra cuculiaria*
Early blue violet	*Viola adunca*
Eastern hemlock	*Tsuga canadensis*
Eastern white cedar	*Thuja occidentalis*
Elatine sp.	*Elatine americana*
Eleocharis sp.	*Eleocharis Intermedia*
False hellebore	*Veratrum viride*
False Solomon's seal	*Smilacina racemosa*
Figwort	*Scrophularia lanceolata*
Fir club-moss	*Huperzia appalachiana*
Fir club-moss	*Huperzia selago*
Flat-topped white aster	*Aster umbellatus*
Fowl meadow-grass	*Poa palustris*
Fragile fern	*Cystopteris fragilis*
Fragrant fern	*Dryopteris fragrans*
Fragrant water-lily	*Nymphaea odorata*
Freshwater cord-grass	*Spartina pectinata*

Glandular wood-fern	*Dryopteris intermedia*
Glaucous lettuce	*Prenanthes racemosa*
Glaucous poa	*Poa glaucantha*
Golden alexanders	*Zizia aurea*
Goldthread	*Coptis trifolia*
Grass-pink	*Calopogon tuberosus*
Green adder's tongue	*Malaxis uniflora*
Green alder	*Alnus viridis*
Green spleenwort	*Asplenium viride*
Green woodland orchis	*Platanthera clavellata*
Grey birch	*Betula populifolia*
Grove meadow-grass	*Poa alsodes*
Hairy rock-cress	*Arabis hirsuta*
Heartleaf twayblade	*Listera cordata*
Helleborine	*Epipactis helleborine*
Hemlock	*Tsuga canadensis*
Hemlock parsley	*Comioselium chinense*
Herb-robert	*Geranium robertianum*
Hooker's orchis	*Platanthera hookeri*
Hyssop-leaved fleabane	*Erigeron hyssopifolius*
Indian cucumber-root	*Medeola virginiana*
Indian pipe	*Monotropa uniflora*
Intermediate wood-fern	*Dryopteris intermedia*
Ironwood	*Ostrya virginiana*
Isoetes sp.	*Isoetes harveyi*
Isoetes sp.	*Isoetes tuckermanii*
Jack-in-the-pulpit	*Arisaema triphyllum*
Jack pine	*Pinus banksiana*
Joe-pye-weed	*Eupatorium maculatum*
Juncus sp.	*Juncus balticus*
Juncus sp.	*Juncus brevicaudatus*
Juncus sp.	*Juncus effusus*
Labrador tea	*Ledum groenlandicum*
Lance-leaved grape-fern	*Botrychium lanceolatum*
Large-leaved aster	*Aster macrophyllus*
Large purple-fringed orchis	*Platanthera grandiflora*
Large round-leaved orchis	*Platanthera macrophylla*
Laurentian bladder fern	*Cystopteris laurentiana*
Leather-leaf	*Chamaedaphne calyculata*
Livelong saxifrage	*Saxifraga paniculata*
Low-bush blueberry	*Vaccinium angustifolium*
Luzula sp.	*Luzula acuminata*
Maidenhair fern	*Adiantum pedatum*
Maidenhair spleenwort	*Asplenium trichomanes*
Maple-leaved goosefoot	*Chenopodium gigantospermum*
Marginal shield-fern	*Dryopteris marginalis*
Marsh fern	*Thelypteris palustris* var. *pubescens*
Marsh-five-finger	*Potentilla palustris*
Mitrewort	*Mitella nuda*
Moccasin flower	*Cypripedium acaule*
Mountain-ash	*Sorbus americana*
Mountain-mint	*Pycnanthemum virginianum*
Mountain wood-fern	*Dryopteris campyloptera*
Myriophyllum sp.	*Myriophyllum heterophyllum*
Narrow-leaved cat-tail	*Typha angustifolia*
Narrow-leaved sundew	*Drosera intermedia*
Nodding beggar-ticks	*Bidens cernua*
Nodding trillium	*Trillium cernuum*
Northern blue violet	*Viola septentrionalis*
Northern green orchis	*Platanthera hyperborea*
Northern white violet	*Viola mackloskeyi*
Northern wild rice	*Zizania palustris*
Oak fern	*Gymnocarpium dryopteris*
Pale corydalis	*Corydalis sempervirens*
Partridge berry	*Mitchella repens*
Pussytoes	*Antennaria neglecta* var. *neglecta*
Pickerelweed	*Pontederia cordata*
Pine-drops	*Pterospora andromedea*
Pinesap	*Monotropa hypopithys*
Pink pyrola	*Pyrola asarifolia*
Pitcher plant	*Sarracenia purpurea*
Poison ivy	*Toxicodendron rydbergii*
Potamogeton sp.	*Potamogeton zosteriformis*
Potamogeton sp.	*Potamogeton oakesianus*
Poverty-grass	*Danthonia spicata*
Prince's pine	*Chimaphila umbellata*
Puccinellia sp.	*Puccinellia americana*
Ragged-fringed orchis	*Platanthera lacera*
Rand's eyebright	*Eurphrasia randii*
Rattlesnake fern	*Botrychium virginianum*
Red ash	*Fraxinus pennsylvanica*
Red maple	*Acer rubrum*
Red oak	*Quercus rubra*
Red pine	*Pinus resinosa*
Red spruce	*Picea rubens*
Reed canary-grass	*Phalaris arundinacea*
Reed meadow-grass	*Glyceria grandis*
Rhodora	*Rhododendron canadense*
Rock-cress draba	*Draba arabisans*
Rock fern	*Polypodium virginianum*
Rock spikemoss	*Selaginella rupestris*
Roseroot	*Sedum rosea*
Rough mountain-rice	*Oryzopsis asperifolia*
Round-leaved sundew	*Drosera rotundifolia*
Royal fern	*Osmunda regalis*
Rusty woodsia	*Woodsia ilvensis*
Sagewort wormwood	*Artemisia campestris*
Sagittaria sp.	*Sagittaria cuneata*
Salix sp.	*Salix pellita*
Salix sp.	*Salix petiolaris*
Salix sp.	*Salix pyrifolia*
Salt-water cord-grass	*Spartina alterniflora*
Scirpus sp.	*Scirpus hudsonianus*
Scirpus sp.	*Scirpus macrocarpus*
Scotch lovage	*Ligusticum scothicum*
Screw-stem	*Bartonia paniculata*
Sea lavender	*Limonium carolinianum*
Sea lyme-grass	*Elymus mollis*

Seaside goldenrod	*Solidago sempervirens*
Seaside-plantain	*Plantago maritima*
Selaginella sp.	*Selaginella selaginoides*
Sheep laurel	*Kalmia angustifolia*
Showy lady's slipper	*Cypripedium reginae*
Silver maple	*Acer saccharinum*
Silverrod	*Solidago bicolor*
Silverweed	*Potentilla anserina*
Skunk-currant	*Ribes glandulosa*
Small cranberry	*Vaccinium oxycoccus*
Smooth woodsia	*Woodsia glabella*
Solomon's seal	*Polygonatum pubescens*
Sparganium sp.	*Sparganium eurycarpum*
Speckled alder	*Alnus incana*
Spergularia sp.	*Spergularia marina*
Spike-grass	*Distichlis spicata*
Spring beauty	*Claytonia caroliniana*
Star-duckweed	*Lemna trisulca*
Steeple-bush	*Spiraea tomentosa*
Swamp-pink	*Arethusa bulbosa*
Sweet-fern	*Comptonia peregrina*
Sweetflag	*Acorus americanus*
Sugar maple	*Acer saccharum*
Sundrops	*Oenothera perennis*
Tall meadow rue	*Thalictrum pubescens*
Tamarack	*Larix laricina*
Tawny cotton-grass	*Eriophorum virginicum*
Three-leaved false Solomon's seal	*Smilacina trifoliata*
Three-toothed cinquefoil	*Potentilla tridentata*
Toad rush	*Juncus bufonus*
Triglochin sp.	*Triglochin maritima*
Trout lily	*Erythronium americanum*
Tufted club-rush	*Scirpus caespitosus* var. *callosus*
Tufted club-rush	*Scirpus caespitosus* var. *delicatulus*
Twinflower	*Linnaea borealis*
Typha sp.	*Typha borealis*
Typha sp.	*Typha latifolia*
Utricularia sp.	*Utricularia geminiscapa*
Water-horsetail	*Equisetum fluviatile*
Water plantain	*Alisma plantago-aquatica*
Water-shield	*Brasenia schreberi*
Wavy hair grass	*Deschampsia flexuosa*
White ash	*Fraxinus americana*
White birch	*Betula papyrifera*
White-buttons	*Eriocaulon septangulare*
White cotton-grass	*Eriophorum angustifolium*
White mandarin	*Streptopus amplexifolius*
White pine	*Pinus strobus*
White snakeroot	*Eupatorium rugosum*
Whorled loosestrife	*Lysimachia quadrifolia*
Whorled wood aster	*Aster acuminatus*
Wild calla	*Calla palustris*
Wild leek	*Allium tricoccum*
Wood anemone	*Anemone quinquifolia*
Wood sorrel	*Oxalis acetosella*
Woodland strawberry	*Fragaria vesca*
Yellow lady's slipper	*Cypripedium calceolus*
Yellow loosestrife	*Lysimachia terrestris*
Yellow pond-lily	*Nuphar luteum*
Yellow water-crowfoot	*Ranunculus flabellaris*

Cryptogams

Lichen spp.	*Cladina* spp.
Lichen spp.	*Gyrophora* spp.
Lichen spp.	*Lecanora* spp.
Lichen spp.	*Lecidia* spp.
Lichen spp.	*Parmelia* spp.
Lichen spp.	*Stereocaulon* spp.
Reindeer moss	*Cladonia* spp.
Liverwort sp.	*Bazzania trilobata*
Liverwort sp.	*Plagiochila asplenioides*
Liverwort sp.	Porella platyphylloides
Liverwort sp.	Radula complanata
Moss sp.	*Bartramia pomiformi*
Moss sp.	Hedwigia ciliata
Moss sp.	Plagiopus oederiana
Moss spp.	*Polytrichum* spp.
Moss sp.	*Rhacomitrium canescens*
Plume moss	*Ptilium crista-castrensis*
Schreber's moss	*Pleurozium schreberi*

Birds

American bittern	*Botaurus lentiginosus*
American redstart	*Setophaga ruticilla*
Bicknell's thrush	*Catharus bicknelli*
Black duck	*Anas rubripes*
Black tern	*Chlidonias niger*
Blue-winged teal	*Anas discors*
Brown-headed cowbird	*Molothrus ater*
Great blue heron	*Ardea herodias*
Green-winged teal	*Anas crecca*
Grey-cheeked thrush	*Catharus minimus*
Mallard	*Anas platyrhynchos*
Northern harrier	*Circus cyaneus*
Northern oriole	*Icterus galbula*
Northern pintail	*Anas acuta*
Northern shoveler	*Anas clypeata*
Ovenbird	*Seiurus aurocapillus*
Peregrine falcon	*Falco peregrinus*
Pied-billed grebe	*Podilymbus podiceps*
Pileated woodpecker	*Hylatomus pileatus*
Red-eyed vireo	*Vireo olivacens*
Red-winged blackbird	*Agelaius phoeniceus*
Ring-necked duck	*Aythya collaris*

Scarlet tanager	*Piranga olivacea*
Sedge wren	*Cistothorus platensis*
Sora rail	*Porzana carolina*
Swamp sparrow	*Melospiza georgiana*
Vesper sparrow	*Pooecetes gramineus*
Virginia rail	*Rallus limicola*
Wood thrush	*Hylocichla mustelina*
Warbling vireo	*Vireo gilvus*

Mammals

Black bear	*Ursa americanus*
Coyote	*Canus latrans*
Eastern pipistrelle	*Pipistrellus subflavus*
Gaspé shrew	*Sorex gaspensis*
Northern flying squirrel	*Glaucomys sabrinus*
Pine marten	*Martes americana*
Rock shrew	*Sorex dispar*

Invertebrates

Dwarf wedge-mussel	*Alasmidonta heterodon*
Swollen wedge-mussel	*Alasmidonta varicosa*

Insects

Crowberry blue butterfly	*Lycaeides argyrognomon empetri*

Amphibians

Four-toed salamander	*Hemidactylium acutatum*

Appendix II

Rare and Uncommon Plant Spp. in the Fundy Model Forest

The following is a list of all uncommon and rare plant species known to occur within the Fundy Model Forest, and the habitat with which they are most often associated. Most records and habitat descriptions are from Hinds (1983; 1986); the remainder were species discovered during field work in the summer of 1994.

Species	Habitat
Lycopodiaceae (Club-Moss Family)	
Juniper club-moss (*Lycopodium sabinifolium*)	Open, dry woods; clearings
Fir club-moss (*Huperzia appalachiana*)	cliff face, shores, headlands
Fir club-moss (*Huperzia selago*)	Cliff face, shores, headlands
Selaginellaceae (Spikemoss Family)	
Low spikemoss (*Selaginella rupestris*)	Dry escarpment
Rock spikemoss (*Selaginella selaginoides*)	Wet, calcareous ledges
Isoetaceae (Quillwort Family)	
Isoetes harveyi	Muddy-bottomed, shallow water
Tuckerman's quillwort (*Isoetes tuckermanii*)	Shallow pond margins
Ophioglossaceae (Adder's Tongue Family)	
Little moonwort (*Botrychium simplex*)	Rich, hardwood forests
Northern adder's tongue (*Ophioglossum vulgatum*)	Boggy meadows
Polypodiaceae (Fern Family)	
Maidenhair fern (*Adiantum pedatum*)	Rich, hardwood forests
Maidenhair-spleenwort (*Asplenium trichomanes*)	Moist, shady ledges
Green spleenwort (*Asplenium viride*)	Moist, shady ledges
Laurentian bladder fern (*Cystopteris laurentiana*)	Moist, shady ledges
Fragrant fern (*Dryopteris fragrans*)	Dry, often exposed ledges
Dryopteris X *triploidea*	Rich, swampy or rocky woods
Braun's holly fern (*Polystichum braunii*)	Rich, calcareous sites
Alpine woodsia (*Woodsia alpina*)	Calcareous ledges
Smooth woodsia (*Woodsia glabella*)	Moist, calcareous ledges
Schizaeacea (Climbing Fern Family)	
Curly-grass fern (*Schizaea pusilla*)	Bog hummocks
Pinaceae (Pine Family)	
Creeping juniper (*Juniperus horizontalis*)	Rocky, sandy, boggy, open areas
Potamogetonaceae (Pondweed Family)	
Oakes pondweed (*Potamogeton oakesianus*)	Peaty or sandy ponds
Robbin's pondweed (*Potamogeton robbinsii*)	Deep water and slow streams
Zostera pondweed (*Potamogeton zosterifolius*)	Quiet, usually alkaline water
Richardson's pondweed (*Potamogeton richardsonii*)	Usually alkaline water
Zannichelliaceae (Horned Pondweed Family)	
Horned pondweed (*Zannichellia palustris*)	Brackish pools
Juncaginaceae (Arrow-grass Family)	
Arrow-grass (*Triglochin gaspense*)	Salt marshes below high tide zone
Poaceae (Grass Family)	
Upland bent (*Agrostis perennans*)	Moist woodlands; flooded shores
Pickering's blue-joint (*Calamagrostis pickeringii*)	Boggy heath; wet woods
Spike-grass (*Distichlis spicata*)	salt marshes; salt springs
Spreading millet grass (*Milium effusum*)	Deciduous woods
Canadian mountain-rice (*Oryzopsis canadensis*)	Sandy barrens; clearings

Slender mountain-rice (*Oryzopsis pungens*)	Sandy barrens; rock crevices
Grove meadow-grass (*Poa alsodes*)	Rich, deciduous woods
Glaucous poa (*Poa glaucantha*)	Calcareous ledges
False oats (*Trisetum triflorum* var. *triflorum*)	Rock crevices
Cyperaceae (Sedge Family)	
Carex adusta	Dry, acid soils
Carex amphibola	Moist, shaded woods; alluvial woods
Carex arcta	Shores; wet woods
Carex atlantica	Boggy, open ground
Carex backii	Shaded ledges, often calcareous
Carex brunnescens var. *brunnescens*	Headlands
Carex capillaris	Varied habitat
Carex conoidea	Damp, grassy areas
Carex eburnea	Moist, calcareous ledges
Carex exilis	Sphagnum bogs, often in rich areas
Carex flaccidula	Rich, wooded slopes
Carex folliculata	Swampy woods
Carex granularis var. *haleana*	Shores and grassy meadows, often calcareous
Carex hirtifolia	Dry woods; rocky floodplains
Carex lacustris	Marshy woodlands, ditches, swamps
Carex limosa	Sphagnum bogs, often surrounding bog ponds
Carex lucorum	Sandy, open heathy barrens; dry, mixed woods
Carex lupulina	Borders of wet woods, swampy shores
Carex michauxiana	Peat bogs and boggy meadows
Carex peckii	Calcareous rocky slopes, clearings, and dry woods
Carex sprengelii	Banks, slopes, bottomlands, often calcareous
Carex salina var. *kattegatensis*	Brackish marshes; coastal bogs
Carex tenera	Moist open ground
Carex tenuiflora	Sphagnum bogs and boggy meadows, often calcareous
Carex tuckermanii	Alluvial woods
Carex wiegandii	Bogs, bog thickets, and shores
Awned cyperus (*Cyperus aristatus*)	Sandy shores
Intermediate spike-rush (*Eleocharis intermedia*)	Wet, muddy soil
Small-headed beak-rush (*Rhynchospora capitellata*)	Damp shores, ledges
Tufted club-rush (*Scirpus caespitosus* var. *delicatulus*)	Wet, calcareous ledges
Clinton's club-rush (*Scirpus clintonii*)	Calcareous ledges or shores
River bulrush (*Scirpus fluviatilis*)	Shallow water
Hudsonian club-rush (*Scirpus hudsonianus*)	Springy shores; boggy meadows
Scirpus lineatus	Calcareous roadside ditches
Scirpus torreyi	Wet, open areas
Araceae (Arum Family)	
Eastern skunk cabbage (*Symplocarpus foetidus*)	Alder thickets; swampy woods
Lemnaceae (Duckweed Family)	
Star-duckweed (*Lemna trisulca*)	Quiet waters
Xyridaceae (Yellow-eyed Grass Family)	
Yellow-eyed grass (*Xyris montana*)	Boggy areas
Juncaceae (Rush Family)	
Juncus alpinoarticulatus	Calcareous shores and springy areas
Knotted rush (*Juncus nodosus*)	Habitat not listed
Vasey's rush (*Juncus vaseyi*)	Rock crevices and wet sandy shores
Small-flowered wood rush (*Luzula parviflora* ssp. *melanocarpa*)	Damp, coniferous or mixed woods; cool ravines and banks

False Solomon's seal (*Smilacina racemosa*)	Open, deciduous woods
Orchidaceae (Orchis Family)	
Bog twayblade (*Liparis loeselii*)	Damp thickets, meadows, sandy areas
Swamp-pink (*Arethusa bulbosa*)	Sphagnum bogs
Grass-pink (*Calopogon tuberosus*)	Sphagnum bogs
Calypso (*Calypso bulbosa*)	Arborvitae swamps
Frog-orchis (*Coeloglossom viride*)	Rich woods and meadows
Albino spotted coral-root (*Corallorhiza maculata* forma *flavida*)	Dryish conifer and mixed woods
Yellow lady's slipper (*Cypripedium calceolus* var. *pubescens*)	Moist rich woods, cedar swamps
Downy rattlesnake-plantain (*Goodyera pubescens*)	Dry or moist coniferous or mixed woods
Checkered rattlesnake plantain (*Goodyera tesselata*)	Dry conifer or mixed woods
Large purple-fringed orchis (*Platanthera grandiflora*)	Open wet areas
Large round-leaved orchis (*Platanthera macrophylla*)	Rich woods, deciduous or mixed with hemlock
Round-leaved orchis (*Platanthera orbiculata*)	Dry or swampy woods
Platanthera X *andrewsii*	Moist, open areas
Broad-leaved ladies' tresses (*Spiranthes lucida*)	Springy shores, meadows, and thickets, often calcareous
Saliceae (Willow Family)	
Bog willow (*Salix pedicellaris*)	Bogs; wet, swampy meadows
Polygonaceae (Buckwheat Family)	
Bushy knotweed (*Polygonum ramosissimum*)	Brackish marshes and ditches
Halberd-leaved tearthumb (*Polygonum arifolium*)	Swampy areas
Chenopodiaceae (Goosefoot Family)	
Maple-leaved goosefoot (*Chenopodium gigantospermum*)	Moist, rocky woods
Caryophyllaceae (Pink Family)	
Alsine-like starwort (*Stellaria alsine*)	Wet banks; springy areas
Low starwort (*Stellaria humifusa*)	Salt marshes and meadows
Nymphaceae (Water-lily Family)	
Fragrant water-lily (*Nymphaea odorata*)	Lakes and ponds
Ranunculaceae (Crowfoot Family)	
Round-leaved hepatica (*Hepatica nobilis*)	Dryish hardwood or mixed slopes
Small yellow water-crowfoot (*Ranunculus gmelinii* var. *hookeri*)	Wet meadows, ponds, and streams
Berberidaceae (Barberry Family)	
Blue cohosh (*Caulophyllum thalictroides*)	Rich, deciduous woods
Brassicaceae or Cruciferеae (Mustard Family)	
Cutleaf toothwort (*Dentaria laciniata*)	Rich woods
Drummond's rock-cress (*Arabis drummondii*)	Ledges and rocky thickets
Hairy rock-cress (*Arabis hirsuta*)	Calcareous ledges and gravels
Rock-cress draba (*Draba arabisans*)	Dry, exposed, calcareous ledges
Saxifragaceae (Saxifrage Family)	
Livelong saxifrage (*Saxifraga paniculata*)	Moist, calcareous ledges
Rosaceae (Rose Family)	
Amelanchier canadensis	Borders of swamps and streams
Amelanchier X *quinti-martii*	Wet woods and heathy barrens
Amelanchier sanguinea	Dry rocky or gravelly soils
Swamp rose (*Rosa palustris*)	Wet shores, marshes, and swamps
Black raspberry (*Rubus occidentalis*)	Open woods, often calcareous
Canada burnet (*Sanguisorba canadensis*)	Bogs; wet, open ground
Geraniaceae (Geranium Family)	
Bicknell's wild geranium (*Geranium bicknellii*)	Disturbed areas
Herb-robert (*Geranium robertianum*)	Rocky woods; wet ledges
Polygalaceae (Milkwort Family)	
Fringed polygala (*Polygala paucifolia*)	Moist, acid, mixed woods
Callitricaceae (Water Starwort Family)	

Anacardiaceae (Cashew Family)	
Poison ivy (*Toxicodendron radicans*)	Swampy woods or thickets
Hypericaceae (St. John's-wort Family)	
Dwarf St. John's-wort (*Hypericum mutilum*)	Damp, open areas
Large St. John's-wort (*Hypericum majus*)	Damp, open areas
Violaceae (Violet Family)	
Alpine violet (*Viola labradorica*)	Cool, moist rock or ledge crevices
Early blue violet (*Viola adunca*)	Rocky slopes, shores, sand plains
Great-spurred violet (*Viola selkirkii*)	Rich, deciduous woods; rocky slopes
Northern bog violet (*Viola nephrophylla*)	Gravelly shores
Onagraceae (Evening Primrose Family)	
Evening primrose (*Oenothera biennis*)	Varied disturbed areas
Hornmann's willow-herb (*Epilobium hornmannii*)	Cool, moist slopes and shores
Narrow willow-herb (*Epilobium strictum*)	Wet meadows, bogs, swamps
Haloragaceae (Water-Milfoil Family)	
Myriophyllum heterophyllum	Slow streams and ponds
Araliaceae (Ginseng Family)	
Dwarf ginseng (*Panax trifolius*)	Rich, deciduous woods
Apiaceae (Parsley Family)	
Honewort (*Cryptotaenia canadensis*)	Rich, deciduous woods
Large-fruited sanicle (*Sanicula trifoliata*)	Rich hardwoods
Osmorhiza chilensis	Moist to dryish woodlands
Osmorhiza longistylis	Moist woods
Pyrolaceae (Wintergreen Family)	
Lesser wintergreen (*Pyrola minor*)	Cool, moist woods
Pinesap (*Monotropa hypopitys*)	Coniferous forests
Pyrola chlorantha	Coniferous forests
Ericaceae (Heath Family)	
Bearberry (*Arctostaphylos uva-ursi*)	Dry ledges
Dwarf bilberry (*Vaccinium caespitosum*)	Rocky shores, ledges, and clearings
Dwarf huckleberry (*Gaylussacia dumosa*)	Sphagnum bogs; wet barrens
Priulaceae (Primrose Family)	
Bird's-eye primrose (*Primula farinosa*)	Sea cliffs, usually calcareous
Tufted loosestrife (*Lysimachia thyrsiflora*)	Swamps, wet thickets, bogs
Whorled loosestrife (*Lysimachia quadrifolia*)	Shores; damp woods
Gentianaceae (Gentian Family)	
Screw-stem (*Bartonia paniculata*)	Wet peaty or sandy lowlands
Lamiaceae (Mint Family)	
American pennyroyal (*Hedeoma pulegoides*)	Ledges and dry gravelly soils
Mountain mint (*Pycnanthemum virginianum*)	Moist shoreline rock crevices
Scrophulariaceae (Figwort Family)	
Lanceolate figwort (*Scrophularia lanceolata*)	Open woods; old fields
Rand's eyebright (*Euphrasia randii*)	Headlands
Lentibulariaceae (Bladderwort Family)	
Twin-scaped bladderwort (*Utricularia geminiscapa*)	Bog ponds; slow streams
Rubiaceae (Madder Family)	
Galium obtusum	Shores; wet places
Northern bedstraw (*Galium boreale*)	Open woods, thickets, meadows
Caprifoliaceae (Honeysuckle Family)	
Squashberry (*Viburnum edule*)	Cool, moist woods; ravines; slopes
Swamp fly-honeysuckle (*Lonicera oblongifolia*)	Calcareous swamps or bogs
Asteraceae (Aster Family)	
Antennaria neglecta var. *randii*	Rocky barrens, open woods
Aster vimineus	Wet woods, fields, shores

Bidens connata	Shores and similar wet areas
Discoid beggar-ticks (*Bidens discoidea*)	Rocky, peaty, or sandy shores
Glaucous lettuce (*Prenanthes racemosa*)	Shores, meadows, and thickets
Hyssop-leaved fleabane (*Erigeron hyssopifolius*)	Calcareous ledges or shores
Kalm's hawkweed (*Hieracium kalmii*)	Clearings; borders of woods
Lake Huron tansy (*Tanacetum bipinnatum*)	Gravelly river strands; rocky banks
Panicled hawkweed (*Hieracium paniculatum*)	Open, rocky woods; thickets
Robinson's hawkweed (*Hieracium robinsonii*)	Ledge crevices along streams
Rush-like aster (*Aster borealis*)	Calcareous bogs, swamps, shores
White snakeroot (*Eupatorium rugosum*)	Moist, cool woods, shores, clearings