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

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Canadian Forest Service
City of Moncton
Conservation Council of New Brunswick
Fisheries and Oceans Canada
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Elmhurst Outdoors
Environment Canada
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University of NB, Fredericton - Faculty of Forestry
University of NB - Saint John Campus
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Washademoak Environmentalists

Possibly rare and endangered plants found in wet cedar forests in southeastern New Brunswick

(Project # 23138-00-0731)

By Faye Doran

INTRODUCTION

New Brunswick is the largest of the Maritime provinces, covering 7.3 million hectares of land, and is Canada's most heavily forested province. Anywhere from 83 – 88% of New Brunswick is covered with forest (Dionne et. al, 1988; Godin and Roberts, 1994). The forest cover type is predominantly softwood, with tolerant hardwood mixed forests.

The topography has been described as rolling, with numerous rivers and valleys. The waters surrounding the province (Bay of Fundy, Gulf of St. Lawrence and Baie de Chaleur) help to moderate the temperatures, resulting in not-so-cold winters and not-very-hot summers (Lynch, 1921).

Eastern white-cedar

Eastern white cedar (*Thuja occidentalis* L.) is a softwood that grows in eastern Canada and the United States, and grows in a relatively humid climate (Johnstone, 1990). It is also referred to in the literature by other common names: northern white-cedar, white-cedar, arborvitae, eastern arborvitae and swamp-cedar (Fowells, 1965; Godman 1958). This tree should not be confused with the Atlantic white-cedar (*Chamaecyparis thyoides* (L.) B.S.P.), which is a tree in an entirely different group (junipers). Atlantic white-cedar is sometimes referred to as southern white-cedar, or simply white cedar, and so there may be some confusion in the literature (especially with the reference to 'Atlantic' in its common name).

Eastern white cedar can be found across the eastern half of Canada, from western Ontario to Nova Scotia, but is of particular importance in New Brunswick. It is the only tree member of the Cypress family that grows in the Maritimes (Ritchie, 1996). Eastern white cedar is present in New Brunswick, but is extremely rare elsewhere in the Maritimes (Rowe, 1972), and is listed as rare in Nova Scotia (Anon, 1999; Maher et. al, 1978). Cedar is scattered and uncommon within the Fundy Model Forest, which is located in southeastern New Brunswick (Woodley and Forbes, 1997). Eastern white cedar can be found growing on a variety of sites and conditions, in pure stands, old fields or in association with other trees. It grows on wet, moist and dry soils, but does not do well at either extreme (Johnston, 1990). It prefers moist, nutrient-rich soils often associated with streams and drainageways or on calcareous mineral soils (Johnston, 1990). However, once established, eastern white cedar can grow fairly well (albeit slowly) on swampy areas, competing with its associates (the spruces, tamarack, balsam fir, eastern hemlock, black ash and red maple). It grows best on moist upland slopes, in association with yellow birch, white pine, silver maple, eastern hemlock, poplar, aspen and elm (Hosie, 1979).

Eastern white cedar has a high to moderate tolerance to shade, and has a slow-to-moderate growth rate. Mature trees can grow to a height of 15 metres and can live anywhere from 150 – 300 years, depending on the site conditions (Ritchie, 1996).

Cedar has many uses: posts, poles, shingles, boat building, and other places where timber may be exposed to the elements. The wood is quite resistant to decay, when it is in contact with the wet ground (Perley, 1847). The wood is fragrant but soft, and is popular for panels in closets and blanket chests, acting as a natural moth repellent.

Poitras (pers. comm.) explained that over half of the current New Brunswick cedar market was for shingles, with the remainder of cedar being used for specialty products such as fencing, posts, turnings and boards.

LITERATURE REVIEW

Historical

New Brunswick and indeed, much of Canada were covered with thick sheets of ice during the last major Ice Age, during the Pleistocene Epoch. This ice age ended about 10,000 years ago, or Before Present (B.P.) (Ferguson and Fyffe, 1985).

New Brunswick was first visited by European settlers in the early 1600's, and over the centuries, many people followed. More and more land was cleared as the settlements grew. Large-scale logging continued well into the early twentieth century. A report on New Brunswick's natural resources published by the Department of the Interior (Lynch, 1921) stated that "progress was gradual but steady" as more and more land was being brought under cultivation. Even the unproductive areas of marshlands, such as were found along the coast of the Bay of Fundy, were altered or reclaimed by building dykes and growing hay. Not only was the forested land to be cleared, but rocky land had the rocks removed, and swampy land had to be drained (Lutz, 1997).

Perley (1863) stated that the cedar swamps, when cleared and drained, were noted for producing large crops of clover, implying that the cedar trees themselves had little value but the land upon which they grew was more valuable for what it could produce in the way of crops. However, Perley, in an earlier report (1847), recognized that harvesting levels of *Thuja occidentalis* were already high. "…the utmost economy should be exercised in cutting the arbor vitae, which has hitherto been used in the most extravagant manner, as if it were an object to get rid of it as much as possible".

Many areas were available for new settlers to move into, some already equipped with abandoned farmhouses, left over from the first wave of settlers the previous century. Perley's report also mentioned that, even though the soil on some of these homesteads was rather "run down from neglect", the new settler could afford to buy hay and fertilizer the first year, since the farm sale price was so cheap.

Lutz (1997) compared the present forest composition in King's County, New Brunswick with the pre-settlement forest type, and discovered that cedar had decreased by 50% from 1880 to 1993. He also discussed the historical aspects of New Brunswick's land clearing. Cedar was primarily harvested from the

central portions of the province (Carleton, Kent and Northumberland counties), as opposed to the southeastern counties. This was likely due to the fact that the road network was more established in central New Brunswick, as it followed the Saint John River valley. The southeastern portion of the province was not as settled, and so, the forests may not have been harvested as intensively.

Climate

The climate of southeast New Brunswick is considered temperate, with cold winters and short summers. The Bay of Fundy has some moderating influence on the coastal climate, and allows for a longer growing season, with higher precipitation conditions (Aalund and Wicklund, 1941).

To help to promote New Brunswick as a highly desirable place to settle, Lynch (1921) published a report on the province's current and yet-to-be-exploited resources. He claimed that the climate was conducive to good health, and that people lived to a great age. Saint John was mentioned as being at the same latitude as Bordeaux [France] and Venice [Italy], implying that the climate here was quite continental and similar to eastern Europe (if that was a desirable thing!).

New Brunswick experiences a wide range in annual temperatures, due to the difference in elevation within the province. The eastern and southern portions are fairly level, or slightly rolling and have many different forest types, including rich, shade-tolerant hardwoods, as well as bottomland hardwoods, mixed wood forests, and swamps (Lutz, 1995). Much of the land in New Brunswick is suitable for agriculture, especially in the lower elevations, and along the river banks, where the soil is fertile. Eastern white cedar can be found growing predominantly along the diagonal line from the south west, central and to the northeast areas of the province, generally following the Lowland Ecoregion (Godin and Roberts, 1994).

Soils

Soil formation of an area is influenced by climate, organic matter decomposition rates, microbial activity, temperature, amount of precipitation, parent material and drainage conditions (Aalund and Wicklund, 1941). New Brunswick was covered with glaciers during the last major Ice Age, and when they retreated, extensive glacial till was left to form the present topography (Godin and Roberts, 1994). The glaciers left surface deposits of till, forming hills and mounds, and helped carve out depressions and valleys. Other agents that influenced the present soil types included the ocean deposits, the rivers and the wind (Colpitts, et. al, 1995).

Soils in New Brunswick can be acidic, neutral or basic, and the level of acidity will affect what types of plants and forest communities will develop. Less acidic (more neutral) sites tend to have better soil fertility than more acidic soils, and so, exhibit a greater diversity of deciduous trees and herbaceous plants (Colpitts, et. al, 1995). Calcareous soils that formed over limestone, being more fertile, have a high value for agricultural purposes (Lutz, 1997) and so were routinely drained for farming.

Classification

The province of New Brunswick is situated at the north end of the Appalachian Mountain system that runs southwest down the east coast of North America.

The **Acadian Forest Region** of Canada includes the provinces of New Brunswick, Nova Scotia and Prince Edward Island, and is made up of red spruce, balsam fir, yellow birch and sugar maple, with some red pine, eastern white pine and eastern hemlock. Over eighty-five percent (85%) of New Brunswick is forested (Natural Resources Canada, 2000; Dionne et. al, 1988).

Rowe (1972) further subdivided his eight regions into 90 forest sections, to highlight the distinctive patterns of vegetation and physiography across Canada. The eastern half of New Brunswick is included in the **Eastern Lowland Forest Section**. Eastern white cedar is found primarily on the lowlands of this Section, where there are broad areas of open peat bogs and forested wetlands (Figure 1).

This coarse classification system has been further refined over the years and in 1989, a group of scientists devised a new classification system that would help to describe the influence of climate on the patterns and qualities of Canada's diverse ecosystems (CCELC, 1989). This system was developed to help land managers (foresters, agriculture and wildlife) make land use decisions. Growth rates, succession and vegetation responses should be similar on comparable soils within the same ecoclimate region.

The **Boreal Ecoclimate Provinc**e covers about one-third of Canada (along the middle and south) and is characterized by closed-canopied forests of conifer or mixed conifer-hardwood species. The southern coast of New Brunswick is considered to be in this ecoclimate region.

The **Cool Temperate Ecoclimate Province** is characterized by mixed forests of shade-tolerant hardwoods and conifers. The rest of New Brunswick, as well as Prince Edward Island and inland Nova Scotia are all in the Cool Temperate Ecoclimate region.

Again, this was a system designed to classify all of Canada's land, using climatic data collected from weather stations that would represent each particular area. This resulted in a generalized approach, with broad areas grouped together based on data from a few different sites, using "normal" sites as reference points. The authors stated that not all possible ecosystems on all land forms, soils and parent materials could possibly be described, due to lack of time and knowledge (CCELC, 1989).

However, for example, a cedar forest in the southeast of the province may grow differently from a cedar forest in the northwest, and so other factors needed to be considered. In 1992, the New Brunswick Department of Natural Resources and Energy adopted the system which had first been developed by the Canada Committee on Ecological Land Classification (as described above), and further refined it using regional data on climate, topography and elevation to link vegetation and forest cover types to factors of the environment order to explain variation across the province. New Brunswick exhibits remarkable variation in vegetation from south to north, but only spans about 3.5 degrees of latitude. It is the range in elevation that influences the differences seen in the vegetation and climate (Hinds, 2000).

This ecological land classification system (or ELCS) allows regional ecologists to differentiate among forest ecosystems by looking at various combinations of climate, soil fertility, elevation, moisture

Figure 1. Distribution of eastern white cedar in New Brunswick, in relation to ecodistricts. (reprinted from Godin and Roberts, 1994).

and slope factors (Lutz, 1997). Canada is now divided into 15 terrestrial ecozones, 194 ecoregions, and has been further subdivided into 1,020 ecodistricts (NRC, 2000).

There are 7 layers of land classification in New Brunswick: ecozone, ecoprovince, ecoregion, ecodistrict, ecosection, ecosite and ecoelement (Godin and Roberts, 1994). New Brunswick is dominated by the **Lowlands Ecoregion** (eastern, central and southern portions of the province), which includes the lower elevations (up to 300 meters) as well as the more southerly areas (Figure 2). There is one area in the southeastern part of the province that does not belong to the Lowlands Ecoregion, and that is the **Fundy Plateau**. It is unique to the area, with elevations ranging from 300 – 460 metres, and as a result, has a different forest cover type (Godin and Roberts, 1994). It is commonly grouped with the **Uplands Ecoregion**, which is located in the northwest of the province. There are 63 ecosites within New Brunswick (Lutz, 1997) and 34 ecodistricts (Figure 3).

This Lowlands Ecoregion can be further divided into **Eastern Lowlands, Valley Lowlands, Grand Lake Lowlands** and **Fundy Coastal Ecoregions.** These terms were introduced by New Brunswick Department of Natural Resources and Energy, as they refined their ecological land classification system.

New Brunswick Department of Natural Resources and Energy developed an edatopic grid, to show the relationship of moisture availability and climate to forest cover type (Figure 4) (see Zelazny et. al, 1997). A person can see what conditions are present at a certain site, and know what tree species will be growing on that general site. Cedar prefers the wet warmer sites, which are also more fertile. These sites support rich mixedwood forests that include balsam fir, red maple, yellow birch and white spruce. These sites are labeled ‘6’ and ‘7’. Calcareous soils adds a modifier ‘c’ to some sites In the Fundy Model Forest, cedar makes up about 30% of the ‘7c’ sites. Cedar can also be found around Saint John and along Anagance Ridge, which runs north of the Fundy Plateau Ecodistrict. There is also a fair amount of cedar stands in the Oromocto River Ecodistrict and the Kennebecasis River Ecodistrict (Zelazny et. al, 1997).

Swamps

In many articles and books, there were references to bogs, swamps, wetlands, peatlands, fens, marshes and barrens. Each organization defines their terms a little different from the next. This paper will be looking at wet cedar swamps, or more specifically, places where cedar grows, that may or may not be categorized as a swamp. Cedar will also grow on drier, upland sites (Curtis, 1944; Johnston, 1990).

A **swamp** is a mineral wetland or a peatland with standing water, or water gently flowing through pools or channels, and the water table is usually at or near the surface (Environment Canada, 1987). A **bog** is a peat-covered wetland that forms in a depression or an area where a lake or pond is filling in. They have acidic soils and a high water table (MacDougall and Loo, 1996). The literature was searched under both of these terms, and others, since the definitions of the various “wet lands” were used so indiscriminately. However, the scope of this paper was to study cedar that grows on land or swamp, with emphasis on

Figure 2. Ecoregions of New Brunswick (reprinted from Hinds, 2000).

Figure 3. Ecodistricts of New Brunswick (reprinted from Zelazny et. al, 1997).

Figure 4. Edatopic Grid and Associated Ecosites for New Brunswick Forests (reprinted from Zelazny et. al, 1997).

calcareous soils. This can occur in both swamp and upland sites, so both types of sites were researched. Bogs do not normally have calcareous soils, and so were not examined.

Historically, cedar has not been an economically commercial species, although harvesting did occur for products such as poles, fence posts and shingles (Lewis, 1915; Curtis, 1944). Bogs and swamps were lumped together with barrens, lakes and cleared lands, totaling 6.1% of the Crown Lands that had been surveyed in New Brunswick in 1919 (Lynch, 1921), implying that swamps were unproductive. If found in pure stands on old-field or upland sites, trees were harvested due to the ease of extraction. When looking at the relative proportions of species, cedar made up only 6% of the merchantable timber that was growing on the surveyed Crown Lands of New Brunswick in 1919. However, cedar made up 10% of the timber harvested from these Crown Lands, still well behind spruce (50.4%) and fir (25.2%) (Lynch, 1921), but tied with pine harvests (10%). So even 80 years ago, cedar was not a large component in New Brunswick forests, but cedar made up one-tenth of the timber harvested. Also in their report, the Natural Resources Intelligence Branch (now the New Brunswick Department of Natural Resources and Energy ??), stated that timber was already scarce, prices were high and demand for softwood constantly exceeded the supply.

The market for cedar products today is still small, but any cedar that is removed from the forests is put to good use; that is to say, there is a healthy demand for cedar. According to Yvon Poitras, President of New Brunswick Forest Products, there are several mills in the province that produce specialty products such as fencing materials (pre-built sections, posts and rails) (pers. Comm., 2001). Cedar shingles produced in the province account for about 50-60% of the cedar used, 35% for fencing products, and 5-15% for cedar boards. Many of these boards are then sold to the fencing mills, to make the fencing sections. The cedar harvested by the 10 main licenses on Crown Land last year (2000) totaled 81, 810 cubic meters. The amount of cedar harvested from private woodlots was not known, but was not significant.

The poorly drained swampy sites have not been spared from harvesting pressures, and as the demand for wood grows, and cedar products in particular, the number of cedar stands is continuing to decline (Lutz, 1997; Singleton et al., 2000). Cedar showed the most striking difference when comparing tree species from pre-settlement New Brunswick, to present day in Kings County. Cedar comprised 7.2% of the forest in 1800, and by 1993, had been reduced to 3.5% - or a decrease by half (Lutz, 1997).

In 1999, the total value of Canadian forest products exports reached an all-time high of $44.2 billion (NRC, 2000). The value of timber, pulp and other products has doubled and even tripled through out the world markets. There has been an increase in national production of softwood timber as well as consumption. It is clear that, with increased consumption and production, the demands placed on Canadian forests can no longer be met under the current system of resource management (NRC, 2000).

Sites of interest for further study

Ecological Reserves

Wein (1975) recommended 65 areas to be set aside for preservation in New Brunswick, for some particular ecological significance, or for scientific purpose, or as bench marks to measure man-made change in the future. They would include rare species (flora and fauna), special ecosystems, geological features or unique landscapes. He recommended that public access (for recreation, hunting, hiking) not be encouraged. Two of the reserves did contain cedar, but neither are located in the southeast area of New Brunswick. Four of these reserves are located in what is now known as the Fundy Model Forest, but none of them contain much or any cedar (Wein, 1975).

As of 1997, there were 15 ecological reserves totaling 1,212 ha and ranging in size from 50 to 200 ha, and which represented a variety of habitats, including a peat bog, a red oak stand, a coastal dune system and a steep forested ravine (LaPierre, 1997). However, these areas are not officially protected by any government agencies.

In 1988, the New Horizons Critical Natural Areas Committee submitted a substantial report that listed many areas in New Brunswick worthy of consideration for preservation as a natural site. They recommended several categories including unique features of biological, ecological, geological or aesthetic values (Dionne, et. al, 1988). They urged greater study of these and other areas, in order to gather better information about the species and ecosystems, in order to achieve a better balance of natural areas.

Two sites in particular had cedar present, as well as some uncommon or rare plant species. Baillie Settlement, Charlotte County and Shea Lake, Victoria County both had orchids present. Shea Lake was also listed as being the only known site for *Ranunculus lapponicus* L. (Lapland Buttercup) in the Maritime provinces. However, neither of these sites are in the focus area of southeastern New Brunswick and will not be discussed further. See Dionne, et. al (1988) for more details.

Protected Areas

Dr. LaPierre (1997) put together a group that would try to develop a strategy (called the Protected Areas Strategy, or PAS) that would allow biologists, wildlife specialists and others to put aside certain habitats or ecosystems to be representatives of each of the 7 important ecoregions in the province. In order to be considered, the candidate site's landscape and soil types would be assessed, and then ranked. The size of the protected areas would relate to the landform, or ecosystem habitat(s) that needed protection, and take into account the historical disturbance or use of the land (including forestry, agriculture, fire, etc.) as well as the current use(s) of the area. The assessment would not include ownership of the land (LaPierre, 1997).

This group came up with 12 possible candidate sites, based on years of research by many natural science people. These sites would protect samples of different kinds of habitats that may not already be protected in the provincial or national parks, conservation, nature or ecological reserves, bird sanctuaries or wetlands. Two of these recommended sites can be found in the southeastern part of New Brunswick. The Canaan Bog, located near Kouchibouguac National Park, is in the Eastern Lowlands Ecoregion, as described earlier. The second site would be an extension of the Caledonia Gorge, found in the Fundy Plateau Ecoregion, near the southeast coast. Of the two sites, only the Canaan Bog contains eastern white cedar, growing on calcareous soils. The Caledonia Gorge has a more tolerant hardwood assemblage, much steeper slopes and is at higher elevations.

The Canaan Bog covers almost 30,000 ha, and has elevations ranging from 60 – 140 metres. The soil is poorly drained, and so much of the cover type in the Canaan Bog is, understandably, bog, mixed with forested islands of black spruce, jack pine, intolerant hardwoods and eastern white-cedar (LaPierre, 1997).

LaPierre (1997) suggested that unique habitats should continue to be identified and that site assessments should be conducted to determine the conservation risk for each habitat type. This would continue the work that was started by the provincial government, led by Martha Gorman. He recommended preparing a priority list of rare and unique habitats that need protection in each ecoregion of the province (LaPierre, 1997).

Unique Areas

As part of the Maine Critical Areas Program, which began in the early 80's, J.D. Irving established a Unique Areas Program in Maine and here in New Brunswick that would help their company to promote environmental conservation, by recognizing some of the more unique elements in the forest, giving weight to multiple values (ecological, social, cultural, historical, etc.). Some of their objectives are to preserve rare or uncommon species, landscapes or habitats, preserve certain 'indicator species' in order to monitor environmental changes, establish a species database, and to educate the public about these unique areas and their management. This program was established through a partnership with New Brunswick Department of Natural Resources and Energy and the Nature Trust of New Brunswick. Currently there are over 320 Unique Areas on Irving land or Crown-leased lands, but again, these areas are not officially recognized as 'protected'.

Protection Laws

In addition to the national rankings of rare and endangered plants, there are two laws that exist in New Brunswick. The New Brunswick Endangered Species Act came into law in 1974 to protect plant species from destruction or interference, but also goes one step further and recognizes the habitat of that particular endangered plant (Hinds, 1983). The Ecological Reserves Act (1975) serves to put aside or protect areas in which rare or endangered native plants and animals are found, or to protect habitats that

may contain unique and rare examples of botanical, zoological, pedological or geological phenomena (Hinds, 1983).

As an example of important sites and habitats, the Furbish's Lousewort (*Pedicularis furbishiae*) is listed as endangered in Canada (Egan, 1989). It is habitat-specific and occurs only in small patches, along with other plants that have similar growth requirements. So it is important to conserve habitats rather than individual species, so as to capture other associated plants that may also be uncommon or rare.

Classification of plants

The International Union for Conservation of Nature and Natural Resources (IUCN, 1994) developed a way to categorize species on the basis of their potential threat of extinction, in order that countries may prioritize species that need immediate protection and which ones needed further study. This system has undergone many drafts, and is still being refined, in order that it becomes easier to use and give more consistent results. The categories include 'extinct' (EX), 'extinct in the wild' (EW), 'endangered' (EN), 'vulnerable' (VU), 'lower risk' (LR), and 'data deficient' (DD). The report urged a re-evaluation of taxa at regular intervals, especially for those species that are in the 'LR' category, but which are also considered 'conservation dependent'.

The Fundy Model Forest (FMF), which is part of the Canadian Model Forest Network, began in 1992, and is located in the southeastern part of the province. There are currently eleven (11) Model Forests in operation, one in each of Canada's major forest regions. They were established across Canada to allow scientists to design and research new forest and land management methods to ensure that there will forests to manage in the future, while considering environmental and social values as well as economic values (LaPierre, 1997). Model Forests bring together local individuals, organizations and government agencies in a unique partnership.

The Fundy Model Forest (FMF) has been extensively researched. MacDougall and Loo (1996) list rare and uncommon plant species that have been found to occur within the FMF in southeastern New Brunswick, using records and descriptions from Hinds (1983, 1986) and personal field work. Many of these plants can be found in bogs, but usually under the sphagnum moss-black spruce association, on acidic soils. Eastern white-cedar forests growing on calcareous soils are more uncommon, and several plants species can be found growing on these sites that cannot be found elsewhere. However, more field work is needed, in order to identify those plant species that ONLY grow in wet cedar forests.

Some of the more unique plant species that have been found on wet cedar calcareous sites include Hooker's Orchis, Showy Lady's Slipper, Blunt-leaved Rein Orchis and Heartleaf Twayblade (Hinds, 2000; Singleton et. al, 2000). The dense cover of the cedars provides shelter for many bird species, as well as an important source of winter browse for deer and other small mammals (Anon., 1940; Curtis, 1944; Johnstone, 1990; Ritchie, 1996). The American Marten is considered to be an indicator species of mature-overmature coniferous forests in the province (Woodley and Forbes, 1997).

Lists of plants

Argus and Pryer (1990) published a substantial list of plant taxa (1009) and species that are considered rare in Canada. Those plants represent a full one-quarter of all the plants known to grow in Canada, with Ontario and British Columbia having 781 of them. New Brunswick has 25 taxa that are rare. There are approximately 400 rare or uncommon plant species in New Brunswick (Anonymous, 1999), but only the Furbish's Lousewort is officially listed as endangered (Egan, 1989).

Hinds (1983) published a New Brunswick list of rare vascular plants following years of research and field work, using previous information from the National Museum of Natural Sciences' Rare and Endangered Plants Project, and other authors, as well as herbarium records. He used the status categories commonly used across Canada and developed by COSEWIC : rare, threatened, endangered or extirpated (Egan, 1989).

The status ranks that are used in New Brunswick are S3 (rare-to-uncommon), S2 (very rare), S1 (extremely rare), SH (historically known, and potentially rediscoverable) and SX (extirpated and/or extinct) (Hinds, 2000). Toner uses a draft ranking system in her work with the New Brunswick Species-at-risk Committee. **'At risk'** is for species for which a formal assessment has been completed and is determined to be at risk of extirpation or extinction. **'May be at risk'** is for species that may be at risk of extirpation or extinction, and are candidates for a detailed risk assessment. **'Sensitive'** is for species which are not believed to be at risk of extirpation or extinction, but may require special attention or protection to prevent them from becoming 'at risk'. **'Secure'** is for species which are not believed to be at risk or sensitive (Toner, pers. comm.).

The following table (Table 1) is a list of vascular plant species that was compiled from information provided by Bagnall, Bishop, Goltz, Hinds and Toner (2001, pers. comm.), indicating possible plant species that can be found in wet cedar forests in southeastern New Brunswick. It is not known at this time if these species can *only* be found on these sites – just that they are likely to be found on these sites, as well as other places. Species with an asterisk (*) have not been found in southeastern New Brunswick, but it is likely that they would be found elsewhere in New Brunswick, growing on calcareous moist woods (see Hinds, 2000).

Table 1. Vascular plants that occur or are likely to occur on wet cedar forests in southeast New Brunswick.

Scientific Name	Common Name(s)	Family [1]	Status [2]	Reference [3]
Selaginella selaginoides	Northern Spike-moss; Rock Spikemoss	Selaginellaceae	S2	D
Botrychium minganense *	Mingan Moonwort	Ophioglossaceae	S1; may be at risk	B, E
B. simplex *	Little Grapefern;		S2; Sensitive	E

	Least Grape-fern			
B. virginianum	Rattlesnake Fern		Common; secure	B, E
Thelypteris simulata	Massachusetts Fern	Thelypteridaceae	S1; may be at risk	E
Cystopteris bulbifera	Bulblet Bladder-fern; Fragile fern; Brittle fern	Dryopteridaceae	secure	E
Dryopteris clintoniana	Clinton's Wood-fern		S1; may be at risk	E
Carex crawei *	Crawe's Sedge	Cyperaceae	S1	D
C. eburnea	Bristle-leaf Sedge; Ivory Sedge		S2; Sensitive	C
C. gynocrates *	Northern Bog Sedge; Ridged Sedge		S2; sensitive	C
C. josselynii *			S1	D
C. livida *	Livid Sedge		S1	D
C. norvegica * (syn. C. media)	Closed-head Sedge		S1	D
C. tenuiflora	Sparse-flowered sedge		S2; may be at risk	D, E
C. viridula sub lepidocarpa	Little Green Sedge			D
Eleocharis quinqueflora (E. pauciflora)	Few-flowered Spike-rush		S2	D
Rhynchospora capitellata	Small-headed Beak-rush		S2	D
Juncus brachycephalus *	Short-headed Rush	Juncaceae	S1	D
J. stygius var. americanus	American Moor Rush		S1	D
Maianthemum trifolium (Smilacina trifolia)	Three-leaved False Solomon's Seal	Liliaceae		B
Amerorchis rotundifolia *	Small round-leaved orchid	Orchidaceae	S1; may be at risk	D, E
Calypso bulbosa	Calypso; Venus'-slipper	Orchidaceae	S2; may be at risk	D, E
Coeloglossum viride	Frog-orchis; Long-bracted Green Orchid		S2; may be at risk	B, E
Corallorrhiza striata *	Striped Coral-root		Unknown	E
Cypripedium parviflorum var. pubescens	Small Yellow Lady's-slipper		S3; sensitive	B, E

C. reginae	Showy Lady's-slipper		S2; sensitive	B, E
Goodyera oblongifolia *	Giant Rattlesnake-Plantain; Menzies' Rattlesnake Plantain		S2; may be at risk	E
G. repens	Dwarf Rattlesnake-plantain; Creeping R-p		Sensitive-to-secure	E
Listera auriculata	Auricled Twayblade		S3; may be at risk	E
L. cordata	Heartleaf Twayblade		secure	B, E
L. convallarioides	Broad-lipped Twayblade		S3; sensitive	B, E
Malaxis monophylla var. brachypoda (syn. M. brachypoda)	White-Adder's Mouth (or –tongue)		S1; may be at risk	D, E
Platanthera clavellata	Green-Woodland Orchis; Club-Spur orchid; Northern Club-spur Little Orchid		Secure	E
P. dilatata	Bog-candle; Scent-bottle; Tall White Northern Bog Orchid		Secure	B, E
P. hookeri	Hooker's Orchid		Sensitive-to-secure	B, E
P. obtusata	Blunt-leaf Rein Orchid; One-leaf Rein Orchid		Secure	B, E
P. psycodes	Small Purple-fringed Orchid; Butterfly Orchid; Soldier's-Plume		Secure	E
Salix candida *	Hoary Willow	Salicaceae	S2; Sensitive	C
S. serissima *	Autumn Willow		S1; May be at risk	C
Ranunculus lapponicus	Lapland Buttercup	Ranunculaceae	S1; may be at risk	D, E
Moneses uniflora	One-flowered Pyrola; One-flowered Wintergreen	Pyrolaceae		B
Pinguicula vulgaris *	Butterwort	Lentibulariaceae	S1; sensitive	D, E
Lonicera oblongifolia *	Swamp Fly Honeysuckle	Caprifoliaceae	S2	C, D
Valeriana dioica subsp. Sylvatica *	Marsh Valerian; Northern Valerian	Valerianaceae	S1	D
V. uliginosa	Mountain Valerian;		S2; Sensitive	C

	Swamp or Sitka Valerian			
Petasites frigidus	Arctic Sweet Coltsfoot	Asteraceae		B

[1] Families are listed in descending taxonomic sequence, following Hinds (1983).

[2] S1= extremely rare; S2 = very rare; S3 = rare-to-uncommon (using ranking system from Hinds, 2000) may be at risk; sensitive; sensitive-to-secure; secure (rank status categories from Toner, 2001)

[3] A = Bagnall; B = Bishop; C = Goltz; D = Hinds; E = Toner

Life Histories

Ferns and Fern allies

Ferns are a very diverse group of plants, and they adapts easily. They can be found throughout Canada, even up in the cold northern areas, and they can grow in different elevations, up to 3,6000 m high (Lukavsky, 1996). They prefer moisture, and are well adapted to temperate zones. They are less common in very dry or very cold regions. Most ferns live in forested regions, where tree cover helps to moderate the temperature, sunlight intensity, the impact intensity of rain and the effects of the wind.

Ferns compete very well with flowering plants. Ferns reproduce with minute spores, and there can be many thousands of spores on a single plant. A constant source of moisture is required when the spores are first germinating. Most plants prefer dappled shade and are easily burnt or scorched by direct sunlight (Lukavsky, 1996).

Not only are ferns attractive to look at, both in a natural setting and in landscaping efforts, they also have a lot of value for wildlife. They provide shelter for small animals, and can be a food source for grazing wildlife, such as deer. Ferns have been used in medicines and decorations, as well as food and beverage items.

There are many sources of threats to ferns, including the draining of wetlands and water-logged areas, and logging. Even plantation establishment can have a detrimental effect on fern populations, due to the mono-culture crop (single age class of the trees). Land clearing for agriculture has decreased fern habitats, and even tourism can put added pressure on the wild habitats in which ferns, and other plants can be found (Lukavsky, 1996). People visiting forests, and unscrupulous collectors can have a significant impact on fern distribution and diversity.

Botrichium. minganense can be found on a variety of sites, including meadows, prairies, woods, and on riverbanks and sand dunes, on acid–to–neutral soils (Lellinger, 1985). It has a ranking of 'S1' (extremely rare) in New Brunswick (Hinds, 2000).

B. simplex has an 'S2' ranking in New Brunswick and is felt to be 'sensitive', which means that it may require special attention to prevent it from becoming 'at-risk' (Toner, 2001). Even back at the turn of the last century, Clute (1901) knew that *B. simplex* was quite rare, whether due to insufficient data or

because of its small size. Mature plants are usually less than 7.5 cm tall, and is extremely variable in its morphology.

B. virginianum is terrestrial in thickets and deciduous woods, growing in rich, neutral-to-subacid soils, but prefers dim moist hollows. It does not like the sun, soon disappearing from a locality when the protecting trees have been removed (Clute, 1901). So it is likely that this species would not return after the site has been disturbed, even though it has a 'secure' rating (Toner, 2001).

Thelypteris simulata was named only within the last 100 years and was long thought of as a hybrid between *T. noveboracense* and another *T.* species (Clute, 1901). Hinds was the first botanist to find a sample in New Brunswick (Grand Lake area, Queens Co.) in 1979 and therefore, it is ranked as extremely rare (S1) (Hinds, 2000). *Thelypteris* species are medium- to large-sized, and expand underground with rhizomes (Lellinger, 1985). For the most part, they tolerate growing in a variety of soil types, light and moisture conditions. The spores germinate readily in greenhouses, so they may be easy to germinate in natural settings as well. *T. simulata* grows in bogs and swamps, preferring very acid soils, usually among sphagnum moss. Hinds (2000) and Toner (pers. comm.) have both indicated that it can be found growing in swampy woods near Grand Lake, with red maple and cedar (see Appendices), but it is likely these sites would tend to be more acidic than normal. Hind (2000) thought that the isolated presence of a small population of *T. simulata* was an indication of the warmth of the regional climate. It appears more frequently in southern Nova Scotia, and from Maine down to Virginia.

Cystopteris bulbifera prefers rocks on shaded driping cliffs, especially in limestone regions (Clute, 1901) but can be found growing terrestrially in hardwood and cedar swamps in the northern part of their range (Lellinger, 1985). Hinds (2000) believes it to be locally common, growing on wet limestone or calcareous soils.

Dryopteris clintoniana is terrestrial in wet woods and swamps, and prefers partial-to-full shade (Lellinger, 1985). It has a 'frequent' rating in southern Quebec and Ontario, but it is extremely rare (S1) in New Brunswick (Hinds, 2000). It is a distinct species unto itself, but is thought to have originated as a hybrid between *D. cristata* (which is found all over New Brunswick) and *D. goldiana* (found only in York, Carleton and Restigouche counties) (Hinds, 2000).

None of these ferns or fern-ally species are officially recognized as rare or endangered in Canada at the present time, but the favoured habitat of ferns is definitely threatened. Wet cedar forests are being logged, or drained, and this habitat is preferred by ferns, orchids, bryophytes and other unusual plants.

Orchids

Terrestrial orchids occur in most of the climatic regions of the world, and can experience seasonal fluctuations in growing conditions. In the temperate areas, there is a distinct change in seasons (summer and winter), with accompanying range in temperature, moisture and light availability. So, in order to survive, terrestrial orchids have to become adapted to a particular range of environmental conditions (Stoutamire, 1974).

The timing of flowering, vegetative growth and seed dispersal can vary from species to species. *Plantanthera* and *Calypso* species flower in the late spring or early summer, whereas *Corallorhiza* species flower in the fall. In temperate regions, rainfall is more evenly distributed throughout the year than in Mediterranean regions, so flowering occurs over a longer period of time (Stoutamire, 1974).

The above ground structures (leaves) of many terrestrial orchids may die off once the plant enters dormancy. Some species, such as *Corallorhiza*, may continue to grow underground, adding to their subterranean stem systems. *Calypso* orchids maintain leaves above ground during the dormant period, and as long as temperatures allow, the plant can photosynthesize (Stoutamire, 1974). *Goodyera* species maintain leaves all year long, and the creeping rhizomes spread out with more leaves. Eventually, a flower is produced at the end of a rhizome. This behaviour is typical of many terrestrial orchids.

Seeds are generally contained within a capsule or pod during the dormant period, and capsules will open once vegetative growth begins again (usually in the spring). Orchid seeds are numerous and may be very light, so seed dispersal may cover a large area. There may be a temperature or light factor that triggers dehiscence – but the literature stated that more research is needed in this area. Seed dissemination is timed so that the maximum number of seeds will germinate. Seed viability can decrease rapidly after release from the capsule in some terrestrial species, while in other species, seeds can remain viable for many years without affecting germination success (Stoutamire, 1974). *Listera cordata* releases seeds very soon after early flowering period so that germination and seedling development can occur during the growing season.

Seeds germinate at different rates, and some seedlings can become photosynthetic quite quickly. Some seedlings may develop at the soil surface, while others may be found in deeper layers. Seedlings at the surface will have to be protected from drying out during the first several months of growth. Some seeds actually require a period of darkness before germination can occur. This has been seen in lab experiments with *Cypripedium reginae*, *Coeloglossum*, *Goodyera* and *Listera* species (Stoutamire, 1974). So, it can be assumed that in natural settings, the seeds of these species need to be buried in soil before they will germinate.

Of course, the deeper seeds will not be able to photosynthesize until they have produced above-ground structures, which is why mycorrhizal fungi may be needed. In order to stimulate germination, a mycorrhizal fungus may need to be present in the soil. These fungi helps new plants to absorb important nutrients and water from the soil, and also helps to defend the plant roots against pathogens (Stoutamire, 1974). This symbiotic relationship is especially important in species that can't photosynthesize at the beginning of their development. Soil and climate conditions often determine whether the specific fungus will be present in the soil.

Orchids can become quickly eliminated by unsuitable habitat conditions (Stoutamire, 1974). Sufficient moisture is needed for plant growth, but there are some orchid species that do well in well-drained drier soils. *Goodyera* and *Cypripedium* grow in well drained soils during part of the growing season, over part of their ranges (Stoutamire, 1974). So, some site disturbance (ie. drainage) may not affect these particular species as drastically. Some levels of disturbance may actually result in an increase in

vegetative growth (Stoutamire, 1974). Some terrestrial orchid species can colonize certain sites, such as sand pits, road embankments, old fields abandoned roads and even city dumps. These species would have faster development in open habitats, and would do well until other competing plant species take over.

Fire can have a beneficial effect on some orchids. It can stimulate flowering in certain areas, and can increase the availability of nutrients and minerals in the soil. Vegetative growth would also be stimulated, partly due to increased light levels and decreased competition. However, fire is not a common occurrence in wet cedar bogs and forests, due to the excessive moisture of the forest floor. Stoutamire (1974) urged that more studies be done on temperate terrestrial orchids (working with the more abundant species, so as not to put rare species at further risk), in order to obtain more information on the life histories and disturbance of orchid habitats.

Bryophytes

According to Ireland and Bellolio-Trucco (1987), there are approximately 550 species of mosses and 200 species of liverworts that occur in eastern Canada. They can be found growing in different habitats, including shady forest floors, beside lakes and waterfalls, on boulders in streams and brooks, and in dense mats in swamps, bogs and fens. The common denominator is water, as they cannot retain water in their cells and leaves. Many species of bryophytes (mosses and liverworts) that can also be found on wet cedar calcareous sites (Bagnall; Frego, pers. comm.). As with the vascular plants, it is not known how many of these species would only be found there, and not on other sites. More studies are needed to determine the plant distributions and densities.

Mosses

The following table (Table 2) was created with data from Bruce Bagnall and Dr. Frego. Mr. Bagnall provided a list of mosses the he thought would be potential candidates for growing in wet cedar forests (see Appendices). Then the list was sent to Dr. Frego at University of New Brunswick – Saint John campus. She and her grad students noted which species were considered common to other habitats (other than calcareous cedar swamps), and so, these species were struck from the list. The remaining 30 mosses are listed in Table 2. Ireland (1982) did not include any specific site maps, and so, only general location information is known of the majority of the listed species.

Table 2. Moss species that occur or are likely to occur on wet cedar forests or swamps in New Brunswick (Bagnall; Frego, pers. comm.).

Scientific Name	Family	Source [1]	Location [2]	Status [3]
Anomodon attenuatus	Leskeaceae	B, F	s.e., c., n.w.	C
Bryoerythrophyllum recurvirostrum	Pottiaceae	B, F	Most	C
Bryum pseudotriquetrum	Bryaceae	F	s.e., c., n.w., s.	C

B. weigelii		B, F	n.	F
Calliergon cordifolium	Hypnaceae	B, F	s., c., w.	C
C. richardsonii		B, F	N/a	U
Fissidens adianthoides	Fissidentaceae	B, F	s.e., n. w.	C
F. osmundoides		B, F	s.e., c., w., n..	C
Helodium blandowii	Thuidiaceae	F	s., c., w.	F
Homalia trichomanoides	Neckeraceae	B, F	c., s., s.e., n.w.	C
Hylocomiastrum pyrenaicum	Hylocomiaceae	B, F	w., c., n.e.	F
Hypnum pratense	Hypnaceae	B, F	w.	R
Leskeella nervosa	Leskeaceae	B, F	s., s.e., n., w.	C
Mnium ambiguum	Mniaceae	B, F	e., c., w.	C
M. stellare		B, F	e., c., w.	F
Plagiomnium medium		B, F	s.e., n.w.	C
Pseudobryum cinclidioides		B, F	s., s.e., n.e.	C
Pylaisiella intricata	Hypnaceae	B, F	Most	C
Rhizomnium appalachianum	Mniaceae	B, F	Most	C
Rhizomnium pseudopunctatum		B, F	*	U
Rhodobryum ontariense	Bryaceae	B, F	s.w., n.	R
Saelania glaucescens	Ditrichaceae	B, F	n.	R
Sanionia uncinata	Unknown	B, F	U/a	U/a
Sphagnum contorortum	Sphagnaceae	B, F	U/a	U/a
S. magellanicum	Sphagnaceae	B, F	Most	C
S. russowii		B, F	n.w., s.e., s.	C
S. wulfianum		B, F	s., s.e., e.	F
Tomenthypnum nitens	Brachytheciaceae	F	w. s.e.	F
Warnstorfia fluitans	unknown	B, F	N/a	N/a
Zygodon viridissimus	Orthotrichaceae	B, F	s., s.e.	F

[1] Source: B=Bagnall; F=Frego (pers. comm.)

[2] Location in the province (if known): n. = north, s.e. = southeast, c. = central, etc. (Ireland, 1982).
Species with an asterisk (*) indicate they have not been seen in the province (Ireland, 1982).
n/a = information not available.

[3] Status in New Brunswick: C = common; F = frequent; R = rare; U = uncertain (Ireland, 1982)
Uncertain: mosses have been reported in the Maritime Provinces, but either their taxonomic status is uncertain, or no specimens have been seen to confirm their presence in the province.
n/a = information not available.

According to Bagnall (pers. comm.), the following mosses are (or may be) entirely restricted to cedar swamps in New Brunswick:

Calliergon richardsonii

Rhizomnium pseudopunctatum

However, more in-depth study is needed, including on-site visits, and it is likely that this list (of 2 species) could grow longer.

Liverworts

The following table (Table 3) was created with data from Bruce Bagnall and Dr. Frego. Mr. Bagnall provided a list of liverworts that he felt would be found in wet cedar forests in New Brunswick (see Appendices). Then the list was sent to Dr. Frego at University of New Brunswick – Saint John campus. She and her grad students noted which species were considered 'common to other habitats' (other than calcareous cedar swamps), and so, these species were struck from the list. The remaining 20 liverworts are listed in Table 3. There has not been as much published about the liverworts of the Maritime Provinces, and so, possible location of each species within the province is not known at this time.

Table 3. Liverwort species that occur or are likely to occur on wet cedar forests or swamps in New Brunswick (Bagnall; Frego, pers. comm.).

Scientific Name	Family	Source [1]	Location [2]
Anastrophyllum hellerianum	Jungermanniaceae	B, F	N/a
A. michauxii		B, F	*
Aneura pinguis	Metzgeria	B, F	N/a
Barbilophozia barbata	Jungermanniaceae	B, F	*
B. lycopodioides		B, F	*
Cololejeunea biddlecomiae	Lejeuneaceae	B, F	N/a
Conocephalum conicum	Conocephalaceae	B, F	*
Frullania tamarisci ssp. asagrayana	Frullaniaceae	B, F	*
Lophocolea minor	Harpanthaceae	B, F	*
Lophozia incisa var. incisa	Jungermanniaceae	B, F	*
L. ventricosa		B, F	*
Moerckia hibernica	Pallaviciniaceae	B, F	N/a
Odontoschisma denudatum	Cephaloziaceae	B, F	N/a
Pellia epiphylla	Pelliaceae	B, F	*
P. neesiana		B, F	N/a

Plagiochila porelloides	Plagiochilaceae	B, F	*
Porella platyphylloidea	Porellaceae	B, F	*
Scapania mucronata	Scapaniaceae	B, F	*
Trichocolea tomentella	Ptilidiaceae	B, F	*
Tritomaria exsectiformis	Jungermanniaceae	B, F	*

1 Source: B=Bagnall; F=Frego (pers. comm.)

2 Location in the province: * = species may exist in province (Ireland and Bellolio-Trucco, 1987)
U/a = information unavailable.

According to Bagnall (pers. comm.), the following liverworts are (or may be) entirely restricted to cedar swamps in New Brunswick:

Anastrophyllum hellerianum
Barbilophozia lycopodioides
Moerckia hibernica
*Scapania mucronat*a

However, more in-depth study is needed, including on-site visits, and it is likely that this list (of 4 species) could grow longer.

Bagnall stressed that these bryophyte lists are not complete, as so little work has been done on the vegetative assemblages of the flora found in and under cedar forests, in wetter conditions (ie. swamps) as well as drier, more upland sites (rocky outcrops). Many bryophytes can be found on a variety of sites, including shaded humid brooksides, minerotrophic peatlands, and rocky calcareous exposures, and hence, there may be a lot of overlap of species.

There would also be differences in the diversity of plants (bryophytes) encountered in the cedar swamp, reflecting the 'pristine' versus 'recently disturbed' sites. Seasonal groundwater fluctuations would also influence the frequency, distribution and mixture of plants (Bagnall, pers. comm.)

Frego and several graduate students have been studying bryophytes in forested conditions, and what levels of response they have to disturbance (specifically harvesting). The harvesting was primarily clear cutting, with skidders, removing the forest canopy. They measured both direct (physical) contact with the plants (including crushing, burying and dragging effects), and indirect effects. The indirect effects of the disturbance included changes in light intensity reaching the ground, soil moisture, humidity, soil texture, water infiltration rates, erosion, etc. No attempts were made to minimize damage to the forest floor, other than the standard harvesting practices, which included confining the skidders to the trails, setting the trails a maximum distance apart (defined by the length of the cutting arm), and to lay slash across the trails to minimize rutting, if the ground becomes too soft (Frego, pers. comm.).

In a related study, bryophytes were studied to determine sensitivity to disturbance, comparing spruce plantations and naturally regenerating forests (Ross, pers. comm.). However, the bryophytes that

were studied would not be specific to cedar swamps, and so were not included in this report (see Appendices for list).

Disturbances such as fire would not occur very often in wet cedar swamps, due to the high moisture content of the forest floor, and groundwater levels that may be just below the surface. According to a report by Wein and Moore (1977), there have been few large fires in the southeastern portion of the province since 1930. However, the native populations from pre-European settlements routinely used fire to clear lands and prepare them for planting. The settlers also used fire to clear land, but there are few records to support this (Wein and Moore, 1977). Cedar is highly susceptible to fire damage because it has such thin bark and the wood has a high oil content (Johnston, 1990).

Fluctuating water levels would have a greater impact on the floristic communities within these wet forest areas. Plants are adapted to a particular set of environmental parameters, including adequate and constant moisture. When an area is flooded or drained, many plant species may not be able to survive long enough to adapt again. With flooding, soil aeration is reduced, and this sometimes kill entire stands of cedar (Johnston, 1990).

Wind is another agent that could cause physical disturbance in forests. Since cedar is a shallow rooted tree, it is susceptible to uprooting (Johnston, 1990), especially along edges, where strip- or clearcuts have occurred.

Deer browsing on the foliage is a major agent of damage to cedar, and the plant species growing underneath may be trampled. However, deer usually congregate in cedar forests during the winter months. The trees offer protection from the wind, and may have less snow on the ground, which means the deer can move around without expending as much energy (as they would if they were out in the open, punching through a top crust on the snow's surface). There have been many studies conducted on the effects of deer browse on cedar (Verme, L.J. , 1965; Van Deelen, T.R. et. al, 1996), but very little has been done about the effects of these deer on the ground vegetation under their hooves. It is likely that deer would frequent the cedar forests that can be found on upland sites, as opposed to the more water-logged wet cedar forests, although this distinction may be less important in the winter, when the ground is frozen.

RECOMMENDATIONS

MacDougall and Loo (1996) identified twenty-four (24) different fine-scale community types, one of which is the Wet Cedar Forest community type. These particular forests are becoming more scarce, especially mature stands that have not been harvested intensively in the past (Singleton et. al, 2000). The few remaining cedar sites, including those that are relatively undisturbed (ie. old-growth stands), may serve as critical habitat for certain species of plants and animals that are uncommon or threatened (Woodley & Forbes, 1997; Singleton et. al, 2000). A 'fine-filter approach' would not only identify the rare or uncommon species on a site, but would also identify the mix or grouping of these species, and the landscapes or habitats that these species grow in.

There have been several articles and publications that specifically include management recommendations for wet cedar forests (Wein, 1975; MacDougall and Loo, 1996; Singleton, et. al, 2000). Ideally, no harvesting should be done on any wet cedar site, because of its rarity in New Brunswick, as well as the presence of many rare and uncommon plant and animal species. However, since cedar is in such high demand, a moratorium on harvesting on these sites is not likely to happen.

Woodley and Forbes (1997) felt that wet cedar forests were very uncommon in New Brunswick due to habitat destruction and increasing harvesting pressure. They recommended that only limited harvesting occur in some of the sites, as long as it reflects natural disturbance levels, respects stream buffer zones, and avoids areas that contain or many contain rare or uncommon plants. MacDougall and Loo (1996) felt that, while cedar may re-establish itself on the wet swamps after harvesting, it was less likely that the rare plant species would come back.

Singleton, et. al (2000) recommended that any site of special interest (ie. sensitive) should be designated as the core, and have a buffer zone with a width of at least 170 m around it. If any harvesting has to be done within the core, a lighter touch is recommended to minimize the impact, and to protect the site biodiversity whenever possible. This would emphasize the ecological aspects of forest management, as opposed to just the economics.

Regeneration of the site is another important outcome of the harvesting method. Cedar can regenerate both from seed and vegetatively (Johnston, 1990). Cedar seed is light and disperses very well. Seeds germinate easily, but in order to survive, the seedlings require a constant moisture supply and warm temperatures. After a harvest, the soil temperatures will be warmer, but soil moisture will be decreased, compared with an undisturbed site. Vegetative root growth occurs when sufficient moisture and shade are present (Johnston, 1990). So it is more likely that cedar will reproduce through root suckers on a site that has been undisturbed, or only minimally harvested (ie. through selective harvesting). When regeneration is inadequate, seedlings should be planted (Singleton, et. al, 2000).

Woodley and Forbes (1997) further recommend that eastern white cedar be allocated as a 'special status tree species', or a 'keystone species'. Keystone species create habitat that is required by other

species, both plants and animals. Eastern white cedar certainly does provide a particular environment that is needed by several species of orchids, bryophytes and ferns.

Goltz also recommended that calcareous fens be studied as well, since may of these fens tend to be surrounded by cedar forests. If there were harvesting done in the cedar forests, the water flow into and within the fens would be greatly affected. There are many species of plants that grow only in calcareous fens as well, which is a similar but unique habitat, different from wet cedar forests (Goltz, 2001).

The Saint John River and its tributaries form the largest watershed flowing to the Atlantic Ocean in eastern North America, south of the St. Lawrence River (Hinds, 2000). The wide range of riparian and upland environments within this system contains a variety of plants. The Saint John watershed has very rich plant diversity, especially on calcareous rock ledges and gravel bars (Hinds, 2000). The Kennebecasis River and the Petitcodiac River are two major waterways found in the southeastern portion of the province.

The soils in the Eastern Lowlands Ecoregion are more calcareous in its northern range than in the southern part of the Ecoregion, due to the sandy and rocky substrate left over from the last glaciation period. Many unusual plant species grow in this area, and of particular interest are the peat black spruce bogs. Species diversity is greater in the coastal bogs than in the inland bogs (Hinds, 2000). A *Platanthera* orchid species and a Twayblade (*Listera*) species have been found in the central and southern peat bogs, but neither of them have been mentioned in the list of species to watch for (Appendices), since the peat bogs are more acidic than cedar swamps.

Much of the Fundy Model Forest has been cut-over or cleared since the land was settled (Loo and MacDougall, 1994), and there are few wet cedar forests left that have not been flooded or harvested. In the FMF, only 5.2 % of the land is protected at this time, either as a National Park, ecological reserve or conservation area (Woodley and Forbes, 1997). There are many habitats and special features that are not yet protected, and it is imperative that more areas be studied and inventoried, in order to increase the protected areas in the FMF and in New Brunswick as a whole. There are several sites that have wet cedar forests, with possibly rare plant assemblages that are not in the southeastern part of the province. These, and other sites need to be preserved for future study, research and ongoing monitoring of site health, in order to maintain biodiversity in New Brunswick's forests.

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APPENDICES

PLANT LISTS AND

ELECTRONIC COMMUNICATIONS RECEIVED FROM

INDIVIDUALS IN NEW BRUNSWICK