Recovery Strategy for the Spoon-leaved Moss (*Bryoandersonia illecebra*) in Canada

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Under the Accord for the Protection of Species at Risk (1996), the federal, provincial, and territorial governments agreed to work together on legislation, programs, and policies to protect wildlife species at risk throughout Canada.

In the spirit of cooperation of the Accord, the Government of Ontario has given permission to the Government of Canada to adopt the *Recovery strategy for the Spoon-leaved Moss (Bryoandersonia illecebra) in Canada* under Section 44 of the *Species at Risk Act* (SARA). Details are provided in the appendix of this document.

This recovery strategy is the recovery strategy of the Minister of the Environment of Canada for this species.

October 2006

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« Programme de rétablissement de l'andersonie charmante *Bryoandersonia illecebra*) au Canada »

RESPONSIBLE JURISDICTIONS

Spoon-leaved Moss occurs in the province of Ontario, and the recovery strategy was developed by the province. The Canadian Wildlife Service - Ontario Region, on behalf of the competent minister (the Minister of the Environment), cooperated in the development of the recovery strategy.

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PREFACE

The Spoon-leaved Moss is under the management jurisdiction of the Ontario provincial government.

The *Species at Risk Act* (SARA, Section 37) requires the competent Minister to prepare a recovery strategy for all listed extirpated, endangered or threatened species. SARA Section 44(1) allows the Minister to adopt an existing plan for the species if it meets the requirements under SARA for content and process (Sections 39-41).

The Spoon-leaved Moss was listed as Endangered under SARA in January 2005. The Ontario Ministry of Natural Resources led the development of this recovery strategy for the species in cooperation with the Canadian Wildlife Service – Ontario Region, Environment Canada. All responsible jurisdictions reviewed and acknowledged receipt of the strategy. This recovery strategy was developed in consultation with the Niagara Peninsula Conservation Authority.

EXECUTIVE SUMMARY

Spoon-leaved Moss (*Bryoandersonia illecebra*), a robust, Endangered moss of seasonally flooded, variably wooded habitats possesses no specialized dispersal mechanisms within its Canadian range. To date, only female plants have been documented in Canada. Very little scientific knowledge exists on the biology or ecology of Spoon-leaved Moss, or the reasons for its rarity.

Although it is abundant in the U.S., its Canadian distribution, representing the northern-most edge of its global range, consists of three widely separated (>170km) stations near the north shore of Lake Erie, Ontario, in Essex and Elgin Counties, and in Niagara Region. This North American distribution pattern is typical of Carolinian or eastern deciduous forest plant species. The small number of isolated locations, the small size of all populations, and the potential for habitat decline prompted COSEWIC to designate the Spoon-leaved Moss as Endangered in Canada in 2003.

All known populations of Spoon-leaved Moss occur on land owned and managed by conservation-oriented organizations. Severe forest fragmentation and development for agricultural or other land uses in densely-populated southern Ontario are often cited as major threats to Carolinian plant species and atmospheric pollution (to which bryophytes can be particularly sensitive) is high. No specific threats to any known extant Canadian population of Spoon-leaved Moss are currently known, although human activities near all populations indicate issues that may become important: habitat fragmentation, changes to moisture regime, competition from invasive plant species, trampling, vegetation or substrate disturbance, and roadside garbage. Habitat change through natural succession may also pose a threat.

The recovery goal for Spoon-leaved Moss is "to conserve existing populations of Spoon-leaved Moss in the long term and, if feasible, restore the species' long-term stability and self-sustainability in Ontario by increasing the size of existing populations and/or the number of known occurrences." Critical habitat cannot be fully defined based on current information; instead, it will be identified incrementally from the baseline of the current area known to be occupied by the species. A research schedule for incremental identification is outlined in this report.

The recovery strategy emphasizes monitoring, management, and research activities supported by a strong communication strategy and continuous re-evaluation and revision based on accumulating data and experience. Priority approaches include 1) full documentation of the extent of known extant populations and surveys for undocumented populations, 2) identification, monitoring and management of threats, 3) monitoring of populations to ensure stable status and to gather demographic data, and 4) research into factors limiting reproductive and dispersal potential in Canadian populations. The recovery strategy should be integrated into management plans for the protected areas in which the species occurs, and into broader scale conservation / restoration initiatives for south-western Ontario and Carolinian species and habitats.

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SPECIES INFORMATION

Common Name: Spoon-leaved Moss

Scientific Name: *Bryoandersonia illecebra*

Assessment Summary: May 2003

COSEWIC Status: Endangered

Reason for designation: This species is endemic to eastern North America. The species reaches its northernmost limit in southern Ontario where it is known presently from only three locations and covers an area of < 14 m2. Although previously recorded from an additional five sites in Canada, the species was not relocated in recent field studies. The species grows in humid deciduous woods and does not disperse easily. In Canada, it occurs in woodlots that are severely fragmented by intense urbanization and agriculture. The status of this species is based on a small number of locations, very small population size, and decline in the quality and quantity of forest habitat.

Canadian Occurrence: Ontario

COSEWIC Status History: Designated Endangered in May 2003. Assessment based on a new status report.

1. BACKGROUND

1.1 Description

1.1.1 Description of the species

Spoon-leaved Moss (*Bryoandersonia illecebra*), of the family Brachythecieaceae, is a shiny, green to greenish yellow-brown species of moss with creeping stems and ascending, intertwined branches that form deep mats. It is quite large and striking compared to most moss species, making it relatively easy to find and identify in the field. Its most distinctive feature is the smoothly cylindrical 'rat-tail' appearance of its stems and branches (especially when they are dry). Upon very close examination of the stems and branches, one may discern closely overlapping, broad, concave (cupped, like the bowl of a spoon, with the dish opening toward the stem) leaves, up to 2.8 mm in length, covering all surfaces. The leaves narrow abruptly to short, twisted points. These characteristics help to distinguish the species from other large, branchy species of moss that overlap Spoon-leaved Moss in distribution. Some large *Brachythecium* species, for example, can grow in Spoon-leaved Moss habitat and range, but have more gradually narrowed, flatter, triangular leaves. Furthermore, *Brachythecium* species tend to taper at their branch tips, whereas Spoon-leaved Moss branches tend to be broad and blunt at their tips.

Throughout most of its range, Spoon-leaved Moss is dispersed as spores (13-17 μm in diameter - small in the range of bryophyte spore size), which are released from tiny (2-3 mm long) capsules,

each held above the stems and branches on a rigid, brown, thread-like stalk. To date, however, sporophytes have not been documented in Canadian populations. Spoon-leaved Moss is dioicous, meaning that there are separate male and female plants (the term 'dioicous' for bryophytes differs from 'dioecious', which applies to vascular plants, reflecting life history differences between the two groups). To date, only female plants have been documented in Ontario (COSEWIC 2003a). Spoon-leaved Moss has no known specialized asexual propagules, but vegetative reproduction through fragmentation is observed in most moss species (e.g. Cleavitt 2005).

Illustrations and more extensive technical descriptions of Spoon-leaved Moss may be found in Robinson (1962), Crum and Anderson (1981), and in COSEWIC (2003a).

1.1.2 Populations and distribution

Spoon-leaved Moss is endemic to eastern North America, where it is most common in the south-eastern United States. Its distribution pattern is typical of many eastern deciduous forest (Carolinian) plant species (e.g. Argus 1992). In the US, it is distributed from New York to Connecticut, Ohio, Indiana, Iowa, Florida, and Texas (Crum & Anderson 1981, Missouri Botanical Garden 2005, New York Botanical Garden 2005) (Figure 1). Within this relatively restricted world range, Spoon-leaved Moss is sufficiently abundant to be ranked G5 (April 1991), indicating that the global population (as well as the US population) is demonstrably secure (NatureServe 2002). The nearest Spoon-leaved Moss population was recorded in Erie, New York, in 1972, about 45 km from Ontario's Niagara Region population (Missouri Botanical Garden 2005, New York Botanical Garden 2005). However, US populations are more typically located 400-500 km from the nearest Canadian population. N. Cleavitt (personal communication) has observed extensive populations in upstate New York.

Canadian populations of Spoon-leaved Moss are peripheral in the context of the species' global distribution, in that they mark the species' northern range limit. The full extent of the Canadian population is in Ontario, where it is ranked S1 (Ontario Natural Heritage Information Centre 2005). All documented locations are in the southern-most part of the province, near the north shore of Lake Erie (Figure 2, Table 1). Three extant populations, one in each of Essex County, Elgin County and Niagara Region (isolated stations separated by at least 170 km), were confirmed in 2002 in association with the COSEWIC (2003a) status report and subsequent designation (Figure 2, Table 1). Field work conducted by Gould (2005) added to the number of colonies known at the Essex and Elgin County sites (Table 1), but the Niagara Region population has not been re-surveyed. The total Canadian population is now estimated to consist of eleven colonies (all healthy in appearance) covering a combined total of about $20m^2$ (Table 1), which represents an increase of about 6.5 m^2 over that reported by COSEWIC 2003a.

Four more populations documented in Elgin and Middlesex Counties within the past 50 years were not found in 2002 despite concerted effort (COSEWIC 2003a). The location of an historical collection made in 1925 (Table 1) cannot be pinpointed, but the record serves to demonstrate the long-term residence of the species in Canada. Another historical record from the Canadian Rocky Mountains has been discounted by recent authorities (Crum & Anderson 1981, New York Botanical Garden 2005, Robinson 1962). Given the global security of Spoon-

leaved Moss and its rarity in Canada, Ontario's population can be assumed to represent less than 1% of the species' global distribution.

The fact that at least four populations that were recorded in the 1970's and 80's were not found in 2002 (COSEWIC 2003a, Table 1) may suggest a declining trend in the number of extant Canadian locations and number of mature individuals in the Canadian population (COSEWIC 2003b). However, a lack of data on the historical sizes and precise locations of 'lost' populations and low recent collecting effort in southern Ontario make it impossible to confirm either the existence or the magnitude of decline. Identifying preferred habitat conditions and re-surveying all examples of these conditions at historical locations would help to substantiate or refute the suggested decline. There have also been insufficient observations to characterize the dynamics of local abundance over time.

Spoon-leaved Moss is long-lived and evergreen, making generation time difficult to establish. It does not die at the end of the growing season, or (in areas where the species produces capsules) after successful reproduction. Instead, it continues to grow and produce new reproductive structures year after year. In Canada, where it is not known to reproduce sexually, generation time may be equal to the life span of a colony, which has not been researched. Records show that at least one (Essex County) and possibly two (whether the Elgin population represents a new or previously-recorded population cannot be confirmed) populations have persisted for over 20 years (Table 1), suggesting that it can occupy a site over the long term and is not given to dramatic natural population fluctuation / extirpation over the short term.

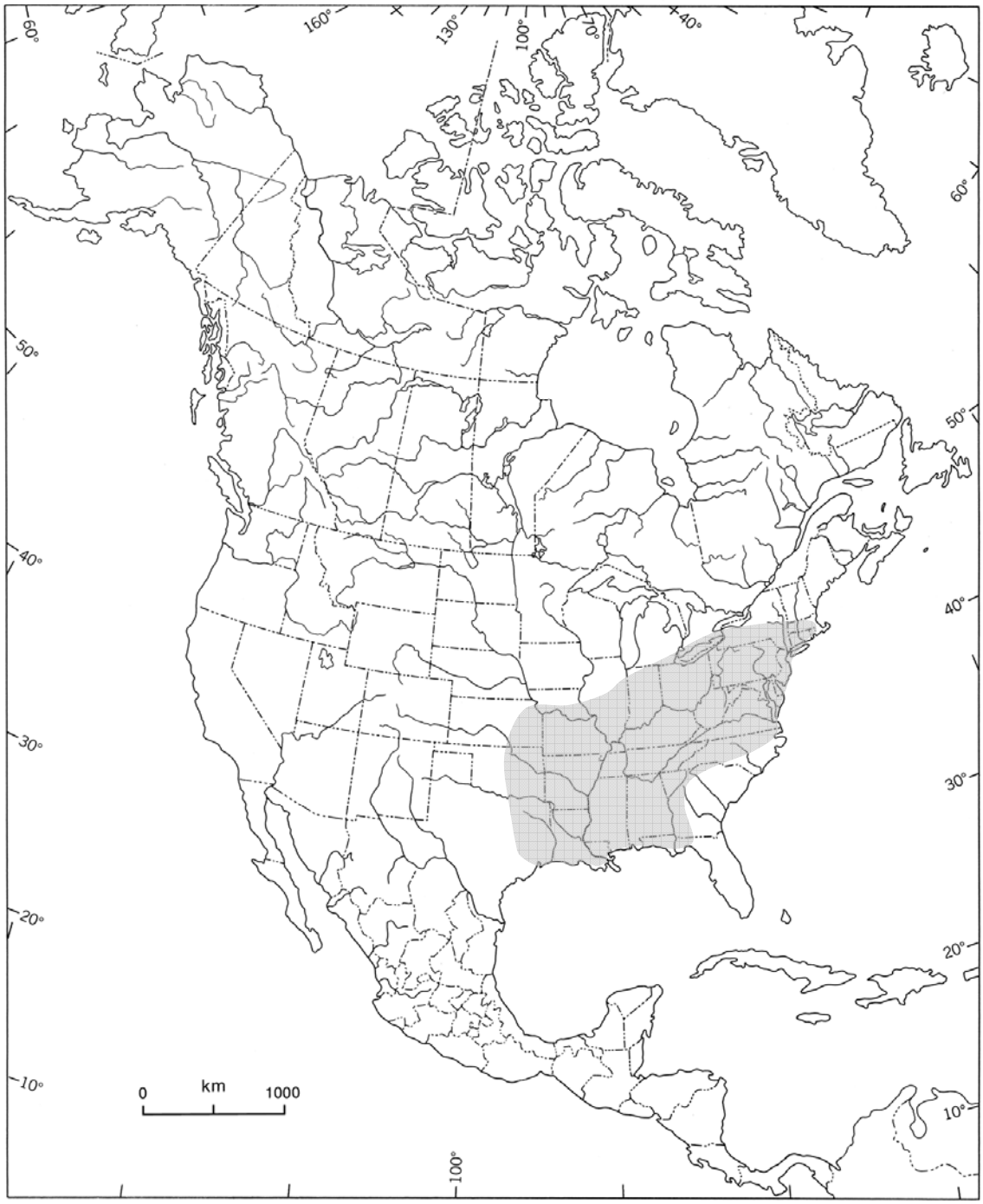

Figure 1. Approximate global distribution of the eastern North American endemic Spoon-leaved Moss (indicated by gray shading), from COSEWIC (2003a) (*reproduced with permission from Environment Canada*).

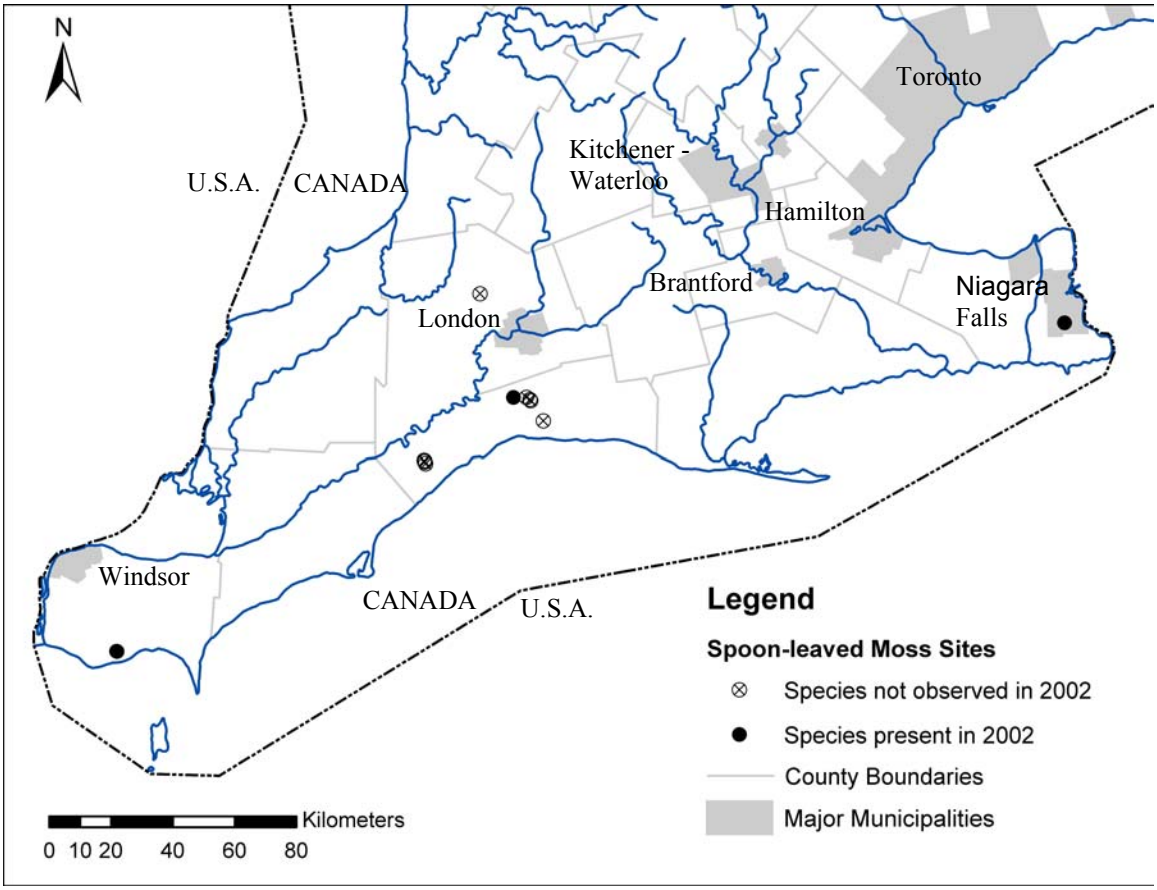

Figure 2. Collecting locations for Canadian specimens of Spoon-leaved Moss, from COSEWIC (2003a) (*reproduced with permission from Environment Canada*). Essex and Elgin populations observed in 2002 were confirmed to persist in 2004.

Table 1. List of current and historical Canadian collecting locations and observation histories for Spoon-leaved Moss (adapted from COSEWIC 2003a).

Locality (Ownership) Habitat	Sex[1]	Collector / Observer - Date	Total Abundance
Confirmed Extant Populations			
Essex County (Ontario Parks) In moist, over-grown field (used for pasture until the mid 1900s) populated by successional cedar-hawthorn scrub and in more mature ash-maple woodland.	U F U	M.J. Oldham - March 1982 J. Doubt – August 2002 R. Gould & A. Woodliffe – December 2004	Unknown 1.53 m^2 (2 colonies, ≈65% cover) 5.8 m^2 (7 colonies, % cover not recorded)
Elgin County (OMNR) *Original habitat description:* On soil, roots and decaying branches on deciduous, wooded hillside. *Current habitat description*: On clay hummocks and tree bases in a flat moist, regenerating (cleared until 1930s) scrub forest habitat, with broken canopy dominated by hawthorn, crab apple, white spruce, ash and maple habitats within surrounding mature hardwood plantation/forest; also in maturing moist ash-maple-hickory plantation forest.	F F U	W.G. Stewart - April 1983 J. Doubt – August 2002 R. Gould & A. Woodliffe – December 2004 *Note*: Some uncertainty surrounds the 1983 collection. Current observations may not reflect the original location (COSEWIC 2003a).	Abundant 12 m^2 (1 colony, 90% cover) 13.53 m^2 (3 colonies, % cover not recorded)
Niagara Region, City of Niagara Falls (Niagara Peninsula Conservation Authority) On exposed and elevated (approx. 15 cm from forest floor) root of maple tree, near roadside, in deciduous swamp	F	J. Doubt - August 2002	0.02 m^2 (1 colony, 100% cover)
Historically documented populations			
Elgin County, Aldborough Twp. (Private) On sandy humus and litter in wet deciduous woodlot.	U -	W.G. Stewart - April 15, 1973 J. Doubt – July 2001, August 2003	Few None found
Elgin County, Yarmouth Twp.,(Private) On soil over cedar roots along stream in swamp of marl and peat / On cedar stump in stream and under grasses on bank of stream	F U -	W.G. Stewart - April 1975 W.G. Stewart - May 1980 J. Doubt – July 2001	Few Few None found

[1] **NOTE:** "Sex" refers to whether the collections represented female (F) plants, or could not be examined / determined (U) (no male plants or sporophytes have ever been documented in Canadian populations, although not all collections have been examined). Note that unsuccessful searches at historical collecting locations should be interpreted in the context of the available detail concerning collecting location (refer to COSEWIC 2003a and herbarium labels), which was generally low.

Locality (Ownership) Habitat	Sex[1]	Collector / Observer - Date	Total Abundance
Elgin County, Southwold Twp., (Private) On soil, roots and decaying branches on deciduous wooded hillside.	U -	W.G. Stewart – April 1983 J. Doubt – August 2002	Abundant None found
Upper Canada. On the ground.	U	T. Drummond -1925-1927	Unknown (but sufficient for exsiccata)
Canada. Rocky Mts.	U	A.R. Wallace	Unknown

1.2 Description of the species' needs

1.2.1 Ecological role, biological needs, and limiting factors

Spoon-leaved moss has no known specialized ecological role anywhere in its range. In general, mosses perform many of the same ecological functions as all plants do by cycling nutrients and fixing them to biologically-useful forms. Some specific ecological roles of mosses, such as those in revegetation, soil stabilization, and animal food / shelter have been reviewed by Longton (1984, 1992b) and Slack (1988).

The physiological needs of Spoon-leaved Moss have not been studied, and research is required to define its preferred growing conditions and its range of ecological tolerance. However, casual observations and inferences from other moss species give evidence of some biological needs and potentially limiting factors.

Overview of moss life cycle and terminology

Rain or flood water is required for the sperm of dioicous mosses such as Spoon-leaved Moss to swim to the eggs borne by female plants. The 10 cm maximum range of moss sperm (e.g. Longton 1976, Mishler 1988, Rohrer 1982, Schofield 1985) necessitates close proximity of male and female colonies. Mosses reproduce sexually to produce short-lived (usually several months) spore-bearing structures known as *sporophytes* that are attached to and dependent on the long-lived (usually many years) leafy green moss *gametophytes*. In the case of Spoon-leaved Moss, which has small spores and relatively long stalks elevating the spore capsules above the still 'boundary-layer' air near the gametophyte, air dispersal is likely (e.g. During 1997, Longton 1997).

Upon contact with a favourable substrate, spores germinate to produce delicate, unspecialized green filaments (*protonemata*) that are very sensitive to dessication (Wiklund & Rydin 2004). Acidity, such as might be imposed by acid rain or other pollutants, impairs germination, extending this vulnerable period (Wiklund & Rydin 2004). Protonemata, in turn, develop into gametophytes possessing specialized features (including those that botanists use to identify moss species) that allow them to exploit their preferred habitat. Alternatively, air- or flood water-dispersed asexual diaspores may initiate protonemata or sprout directly as new gametophytes. Even as mature gametophytes, mosses are relatively unprotected from their environments.

Leaves generally possess no cuticle or epidermal layers; often taking up water and nutrients (and pollutants) directly from all exposed surfaces.

The Spoon-leaved Moss continues to branch and grow until it exhausts the available space or resources. The proliferation of stems and branches forms moss *colonies,* or patches. Within colonies, stems and branches are intertwined and difficult to separate. They may break in response to disturbance to form multiple (possibly genetically identical) colonies or they may expand and merge with adjacent colonies. For these reasons, it can be difficult to define a moss 'individual', and several measures (number of colonies, distribution of colonies, colony dimensions, percent cover occupied by moss within each colony) are required to accurately characterize the extent of a population.

Mosses respond physiologically not only to regional climate and site-scale geology and vegetation, but also to *microhabitat* factors (e.g. localized patches of distinct substrate chemistry, moisture, shade, temperature, substrate texture, organic debris, and microtopography) that can vary within centimeters. The well-known specificity of some bryophyte species for their preferred microhabitats (Slack 1990, Vitt & Belland 1997) has led researchers to use them as indicators of local environmental factors such as substrate chemistry and air pollution (e.g. Shacklette 1967, Rao 1982, Burton 1990, Glime 1992), which highlights the potential vulnerability of mosses to very small-magnitude chemical changes or very local habitat disturbance (Rao 1982, Lepp & Salmon 1999). It also limits the applicability of conventional mapping and modeling techniques to identify sites likely to support rare moss species, because predictive variables can change on a finer scale than is available in most conventional map products, and may be poorly correlated with broader habitat types.

Summary of biological needs and limiting factors of Spoon-leaved Moss

Although demographic evidence is not available to support hypotheses concerning the relative importance of life history stages to Spoon-leaved Moss persistence (Schemske et al. 1994, Helernum 1998), accumulated observations (COSEWIC 2003a) suggest that diaspore production and dispersal may be the most critical limiting factors for the species in Canada. These observations include the lack or rarity of sporophytes, absence of specialized asexual reproductive structures, perennial stayer life strategy (characterized by relatively low spore output), dioicy (associated with reduced sporophyte production), lack or rarity of male plants in the Canadian population, potential loss (without apparent replacement) of populations, small population size, isolated populations, and severely fragmented habitat.

Rarity in dioicous species (such as Spoon-leaved moss), which produce sporophytes less frequently than monoicous species (Gemmell 1950, Longton 1992a, Longton & Schuster 1983, Mishler 1988), has been linked to their failure to produce sporophytes (Longton 1992a). Factors contributing to this lower reproductive success may be exacerbated at a species' northern range limit. For example, favourable microhabitats are likely to be smaller and more spatially separated in the northern part of species' range (Gemmell 1950, Longton 1976, Lesica & Allendorf 1995, Nantel & Gagnon 1999, COSEWIC 2003a), leading to reduced co-occurrence of male and female plants. Furthermore, Bopp (1983) showed that environmental factors linked to latitude (e.g. light intensity, day length, temperature) can affect the production of male and

female moss inflorescences, leading to uneven sex ratios and lower sporophyte production (Longton & Schuster 1983). Kallio & Saarnio (1986) also observed reduced sporophyte production in northern climates, whereas vegetative diaspore production (plant fragments, in the case of Spoon-leaved Moss) depend less on seasonal stimuli. The life strategy of Spoon-leaved Moss is also associated with reduced sexual reproduction, in that perennial stayers (During 1979) naturally devote less energy to spore production than to vegetative proliferation (Longton 1992a, 1997), and are known to be underrepresented in diaspore banks (During 1997).

Dispersal range and the relative importance of various dispersal modes of Spoon-leaved Moss have not been studied in any portion of its distributional range. Most moss spores are known to fall close to their parent plants (e.g. Longton 1976, Wyatt 1982), but the high number of spores per capsule and small spore size characteristic of perennial stayers (Longton 1997) suit them well to dispersal over longer distances. Some researchers (e.g. Miles & Longton 1992, Stoneburner et al. 1992) have shown that many spores escape the immediate vicinity, and Pharo et al. (2004) found that many bryophytes have sufficient dispersal and establishment ability to overcome barriers imposed by temperate forest fragmentation in Australia. Very little work has been done on the dispersal modes and dispersal ranges of moss fragments in any species (Cleavitt 2005). Dependence on asexual reproduction implies reduced mobility, and increased efficacy of diaspore establishment (Wiklund & Rydin 2004), yet Mogensen (1981) and Shaw (1993) suggest that long-distance fragment dispersal may occur in some species.

Spoon-leaved Moss populations in the nearby northern United States, where the climate is similar to that of southern Ontario, are a potential source of immigrant propagules (spores or fragments) in Canada. However, the apparent rarity of such a large, distinctive species in south-western Ontario - a once relatively well-collected region (Ireland & Ley 1992, COSEWIC 2003a) despite limited bryological study and access to private land in recent years – may indicate that successful dispersal from the south (or within Ontario) is rare. The possibility of a declining trend in the number of populations in southern Ontario (COSEWIC 2003a) supports the increasing isolation of populations rather than successful dispersal over long distances.

1.2.2 Habitat needs

As outlined in the preceding section, mosses such as Spoon-leaved moss respond to their environment on microhabitat, habitat, and regional scales. In general, Spoon-leaved Moss prefers soil substrates, particularly on banks, but sometimes on rocks or tree bases. In Canada, it is usually associated with exposed clay, often avoiding deciduous litter cover by occupying soil hummocks, or tree bases and tree roots.

All extant (and at least some past) Canadian populations were found in close proximity to *Helodium paludosum*, an infrequent moss species of temperate affinity which also reaches its northern range limit in southern Canada, and which is generally associated with swamps, marshes, and wet meadows. *H. paludosum* and other bryophyte associates of Spoon-leaved Moss are much wider-spread and more abundant and no useful indicator species are known. Similarly, no rare vascular plants are known to occupy the immediate vicinity of Spoon-leaved Moss populations (R. Gould, K. Frolich, personal communication) in such a way as to provide additional clues to habitat needs.

In its Canadian range, Spoon-leaved Moss is associated with a wide variety of habitat types and moisture regimes (Table 1, Gould 2005), but all confirmed extant populations occur in areas that are at least seasonally moist or flooded. Spoon-leaved moss is found under mature and regenerating deciduous or mixed tree canopies (Table 1). Past and present sites of occurrence vary considerably in overstory age and composition. Perennial stayer life strategy indicates preference for long-term habitat continuity (Longton 1992a, 1997), but Gould (2005) describes a history of deforestation at the species' Essex and Elgin sites, raising intriguing questions regarding past colonization ability and the species' capacity to withstand disturbance or successional change. The occurrence of Spoon-leaved Moss in regenerating fields and its apparent disappearance from sites that have become overgrown suggests an affinity for open overstory vegetation.

Spoon-leaved Moss appears not to be associated with rare vegetation or plant community types (e.g. old-growth deciduous forest), and many sites similar, at least superficially, to those at which the species has been found in Essex and Elgin Counties exist across the species' known Canadian range. If Spoon-leaved moss is as rare as current records suggest, this indicates either: 1) limitation by habitat qualities that are not immediately obvious or 2) limitation by factors other than habitat, such as biology, competitive interactions, or historical events.

As a Carolinian species, spoon-leaved Moss appears to be limited by climate on a regional scale. Only a very small, southern part of Canada supports Carolinian species, and even if this region were pristine, suitable habitats may not be as common as they are near the centre of the species' range (Lesica & Allendorf 1995, Nantel & Gagnon 1999, COSEWIC 2003a). This natural limitation may leave relatively little leeway for anthropogenic threats to impact Ontario's small, isolated populations without significantly impacting the Canadian population as a whole.

1.3 Threats

In section 1.2.1, some potentially limiting biological characteristics of Spoon-leaved moss, such as its reproductive system, dispersal ability, life strategy, and habitat specificity, were summarized. Keeping in mind these limiting biological characteristics, this section outlines the factors that may threaten the species' stability in Canada. The significance of threats cannot be ranked without more conclusive information on the species preferences, tolerances, and limiting factors.

Many of the threats described below may be classified as specific threats to individual populations. However, it should be noted that there is little evidence of local anthropogenic disturbance accounting for the potential disappearance of Spoon-leaved Moss from sites where it has been documented in the past (COSEWIC 2003a).

1.3.1 Roadside Debris & Roadside Herbicide Application

In Niagara Region, the single documented colony of Spoon-leaved Moss lies within twenty metres of a road, near a littered roadside ditch. There is no trail in the vicinity to draw visitors near to the colony, but given its small size, the population is particularly vulnerable to

interference from roadside debris, application of road salt or roadside herbicide application (no herbicide application is currently confirmed to occur on the Niagara Peninsula Conservation Authority lands (K. Frolich, personal communication)).

1.3.2 Concentration of Wildlife Activity

Increased wildlife populations (e.g. deer, wild turkey) have degraded many woodland habitats in southern Ontario and may affect Spoon-leaved Moss or its habitat in Essex if wildlife activity intensifies (R. Gould, personal communication). Gould (2005) has documented some minor wildlife disturbance to part of the Elgin population.

1.3.3 Invasive Species

Although no formal assessment of invasive plant species has been done, garlic mustard is present at both Essex and Elgin Spoon-leaved Moss sites, and has become detrimental to most local habitats (R. Gould, personal communication).

1.3.4 Succession

Successional habitat change appears to have contributed to the loss of some historical populations of Spoon-leaved Moss (COSEWIC 2003a). While succession may involve natural revegetation of cleared land, it may also be driven by anthropogenic changes in drainage patterns. Although the causes have yet to be researched, several past Spoon-leaved Moss sites are thought to have become drier and/or more densely vegetated since the species was first collected (COSEWIC 2003a). Given its apparently limited reproductive and dispersal ability in Canada, Spoon-leaved Moss may have limited potential to replace populations lost to successional change in once-suitable habitats. Despite the relatively long-term persistence of one population (COSEWIC 2003a, Table 1), and the species apparent adaptation to longer-lived habitats, populations in regenerating stands (Table 1) are vulnerable to extirpation as habitat conditions naturally change over time. Without natural dispersal or intervention to re-establish the species in suitable habitat, the Canadian population as a whole is at risk.

1.3.5 Hydrological Changes

Hydrological changes resulting from global warming trends (Kutner & Morse 1996) and development may affect the moisture regime of plant habitats in southern Ontario, which in the context of limited dispersal ability, may lead to local extirpation of Spoon-leaved Moss without re-establishment of new colonies. Habitat fragmentation may exacerbate the problem by necessitating dispersal over longer distances. On the other hand, the position of Canadian populations of Spoon-leaved Moss on the northern periphery of the species' range may place it well for climate-related northern range expansion due to migration from the south (N. Cleavitt, personal communication), as has been predicted for some plants (Kutner & Morse 1996), including tree species in the Great Lakes Region (Walker et al. 2002).

1.3.6 Recreation

Although the habitats of the three known extant populations of Spoon-leaved Moss occupy small, variably wooded habitat fragments in close proximity to human activity (trails, roads, and active agriculture) (COSEWIC 2003a), there is no known specific, immediate threat to the populations. Gould (2005) reports that the small foot and game trails away from the main recreational rail trail ('Greenway') adjacent to the Essex County population are used infrequently and thus appear not to present a direct human threat to the moss colonies. COSEWIC (2003a) observed that the site is uninviting to passersby due to dense hawthorn, poison ivy and mosquitoes. Similarly, in Elgin County, the population lies within a few metres of a well-used hiking trail, but there is no evidence of hikers frequently diverting from the trail or of all-terrain vehicle traffic in the area of the colonies.

1.3.7 Habitat destruction and fragmentation, including air quality degradation

While larger-scale, regional threats to Spoon-leaved Moss survival are on-going, they are likely to affect populations and availability of recovery habitat in a more gradual manner than most local threats. These regional threats include habitat destruction and fragmentation due to intense urban, industrial and agricultural development as well as air quality degradation. Air quality reports for Ontario (Ontario Ministry of the Environment 2004) show that the region has some of the highest pollutant levels in the province. Agricultural land-use intensity has been shown to be negatively correlated with bryophyte species richness (Zechmeister & Moser 2001). The intensification of land uses arising from the dense population of southern Ontario has long been cited as a threat to Carolinian habitats and flora in Canada (Maycock 1963, Maycock & Fahselt 1987, Allen et al. 1990, Argus & Pryer 1990, Oldham 1990, Klinkenberg et al. 1990, Argus 1992, Keddy & Drummond 1996, Cadotte & Lovett-Doust 2002).

1.3.8 Stochastic Factors (genetic drift, inbreeding)

The effect of stochastic factors on Spoon-leaved Moss demography has not been studied. The threat imposed by environmental stochasticity (Lande 1993, references cited in Schemske et al. 1994), as well as inbreeding and genetic drift (Barrett & Kohn 1991, Ellstrand & Elam 1993, Young et al. 1996, Lesica & Allendorf 1992) may increase with decreasing population size. All Canadian populations of spoon-leaved moss are relatively small, but the Niagara Region population (200 cm^2) is especially vulnerable in this respect. Low genetic diversity resulting from, for example, lack of sexual reproduction and/or founder effect from chance dispersal from U.S. populations (which has not been studied or confirmed in Canadian Spoon-leaved Moss) may also increase species' vulnerability to stochastic events.

1.4 Critical Habitat

1.4.1 Proposed identification of the critical habitat of Spoon-leaved Moss

The general habitat preferences of Spoon-leaved Moss and descriptions of the habitats it occupies in Ontario, to the extent they are known, have been described in section 1.2.2 (Habitat

needs) of this recovery strategy. For current purposes, section 2 of the *Species at Risk Act* defines critical habitat as "…the habitat that is necessary for the survival or recovery of [Spoon-leaved Moss]" (Environment Canada 2004). The recovery goal, therefore, is integral to the concept of critical habitat in that sufficient habitat must be identified to allow for the recovery goals to be accomplished. The recovery goal for Spoon-leaved Moss (see section 2.2) is to conserve existing populations in the long term and, if possible, to restore the species' long-term stability and self-sustainability in Ontario by increasing the size of existing populations and/or increasing the number of known occurrences.

Only those three sites that currently support populations of Spoon-leaved Moss in Ontario (Table 1) are known to be suitable for the species' growth and are thus identified as proposed critical habitat in this recovery strategy. The boundary of the critical habitat cannot be strictly delineated at this time because of the uncertainty as to the size of the surrounding area on which activities could affect change to the habitat. For example, the area within which change in overstory vegetation is likely to affect the moss populations may be smaller than that within which drainage patterns must be maintained. In the interim, however, the minimum area of critical habitat for Spoon-leaved Moss is proposed to include the area occupied by extant populations and the extent of the vegetation community (based on the Ecological Land Classification for southern Ontario) in which it occurs at each site (habitat characteristics of sites are described in Table 1). This boundary should be refined as more information is gained on the factors that may influence habitat suitability and quality.

The vulnerability of the few known populations to local or regional disturbance, in combination with apparent extirpation of populations at sites that have recently undergone natural successional change, suggests that securing the Ontario population also requires the expansion of known populations and/or increasing the number of known populations. To meet this part of the recovery goal, habitat that is not currently occupied by the species (or not currently known to be occupied) may need to be identified as critical habitat in the future as research and recovery proceed. For example, the discovery of additional colonies associated with known populations, or of additional populations will add to the critical habitat and will provide data for critical habitat characterization. An incremental approach to critical habitat identification is therefore recommended for Spoon-leaved Moss. A research schedule to fully identify critical habitat is given in section 1.4.4 of this recovery strategy.

1.4.2 Examples of activities likely to result in destruction of the critical habitat

As outlined in section 1.3 (Threats), no direct, specific threats to Spoon-leaved Moss habitat at known extant sites are currently known or anticipated. However, Spoon-leaved Moss possesses specific points of vulnerability with respect to activities characteristic of prevailing land use. With this in mind, activities that are likely to result in destruction of the critical habitat include (but are not limited to):

- Hydrological change (increasing or decreasing moisture levels, alteration of seasonal moisture regime, changes in water flow patterns, even on a very small scale) resulting from water use / re-direction on adjacent land, which may impact populations directly or trigger successional change in favour of overstory vegetation that alters growing conditions (e.g. light, moisture, temperature) in the understory;

- Contamination of, or other chemical change in, moss substrate or run-off from adjacent land;
- Trampling by foot access, or other recreational activity, or by wildlife;
- Removal (intentional or unintentional) of overstory and/or ground vegetation by humans or wildlife, except for the purposes of habitat enhancement;
- Removal or disturbance of substrate;
- Overgrowth by invasive, competitive plant species;
- Accumulation of roadside garbage;
- Use of herbicides for weed and woody plant control (in the case of the population in Niagara Region); and,
- Application of salt to roads adjacent to sites.

1.4.3 Existing and recommended approaches to habitat protection

Spoon-leaved Moss is Endangered in Canada, meaning that it faces imminent extirpation or extinction (COSEWIC 2003b) and has been appended to the list of Wildlife Species at Risk (Schedule 1) of the *Species at Risk Act*. It is also designated Endangered on the list of Species at Risk in Ontario (Ontario Ministry of Natural Resources 2004), and is regulated under the provincial *Endangered Species Act* (Ontario Ministry of Natural Resoures 2005).

All sites currently identified as critical habitat are protected at this time. The Ontario Ministry of Natural Resources owns and manages the property where the Elgin County population occurs, and the site in Niagara Region is owned and managed by the Niagara Peninsula Conservation Authority. At the time of the COSEWIC (2003a) status report, the Essex County site was privately owned, but has since been acquired by Ontario Parks with the assistance of the Nature Conservancy of Canada (B. Huis, R. Gould, personal communication). Current management plans do not account for Spoon-leaved moss (Poirier et al. 1982), but amendments are expected as management plans are developed (K. Vlasman, R. Gould, personal communication).

Despite the proximity of Spoon-leaved Moss populations to recreational and agricultural activity, it seems likely that any infrastructure placed at the sites to prevent access from nearby trails or roads would only serve to draw attention to the populations (thereby increasing traffic to the sites) and may critically alter habitat quality. Broad strategies of monitoring, management, and research are therefore recommended (sections 1.3.4 and 2.2.3). For example, habitat conditions at the sites should be monitored for threats, so they can be managed as they arise to prevent the loss or destruction of critical habitat. Research (including surveys) must precede the identification of additional critical habitat and its protection. Protected areas within the distributional range of Spoon-leaved Moss should be targeted for preliminary research aimed at increasing the number/size of populations through inventory, or introduction.

1.4.4 Schedule of studies

The schedule of studies (Table 2) outlines steps in the incremental identification of critical habitat for Spoon-leaved Moss. The activities are listed in priority order. The results of initial activities may necessitate modification of the order or nature of subsequent activities. These research activities are interdependent with the recovery approaches outlined in section 2.2.3 of

this report and the schedules (activities listed in Tables 2 and 3) should be considered in combination with each other.

Table 2. Schedule of Studies: Recommended research activities for the identification of additional critical habitat for Spoon-leaved Moss in Canada. These research activities will be incorporated into the action plan for this species.

Description of Research Activity	Rationale
Seek undocumented colonies of Spoon-leaved Moss in protected areas where populations are known to reside and at historic sites of occurrence	Confirm current area of occupancy of extant and historically documented sites (identify direct critical habitat)
Monitor populations of Spoon-leaved Moss (for example through fixed-point photography, colony mapping, colony tracing) to gather data on temporal variability in abundance and distribution (and therefore critical habitat) within sites	Modify area of critical habitat based on area within which population is likely to vary over time
Seek and monitor undocumented populations off protected areas and characterize their habitats, especially near previously-documented occurrences	Identify additional critical habitat
Fully characterize the habitats and microhabitats of existing populations	Quantify habitat variables for a detailed understanding of growing conditions where colonies occur for habitat modeling. Further refine critical habitat.
Characterize habitats and microhabitats of populations in the northern United States	Take advantage of increased abundance (more data points) to characterize species' habitat preferences in a climatically similar region for habitat model; identify potential source populations should re-introduction become desirable
Apply habitat mapping and modeling; correlate with protected areas and land use / management activities	Identify potential critical habitat for seeking (or introducing, if necessary) undocumented populations
Conduct spore establishment and/or transplant experiments	Determine suitability of unoccupied potential critical habitat

1.5 Actions already completed or underway

Gould (2005) began implementing the schedule of studies by conducting field surveys that resulted in an increase in the known area directly occupied by Spoon-leaved Moss (and therefore critical habitat) for the populations in Essex and Elgin Counties beyond that reported by COSEWIC (2003a) (Table 1). All managers of affected sites are aware of the locations and significance of Spoon-leaved Moss. No other recovery activities have been initiated.

2. RECOVERY

2.1 Recovery Feasibility

All Canadian specimens of Spoon-leaved Moss are female, and no sporophytes have ever been documented. However, the Canadian population cannot be surveyed in its entirety for male plants because sex determination in bryophytes requires destructive sampling, and the absence of sporophytes in collections does not definitively confirm the inability of Canadian populations to produce them. With respect to asexual reproduction, extant colonies are presumably capable of expansion within their respective sites, and plant fragments are probably capable of dispersal over short distances, particularly with the assistance of water or other local vectors. The extent to which vegetative propagation might be able to improve growth rate or abundance depends on factors such as natural rates and patterns of senescence, extent of available suitable habitat, and current trend in population size, which have yet to be documented. Minimum viable population is not known for Spoon-leaved Moss, or for most bryophytes (if any), and modification of commonly-used methods (e.g. Menges 1990, 1991) would be required before it could be defined.

Without temporal demographic data for Spoon-leaved Moss or data pinpointing reasons for the species' limitation and its potential decline, it is not clear that protecting current populations will be sufficient to ensure long-term persistence. Spoon-leaved Moss has been known from one or two sites since the early 1980's, which suggests that persistence is possible without intervention. Intervention-based attempts to recover rare bryophyte populations, such as transplanting colonies, plants, fragments, or spores to manipulate gender ratios or augment populations, are not known in North America (but note that peatland restoration involves re-introducing moss diaspores (e.g. Rochefort & Bastien 1998, Rochefort et al. 2003)). In Europe, however, ex-situ conservation and re-introduction have been applied to several rare bryophytes (e.g. Kooijman & Beltman 1994, UK Biodiversity Action Plan 2005). Their potential for success in the current context cannot be predicted, but this recovery strategy provides an important opportunity for research that may serve future attempts to recover rare bryophyte species. A wide body of literature exists describing bryophyte plant and diaspore propagation for experimental purposes (e.g. references cited in Kallio & Saarnio 1986, Wiklund & Rydin 2004, Cleavitt 2005), and can provide important background information to help increase the chances of success.

Additional considerations for recovery feasibility include the existence of sufficient habitat to support the species, and the ability to reduce threats to the species or its habitat. These criteria appear to be met for Spoon-leaved Moss, as shown by the species' persistence in the region despite dense human activity, the protective designations placed on all sites where it occurs, and observations that direct human disturbance of the sites is unlikely (R. Gould, personal communication).

In brief, recovery of Spoon-leaved Moss is currently considered to be feasible. This conclusion will be reviewed in the context of future research findings.

2.2 Recovery Goal, objectives and corresponding approaches

2.2.1 Recovery Goal

The goal of this recovery strategy is to conserve existing populations of Spoon-leaved Moss in the long term and, if possible, to restore the species' long-term stability and self-sustainability in Ontario by increasing the size of existing populations and/or increasing the number of known occurrences. Target population number and size are therefore set at the minimum of current levels for each of the three sites of occurrence in 2005, pending research to determine the feasibility of increased targets.

2.2.2 Recovery Objectives

Without specific demographic information with which to confirm the trends in the Canadian population or to define the minimum viable population, and without a firm understanding of key factors limiting Spoon-leaved Moss, setting realistic, relevant recovery objectives and performance measures is an uncertain process reflecting the best interpretation of available data (Menges 1991, Schemske et al. 1994, Nantel & Gagnon 1999). However, this does not preclude the development of recovery targets or commencement of activities. It is also important to recognize the distinction between rarity, which may be normal for Spoon-leaved Moss as a peripheral species in Canada, and endangerment (e.g. Morse 1996), which the recovery process is designed to reverse. Threat management can only increase the species' status within the bounds of its naturally limited capacity.

With this in mind, the following objectives are to be addressed within the next five years in support of the recovery goal.

1. Monitor habitat to detect potential threats at all three sites of occurrence annually (or more frequently) and address causal agents.
2. Maintain or increase current population size (measured as area occupied by moss and number of colonies) at each site of occurrence by protecting plants and critical habitat.
3. Identify broad-scale conservation initiatives in the Carolinean life zone relevant to the Spoon-leaved Moss and identify activities on which to collaborate.
4. Increase the knowledge base with respect to species demography, biology, distribution, abundance, habitat requirements, critical habitat, threats, transplant/introduction techniques, and/or feasibility of recovery to the extent that long-term sustainability is confirmed or that:
    - 4.1. Recovery goals and activities necessary for long term persistence of Spoon-leaved Moss populations, as outlined in this document, are supported or can be justifiably modified,
    - 4.2. The necessity/feasibility of restoring population size and/or number can be assessed.

2.2.3 Broad strategy to be taken to address threats

Threats of habitat degradation and population decline must be addressed through the broad strategies of monitoring, management and research (Table 3). All activities (Table 3) involve careful on-going planning, re-evaluation and communication throughout the recovery process. They take into consideration the three-step approach advocated by Schemske et al. (1994) for developing efficient recovery strategies: 1) determine the biological status (increasing, decreasing, or stable) of the species through demographic research, 2) identify the life history stages with the greatest effect on biological status, 3) explore the biological reasons for variation in those life history stages. These steps serve to prioritize research and, subsequently, recovery activities according to factors that are of greatest relevance to the species' persistence.

There is no detailed demographic information on Spoon-leaved Moss, and collecting these data is given first priority (along with threat monitoring) among research and recovery activities. It seems doubtful, however, that sufficient data can be gained from Canadian populations, given their limited number and extent and their long-lived perennial life strategy, to apply population modeling. Monitoring of core (US) populations (Nantel & Gagnon 1999), which are more numerous and thus more conducive to demographic modeling, may help to identify vulnerable life history stages in the species, and the degree to which populations north of the international border are characteristic of the species in general. In the meantime, however, casual observation suggests that important demographic components of the species (male plants, reproducing individuals) are absent or rare in Canada. At least one population has persisted for over twenty years, but overall population decline is inferred. In the absence of hard demographic evidence, it seems most likely that barriers to reproduction (and therefore dispersal) may be greater than those to growth and survivorship, and the proposed research reflects this priority. Investigating these barriers (e.g. through transplant trials, controlled growth experiments) will reveal the human activities likely to affect reproductive ability, and the feasibility and methods of reducing their limiting effect.

Although the results of genetic studies are difficult to relate directly to population viability or demographic 'fitness' of a plant population (Ellstrand & Elam 1993, Schemske et al. 1994), they are proposed here as a means of researching dispersal distances and paths, as well as gender, within the Canadian population and between Canadian and US populations. Despite the rationale presented above, reproductive limitation may not be the key limiting factor for Spoon-leaved Moss in Canada. Thus, although studies of factors limiting establishment and growth are not given first priority at this time, all research of ecological requirements (see section 2.3 – data gaps) is encouraged for its potential value in determining current limiting factors (Schemske et al. 1994), or in facilitating re-introduction if it becomes necessary. Although full scientific certainty may never be achieved, measures should be set in place immediately with the understanding that the broad strategy is dynamic and that the results of monitoring, management and research will continually supply information for ongoing development of the recovery strategy.

Table 3. Strategies to effect recovery of Spoon-leaved Moss in Ontario. Priorities are defined as U – urgent, N – necessary. 'Obj. No.' refers to recovery objective as defined in section 2.2.2. Note that research activities described below also support the identification of critical habitat as described in section 1.3.1, and should be combined with them.

Priority	Obj. No.	Broad Approach / Strategy	Threats addressed	Specific Steps	Outcomes or Deliverables (identify measurable targets)
U	1,2,3,4	Communication and Co-ordination	All	• Identify partner organizations (e.g. Ministry of Natural Resources, Niagara Peninsula Conservation Authority and relevant affiliates/associates) in the implementation and facilitation of recovery strategy; identify lead co-ordinating agency; identify land users/stakeholders • Develop and implement communication strategy among partner organizations (including methods and frequency of activity reports, data submission, and strategy re-evaluation); Develop and implement strategy for communicating with land users/stakeholders with respect to recovery activities as required • Partner with broad conservation initiatives (e.g. Carolinian Canada programs, Carolinian Canada Woodland Plant Recovery Team) targeting general threats such as habitat fragmentation, atmospheric pollution, acid rain, by restoring ecological integrity of southern Ontario as well as land use planners such as provincial/regional/municipal governments to encourage both direct habitat protection and indirect (e.g. changes to hydrology). • Submit all new data to the Ontario Natural Heritage Information Centre in a timely manner	• Recovery activities are consistent and co-ordinated • Data are pooled and evaluated regularly • Land-users and stakeholder activities are compatible with recovery activities • Maximize availability of resources for recovery and efficiency of resource use
U	1	Threat Monitoring	All	• Develop and implement monitoring protocol to detect human and natural threats at each known site of occurrence (adding sites if they are discovered), especially those to which Spoon-leaved Moss is particularly vulnerable as described in this report • Monitor sites to assess the effects of any management actions	• Annual summary of threat monitoring results (description, magnitude, action initiated) and mitigation efforts by site
U	2,4	Population Monitoring	All	• Develop and implement monitoring protocol for Spoon-leaved Moss distribution / abundance / sporophyte occurrence (census) at each site (adding	• Annual summary of population monitoring results (distribution and abundance) by site

Priority	Obj. No.	Broad Approach / Strategy	Threats addressed	Specific Steps	Outcomes or Deliverables (identify measurable targets)
				sites and colonies if they are discovered) • Correlate monitoring results with threat monitoring and management activities	• Documentation of local population dynamics
U	1,2	Site Management	All	• Develop population-specific management plans to reduce / remove threats to populations and to critical habitat as it is incrementally identified (e.g. trampling, removal of overstory and /or ground vegetation by humans or wildlife) • Adapt management plan annually (or more frequently) to take new information into account • Identify criteria with respect to rate of population decline (size/distribution) that would trigger immediate re-evaluation of recovery priorities and activities, and incorporate them into the management plans • Incorporate management plans into existing management documents for the protected areas in which the sites occur	• Management plans developed and implemented for all populations and their critical habitat • Population-specific management plans fully integrated into site management plans • Annual summary of management activities and outcomes • Habitat and populations maintained or increased at managed sites
U	4	Research	Succession Stochastic Factors Habitat Destruction and Fragmentation Hydrological Changes	• Develop, prioritize, and initiate a research schedule to: o Implement research schedule to identify critical habitat o Determine demographic status and trends in Canada and the nearby US o Pinpoint factors affecting reproduction and dispersal ability in Canada o Explore reproduction and dispersal patterns / ability through genetic relationships o Characterize species' biology and ecology at all life history stages in Canada and the adjacent northern US (especially New York, Michigan) o Modify Minimum Viable Population methods and determine MVP for Spoon-leaved Moss o Research re-introduction attempts in European jurisdictions and experimental transplant methods; initiate trials (e.g. transplant, spore plot) with potential source populations and target sites (e.g. historical sites) in Canada • Incorporate research findings into population-	• Incremental critical habitat identification progresses • Detailed distribution and abundance of Spoon-leaved Moss among and within Canadian populations, and their temporal dynamics, are used to identify limiting life history stages and place Canadian populations in context of general species patterns • Factors limiting distribution/abundance are confirmed or discounted • Spoon-leaved Moss biology and needs are characterized • Feasibility and potential strategies of (re)introduction to restore or augment Canadian population are justified and documented when they become relevant • Recovery potential is determined

Priority	Obj. No.	Broad Approach / Strategy	Threats addressed	Specific Steps	Outcomes or Deliverables (identify measurable targets)
				specific management plans	
N		Restoration	Stochastic Factors Succession Habitat Destruction and Fragmentation	• Evaluate need for (re)introduction to restore Canadian population based on research and monitoring results • Develop (re)introduction strategy according to research results and incorporate into population-specific management plans as required	• Canadian population is restored to more stable, self-sustainable levels

2.2.4 Effects on other species

No immediate negative impacts on non-target species, natural communities or ecological processes are anticipated to result from the proposed recovery activities. Generally speaking, the protection of Carolinian habitat from degradation will benefit all species at affected sites. Research and monitoring activities that take place at Spoon-leaved Moss sites should be structured in such a way that neither site access nor the activities themselves significantly modify or damage the site or its resident biota (including Spoon-leaved Moss), and the effects of recovery activities should themselves be monitored to ensure that this is the case. The need to collect Spoon-leaved Moss, for genetic studies for example, will be carefully evaluated and regulated so as to minimize impact on the populations.

2.2.5 Evaluation

Performance measures for evaluating success in meeting the stated recovery objectives will include the extent to which each objective has been met, using the broad strategies identified above.

Performance measures of biological effect of recovery activities:

- Status and condition of known populations
  - Population number, colony number, and area occupied at minimum of 2005 level
  - National status maintained or upgraded at next assessment (2013)
  - Stable or increasing provincial and local populations in terms of number of localities and local abundance

Performance measures of recovery activity process:

- Establishment and ongoing implementation of threat monitoring
  - Annual monitoring and documentation complete
  - Management and research plans reflect results of threat monitoring
- Establishment and ongoing implementation of population monitoring
  - Temporal trend or fluctuation (or lack thereof) in local population size (colony number, area occupied) has been described
  - Annual monitoring and documentation complete
  - Management and research plans reflect results of population monitoring
- Establishment and ongoing implementation of research
  - Critical habitat identification has progressed beyond 2005 level
  - Recovery feasibility is established with respect to at least one additional criterion
  - Additional populations found are mapped and incorporated into the recovery program and areas searched are fully documented
  - Identification of limiting factors has progressed beyond 2005 level
  - Species biology and ecology can be described in greater detail than in 2005
  - Research results are incorporated into updated research schedule
  - The necessity of and approaches to re-introduction has been evaluated in preparation for incorporation into management plans
  - Published research articles reflect research results

- Establishment and ongoing implementation of communication strategy
    - Spoon-leaved Moss management activities incorporated into all relevant management/planning documents
    - All land use compatible with recovery activities
- Establishment and ongoing implementation of management plans
    - Management plans and activities reflect most recent available data from within and outside the recovery program

2.3 Knowledge Gaps

As stated above, although recovery activities should commence immediately based on the available information, the recovery objectives and activities are designed in this recovery strategy to undergo regular revision based on new information arising from research and monitoring. Four main knowledge gaps have been suggested throughout this document (Table 4) and are addressed in the preceding research schedules.

Table 4. Summary of knowledge gaps relating to the recovery of Spoon-leaved Moss in Canada, and sections of this report where they are discussed in greater detail.

Gap	Value of Research
Demography (rates of population and metapopulation growth/decline, gender ratio, sporophyte production) in Canada and the nearby US	As discussed in section 2.2.3, demographic data are key to establishing status and to revealing life history stages with the greatest effect on status. They are also vital to the identification of critical habitat (section 1.4.1). Routine (annual, if possible) census of each Canadian population, and of northern US populations, is recommended, as is the development of minimum viability population methods for Spoon-leaved Moss (research in the US is necessary to inform recovery in Canada). Vulnerability to stochastic events may also be partly revealed through demographic studies.
Dispersal ability of sexual and asexual diaspores	As outlined in sections 1.2 and 2.2.3, dispersal ability may be a critical limiting factor for Spoon-leaved Moss, in view of the apparent rarity of sporophyte production. Other approaches to determining dispersal limitation may be to introduce plants or diaspores to suitable habitat and cross-reference results with propagule viability to exclude establishment/habitat limitation. Dispersal ability may also be inferred from characters such as spore size or viability after storage (Cleavitt 2002, references in Cleavitt 2005). Genetic data could also help to reveal the species' local and regional reproductive and dispersal patterns.
Ecological preference / tolerance associated with each life history stage (reproduction, dispersal, establishment, growth)	It is emphasized throughout this report that very little is known about the biology or ecology (e.g. substrate composition and chemistry; water chemistry; moisture, temperature, & light regimes; neighbour effects; overstory vegetation) of Spoon-leaved Moss. Regional, local, and micro-habitat scale preferences and tolerances should be explored, in both Ontario and in the northern US, where the species is more common and available for study. These studies would both provide information on the species as a whole and reveal ecological peculiarities of peripheral populations. It would also help to reveal the relative significance of potential threats.
(Re)introduction feasibility and methods	If it becomes necessary to consider intervention (introduction of plants or propagules) to augment populations or gender ratios in Canada, as mentioned in sections 1.2, 2.1 and 2.2, the feasibility, source populations,

Gap	Value of Research
	target sites, and methods of these activities will need to be established. This requires full exploration of moss re-introduction literature (mainly in Europe) and field trials. Genetic differences between Canadian and US populations could affect the sexual or ecological compatibility of introduced plants (Barrett & Kohn 1991, Kutner & Morse 1996, Helenurm 1998).

2.4 Recommended Approach for Recovery

It has already been emphasized that recovery goals and activities for Spoon-leaved Moss should be incorporated into the management plans of the organizations (Ontario Ministry of Natural Resources, Niagara Peninsula Conservation Authority, Ontario Parks) that own and manage the land on which the species resides. No recovery strategies for individual species currently overlap with that of Spoon-leaved Moss, but there may be other opportunities for integrating species-specific recovery into other recovery or conservation efforts. For example, the plight of Carolinian species in southern Ontario is the object of considerable, well-publicized concern, and research and recovery activities have been initiated on many scales. The accessibility of the recovery goal for Spoon-leaved Moss, as for all rare Carolinian species, will be affected by the success of management activities directed to preserving other Carolinian species and to restoring ecological integrity to the landscape of southern Ontario (e.g. Ambrose & Kirk 2004). Consultation with the Carolinian Woodland Plant Recovery Team, which is attempting to address the ecosystem approach to recovery of Carolinian woodland habitat, and the associated draft recovery strategy (in preparation) would also be productive.

Some of the research recommended in this strategy involves monitoring or measuring populations in the United States. Cross-border initiatives such the Canada-US Framework for Co-operation in identifying and recovering shared species at risk (Environment Canada 2001) highlight the potential for data exchange and resource sharing with respect to rare plants. While Spoon-leaved Moss is not rare in the United States, opportunities for the Framework or other programs to facilitate co-operation should be explored. For example, the genetic or adaptive features of Canada's peripheral populations may be of conservation significance in the global context.

2.5 Statement of When One or More Action Plans in Relation to the Recovery Strategy Will Be Completed

In the absence of a recovery team for Spoon-leaved Moss, a Recovery Implementation Group will need to be formed to develop an Action Plan and implement the recovery activities. It is suggested that an Action Plan to implement the broad strategies identified in this recovery strategy be developed by 2008.

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3.1 Authorities Consulted

The following authorities were consulted with respect to the initial drafting of this report. Personal communications cited in the text may be referred to this list.

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APPENDIX

Jurisdiction responses

Ontario

Acknowledgement of Receipt of the
Draft National Recovery Strategy for the Spoon-leaved Moss (December 2005)
by the Ontario Ministry of Natural Resources
on behalf of the Province of Ontario

This draft National Recovery Strategy for the Spoon-leaved Moss has been prepared in cooperation with the members of the Spoon-leaved Moss Recovery Team, Canadian Wildlife Service (CWS) and the Ontario Ministry of Natural Resources (OMNR). It represents advice to the OMNR on the recovery goals, approaches and objectives that are recommended to protect and recover the species. It does not necessarily represent the views of all individual members of the recovery team, or the official positions of the organizations with which the individual committee members are associated. The goals, objectives and recovery approaches identified in the strategy are based on the best existing knowledge and are subject to modifications resulting from new findings and revised objectives. Implementation of the plan is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

Received by:

- original signed by Cameron Mack

Cameron Mack
Director, Fish and Wildlife Branch
Natural Resource Management Division
Ontario Ministry of Natural Resources
On behalf of the Province of Ontario

Date: February 20, 2006

Species at risk – act today so they have tomorrow

Declaration from Environment Canada

This recovery strategy has been prepared in cooperation with the jurisdictions responsible for the Spoon-leaved Moss. Environment Canada has reviewed and accepts this document as its recovery strategy for the Spoon-leaved Moss, as required under the *Species at Risk Act*. This recovery strategy also constitutes advice to other jurisdictions and organizations that may be involved in recovering the species.

The goals, objectives and recovery approaches identified in the strategy are based on the best existing knowledge and are subject to modifications resulting from new findings and revised objectives.

This recovery strategy will be the basis for one or more action plans that will provide details on specific recovery measures to be taken to support conservation and recovery of the species. The Minister of the Environment will report on progress within five years.

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this strategy and will not be achieved by Environment Canada or any other jurisdiction alone. In the spirit of the Accord for the Protection of Species at Risk, the Minister of the Environment invites all responsible jurisdictions and Canadians to join Environment Canada in supporting and implementing this strategy for the benefit of the Spoon-leaved Moss and Canadian society as a whole.

STRATEGIC ENVIRONMENTAL ASSESSMENT

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision-making.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that strategies may also inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts on non-target species or habitats. The results of the SEA are incorporated directly into the strategy itself, but are also summarized below.

This Recovery Strategy will clearly benefit the environment by promoting the recovery of the Spoon-leaved Moss. The potential for the Strategy to inadvertently lead to adverse effects on other species was considered. The SEA concluded that this Strategy will clearly benefit the environment and will not entail any significant adverse effects. The reader should refer to the following sections of the document in particular: Description of the species' needs – ecological role, biological needs, and limiting factors; Effects on other species; and Recommended approach for recovery.

RESIDENCE

SARA defines residence as: "*a dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating*" **[SARA S2(1)]**.

Residence descriptions, or the rationale for why the residence concept does not apply to a given species, are posted on the SARA public registry: http://www.sararegistry.gc.ca/plans/residence_e.cfm