Conservation Assessment
for
Bulrush Sedge (*Carex scirpoidea* Michx.):
Subspecies scirpoidea and *convoluta* (Kükenth.) Dunlop

USDA Natural Resources Conservation Service (No date).
Photo by Robert H. Mohlenbrock

USDA Forest Service, Eastern Region
June 2003

Ramona Shackleford
Hiawatha National Forest

This Conservation Assessment was prepared to compile the published and unpublished information on the subject taxon or community; or this document was prepared by another organization and provides information to serve as a Conservation Assessment for the Eastern Region of the Forest Service. It does not represent a management decision by the U.S. Forest Service. Though the best scientific information available was used and subject experts were consulted in preparation of this document, it is expected that new information will arise. In the spirit of continuous learning and adaptive management, if you have information that will assist in conserving the subject taxon, please contact the Eastern Region of the Forest Service - Threatened and Endangered Species Program at 626 East Wisconsin Avenue, Milwaukee, Wisconsin 53203.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Carex scirpoidea Michx. (bulrush sedge) is designated as a Regional Forester Sensitive Species in the Eastern Region of the U.S. Forest Service on the Green Mountain National Forest in Vermont and the Hiawatha National Forest in Michigan. The species also occurs without a special rarity listing on the White Mountain National Forest in New Hampshire. This Conservation Assessment distinguishes subspecies of *C. scirpoidea* that have been recognized in recent literature (Dunlop 2002). Occurrences of *C. scirpoidea* on the White Mountain and Green Mountain National Forests are subspecies *scirpoidea*, while the occurrence on the Hiawatha National Forest is subspecies *convoluta (Kükenth.) Dunlop*. The purpose of this Conservation Assessment is to provide background information necessary to create a management plan known as a "Conservation Strategy," which will be designed specifically to conserve this species.

Although *C. scirpoidea* ssp. *scirpoidea* occurs in areas of Eurasia, the primary range of the subspecies is in northern North America where it occurs from Greenland to Alaska and south through Canada into northern parts of the contiguous United States. In the lower 48 states, subspecies *scirpoidea* occurs at high altitudes in the Cordilleras (CO, ID, MT, NV, OR, UT, WA, WY) and northern Appalachians (VT, NH, ME, and northern NY), while at low altitudes in the Great Lakes region (MI, MN, and ND). In the contiguous United States, it occurs primarily on calcareous soils in a variety of habitats including: fens, mesic prairies, alvars, mountain cliffs, rocky riverbanks, and rocky lakeshores (Voss 1972, Smith 1988, Cronquist *et al.* 1998, Magee & Ahles 1999). Although common and widespread in parts of Canada and Alaska, subspecies *scirpoidea* is tracked due to its rarity in ten of the fourteen states in which it occurs (NatureServe Explorer 2002). Subspecies *convoluta* is restricted to Michigan and Ontario (Dunlop 2002) where it occurs in alvars and northern fens that are near the shores of Lake Huron (often on islands) (Michigan Natural Feature Inventory [MNFI] 2003). Subspecies *convoluta* is tracked due to its rarity in both Ontario and Michigan (NatureServe Explorer 2002). Protection of *C. scirpoidea* ssp. *scirpoidea* and ssp. *convoluta* in the eastern United States is promoted not only by their rarity, but also by the rarity of the habitats in which they tend to occur.

Carex scirpoidea is distinguished from other *Carex* species by terminal spikes that are solitary, unisexual, and between 1 and 4 cm long; trigonous achenes with three stigmas; and hairy perigynia that are 1.5-3 mm long (Ball & Reznicek 2002). Perigynia do not have winged margins, are nearly nerveless, and are a similar length as the perigynia scales (Gleason & Cronquist 1991). *Carex scirpoidea* ssp. *convoluta* has leaves on pistillate culms that are less than 1.5 mm wide and narrowly V-shaped in cross-section, while subspecies *scirpoidea* has leaves on pistillate culms that are widely V-shaped and more than 1.5 mm wide (Dunlop 2002). Given that *C. scirpoidea* is usually dioecious, the morphology of the species prevents most plants from being able to self-fertilize. As a result, outcrossing is the most common mode of sexual reproduction. Species that tend to outcross tend to have less inbreeding and greater genetic variation than selfing species (Hamrick & Godt 1990). Due to being a dominant species in parts of its range, *C. scirpoidea* has been analyzed in ecological studies and is an indicator species for a few ecological community types (NatureServe Explorer 2002).

ACKNOWLEDGEMENTS

Hanes Trust Fund: We thank the Hanes Trust and Dr. Elwood Ehrle at Western Michigan University for his assistance in processing the grant to provide funding for this Conservation Assessment.

Document Review: We thank Professor Debra Dunlop of New England College in Henniker New Hampshire for her helpful comments and corrections on this manuscript. Debra Dunlop has published multiple papers concerning this species.

Herbarium and Natural Heritage Data: We thank the personnel of natural heritage programs and herbaria in the United States and Canada that contributed element occurrence information for this Conservation Assessment (see "contacts" section for a complete list).

Drawing and photo permission: We thank the USDA Natural Resources Conservation Service for use of the photo on the front cover and illustration found on page two of this document. Both are from "Northeast Wetland Flora" (US Department of Agriculture, no date). The photographer is Robert H. Mohlenbrock and the artist of the illustration (Figure 1) is Mark Mohlenbrock

Initial Draft: We are grateful to Ramona Shackleford, contract botanist, for her efforts in providing us with an original draft of this Conservation Assessment.

Editorial Committee: We thank Jan Schultz, of the Hiawatha National Forest, for her suggestions and patience through numerous revisions.

Literature Search: We thank Laura Hutchinson of the North Central Research Library for performing initial species inquires and sending us relevant research articles. We thank Jan Schultz for sharing information from her library. We also thank Beverly Braden for additional literature searches at Northern Michigan University in Marquette, Michigan State University in East Lansing, and the University of Michigan in Ann Arbor; and Ramona Shackleford for doing additional literature searches at the University of Wisconsin at Madison and University of Minnesota at Duluth.

NOMENCLATURE AND TAXONOMY

Carex scirpoidea (bulrush sedge) is grouped within the *Carex* genus of the Cyperaceae family (Table 1). The *Carex* genus contains about 2000 species that are commonly referred to as sedges (Reznicek 1990). Basic characteristics of the genus include narrow grass-like leaves that are three-ranked, triangular stems, and closed sheaths (Gleason & Cronquist 1991). Flowers do not have perianths and occur on spikes that are bisexual or unisexual (Gleason & Cronquist 1991). Each flower is subtended by a scale; pistillate flowers are within a sac-like structure called the perigynium. Other characteristics often used in distinguishing species include the shape of the achene, the number of stigmas, and the number spikes. This large and difficult genus is broken into smaller taxonomical categories called "sections."

Carex scirpoidea is the only species of the Scirpinae section found in the northeastern United States. *Carex scirpoidea* is divided into four subspecies including *scirpoidea*, *stenochlaena*, *convoluta*, and *pseudoscirpoidea* (Dunlop 1997, Dunlop & Crow 1999, Dunlop 2002). Dunlop (1997) determined that these subspecies are distinguished by a few consistent morphological characters and differing geographical ranges. The subspecies are included within the same species as they share most morphological traits, chromosome numbers, achene micromorphology, leaf anatomy, and can interbreed (Dunlop & Crow 1999). Subspecies *convoluta* and *scirpoidea* are analyzed in this document as they are the only subspecies located in eastern North America (Dunlop & Crow 1999).

Table 1. Current taxonomic placement and nomenclature of *Carex scirpoidea* in eastern North America (Dunlop 1997, Dunlop & Crow 1999, Dunlop 2002)

Family:	Cyperaceae
Genus:	*Carex* Linnaeus
Section:	*Scirpinae* (Tuckerman) Kükenthal
Scientific name:	*Carex scirpoidea* Michaux
Common names:	bulrush sedge, bulrush-like sedge, scirpus-like sedge, northern single-spike sedge, Canadian single-spike sedge
USDA Symbol:	CASC10 (PLANTS Database 2002)
a. Subspecies	*convoluta* (Kükenthal) D.A. Dunlop
Synonym:	*Carex scirpoidea* var. *convoluta* Kükenthal
b. Subspecies	*scirpoidea*
Synonyms:	*Carex scirpoidea* subsp. *scirpiformis* *Carex scirpoidea* var. *scirpiformis* (Mackenzie) O'Neill & Duman *Carex scirpiformis* Mackenzie *Carex athabascensis* F.J. Hermann *Carex scirpoidea* var. *europae* Kükenthal

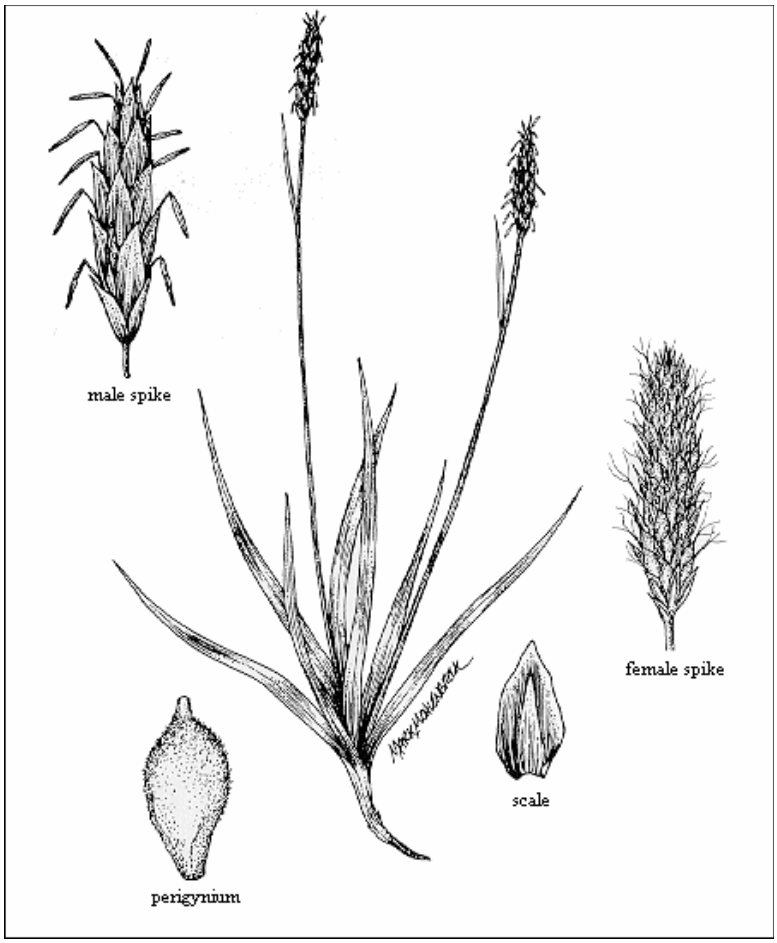
DESCRIPTION OF SPECIES

Table 2 displays details of the technical characteristics of *C. scirpoidea* including distinct characteristics of subspecies *convoluta* and *scirpoidea*. *Carex scirpoidea* is distinguished

from other *Carex* species by terminal spikes that are solitary, unisexual, and between 1 and 4 cm long; trigonous achenes with three stigmas and hairy perigynia that are 1.5-3 mm long (Figure 1; Voss 1972, Gleason & Cronquist 1991, Ball & Reznicek 2002). Perigynia do not have winged margins, are nearly nerveless, and are similar in length to the perigynia scales (Gleason & Cronquist 1991). If only staminate culms are available, additional characters may aid in positive identification such as: ciliate staminate scales, culms that are taller than leaves, reddish-purple color at the bases of culms, upper blades of culms are well-developed, and puberulent leaf sheaths (Ball & Reznicek 2002). *Carex scirpoidea* ssp. *convoluta* has leaves on pistillate culms that are less than 1.5 mm wide and narrowly V-shaped in cross-section, while subspecies *scirpoidea* has leaves on pistillate culms that are widely V-shaped and more than 1.5 mm wide (Dunlop 2002).

Table 2. Technical characteristics of *Carex scirpoidea*. In the description below, "SC" indicates characteristics specific to subspecies *scirpoidea* and "CO" indicates characteristics specific to subspecies *convoluta*. Characteristics with "SC & CO" differ in one or both of the two western subspecies (*stenochlaena* and *pseudoscirpoidea*). References for descriptions include: Voss 1972, Gleason & Cronquist 1991, Ball & Reznicek 2002, Dunlop 2002 (distinctions among subspecies).

General:	**Dioecious**; 2n=62; Short cespitose (SC), inconspicuous cespitose (CO); **Flowering culms** 5-40 cm, erect (SC & CO), taller than leaves, reddish at base. No sheaths from previous year's leaves present at leaf bases (SC & CO).
Leaves:	Basal leaves scale-like, leaves well developed distally (SC & CO), puberulent leaf sheaths. Leaves 1-3 mm wide (CO leaves on pistillate culms < 1.5 mm wide, cross-section narrowly V-shaped; SC leaves on pistillate culms > 1.5 mm wide, cross-section widely V-shaped to flat)
Inflorescence:	**Spikes** unisexual, solitary, terminal (rarely lateral spike of same sex), 1-4 cm long, erect, slender (Fig. 1); **Bracts** one, minute.
Flowers:	**Pistillate**: Three stigmas; **Perigynia** ovate to obovate (SC & CO), not-winged, 1.5-3 mm, two-keeled, nearly nerveless except two marginal veins, white short hairs, minute beak (.1-.5mm), no rachilla (Fig. 1); **Pistillate scale**s ovate (SC & CO) to lanceolate, dark brown to purple, scattered hairs, hyaline margins, narrow to broad, similar length as perigynia. **Achenes**: Trigonous or round, mostly filling perigynia, 1-1.8 mm. **Staminate**: Staminate scales ciliate, nearly white.



Drawing Credit: USDA Natural Resources Conservation Service (No date).
Drawing by Mark Mohlenbrock

Figure 1. *Carex scirpoidea* ssp. *scirpoidea*.

LIFE HISTORY

Reproduction

Sexual Reproduction

Unlike most *Carex* species, *C. scirpoidea* is dioecious with plants either having pistillate spikes or staminate spikes. With only four percent of all angiosperms dioecious, dioecy is notably unusual not only within the *Carex* genus, but also among angiosperms (Richards 1986, cited in Briggs & Walters 1997). Some dioecious species are actually gynodioecious (having a combination of hermaphoditic and pistillate plants) or androdioecious (having a combination of hermaphoditic and staminate plants). The sex ratio of staminate to pistillate plants is 1:1 in most populations of *C. scirpoidea* (Dunlop 1990, cited in Yarbrough 2000). From an examination of herbarium specimens, only one to five percent of culms with a terminal staminate spike have a second smaller pistillate spike below it; likewise, a low percentage of culms with terminal pistillate spikes have a second smaller staminate spike (D. Dunlop pers. comm. 2003). The majority of *C. scirpoidea* plants are, therefore, unisexual (dioecious) and do not have the capacity to self-pollinate. Sexual reproduction in this species, therefore, is usually the result of

cross-fertilizations (outcrossing). In contrast, most *Carex* species are self-compatible (Catling *et al.* 1990). Outcrossing and dioecy may be significant factors that affect the population biology of this species (see "Population Biology and Viability" section).

Research suggests that *Carex* species, like other plants that have rhizomatous (clonal) growth, tend to establish new seedlings infrequently (Schütz 2000). Schütz (2000) also indicates that most *Carex* species have persistent seed banks. Results from many studies have shown that viable *Carex* seeds tend to occur in deep soil layers, suggesting that the seeds can persist for decades in the soil (McGraw *et al*. 1991, Hendry *et al*. 1995, Schütz 2000).

Many *Carex* species have primary dormancy, in which ripe seeds are dormant until the dormancy mechanism is broken (Schütz 2000). To be released from dormancy, the seeds of many *Carex* species must go through cold stratification. In a study of 32 temperate *Carex* species, Schütz & Rave (1999) determined that 70-80% of species had increased germination rates after a period of cold stratification. This dormancy mechanism prevents seeds from germinating in the summer when the competition of other plants would make their establishment difficult (Schütz 2000). Schütz (2000) indicates that in the spring, germination is initiated when a combination of specific conditions occur including relatively high temperatures, daily fluctuations in temperatures, and light exposure. The seeds of many *Carex* species are believed to go through annual dormancy cycles (Schütz 2000). If seeds do not germinate in the spring, they may become secondarily dormant as the temperature rises (Schütz 2000). Each year cold winter temperatures may release the seeds from dormancy (Schütz 2000).

Research has shown that in some *Carex* species, primary induction of flowering shoots (development of floral primordia) begins in the fall and overwinters, while secondary induction (culm elongation and inflorescence development) tends to occur in the spring and summer (Bernard 1990, Heide 1997). Heide (1997) determined that a combination of temperature and photoperiod (daylight length) conditions during a primary induction period affect the percent of plants that flower and the number of culms per plant that flower during a secondary induction period. Such research suggests that a combination of the photoperiod and temperatures in the fall influences the numbers of flowering culms in the spring. Shoots die after flowering which is often within a year of development (Bernard 1990, Heide 1997). In arctic and alpine habitats that have short growing seasons, flowering shoots may take multiple years to develop, depending on the conditions (Alexeev 1988).

Asexual Reproduction

In addition to sexual reproduction, *C. scirpoidea* (like all *Carex* species) reproduces asexually by vegetative or "clonal" growth (Bernard 1990, Gleason & Cronquist 1991). The different subspecies of *C. scirpoidea* are in part distinguished by their differing vegetative growth. Subspecies *pseudoscirpoidea* has long rhizomes, while subspecies *scirpoidea* has tufted or cespitose growth, and subspecies *convoluta* and *stenochlaena* have "inconspicuous" cespitose growth (Dunlop 2002).

Carex genets (genetically distinct individuals) may take years to mature and tend to be long-lived (Alexeev 1988, Bernard 1990). In fact, a genet could theoretically live hundreds of years (Bernard 1990). Species with cespitose growth, such as *C. scirpoidea* ssp. *scirpoidea* and ssp. *convoluta*, are thought to have a shorter lifespan than *Carex* species with long-rhizomes (Alexeev 1988, Eriksson 1989). Nevertheless, species with this growth form have been documented as living at least ten to twenty years (Bernard 1990).

Ecology

A few community ecology studies have located *C. scirpoidea* in relevés (Ratcliffe & Turkington 1987, Ouellet *et al.* 1994, Razzhivin 1994). Although these studies do not indicate the subspecies, the locations of the studies suggest that it is subspecies *scirpoidea*. Subspecies *convoluta* and *scirpoidea* may differ ecologically due to site specific adaptations, however, these subspecies probably share general ecological capabilities described below given their morphological similarities, their ability to interbreed (Dunlop 1990, cited in Dunlop 1997) and similar habitats near the Great Lakes (see "Habitat" section).

In snowbed plant communities of far northeastern Asia, *C. scirpoidea* occurs in mesic to dry soil at a soil pH ranging between 5.0 and 7.8, with the optimal pH being between 6.5 to 6.9 (Razzhivin 1994). Razzhivin (1994) classifies the species as a "hemibasiphyte" which is a "dominant species of broad ecological amplitude on carbonate–rich parent material that occurs in acid landscapes in calcite accumulation facies only." *Carex scirpoidea* occurs in areas of very snow rich habitats (>5 meters deep snow) and in moderate snow rich habitats (2-5 meters deep) (Razzhivin 1994). The species occurs in acidic soils of snow rich habitats, but at much lower frequency and cover than in calcium rich soil with calciphytes (Razzhivin 1994).

Carex scirpoidea tends to be a dominant species in communities in much of its range. In alpine habitat of British Columbia, *C. scirpoidea* was determined to be dominant species in all six transects sampled (Ratcliffe & Turkington 1987). In certain "high, windswept alpine slopes" of southwestern Montana (NatureServe Explorer 2002), *C. scirpoidea* is also the distinguished dominant species in a few plant associations of the "*Carex scirpoidea* herbaceous alliance" (Cooper *et al*. 1999, NatureServe Explorer 2002, Appendix 1). In far northeastern Asia and islands of the Northwest Territories, it is also recognized as a dominant species in certain habitats (Ouellet *et al.* 1994, Razzhivin 1994). Even in Colorado where it occurs in scattered disjunct populations at the southern edge of its range, *C. scirpoidea* is the dominant species in certain areas of one extreme rich fen and is described as an "important component" that was used as one of the indicator species when comparing the fen to other fens (Cooper 1996). Specifically in the extreme rich fen of Colorado, *C. scirpoidea* is dominant in peat hummocks with more than 20% organic carbon that are along dry and saline margins of the fen.

In dry alpine habitat (2402-2500 m. altitude) of British Columbia, *C. scirpoidea* occurs in acidic soils with high calcium and magnesium in the A-horizon. Ratcliffe and Turkington (1987) suggest that in this alpine habitat, differences in root morphology may

decrease competition among species. In support of this, they note that species with fibrous roots such as *C. scirpoidea* have positive associations with species that have tap roots. Ratcliffe and Turkington (1987, p. 2515) indicate that *C. scirpoidea* is the least competitive species of the dominant species in their study "evidenced by the lack of negative association with subordinate vascular species, as well as the lack of positive lichen and moss associations." Negative associations "indicate frequent spatial separation of two species" (Ratcliffe & Turkington 1987) and tend to occur between competitive species (Del Moral *et al.* 1985, cited in Ratcliffe & Turkington 1987). Positive associations between vascular plants and lichen and moss result "where competitive exclusion of other vascular species has occurred" (Ratcliffe & Turkington 1987, p. 2514). The lack of positive lichen and moss associations suggests that *C. scirpoidea* does not exclude its competitors from the microsite.

Carex scirpoidea is limited to arctic and alpine habitats or habitats with an arctic- alpine element (Given & Soper 1981). Species of such habitats tend to be poor competitors and stress tolerant (Given & Soper 1981). Many of the habitats in which *C. scirpoidea* occurs have relatively low plant cover (e.g. alvars, cliffs and high altitude ridges) suggesting stressful conditions and low competition levels. However, *C. scirpoidea* must be relatively competitive in certain conditions given its tendency to be a dominant species (as described in preceding paragraphs).

In a study of vegetation along an abandoned crude-oil pipeline in the Northwest Territories of Canada, investigators determined that most plant species had lower cover in 35-year-old oil spills compared to locations without oil spills (Kershaw & Kershaw 1986). *Carex scirpoidea*, however, was one of the species that increased cover in oil spills (Kershaw & Kershaw 1986).

Carex leaves are an important food source for both wild and domestic animals, especially in the arctic (Bernard 1990). *Carex scirpoidea* may be particularly grazed upon in prairies, meadows, and fens at low altitudes where ungulates and birds are likely to feed. *Carex* plants that are grazed upon can regrow new leaves since the meristems of the shoots are usually not damaged (Kotanen & Jefferies 1989). Although herbivory is usually not beneficial to plants, its negative effects may be mild (Barbour *et al.* 1987). Herbivory may shorten the life of individual shoots (Bernard 1990). Due to its notable presence in areas of Southhampton Island of the Northwest Territories, *C. scirpoidea* (growing in exclosures) was one of the species that was clipped for one growing season to simulate grazing caribou. *Carex scirpoidea* had no significant change to net production during clipping treatments or during the following recovery year, indicating that *C. scirpoidea* can have compensatory growth (Ouellet *et al.* 1994). Compensatory growth occurs when defoliation triggers the plant to grow new tissue at a faster rate (Barbour *et al.* 1987, Kotanen & Jefferies 1989). This study suggests that *C. scirpoidea* responds relatively well to grazing.

Fungi (including arbuscular mycorrhizal, ectomycorrhizal, and dark septate fungi) have been found in association with the roots of certain *Carex* species (Miller *et al.* 1999). The fungi may have a mutualistic relationship with these *Carex* species, as such an

association has been found in other plant groups. This relationship, however, is probably not obligate since fungi have been found seasonally or only in some populations of a given species (Miller *et al.* 1999). In a study of 23 *Carex* species in Illinois, sixteen had arbuscular fungi present in the roots (Miller *et al.* 1999). From that study, Miller *et al.* found that *Carex* species occurring in alkaline conditions were more often associated with arbuscular mycorrhizal fungi than those occurring in acidic conditions. Species of wet habitats were less likely to have an arbuscular mycorrhizal association (Miller *et al.* 1999). An association with fungi has not been examined in *C. scirpoidea*.

Dispersal/Migration

The presence of viable *Carex* seeds in the digestive tract of some ducks suggests that some *Carex* species may be dispersed by birds and ducks that feed on *Carex* seeds (Catling *et al.* 1990). Although seed dispersal by ingestion is a possible mechanism, seed dispersal has not been examined in *C. scirpoidea*.

Most pollen from wind-pollinated herbs disperses short distances (Levin & Kerster 1974). With distance from the pollen source, pollination decreases rapidly. In almost any wind-pollinated species, the majority of pollen lands within 50 meters of the source (Levin & Kerster 1974). Recent studies of outcrossing plants in open areas indicate that a small fraction of pollen may potentially pollinate plants over 200 meters from a given source (Rognli *et al.*, 2000; Luna V. *et al.* 2001).

HABITAT

Range-wide

Carex scirpoidea ssp. *scirpoidea*

Within its wide geographical range, *C. scirpoidea* ssp. *scirpoidea* occurs in many different habitats that are difficult to generalize (Appendix 1). Most habitats are open and in calcareous soils or soils with high calcium content (Dunlop & Crow 1999). The subspecies, however, can occur on acidic (Ratcliffe & Turkington 1987, Razzhivin 1994) and serpentine substrates (Damman 1964). Although in most habitats the soil is described as moist or wet (Dunlop & Crow 1999, Minnesota Natural Heritage and Nongame Research Program [MNNHP] 2003), it also occurs in areas with dry soil (Aiken *et al.* 1999, Douglas & Ceska 2001).

In northern Canada and Alaska subspecies *scirpoidea* is found in meadows, rocky slopes, tundra, heathlands, woods, and sea shores of the Arctic Archipelago (Appendix 1a & 1c). In the western contiguous United States the subspecies occurs at high altitudes of the Cordilleras in rich fens, meadows, stream banks, and rocky slopes (Appendix 1a; Hermann 1970, cited in Fertig 1999, Hitchcock *et al.* 1977).

Table 3. Summary of habitat information for element occurrences listed in Appendix 2. Number of element occurrences in each habitat listed by surveyors of *C. scirpoidea* ssp. *scirpoidea* and *convoluta* in a. Michigan (Appendix 2) and b. Minnesota (Minnesota Natural Heritage and Nongame Research Program [MNNHP] 2003).

a.) Michigan

Habitat	Subspecies *scirpoidea*	Subspecies *convoluta*	Subspecies not identified
On an island in Lake Huron, along rocky shore (most on limestone pavement/in an alvar).		6	4
On an island in Lake Huron, not along shore.		1 (alvar)	1
Fen-like.		2	
Along shore of a Great Lake.	1		1
Along river (on calcareous rock, or dolomite below organic layer).	3		
Total	4	9	6

b.) Minnesota

Habitat	Subspecies *scirpoidea*
Wet/ mesic prairie	22
Wet/mesic brush prairie	8
Wet/mesic saline prairie	5
Brush prairie	3
Upland prairie	3
Sedge meadow or fen-like	2
Cliff ledge along river	1
No description	2
Total	46

In the Great Lakes region and New England, subspecies *scirpoidea* also occurs in a variety of habitats. Occurrences identified as subspecies *scirpoidea* in Michigan are located along river banks and along the Lake Superior shoreline, primarily on calcareous and rocky substrates (Table 3). On the north shore of Lake Superior in Ontario, subspecies *scirpoidea* occurs in two plant associations (*Potentilla-Sagina* rock herbfield and *Carex-Sagina* rock-pool herbfield) in rocky shoreline habitats (Given & Soper 1981, Appendix 1c). In contrast, a majority of populations in Minnesota occur in wet or mesic prairies and meadows (Table 3), many of which are localized "between old strandlines and beach ridges of Glacial Lake Agassiz" (Smith 1988, p. 173). In New England the subspecies occurs on "turf, cliffs, ledges, talus, gravel and dry, especially calcareous soil in alpine areas" (Magee & Ahles 1999, p.236, Appendix 2). Debra Dunlop (pers. comm.

2003) contends that the species occurs in seasonally dry soils in New England, not dry soils.

Carex scirpoidea ssp. convoluta

Carex scirpoidea ssp. *convoluta* occurs in a limited area of Michigan and Ontario where it occurs primarily on islands and shores of Lake Huron growing "… in cracks of outcropped limestone 'pavements'" (Dunlop & Crow 1999) along shorelines and "prairie pavement barrens" (Dunlop 2002). A few populations in Michigan also occur in fen-like habitat (Appendix 2).

Michigan is the only state that has both *C. scirpoidea* ssp. *convoluta* and *scirpoidea*. However, a number of occurrences in the State have not been identified to the subspecies level. By matching habitat descriptions and location information from the Michigan Natural Features Inventory (MNFI) Database (2003) and from herbarium labels at the University of Michigan Herbarium (MICH) twenty occurrences of *C. scirpoidea* are identified in Michigan (Appendix 2), nine of which are subspecies *convoluta,* four are subspecies *scirpoidea,* and seven are not identified to the subspecies. Many that are not identified to the subspecies level are probably subspecies *convoluta* given that six of these occur in the vicinity of five occurrences of subspecies *convoluta*.

Table 4. Species listed most frequently in descriptions of *C. scirpoidea* ssp. *convoluta* in Michigan (Appendix 1b & Appendix 2a).

Trees:	*Thuja occidentalis* (white cedar), *Picea glauca* (white spruce), *Abies balsamea* (balsam fir)
Shrubs:	*Potentilla fruticosa* (shrubby five-fingers), *Juniperus communis* (common juniper), *Juniperus horizontalis* (creeping juniper).
Graminoids:	*Andropogon* (*Schizachyrium*) *scoparium* (little bluestem), *Carex garberi* (sedge), *Carex viridula* (sedge), *Eleocharis elliptica* (*tenuis*) (spike-rush).
Forbs:	*Primula mistassinica* (Mistassini primrose), *Satureja glabella var. angustifolia (arkansana), Senecio pauperculus* (northern-meadow groundsel), *Arenaria stricta* (sandwort), *Campanula rotundifolia* (harebell), *Selaginella eclipes (apoda)* (meadow-spikemoss), *Sisyrinchium montanum* (blue-eyed grass), *Zigadenus elegans* (death-camas).

Six of nine populations identified as subspecies *convoluta* in Michigan are located on islands in Lake Huron (Table 3). Five of these occurrences grow in cracks of limestone pavement or cobbly beach along the shoreline. Many occurrences of subspecies *convoluta* are in open areas that border boreal forest of *Thuja occidentalis* (white cedar), *Picea glauca* (white spruce), and *Abies balsamea* (balsam-fir). A few occurrences identified as subspecies *convoluta* grow in fen-like habitat. Table 4 lists species associated with at least two Michigan populations.

"Creeping juniper-shrubby cinquefoil alvar pavement" and "little bluestem alvar grassland" are two rare ecological communities described by NatureServe Explorer

(2002) that include *C. scirpoidea* among the associated species. These communities occur primarily in Ontario and the Upper Peninsula of Michigan near northern shores of Lake Huron. Most likely *convoluta* is the subspecies present given the location of the communities. Creeping juniper-shrubby cinquefoil alvar pavement occurs "on very shallow soils over flat dolostone outcrops (pavements)" (NatureServe Explorer 2002). The community has at least 25 percent cover by "dwarf" shrubs such as *Juniperus horizontalis* and *Potentilla fruticosa* (<0.5 m height), less than 50 percent cover by herbaceous plants, much exposed rock covered with moss, lichens, and algae, and low tree cover (NatureServe Explorer 2002). Little bluestem alvar grassland, the other community type, occurs on thin soil over flat limestone and dolostone outcrops (pavements) (NatureServe Explorer 2002). In this community, soil moisture fluctuates annually from wet to dry. Sedges and grasses have at least 50% cover, shrubs over 0.5 m height have 10% cover, dwarf shrubs (<0.5 m height) growing under the canopy of grasses makeup 50% cover, and less than 50% of the ground is exposed bedrock (NatureServe Explorer 2002).

Species that are listed by these two community associations and were listed in at least two Michigan occurrences of *C. scirpoidea* ssp. *convoluta* include: *Potentilla fruticosa* (shrubby cinquefoil), *Juniperus horizontalis* (creeping juniper), *Andropogon* (*Schizachyrium*) *scoparium* (little bluestem), and *Senecio pauperculus* (northern-meadow groundsel).

National Forests

Below are habitat descriptions of specific occurrences of *C. scirpoidea* that occur on or near National Forests in the Eastern Region of the U.S. Forest Service. *Carex scirpoidea* ssp. *convoluta* occurs on the Hiawatha National Forest in Michigan. Subspecies *scirpoidea* occurs on the White Mountain in New Hampshire and Green Mountain in Vermont. In addition, one population is within five miles of the Superior National Forest in Minnesota.

Green Mountain National Forest, Vermont

One extant occurrence of *Carex scirpoidea* ssp. *scirpoidea* is located on this forest growing in a northern New England calcareous cliff community (Green Mountain National Forest 2002).

Hiawatha National Forest, Michigan

The single occurrence of subspecies *convoluta* on this forest is within a mile of Lake Huron growing along the shore of a marly pool with species associated with fens (MNFI Database 2003). *Thuja occidentalis* (white cedar) grows in the vicinity. Associated species include *Parnassia glauca* (grass-of-parnassus), *Sarracenia purpurea* (pitcher plant), *Andropogon* (*Schizachyrium*) *scoparium* (little bluestem), *Lobelia kalmii* (Kalm's lobella), *Juniperous horizontalis* (creeping juniper), and *Gaylussacia* spp. (huckleberry) (MNFI Database 2003).

A second population of subspecies *convoluta* occurs on private land within the boundaries of this National Forest. This population occurs along a road in an "upland

transition zone" of a large northern fen (Penskar & Higman 2002). Associated species include the federally endangered species *Hymenoxys herbacea* (lakeside daisy) (*Voss 16582*).

Superior National Forest, Minnesota

One known occurrence of subspecies *scirpoidea* is less than five miles from the Superior National Forest boundary and about 1.5 mile from Lake Superior (MNNHP 2003). The population occurs in unforested ledges and crevices of north facing cliffs of the upper portion of a 450 ft high ridge along a river. This population is different from other Minnesota occurrences by its cliff habitat and its location in northeastern Minnesota (Table 2). Associated species include: *Carex eburnea* (ebony sedge), *Agrostis scabra* (bent-grass), *Huperzia appalachianum* (club-moss), *Huperzia selago* (fir club-moss), *Saxifraga aizoon* (white alpine saxifrage), *Thelypteris phegopteris* (northern-beech fern), *Aquilegia canadensis* (Canada columbine), *Campanula rotundifolia* (harebell), *Solidago hispida* (hairy goldenrod), and *Fragaria virginiana* (wild strawberry) (MNNHP 2003).

White Mountain National Forest, New Hampshire

Two extant occurrences of *C. scirpoidea* ssp. *scirpoidea* are at high altitudes (>3000 feet) on the White Mountain National Forest (New Hampshire Natural Heritage Inventory [NHNHI] 2003, Appendix 2). Four historic occurrences, last located prior to 1939, are also documented on the forest. Habitat descriptions are limited to the altitude and associated species of the extant populations. One site is associated with northern New England circumneutral cliff community including *Potentilla fruticosa* (shrubby cinquefoil), *P. tridentata* (mountain white potentilla), *Aster radula* (low rough aster), *Woodsia ilvensis* (rusty cliff-fern), and *Paronychia argyrocoma* (silver whitlow-wort). The other population occurs with moss, *Juncus trifidus* (highland rush), *Salix uva-ursi* (bearberry willow), *Prenanthes* sp. (Rattlesnake-root), *Diapensia lapponica* (lapland diapansia), and *Solidago* sp. (goldenrod) (NHNHI 2003).

DISTRIBUTION AND ABUNDANCE

Range-wide Distribution

Carex scirpoidea ssp. *convoluta*

Carex scirpoidea ssp. *convoluta* has a limited range, primarily occurring on islands and along shores of Lake Huron in Michigan and Ontario (Dunlop & Crow 1999, Dunlop 2002). Within its limited range, subspecies *convoluta* is restricted to rare habitats that limit the size and number of occurrences.

Carex scirpoidea subspecies *scirpoidea*

Carex scirpoidea ssp. *scirpoidea* occurs across northern North America, from Greenland to Alaska and south through Canada into northern parts of the contiguous United States. Populations south of the Canadian border are scattered in western mountains (CO, ID, MT, NV, OR, UT, WA, WY), the northern Appalachian Mountains (VT, NH, ME, and northern NY) and northern areas of Minnesota, Michigan, and North Dakota (Dunlop & Crow 1999). In northeastern Russia the species occurs on the Kamtchatka and

Chukotskiy Peninsulas, and in Europe one disjunct population also occurs in Norway (Dunlop & Crow 1999).

Table 5. Number of occurrences of *C. scirpoidea* ssp. *scirpoidea* and ssp. *convoluta* throughout the United States. Note that Michigan is the only state with occurrences of subspecies *convoluta*, therefore, occurrences in other states listed below are for subspecies *scirpoidea*.

State	**Number of Occurrences**			**Description of Abundance; Sources**
	Extant	Historic	Total	
Alaska			?	"common in mountains" (Hultén 1968).
Colorado	8		8	Yarbrough 2000.
Idaho			?	
Maine	5	1	6	Green Mountain National Forest 2002.
Michigan				Appendix 2a.
ssp. unidentified	9	1	10	
ssp. *convoluta*	6		6	
ssp. *scirpoidea*	4		4	
Minnesota			46	MNNHP 2002.
Montana			?	Dominant species in plant communities of SW Montana (NatureServe Explorer 2002).
Nevada			?	No rarity listing.
New Hampshire	6	5	11	NHNHI 2002.
New York	6		6	New York Natural Heritage Program 2003.
North Dakota			?	Known from 3 counties, Endangered (Bry 1986).
Oregon			?	No rarity listing.
Utah			?	Known from three counties (D. Dunlop pers. comm. 2003).
Vermont	10		10	Green Mountain National Forest 2002.
Washington			?	"Sensitive."
Wyoming	2		2	Fertig 1999.

Razzhivin (1994) classified *C. scirpoidea* (specifically subspecies *scirpoidea* given the location of the study) as a subarctic mountain species that can also be found in alpine and subalpine areas south of the arctic. *Carex scirpoidea* subspecies *scirpoidea* occurs in certain areas that are not arctic or alpine including boreal areas (within areas of Alaska, Saskatchewan, Manitoba, Minnesota and Ontario), Canadian prairies, basins of Lake Superior and Lake Huron, and the Gulf of St. Lawrence (Given and Soper 1981). Given and Soper (1981) explain that all of these locations have an arctic-alpine element usually in habitats such as cliffs, lake shores, and river gorges that allow typically arctic or alpine flora to persist.

Subspecies *scirpoidea* is described as "common" in the Arctic Archipelago of Nunavut (Aiken *et al.* 1999, Appendix 1c) and "common in the mountains" (Hultén 1968, Appendix 1a) of Alaska. In British Columbia it is described as "frequent" in the North and Southeast (Douglas & Ceska 2001); and in Newfoundland it is "fairly common" (Damman 1964, p.21). In the contiguous United States, the subspecies is relatively rare. In nine of the fifteen states where it occurs south of the Canadian border, subspecies *scirpoidea* is tracked due to its rarity. Seven of these states have fewer than twenty occurrences of *C. scirpoidea* ssp. *scirpoidea* (Table 5).

National Forest Distribution

The Hiawatha National Forest in Michigan is the only National Forest in the United States with an occurrence of *Carex scirpoidea* ssp. *convoluta*. Subspecies *scirpoidea*, on the other hand, occurs in six regions of the U.S. Forest Service including: the Alaska (R10), the Eastern (R9), the Intermountain (R4), the Northern (R1), the Pacific Northwest (R6), and the Rocky Mountain (R2) Regions. In the Eastern Region, this subspecies occurs on the Green Mountain and White Mountain National Forests (USDA Forest Service 2000). Recently it has been found within five miles of the Superior National Forest (MNNHP 2003). It also occurs on the Mount Baker-Snoqualmie and the Okanogan National Forests of the Pacific Northwest Region (R6) (USDA Roadless Area Conservation 2001), the Shoshone National Forest in Wyoming (Rocky Mountain Region, 2) (Fertig 1999), and the Ashley and Dixie National Forests in Utah (Intermountain Region, R4) (Dunlop & Crow 1999). Given the broad distribution of subspecies *scirpoidea* and the size of National Forests in the western United States, many other National Forests probably have this subspecies.

RANGE WIDE STATUS

The Nature Conservancy's Ranking

Rangewide status can be assessed by a ranking system developed by The Nature Conservancy, NatureServe, and the Natural Heritage Network (NatureServe Explorer 2002). This ranking system uses information on species that are tracked by The Nature Conservancy and natural heritage programs throughout the world. The global ranking (G-rank) gives the status of a species throughout its range. Each country where the species occurs has a national ranking (N-rank) that indicates the species vulnerability within that country. If the species occurs within the boundaries of provinces, states, or other divisions within a country, the species is given a subnational ranking (S-rank) for that area (NatureServe Explorer 2002).

The number or letter following G, N, or S is the ranking of current vulnerability of the species within the given geographical boundary (NatureServe Explorer 2001). Numeral ratings range from 1 to 5. The more vulnerable a species is to extirpation within the given geographical boundary, the lower the numeral rating. If a letter or punctuation follows the G, N, or S, the current status has not been determined; the letter indicates what is known about the species (NatureServe Explorer 2002).

Carex scirpoidea has a global rank (G-rank) of "G5" indicating that the species is "secure" globally (28 Sept 2000; NatureServe Explorer 2002). The species is ranked as secure, "N5," in the United States (17 Dec 1994) and in Canada (24 Oct 2000).

Carex scirpoidea ssp. *scirpoidea*

Subspecies *scirpoidea* has a global rank of "T4T5" (28 Sept 2000) indicating that it is ranked within the range of "secure" and "apparently secure" throughout most of its range (NatureServe Explorer 2002). Subspecies *scirpoidea* is ranked as "N3N4" in the United States indicating that it is ranked ranging between "apparently secure" and "vulnerable." *Carex scirpoidea* ssp. *scirpoidea* is ranked as "critically imperiled" (S1) for the States of New Hampshire, Wyoming and New York, while it is ranked between "critically imperiled" and "imperiled" (S1S2) in North Dakota (NatureServe Explorer 2002). It is ranked as "imperiled" (S2) in five other states including: Colorado, Maine, Michigan, Vermont and Washington (Table 6, NatureServe Explorer 2002). It is unranked (S?) in the seven other states that it occurs (Alaska, Idaho, Minnesota, Montana, Nevada, Oregon, and Utah) (NatureServe Explorer 2002). Despite no current S-ranking, Minnesota tracks the subspecies and has included it in rare species lists (MNNHP 2003).

In Canada, the natural heritage status of *C. scirpoidea* ssp. *scirpoidea* is "unranked" (N?, NatureServe Explorer 2002). The natural heritage status of this subspecies is also "unranked" (S?) in six of thirteen provinces in which it occurs (Table 6, NatureServe Explorer 2002). Alberta, Manitoba, Ontario, and Saskatchewan have listed the species as "secure" (S5). British Columbia has ranked the subspecies as "apparently secure" (S4), while Newfoundland Island has ranked the subspecies as ranging between "vulnerable" and "secure" (S3S5) (NatureServe Explorer 2002). New Brunswick has ranked the species as having historical populations (SH, Table 6).

Carex scirpoidea ssp. *convoluta*

Carex scirpoidea ssp. *convoluta* is currently unranked (T?) throughout its range (NatureServe Explorer 2002). The national rankings for this subspecies in both the United States and Canada are also unranked (N?, 22 November 2000) (NatureServe Explorer 2002). Michigan is the only state in the United States that has occurrences of this subspecies. MNFI (2003) does not distinguish the subspecies of *C. scirpoidea*, therefore the ranking for the species, S2 or "imperiled," applies to both subspecies. In Canada, subspecies *convoluta* only occurs in the Province of Ontario, where it is listed as "S3?" or vulnerable (the question mark indicates uncertainty in the ranking) (Ontario Natural Heritage Information Centre 2003). This subspecies is tracked in Ontario, although subspecies *scirpoidea* is not tracked (Ontario Natural Heritage Information Centre 2003).

Ranking by States and the U.S. Forest Service

Ten of the fourteen states that have occurrences of *C. scirpoidea* subspecies *scirpoidea* include the species in lists of rare plants (Table 6). Two of these states (New York and North Dakota) list the subspecies as "endangered," and three states (Maine, Michigan, and New Hampshire) list the subspecies as "threatened" (Table 6). The five other states that track the species due to its rarity (Colorado, Minnesota, Vermont, Wyoming, and

Washington) either give a less significant rarity ranking such as "sensitive" or "special concern" or do not give it a special ranking (Table 6).

Table 6. Subnational rank (S-rank) of *C. scirpoidea* ssp. *scirpoidea* in U.S. states and Canadian provinces that it occurs as listed by NatureServe Explorer (2002) or the Natural Heritage Programs for the given states and provinces.[†] Key to S-rankings: S2 = imperiled, S4 = apparently secure, S5= secure, SH= historic, S?= unranked.

U. S. State	S-rank	State listing	Canadian Province	S-rank
Alaska	S?	None	Alberta[†]	S5
Colorado[†]	S2	Tracked	British Columbia[†]	S4
Idaho	S?	None	Labrador	S?
Maine[†]	S2	threatened	Manitoba[†]	S5
Michigan[†]	S2*	threatened	New Brunswick[†]	SH
Minnesota[†]	S?	Special concern	Newfoundland Island[†]	S3S5
Montana	S?	None	Northwest Territories	S?
Nevada	S?	None	Nova Scotia	S?
New Hampshire[†]	S1	threatened	Nunavut	S?
New York[†]	S1	endangered	Ontario[†]	S5*
North Dakota[†]	S1S2	endangered	Quebec	S?
Oregon	S?	None	Saskatchewan[†]	S5
Utah	S?	None	Yukon Territory	S?
Vermont[†]	S2	Tracked		
Washington	S2	sensitive		
Wyoming[†]	S1	None		

*Michigan and Ontario also have subspecies *convoluta*. See text for ranking of that subspecies.

[†]Natural heritage programs of these states and provinces were sources for the S-rank and/or state listing including: Colorado Natural Heritage Program 2002, Maine Department of Conservation 1999, MNFI 2003, MNNHP 2003, NHNHI 2003, New York Natural Heritage Program 2003, North Dakota Natural Heritage Inventory 2003, Vermont Nongame and Natural Heritage Program 2000, Wyoming (Fertig 1999), Alberta Natural Heritage Information Centre 2003, British Columbia Species Explorer 2002, Manitoba Conservation Data Centre 2001, Newfoundland Island and New Brunswick: Atlantic Canada Conservation Data Centre 2003, Ontario Natural Heritage Information Centre 2003.

Michigan is the only state with subspecies *convoluta*. The MNFI (2003), however, does not distinguish the two subspecies, therefore the "threatened" ranking of the species applies to both subspecies *convoluta* and *scirpoidea*.

Carex scirpoidea is listed as a Regional Forester Sensitive Species on the Green Mountain National Forest in Vermont and the Hiawatha National Forest in Michigan in the Eastern Region of the U.S. Forest Service (USDA Forest Service 2000). The subspecies on the Green Mountain National Forest is *scirpoidea*, while that of the Hiawatha National Forest is *convoluta*. Rationale for listing the species on these National Forests is based on the fact that only one or two known populations occur within the proclamation boundaries of each of these forests (Green Mountain National Forest 2000, Hiawatha National Forest 1999). The "risk evaluation" for this species from the Green

Mountain National Forest indicates, in addition, that the habitat is rare on the forest and may be vulnerable to disturbances by rock climbers (Green Mountain National Forest 2000). The White Mountain National Forest in New Hampshire is the only other National Forest in the Eastern Region with known occurrences of the species. This forest does not list the species as a Regional Forester Sensitive Species by the rationale that the species is "uncommon on [the National Forest] but not threatened; stable" (White Mountain National Forest 1999).

POPULATION BIOLOGY AND VIABILITY

One would expect that the population biology and viability of *C. scirpoidea* ssp. *scirpoidea* and *convoluta* would be affected by similar factors given their similar habitats and ecology. These subspecies establish in habitats that many plants may find too stressful and possibly competition is less, such as habitats with high pH, high salt content, calcareous soil, deep snow levels, thin soils and/or cool arctic or alpine conditions (see "Ecology" section).

In areas that *C. scirpoidea* is not rare, the species is often a dominant component of its plant community (see "Ecology" section, Ratcliffe & Turkington 1987, Razzhivin 1994, Ouellet *et al.* 1994). Even in areas that the species is rare, populations tend to relatively large and the species may be locally abundant. For example, more than half of the populations in Michigan, New York, and extant populations in New Hampshire are described by surveyors as being large, locally common, or have hundreds or thousands of plants over a large area (Appendix 2). Apparently, *C. scirpoidea* ssp. *scirpoidea* tends to establish and maintain rather large populations even at the edge of its range. Large populations tend to have more genetic variation and are less prone to negative effects of inbreeding (Primack 1993). This may increase the viability of the species at the edge of its range.

In assessing the size of populations, however, one must be aware of the clonal growth habit of *C. scirpoidea*. The presence of many culms does not necessarily indicate the presence of many genets. Genets may be long-lived and a single old clone may have hundreds of culms (Steinger *et al*. 1996). Given that *C. scirpoidea* ssp. *scirpoidea* and *convoluta* have short stolons, discreet tufts of culms might relate to individual genets. The sex and structure of culms throughout a population may suggest if the population contains many genets or if it consists of a few large genets with many culms. For example, a population consisting of pistillate and staminate culms scattered in discreet clumps over a large area would probably contain many genets. A population with a few large unisexual patches would suggest that the population may actually contain only a few genets.

Most *Carex* species are self-compatible (Catling *et al*. 1990). In contrast, *C. scirpoidea* rarely has both pistillate and staminate flowers on the same plants (plants are usually dioecious), thus plants have less capacity to self-fertilize (Dunlop 1990, cited in Yarbrough 2000). One would expect, therefore, that sexual reproduction tends to be primarily from cross-fertilizations (outcrossing). Outcrossing species have theoretical advantages as well as disadvantages in establishing and maintaining populations

compared to species that tend to self-fertilize. Self-fertilizing species could theoretically establish a population from a single founder individual (Briggs & Walters 1997). If isolated from other populations, however, the new population would be limited to inbreeding. Consequences of inbreeding could decrease fecundity and survival of offspring, and subsequently could threaten the persistence of the isolated population (Briggs & Walters 1997). Dioecious species cannot self-fertilize or cross-fertilize plants of the same sex, and therefore have a limited number of potential mates within a population. Dioecious species may also be more restricted in early stages of establishing an isolated population as such species could not breed until two plants establish independently or a pistillate founder plant is pollinated from an outside source (Briggs & Walters 1997). Dioecious species in a small and isolated population, however, may be more likely to reproduce viable offspring due to the lower frequency of inbreeding in the population compared to selfing species (Briggs & Walters 1997).

With more genetic variation a species may be able to adapt to environmental changes and be less vulnerable to diseases (Primack 1993). A few characteristics of *C. scirpoidea* ssp. *scirpoidea* are associated with species that have relatively high genetic variation including outcrossing, wind-pollination, and wide geographical range (Hamrick & Godt 1990). *Carex* species with long-rhizomes, on the other hand, tend to have greater genetic variability than species that have cespitose growth (such as *C. scirpoidea* ssp. *scirpoidea*) (Jonsson 1998, cited in Stenström *et al.* 2001). Yarbrough (2000) determined that genetic variability of *C. scirpoidea* ssp. *scirpoidea* in Colorado was in general greater than other cespitose *Carex* species, but not as high as *Carex* species with long rhizomes. Genetic variation, however, often varies across a species range depending on many characteristics such as gene flow among populations, glaciation history, and microsite adaptations (Futuyma 1986, Stenström *et al*. 2001). One might expect that the genetic variation of *C. scirpoidea* ssp. *scirpoidea* may be greater in areas that it is relatively common compared to the relatively isolated populations Yarbrough studied in Colorado.

Carex scirpoidea ssp. *convoluta* may more likely have low genetic variation compared to subspecies *scirpoidea* due to its rather restricted distribution. Given that the two subspecies can interbreed (Dunlop 1990, cited in Dunlop 1997), gene flow could potentially occur between these subspecies and maintain genetic variation to some degree in subspecies *convoluta*. Debra Dunlop (pers. comm. 2003) contends that given the current distribution and geographic barriers, such gene flow probably does not occur.

POTENTIAL THREATS

Carex scirpoidea ssp. *scirpoidea* is relatively rare in the eastern United States. In part, its rarity in this region may be due to it being at the edge of its historic range where its habitat is naturally uncommon. This subspecies, however, has a wide distribution, is common in many areas of its primarily mid- to sub-arctic range, and is globally ranked as ranging between "secure" and "apparently secure" (NatureServe Explorer 2002). Even within the borders of Ontario and Manitoba, two Canadian provinces neighboring the eastern United States from Minnesota to New York, this subspecies is ranked as "secure." Given its wide range and natural heritage rankings, threats to subspecies *scirpoidea* may

not be as significant to the long-term persistence of the species as such threats might be to the more restricted subspecies *convoluta*.

Present or Threatened Risks to Habitat

a. Alvar habitat

Carex scirpoidea (primarily ssp. *convoluta*) occurs in the Michigan community-type known as "limestone pavement lakeshore" or "alvar." This community is ranked "S2" or "imperiled" within the Michigan (Comer *et al*. 1997). Threats to this habitat include trampling, introduction of invasive and non-native plants, off-road vehicle use, and water pollution (Comer *et al*. 1997). In addition, given that many occurrences are along lakeshore, shoreline development may be a threat (Hiawatha National Forest 1999).

"Creeping juniper-shrubby cinquefoil alvar pavement" and "little bluestem alvar grassland" are the names of two ecological communities described by NatureServe Explorer (2002) that occur in Michigan and Ontario. These ecological communities may correspond to the "limestone pavement lakeshore" community in Michigan as described by Comer *et al.* (1997) of MNFI. The creeping juniper-shrubby cinquefoil alvar pavement and little bluestem alvar grassland communities include *C. scirpoidea* (most likely subspecies *convoluta*) as one of the associated species (see "Habitat" section). Both of these ecological communities are ranked "G2" or "globally imperiled" (NatureServe Explorer 2002). These habitats are noted to be threatened in Ontario by possible quarry development, residential development, cattle grazing, and the use of large machinery in collecting rocks for landscaping (NatureServe Explorer 2002).

b. Northern fen habitat

Three populations of subspecies *convoluta*, including the population that occurs on the Hiawatha National Forest, occur in or near northern fens (at least in part). Fen flora may be affected by hydrologic disturbances, off-terrain vehicles, and trampling by hikers (MNFI 2003). One of these populations is threatened by vehicle pollution and other disruptive effects of occurring along a road. The population on the Hiawatha National Forest may be less affected by disturbances as it occurs within a "wilderness research natural area." Given that *C. scirpoidea* tends to occur in the open and *Thuja occidentalis* (white cedar) occurs in the vicinity of the population on the Hiawatha National Forest, tree encroachment could potentially threaten this population.

c. Prairie habitat

Minnesota has 46 occurrences of *C. scirpoidea* ssp. *scirpoidea* that are primarily in prairie habitats (MNNHP 2003). Prairies have been severely affected by agriculture and only a small portion (less than one percent) of the original habitat is still intact (Minnesota Department of Natural Resources 2003). More than half of the occurrences in Minnesota are not on public land and a few were noted by surveyors as being on land that is mowed for hay or has been plowed (MNNHP 2003, Appendix 2). Occurrences in Minnesota that are not on public land or in nature preserves may be imminently threatened by agriculture, gravel excavation, and exotic species (Smith 1988).

d. High-altitude cliff habitat

In New Hampshire five of eleven occurrences are historical as they have not been relocated for over fifty years, suggesting that the number of occurrences may have decreased in the last century (NHNHI 2003, Appendix 2). Three of the six extant occurrences are located on calcareous or circumneutral cliffs (NHNHI 2003). Both habitats are described as "rare" in New Hampshire (Sperduto & Crowley 2001). On the Green Mountain National Forest in Vermont, habitats in high elevation cliffs and rock outcrops are rare, thus limiting species of such habitats to small scattered patches (Green Mountain National Forest 2003).

Current or future threats listed by the White Mountain and Green Mountain National Forests include hiking, rock climbing, and invasive exotic species (Green Mountain National Forest 2003). The location of *C. scirpoidea* habitat in high elevations and rugged terrain of New England and New York may make development and construction less significant threats. Fire suppression may also threaten species of this habitat by allowing organic matter to accumulate in the soil which may subsequently allow competitive species to establish (Green Mountain National Forest 2003). On the other hand, no research has studied if fire has a positive effect on the persistence of *C. scirpoidea* ssp. *scirpoidea* populations.

Climate change

Climate change may be a significant threat to habitat of *C. scirpoidea* ssp. *scirpoidea* and ssp. *convoluta* in the contiguous United States. Scientists throughout the world have predicted that a worldwide warming trend (Global Warming) is beginning to occur and will continue to increase during the coming century (Primack 1993, Levitus *et al.* 2001). Global Warming is an expected effect of the increase in carbon dioxide and other "greenhouse gases" in the atmosphere from human activities (Primack 1993, Levitus *et al.* 2001). Given that *C. scirpoidea* ssp. *scirpoidea* is most common and widespread in the mid- to sub-arctic (Given & Soper 1981), populations at the southern margin of the species' range in Canada and the United States may be negatively affected by an increase in annual temperatures.

Disease or Predation

As noted in the "Ecology" section, *C. scirpoidea* may be grazed by ungulates and birds. In the eastern United States, grazing is probably most likely in populations occurring in open and flat habitats such as fens and prairies in Michigan and Minnesota. When grazing is simulated, *C. scirpoidea* responds with compensatory growth (Ouellet *et al.* 1994). At least when animals are not overpopulated, such results suggest that the negative effect on *C. scirpoidea* from grazing may not be noticeable. Grazing animals may also affect plant populations negatively by trampling and waste excretion.

Other Natural or Human Factors

Although many populations of *C. scirpoidea* in eastern North America are large, the single known population that occurs on the Hiawatha National Forest is small, having only twenty culms in two clumps when it was last observed in 1987 (MNFI Database 2003). The small size of the population may be the greatest threat to this occurrence.

Such a small population could be destroyed by a random natural disturbance. In addition, such a small population may be negatively affected by inbreeding depression.

SUMMARY OF LAND OWNERSHIP & EXISTING HABITAT PROTECTION

Natural heritage programs from three eastern states (Michigan, Minnesota, and New Hampshire) contributed information regarding land ownership of *C. scirpoidea* occurrences (Table 4). Less than half of populations in Michigan (35%) and Minnesota (40%) occur on public land or non-governmental nature preserves. New Hampshire has the highest percent of populations that are on public land or nature preserves (82%), however, more than half of these relatively protected populations are historical as they have not been re-located for at least 50 years. Habitat in New Hampshire is at high elevations that may be somewhat innately protected from severe human disturbances such as construction.

In Michigan and Ontario, *C. scirpoidea* (ssp. *convoluta*) is listed as an associated species of two ecological communities (creeping juniper-shrubby cinquefoil alvar pavement and little bluestem alvar grassland) that are ranked as globally imperiled (G2) (NatureServe Explorer 2002, see "Habitat" section). Both Michigan and Ontario rank this habitat as S2 or "imperiled." Michigan has proposed to designate a portion of alvar habitat into a "natural area" due to the uniqueness and rarity of the habitat. Natural areas in Michigan are created to protect and monitor natural ecosystems of the State. This natural area contains ten rare plants as ranked by Michigan in addition to a mix of arctic and prairie species (Michigan Department of Natural Resources 2003). In the same vicinity, The Nature Conservancy (TNC) has created a nature preserve to protect additional alvar habitat (TNC Michigan Chapter 2003). The population of subspecies *convoluta* on the Hiawatha National Forest is in a "wilderness area" which protects this population from logging, off-road vehicles, and other potentially disruptive activities.

Table 4. Number of element occurrences of *C. scirpoidea* that are located on land owned by the federal, state, county, or nongovernmental organizations in Michigan, Minnesota, and New Hampshire. "H" indicates the portion of populations that have not been re-located for at least 50 years.

	States		
Ownership	Minnesota	Michigan	New Hampshire
Federal	0	2	6 (4H)
State	12	3	3 (1H)
County	1	0	0
Non-governmental Nature Preserve	6	2	0
Unknown	10	13	1
Private	17	0	1
Total	46	20	11 (5H)
Percent on public land or in nature preserves	40%	35%	82%

Carex scirpoidea ssp. *scirpoidea* occurrences in Minnesota that are on land with private or unknown ownership (59%) may be quite vulnerable to extirpation given that the land is relatively flat and could be used for farmland or development. The one disjunct population near the Superior National Forest is on county-owned land. Given the cliff habitat of the population, it may be protected from many human disturbances. Many occurrences in Minnesota (22%) are managed by the Department of Natural Resources as "wildlife management areas" (MNNHP 2003). Such land is managed mainly for wildlife, with less emphasis on protecting rare plants. Occurrences with optimal habitat protection in Minnesota (17%) are within land designated by the Department of Natural Resources as Scientific and Natural Areas (SNAs) and/or are in preserves owned by The Nature Conservancy (MNNHP 2003). Land that is designated as SNAs has a specific exemplary natural habitat, and management of SNAs is directed towards maintaining natural habitat and rare species (Minnesota Department of Natural Resources 2003). The Nature Conservancy has a history of acquiring land, at least in part, to protect and restore native habitat.

SUMMARY OF EXISTING MANAGEMENT ACTIVITIES

In Minnesota, *C. scirpoidea* occurs in SNAs and preserves owned by The Nature Conservancy that are managed to promote native prairie. Management techniques include prescribed burns, species inventories, and controlling exotic species by hand-removal, mowing and localized pesticide spraying (TNC Minnesota Chapter 2003). Such techniques may improve the habitat for native species such as *C. scirpoidea* ssp. *scirpoidea*.

The *C. scirpoidea* ssp. *convoluta* population on the Hiawatha National Forest occurs in a "research natural area" within a wilderness area that has not been actively managed. Management instead takes the form of regulating human impacts to the area by prohibiting off-road vehicles, tree harvests, and regulating other human impacts. The other population that occurs within the proclamation boundary of the National Forest is on private land along a highway. Due to the presence of a federally endangered species in the same area, the county has erected a sign along the road to caution maintenance crews. Other management plans to improve the habitat are being considered (Penskar & Higman 2002).

Management of cliff habitat on the Green Mountain National Forest in Vermont primarily occurs by limiting use of sensitive areas by rock climbers (Green Mountain National Forest 2003). The Green Mountain National Forest (2003) may also start prescribed burning to maintain open habitat for cliff dwelling species. Debra Dunlop (pers. comm. 2003) suggests that research of the effects of fire on the species should be carried out prior to implementing prescribed burning.

PAST AND CURRENT CONSERVATION ACTIVITIES

The Nature Conservancy may have effectively conserved populations of *C. scirpoidea* by acquiring land where populations occur in Minnesota and Michigan. Such acquisitions were not made to protect this species in particular, but the habitat in which it occurs. Given that land with similar ecological communities in Minnesota has been used for

agriculture and gravel pits in the past, these populations could have been destroyed, if the land had not been bought (Smith 1988). The Nature Conservancy bought a large tract of land adjacent to known locations of *C. scirpoidea* in 2000 and is in the process of restoring prairie habitat to more than 17,000 acres of this land (TNC Minnesota Chapter 2003). As the natural habitat is restored, populations may be discovered or old seed banks of *C. scirpoidea* could be uncovered and new populations could have an opportunity to establish. Populations that occur in SNAs in Minnesota, "natural areas" in Michigan, and lands owned by The Nature Conservancy in both states may benefit from the management techniques in these areas that promote native vegetation of the natural habitat.

RESEARCH AND MONITORING

Existing Surveys, Monitoring, and Research

During management projects on the Hiawatha and Green Mountain National Forests, *C. scirpoidea* is included in the list of Regional Forester Sensitive Species that botanists search for. Given that surveys are usually related to tree harvesting, such surveys may not often include the unforested and rugged terrain in which this species tends to occur. The Minnesota DNR and Minnesota branch of The Nature Conservancy may survey or monitor populations in SNAs and nature preserves incidentally during species inventories.

A number of plant community studies that are described in the "Ecology" section document the presence, ecology, and habitat of *C. scirpoidea* ssp. *scirpoidea* (Kershaw & Kershaw 1986, Ratcliffe & Turkington 1987, Ouellet *et al.* 1994, Razzhivin 1994, Cooper 1996). These studies were not initiated to examine the biology of *C. scirpoidea* in particular, but instead they were undertaken to examine certain aspects of the community in which it occurs, such as the snow bed community in far northeastern Asia, the extreme rich fen of Colorado, and the dry alpine community in British Columbia. In the future, *C. scirpoidea* will most likely occasionally be included in plant community studies, especially in areas that it is a dominant species. Yarbrough (2000) studied the effect of dioecy on genetic structure of *C. scirpoidea* populations in Colorado (see "Population Biology and Viability" section). Dioecy is a relatively unique and biologically important characteristic of *C. scirpoidea* that could inspire future research of this species.

Survey Protocol

1. Survey known populations. Known populations of *C. scirpoidea* that occur on National Forests of the eastern United States should be re-visited, especially if they have not been surveyed in the last ten years, to determine the viability of populations. Surveyors should note the size and structure of populations, their habitat, and associated species. In small populations, they should count the number of pistillate and staminate culms as the effective population size is dependent on numbers of each sex. In addition, the numbers of clumps of culms and their organization should be described to give an idea of the numbers of genets within the population. In larger populations, surveyors should estimate population size, the area it is scattered, and note the approximate ratio of

pistillate to staminate culms. An effort should be made to search the area surrounding the population to determine the entire size of the population.

In particular, the occurrence on the Hiawatha National Forest should be re-surveyed given the small size of the population when it was last described in 1987 (twenty culms in two clumps). Even though the occurrence on the Green Mountain National Forest was visited within ten years (last visited in 1994), this occurrence should be surveyed since the population and habitat were not described. Although the species is not listed as Regional Forester Sensitive Species on the White Mountain National Forest, four of the six populations known on the forest have not been documented for over 60 years. An effort to re-locate these populations might be worthwhile as the decision that this species is not at risk is based on the assumption that all six populations persist. These occurrences may persist and have just been overlooked given their high altitude and the inconspicuous nature of *Carex* species.

2. Identify and search potential habitat for *Carex scirpoidea*. Unknown populations should be located with surveys carried out in likely habitat of the Hiawatha, Superior and Green Mountain National Forests. *Carex scirpoidea* occurs on slightly different habitat in or near each of these National Forests. On the Superior and the Hiawatha National Forests, cliffs and ridges along Lake Superior, Lake Huron, Lake Michigan and rivers may be the focus of surveys, in addition to fen habitat near these Great Lakes. On the Green Mountain National Forest, mid to high altitude calcareous and circumneutral cliffs and other alpine areas should be targeted. Habitat and associated species might be similar to that described for New Hampshire populations (Appendix 2) and New York populations (Appendix 2).

Since *C. scirpoidea* is inconspicuous and difficult to identify, populations may be easily overlooked if the species is not targeted specifically. To increase the likelihood of locating populations, botany surveyors should be aware of the distinguishing characteristics of *C. scirpoidea* when entering potential habitat. Given that this species often occurs in rare habitats, a search for this species might be coordinated with surveys of the habitat. Such a project might reveal populations of other rare species.

Research Priorities

1. Population ecology. Population dynamics and species associations could be studied in the field by monitoring multiple populations over many years. Entire populations could be described, if they are small. For large populations, data could be gathered along multiple transects that pass through populations. Every 10 meters (or whatever distance is appropriate) surveyors could record the species present and their cover within small plots (such as one meter diameter). By gathering data annually, one could determine how population sizes and structure changes over time. Such a study would also indicate associated species. Data on characteristics of the soil (type, moisture, texture, and pH), percent cover of bare ground, slope, and aspect might indicate the microsite conditions that *C. scirpoidea* tends to occur in.

2. Determine competitive abilities. One might expect that *C. scirpoidea* may be limited to relatively stressful habitats due to poor competitive abilities. Such a tendency has been documented in other arctic and alpine species (Given & Soper 1981, Razzhivin 1994). The competitive abilities of *C. scirpoidea* could be studied by habitat manipulation. Data on survivorship, growth rates, and establishment rates could be gathered from a set of plots where certain dominant species were clipped or removed compared to control plots in which no manipulation was done.

Other information regarding competition could be gathered by growing or transplanting *C. scirpoidea* into an experimental field that does not have stressful conditions. The species could be grown in the field in non-competitive conditions, as well as with an assortment of competitive species to determine if competition is the main force that excludes the species from such a habitat. Competition could also be studied in a greenhouse by growing replicates of seeds alone as well as with an assortment of competitive species. Before growing plants from seed, one would treat seeds by cold stratification as described by Schütz and Rave (1999). One could vary the soil conditions to determine if *C. scirpoidea* is more competitive in soils that are more stressful to other species such as soils with high salt content, high pH, or fluctuating moisture levels.

3. Determine effects of fire. Prescribed burning has been suggested as a possible manner to manage for native vegetation such as *C. scirpoidea* in Minnesota (TNC Minnesota Chapter 2003) and Vermont (Green Mountain National Forest, 2003). Prairies in Minnesota and cliffs in Vermont are believed to have had occasional fire prior to European settlements. Fire suppression during the last century may have allowed exotic and woody species to out-compete native herbaceous species. Native herbaceous plants in such areas are assumed to be adapted to fires and are believed to be able to re-establish after fire better than exotic species and many woody species. No research has, however, has been carried out on the effects that fire has on *C. scirpoidea* populations. A study of the ability of *C. scirpoidea* to maintain populations after fire would be important before implementing fire as a management technique. Preliminary data could be gathered in areas that the species is relatively common such as Montana or in Minnesota where prescribed burns are often used in native prairie management. Plots could be created in areas that are planned to be burned and in control plots that would not be burned. Vegetation cover and species would be recorded before the prescribed burn and for a number of years following the prescribed burn. If *C. scirpoidea* responds well to fire in Minnesota, similar preliminary trials could be done in Vermont before using fire as an accepted management technique.

4. Establishment in oil spills. Due to its higher percent cover on oil spills compared to areas without oil spills, Kershaw and Kershaw (1986) suggest that *C. scirpoidea* could be considered to be used in an oil-reclamation program to assist in re-vegetating areas after oil spills. Although Kershaw and Kershaw's study was carried out in the Northwest Territories of Canada, the species may be able to tolerate soil contaminated by oil in it any part of its range. In fact, if the species is limited to some degree by competition, its ability to tolerate oil contaminated soil may allow it to grow in areas that it would not otherwise occur due to competition. One might, therefore, study the ability of *C.*

scirpoidea to establish and mature in the soil of an experimental oil spill. Such a study might be included in the greenhouse study of the competitive abilities of *C. scirpoidea*. Replicates of *C. scirpoidea* seeds along with a few control species could be grown in soil with various oil spill conditions.

5. Genetic structure of populations. The study of genetic structure of *C. scirpoidea* ssp. *scirpoidea* (Yarbrough 2000) indicates that genetic variation of this species in Colorado is greater than that of other cespitose *Carex* species, while less than rhizomatous *Carex* species. On the other hand, populations of *C. scirpoidea* in Colorado had less genetic diversity than the average genetic diversity of dioecious and monoecious flowering plants (Yarbrough 2000). A study with a similar basis of determining the genetic structure of the species, but in a wider geographic range, might indicate if the genetic variation is greater in areas that the species is more common. In addition, a second genetic study could analyze the genetic structure of populations of *C. scirpoidea* ssp. *convoluta*. A systematics study could indicate the degree that subspecies *convoluta* is genetically distinct from subspecies *scirpoidea*. Such a study might also suggest the level of genetic isolation that separates these two subspecies.

REFERENCES

Aiken, S.G., Boles, R.L., and Dallwitz, M.J. (1999). Cyperaceae of the Canadian Arctic Archipelago: Descriptions, Illustrations, Identification, and Information Retrieval. Version: 6th November 2000. http://http://www.mun.ca/biology/delta/arcticf/.

Alberta Natural Heritage Information Centre (2002) List of all Vascular Plant Elements; Parks and Protected Areas Division, Alberta Community Development; Edmonton, Alberta; Available at: (http://www.cd.gov.ab.ca/preserving/parks/anhic/flashindex.asp); Accessed 8 May 2003.

Alexeev, Yurii Evgeneevich. (1988). Ontogenesis in *Carex* species. *Aquat. Bot.*, **30**; pp. 39-48.

Atlantic Canada Conservation Data Centre (2003) Provincial Lists and Ranks; Atlantic Canada Conservation Data Centre; Mount Allison University; Sackville New Bruswick, Canada (Available: accdc.com); Accessed: (6 March 2003)

Ball, Peter W. and Reznicek, A.A.. (2002). *Carex* Linnaeus; In: Flora of North America, Vol. 23; Oxford University Press; New York, N.Y.; pp. 254-273.

Bernard, John M. (1990). Life history and vegetative reproduction in *Carex*. *Can. J. Bot.*, **68**; pp. 1441-1448.

Barbour, Michael G.; Burk, Jack H.; Pitts, Wanna D. (1987) Herbivory. In: Terrestrial Plant Ecology. 2nd ed. The Benjamin/Cummings Publishing Company, Inc.; Menlo Park, California; pp. 147-152.

Briggs, D; and Walters, S.M. (1997). Chapter 7 Breeding systems. In: Plant variation and evolution. 3rd Ed. Cambridge University Press; Cambridge, U.K.; pp. 124-166.

British Columbia Species Explorer (updated, December 2002) B.C. Conservation Data Centre, Ministry of Sustainable Resource and Biodiversity Branch, Ministry of Water, Land and Air Protection; Victoria, BC. Available: (http://srmwww.gov.bc.ca/atrisk/index.html); Accessed (6 March 2003).

Bry, Ed, ed. (1986). The rare ones. North Dakota Outdoors 49(2):2-33. Jamestown, ND: Northern Prairie Wildlife Research Center Home Page. http://www.npwrc.usgs.gov/resource/othrdata/rareone/rareone.htm (Version 16JUL97).

Catling, P.M.; Reznicek, A.A.; and Crins, W.J. (1990). Introduction "Symposium on Systematics and Ecology of the Genus *Carex* (Cyperaceae)." *Can. J. Bot*:, **68**; pp. 1405-1408.

Colorado Natural Heritage Program [website]. (2002) Statewide species and natural community tracking list; Colorado State University; Fort Collins, Colorado**;** Available at: (http://www.cnhp.colostate.edu/list.html) Accessed: 5 March 2003

Comer, P.J.; Cuthrell, D.L.; Albert, D.A.; and Penskar, M.R. (1997). Natural community abstract for limestone/dolostone pavement lakeshore. Michigan Natural Features Inventory; Lansing, Michigan; 3 pp.

Cooper, David J. (1996). Water and soil chemistry, floristics, and phytosociology of the extreme rich High Creek fen, in South Park, Colorado, USA; *Can. J. Bot.* **74**; pp. 1801-1811.

Cooper, S. V.; Jean, C.; and Heidel, B. L. (1999). Plant associations and related botanical inventory of the Beaverhead Mountains Section, Montana. Unpublished report to the Bureau of Land Management. Montana Natural Heritage Program, Helena. 235 pp.

Cronquist, Arthur; Holmgren, Arthur H.; Holmgren, Noel H.; Reveal, James L.; and Holmgren, Patricia K. (1998) Intermountain Flora; Vascular Plants of the Intermountain West, U.S.A. Vol. six. The New York Botanical Garden; New York, New York; 566 pp.

Damman, A.W.H. (1964) Key to the *Carex* species of Newfoundland by vegetative characteristics. Ministery of Forestry; Ottawa, Ontario.

Del Moral, R.; Clampitt, C.A..; and Wood, D.M. (1985). Does interference cause niche differentiation? Evidence from subalpine plant communities. *Am. J. Bot.*; **72**; pp. 1891-1901. (Cited in Ratcliffe & Turkington 1987.)

Douglas, G.W.; and Ceska, A. (2001) *Carex* In: Illustrated Flora of British Columbia Vol. 6. George W. Douglas, Del Meidinger, and Jim Pojar (eds). British Columbia Ministry of Environment, Lands and Parks and British Columbia Ministry of Forests; British Columbia, Canada; p..

Dunlop, D.A. (1990). The biosystematics of *Carex* section *Scirpinae* (Cyperaceae). PhD. Dissertation. University of New Hampshire, Durham. (Cited in Dunlop 1997 and Yarbrough 2000.)

Dunlop, Debra A. (1997). Taxonomic changes in *Carex* (Section *Scirpinae*, Cyperaceae); *Novon*; **7;** pp. 355-356.

Dunlop, Debra A. (2002). *Carex* Linnaeus sect. *Scirpinae*; In: Flora of North America; Oxford University Press; New York, N.Y.; pp. 549-553.

Dunlop, Debra and Crow, Garrett E. (1999). The taxonomy of *Carex* section *Scirpinae* (Cyperaceae); *Rhodora*, **101**: 906; pp. 163-199.

Eriksson, Ove (1989). Seedling dynamics and life histories in clonal plants. *Oikos*, **55**; pp. 231-238.

Fertig, Walter. (1999) State species abstract on *Carex scirpoidea* var. *scirpiformis*, Canadian single-spike sedge; Wyoming Natural Diversity Database; Laramie, Wyoming; Available at: http://uwadmnweb.uwyo.edu/WYNDD/; Accessed: April 30, 2003.

Futuyma, Douglas J. (1986) Chapter five: Population structure and genetic drift. In: Evolutionary Biology. Sinauer Associates, Inc.; Sunderland, Massachusetts; pp. 120-148.

Given, David R. and Soper, James H. (1981) The arctic-alpine element of the vascular flora at Lake Superior. National Museum of Natural Sciences; Publications in Botany, No. 10; 70 pp.

Gleason, Henry A. and Cronquist, Arthur. (1991). Manual of Vascular Plants of Northeastern United States and Adjacent Canada (2nd Ed). The New York Botanical Garden; Bronx, New York; pp. 693-719.

Green Mountain National Forest [website]. (2003). Biological evaluation of the Green Mountain National Forest Land and resource management plan for conservation and management of Regional Forester Sensitive Species. Prepared by Clayton Grove & Diane Harlow Burbank; Listed under "Threatened and Endangered Plants;" Green Mountain National Forest, U.S.D.A. Forest Service; Vermont; 54 pp. (Available at: http://www.fs.fed.us/r9/gmfl/; Accessed 12 Dec 2003).

Green Mountain National Forest. (2000). Risk evaluation for *Carex scirpoidea*. Prepared by Diane Harlow Burbank; USDA Forest Service, Eastern Region; Milwaukee, Wisconsin.

Green Mountain National Forest (2002). Species Data Collection Form for *Carex scirpoidea*. Prepared by Peter Steckler and Melanie Schori; USDA Forest Service; Vermont; 15 pp.

Hamrick, J.L.; and Godt, M.J.W. (1990). Allozyme diversity in plant species. In: Plant Population Genetics, Breeding, and Genetic Resources. (eds. Brown, A.H.D; Clegg, M.T.; Kahler, A.L.; and Weir, B.S.);Sinauer Associates Inc., Sunderland; pp. 42-63

Heide, O.M. (1997). Environmental control of flowering in some northern *Carex* species. *Ann. Bot*., **79**; pp. 319-327.

Hendry, G.A.F., Thompson, K., and Band, S.R. (1995). Seed survival and persistence on a calcareous land surface after a 32-year burial. *J. Veg. Sci.*, **6**; pp. 153-156.

Hermann, F.J. (1970). Manual of the *Carices* of the Rocky Mountains and Colorado Basin. Agriculture Handbook 374: 1-397. USDA Forest Service, Washington D.C. (Cited in Fertig 1999.)

Hiawatha National Forest. (1999). Risk evaluation for *Carex scirpoidea*. Prepared by Janet Schultz; USDA Forest Service, Eastern Region; Milwaukee, Wisconsin.

Hitchcock, C. Leo; Cronquist, Arthur; Ownbey, Marion; and Thompson, J.W. (1977). Vascular Plants of the Pacific Northwest Part 1. University of Washington Press; Seattle, Washington; 914 pp.

Hultén, Eric. (1968) Flora of Alaska and Neighboring Territories. Stanford University Press; Stanford California; 1008 pp.

Jonsson, B.O. (1998). Genetic variation, clonal diversity and breeding system in sedges (*Carex*). PhD. Thesis, Lund University Sweden. (Cited in Stenström *et al*. 2001.)

Kershaw, G. Peter; and Kershaw, Linda J. (1986). Ecological characteristics of 35-year-old crude-oil spills in tundra plant communities of the Mackenzie Mountains, N.W. T; *Can. J. Bot.*; **64**; pp. 2935-2947.

Kotanen, P.M. and Jefferies, R.L. (1989) Responses of arctic sedges to release from grazing: leaf demography of *Carex* X *flavicans*. *Can. J. Bot.*, **67**; pp. 1408-1413.

Levin, Donald A. and Kerster, Harold W. (1974). Gene Flow in Seed Plants. In: Evolutionary Biology (Vol. 7). Dobzhansky, Hecht, Steve (Eds). Plenum Press; New York, New York. pp. 139-219.

Levitus, Sydney; Antonov, John I.; Wang, Julian; Delworth, Thomas L.; Dixon, Keith W.; Broccoli, Anthony J. (2001) Anthropogenic warming of the Earth's climate system; *Science*, **292**; pp. 267-270.

Luna V., S.; Figueroa M., J.; Baltazar M., B.; Gomez L., R.; Townsend, R.; and Schoper, J.B. (2001) Maize pollen longevity and distance isolation requirements for effective pollen control. *Crop Science*; **41**; pp. 1551-1557.

Magee, Dennis W. and Ahles, Harry E. (1999). Flora of the Northeast. University of Massachusetts Press. Amherst, MA; pp. 256-261.

Maine Department of Conservation. (1999). Rare plant fact sheet on "*Carex scirpoidea* Michx, bulrush sedge"; Downloaded from Bureau of Geology and Natural Areas website; Augusta, Maine; Available at: http://www.state.me.us/doc/nrimc/mnap/home.htm; Accessed: 5 March 2003.

Manitoba Conservation Data Centre (2001) Species information search; Winnipeg, Manitoba; Available: http://web2.gov.mb.ca/conservation/cdc/index.php; Accessed: 6 March 2003.

McGraw, J.B., Vavrek, M.C., and Bennington, C.C. (1991). Ecological genetic variation in seed banks I. Establishment of a time transect. *J. Ecol.*, **79**; pp. 617-625.

Michigan Department of Natural Resources (2003) Natural Areas; State of Michigan Website; Lansing, Michigan [Available: http://www.michigan.gov/dnr], [Accessed April30 2003].

Michigan Natural Features Inventory (MNFI) Database (2003).University of Michigan Extension and Endangered Species Program. Lansing, Michigan.

Michigan Natural Features Inventory (MNFI). (2003). Rare plant reference guide for *Carex scirpoidea* Michaux, bulrush sedge." Lansing, Michigan. Available at: (http://web4.msue.msu.edu/mnfi/data/specialplants.cfm); Accessed 8 May 2003.

Miller, R. Michael; Smith, Christopher I.; Jastrow, Julie D.; and Bever, James D. (1999). Mycorrhizal status of the genus *Carex* (Cyperaceae). *Am. J. Bot.*, **86**(4); pp. 547-553.

Minnesota Natural Heritage and Nongame Research Program (MNNHP) (2003). Element occurrence records for *Carex scirpoidea* from the Minnesota Natural Heritage Database; Minnesota Department of Natural Resources; St. Paul, Minnesota.

Minnesota Department of Natural Resources (2003) Minnesota Scientific and Natural Areas Program; St. Paul, Minnesota; Available at: (http://www.dnr.state.mn.us/ecological_services/sna/index.html).

NatureServe Explorer: An online encyclopedia of life [web application]. (2002). Version 1.6; Arlington, Virginia, USA: NatureServe; Available: (http://www.natureserve.org/explorer); Accessed: (April 10, 2003).

New Hampshire Natural Heritage Inventory (NHNHI). (2003). Plant records for *Carex scirpoidea*; State of New Hampshire, Division of Forests and Lands; Concord, New Hampshire.

New York Natural Heritage Program. (2003). Information on *Carex scirpoidea* from New York Natural Heritage's BCD database; New York Natural Heritage Program; New York State Department of Environmental Conservation; Albany, New York

North Dakota Natural Heritage Inventory. (2003). Rare Plant List 2003. North Dakota Parks and Recreation Department; Bismarck, North Dakota.

Ontario Natural Heritage Information Centre [website]. (2003). Species list for vascular plants; Ministry of Natural Resources; Peterborough, Ontario; Available at:

(http://www.mnr.gov.on.ca/MNR/nhic/species/species_list.cfm); Accessed 5 May 2003.

Ouellet, Jean-Pierre; Boutin, Stan; and Heard, Doug C. (1994). Responses to simulated grazing and browsing of vegetation available to caribou in the Arctic. *Can. J. Zool.* **72**; pp. 1426-1435.

Penskar; M.R. and Higman; P.J. (2002). Special Plant Abstract for *Hymenoxys herbacea* (Lakeside daisy). Michigan Natural Features Inventory. Lansing, MI. 3 pp.

PLANTS Database, USDA, NRCS. [web application] (2002). Version 3.1. National Plant Data Center, Baton Rouge, LA 70874-4490 USA; Available: (http://plants.usda.gov). Accessed (10 April 2003).

Primack, Richard B. (1993) Essentials of Conservation Biology. Sinauer Associates, Inc.; Sunderland, Massachusetts; 564 pp.

Reznicek, A.A. (1990). Evolution in sedges (*Carex*, Cyperaceae). *Can. J. Bot.*, **68**; pp. 1409-1432.

Ratcliffe, Marilyn and Turkington, Roy. (1987). Vegetation patterns and environment of some alpine plant communities on Lakeview Mountain, southern British Columbia. *Can. J. Bot.*; **65**; pp. 2507-2516.

Razzhivin, V. Yu. (1994). Snowbed vegetation of far northeastern Asia. *J. of Veg. Sci.* **5**; pp. 829-842.

Richards, A.J. (1986). Plant breeding systems. London; George Allen and Unwin. (Cited in Briggs & Walters 1997.)

Rognli, Odd Arne; Nilsson, Nils-Otto; and Nurminiemi, Minna. (2000) Effects of distance and pollen competition on gene flow in the wind-pollinated grass *Festuca pratensis* Huds. *Heredity*; **85**; pp. 550-560.

Schütz, Wolfgang. (2000). Ecology of seed dormancy and germination in sedges (*Carex*). *Persp. Plant Ecol. Evol. and Syst.*; **3**(1); pp. 67-89.

Schütz, Wolfgang and Rave, Gerhard. (1999). The effect of cold stratification and light on the seed germination of temperate sedges (*Carex*) from various habitats and implications for regenerative strategies. *Plant Ecol.*, **144**; pp. 215-230.

Scoggan, H.J. (1978). The Flora of Canada. National Museum of Canada; Ottawa, Canada.

Smith, W.R. (1988) Flora Vol. 1. In: Minnesota's Endangered Flora and Fauna. Coffin, Barbara and Pfanmuller, Lee (Eds). University of Minnesota Press; Minneapolis, Minnesota.

Sperduto, Daniel D.; Crowley, Katherine F. (2001). Overview of Natural Communities in New Hampshire; New Hampshire Natural Heritage Inventory (NHNHI); Divisions of Forests & Lands and The Nature Conservancy; Concord, New Hampshire; 28 pp.

Steinger, Thomas; Körner, Christian; Schmid, Bernhard. (1996). Long-term persistence in a changing climate: DNA analysis suggests very old ages of clones of alpine *Carex curvula*. *Oecologia*; **105**; pp. 94-99.

Stenström, Anna; Jonsson, B. Olle; Jonsdottir, Ingibjörg S.; Fagerström, Torbjörn; Augner, Magnus. (2001). Genetic variation and clonal diversity in four clonal sedges (*Carex*) along the Arctic coast of Eurasia. *Molecular Ecol.*, **10**; pp. 497-513.

The Nature Conservancy (TNC), Michigan Chapter. (Website 2003) "Places we protect." Available at http://nature.org/wherewework/northamerica/states/michigan/; Accessed 30 April 2003.

The Nature Conservancy (TNC), Minnesota Chapter. (Website 2003) "Places we protect." Available at http://nature.org/wherewework/northamerica/states/minnesota/; Accessed 30 April 2003.

USDA Forest Service, Eastern Region (Region 9). (2000). Regional Forester Sensitive Plants. Milwaukee, Wisconsin; 19 pp.

USDA Natural Resources Conservation Service. No date. Northeast wetland flora: Field office guide to plant species. U.S.D.A., Northeast National Technical Center, Chester, Pennsylvania. Jamestown, ND: Northern Prairie Wildlife Research Center Home Page. http://www.npwrc.usgs.gov/resource/1999/neflor/neflor.htm (Version 12APR99).

USDA Roadless Area Conservation (2001) Spreadsheet Summary Data; Regional Forester Sensitive Species Lists; Available at: (http://roadless.fs.fed.us/); Accessed: (9 April 2003)

Vermont Nongame and Natural Heritage Program, Department of Fish and Wildlife (2000) Rare and uncommon native plants of Vermont; Waterbury, Vermont; Available at: (http://www.anr.state.vt.us/fw/fwhome/nnhp/index.html); Accessed: 8 May 2003.

Welsh, Stanley L. (1974) Anderson's Flora of Alaska and Adjacent Parts of Canada. Brigham Young University Press; Provo, Utah; p. 525.

White Mountain National Forest. (1999). Risk evaluation for *Carex scirpoidea*. Prepared by K. Starke; USDA Forest Service, Eastern Region; Milwaukee, Wisconsin.

Yarbrough, Stephen. (2000). Effects of dioecy on population genetic structure in *Carex scirpoidea* Michaux ssp. *scirpoidea*. M.A. Thesis; University of Colorado; Denver, Colorado; 88 pp.

Voss, Edward G. (1972) Michigan Flora Part 1 Gymnosperms and Monocots. Cranbrook Institute of Science, Bloomfield Hills, Michigan; p. 289.

APPENDIX 1: HABITATS OF SUBSPECIES *SCIRPOIDEA*

Habitats of *C. scirpoidea* ssp. *scirpoidea* in North America as quoted by technical field manuals and summarized habitat information from state natural heritage programs in a) Western United States, b) Eastern United States, c) Canada, and d) Russia.

APPENDIX 1A: WESTERN UNITED STATES (AK, CO, ID, MT, NV, ND, WY)

Intermountain region (NV & ID)

"Meadows, streambanks, and open, rocky slopes at high alt. in the mts., often above timberline" (Cronquist *et al*. 1998, p.114).

Rocky Mountains and Colorado

"Occurs in open, sunny sites, often at the edge of wet meadows, on calcareous substrates" (Hermann 1970, cited in Fertig 1999).

Alaska

"Meadows, heaths, wet places to at least 2,000 meters" (Hultén 1968, p. 223). "Muskegs, talus slopes, rock outcrops, heathlands, woods, gravelly spits, hilltops and tundra (Welsh 1974, p.525)

Colorado

"Colorado populations... are principally found covering peaty hummocks at the edge of rich to extreme rich fens. These habitats are found in the upper montane through alpine life zones, and exist in areas with groundwater discharge over or through calcareous bedrock or alluvium" (Yarbrough 2000, p.7). In one extreme rich fen of Colorado, *C. scirpoidea* is dominant in peat hummocks with more than 20% organic carbon that are along dry and saline margins of the fen.

In one rich extreme fen, *C. scirpoidea* ssp. *scirpoidea* was found in drier more saline margins of the fen. Associated species include: *Psilochenia runcinata, Thalictrum alpinum, Potentilla anserina, Calamagrostis stricta, Psilochenia* (*Crepis*) *runcinata*.

Montana

C. scirpoidea is a dominant species at high elevations (2800-3140 m) in alpine tundra of southwestern Montana (NatureServe Explorer 2002). In fact, it is the first named indicator species of two plant associations in that area (*Carex scirpoidea/Geum rossii* and *Carex scirpoidea /Potentilla diversifolia*) (Cooper *et al*. 1999, NatureServe Explorer 2002). These plant associations occur in areas with 75-175 cm of precipitation annually; at gentle to moderate slopes; on soils with a pH of between 5.5 and 7.2; and soil textures ranging from fine clay to sandy loam. These plant associations occur on "windswept slopes." Microsites are moist, often rocky, sometimes have a greater snow accumulation than surrounding areas, and may have late snowmelt or snow runoff. Associated species include: *Carex scirpoidea*, *C. phaeocephala, C. albonigra, Potentilla diversifoia*, *Phlox pulvinata, Lupinus argenteus*, *Geum rossii*, and *Erigeron simplex*.

North Dakota
C. scirpoidea ssp. *scirpoidea* (listed as synonym ssp. *scirpiformis*) "has been found growing on rocky ridge tops, in aspen woodland in the …mountains and in low meadow" (Bry 1986, "woodland plants")

Washington
"Meadows, streambanks, and open, rocky slopes at high altitudes in the mts., often above timber line" (Hitchcock *et al.* 1977, p. 326).

Wyoming
One occurrence is in moist hummocks and the other occurrence is on dry to moist clay near seep springs (Fertig 1999).

APPENDIX 1B. EASTERN UNITED STATES (ME, MI, MN, NH, NY, VT)
"Dry soil, especially in calcareous regions" (Gleason & Cronquist 1991, p. 709)

Maine
"Turfy, peaty or rocky situations and alpine areas. [Rocky summits and outcrops (Non-forested, upland); Non-tidal rivershore (non-forested, seasonally wet)]" (Maine Department of Conservation 1999).

Michigan
Occurrences identified as subspecies *scirpoidea* in Michigan are located along river banks and the Lake Superior shoreline, primarily on calcareous and rocky substrate (Table 2, Appendix 2).

Minnesota
"Most populations [in Minnesota] occur in swales, meadows, and wet prairies between old strandlines and beach ridges of Glacial Lake Agassiz. These are sunny, wet, calcareous habitats" (Smith 1988, p. 173). Associated species are listed below. In parenthesis is the number of *C. scirpoidea* populations in which the species had been associated. See Appendix 2 for details.

Shrubs**:** *Betula glandulifera* (10), *Salix spp.* (3)

Graminoids (number of occurrences with association):
Andropogon gerardii (20), *Sporobolus heterolepis* (15), *Muhlenbergia richardsonis* (14), *Sorghastrum nutans* (11), *Deschampsia cespitosa* (7), *Deschampsia* spp. (5), *Spartina pectinata* (5), *Carex buxbaumii* (4), *Carex hallii* (4), *Carex tetanica* (4), *Schizachyrium scoparium* (4), *Calamagrostis inexpansa* (3), *Poa pratensis* (3), *Distichlis stricta* (2), *Juncus balticus* (2), *Triglochin maritima* (2)

Herbs (number of occurrences with association):
Tofieldia glutinosa (10), *Lysimachia quadriflora* (9), *Potentilla fruticosa* (6), *Fragaria virginiana* (4), *Solidago nemoralis* (4), *Solidago ptarmicoides* (4), *Zizia aptera* (4), *Cypripedium candidum* (3), *Parnassia* spp. (3), *Rudbeckia hirta* (3), *Campanula rotundifolia* (2), *Castelleja coccinea* (2), *Comandra umbellata* (2), *Hypoxis hirsuta* (2), *Liatris ligulistylis* (2), *Prunella vulgaris* (2), *Ranunculus cymbalaris* (2)

New England
"In New England, ssp. *scirpoidea* occurs in widely scattered sites where there is some influence from calcareous parent material, and with associated calcicoles such as *Potentilla fruticosa* L. and *Juniperus horizontalis* Moench" (Dunlop & Crow 1999).

New Hampshire
Altitudes of populations range from 1500 ft to over 5000 ft (NHNHI 2003, Appendix 2). Occurrences are known to occur on calcareous and circumneutral cliffs (NHNHI 2003). Species associated with one or more occurrence as indicated by the New Hampshire Natural Heritage Inventory (2003):

Tree: *Betula alleghaniensis* (yellow birch), *Betula papyrifera* (paper birch), *Quercus rubra* (red oak).

Shrubs: *Alnus incana* var. *americana* (speckled alder), Diapensia lapponica (lapland diapansia), *Diervilla lonicera* (bush honeysuckle), *Juniperus horizontalis* (creeping juniper), *Potentilla fruticosa* (floribunda) (shrubby cinquefoil), *Salix uva-ursi* (bearberry willow), *Spirea alba* var. *latifolia* (eastern meadow-sweet).

Herbs: *Aster ptarmicoides* (Aster), *Campanula rotundifolia* (harebell), *Danthonia spicata* (poverty oat-grass), *Eupatorium rugosum*(white snakeroot), *Euthamia graminifolia* (grass-leaved goldenrod), *Geum peckii* (mountain avens), *Juncus trifidus* (highland rush), *Muhlenbergia* sp. (muhly), *Paronychia argyrocoma* (silverling), *Potentilla tridentata*, *Prenanthes* sp. (Rattlesnake-root), *Scirpus cespitosus* (tussock bulrush), *Solidago* sp. (goldenrod), *Woodsia ilvensis* (rusty woodsia).

New York
The six occurrences occur in thin soil on ledges, steep slopes, cliffs, gravel, and an alpine meadow (New York Natural Heritage Program 2003, Appendix 2).

Vermont
"High elevation calcareous cliffs scattered throughout Vermont" (Green Mountain National Forest 2003, p. 9)

APPENDIX 1C: CANADA
"Rocky barrens, bogs, and shores" (Scoggan 1978, p. 417).

British Columbia
"...mesic to dry meadows and open rocky slopes... from the montane to alpine zones" (var. *scirpoidea* = ssp. *scirpoidea*) (Douglas & Ceska 2001 p. 134).

Nunavut (Arctic Archipelago)
"Substrate wet meadows (less commonly), along streams, river terraces (older and raised), lake shores (on beach ridges), tundra, slopes, sea shore (on rocky sites under the influence of sea spray); dry, or imperfectly drained (less commonly); calcareous, or halophytic (occasionally); rock (sometimes on carbonate plates or cobble), gravel, sand, till, moss; peat, or with low organic content. Although this species can be found in damp places with *Sphagnum* or *Equisetum arvense*, it is more commonly found in dry tundra with *Dryas integrifolium*, *Epilobium latifolium*, *Oxytropis maydelliana* and *Carex*

bigelowii subsp. *bigelowii*, or *Poa glauca*. On beach ridges, it can be found with *Saxifraga tricuspidata*." (Aiken *et al*. 1999)

Newfoundland
"Dry rocky barrens and serpentine areas but occasionally on moist, gravelly river banks" (Damman 1964, p. 21)

Ontario
Along the northern shore of Lake Superior *C. scirpoidea* ssp. *scirpoidea* occurs in two plant associations as described by (Given & Soper 1981). In the "*Potentilla-Sagina* Rock Herbfield," plants occur on bare rock with shallow crevices and no pools of water. Some associated species include: *Achillea millefolium*, *Arctostaphylos uva-ursi*, *Campanula rotundifolia*, *Potentilla fruticosa*, *Potentilla tridentata*, *Solidago randii*, and *Sagina nodosa*. The other plant association is the "*Carex-Sagina* Rock-pool Herbfield." This association occurs in areas with wide crevices of broken rock, pools of water in the crevices and large rectangular blocks of rock that form large steps up the shore that consist of broad ledges and steep vertical rises. Associated species include: *Anemone parviflora, Arabis lyrata, Campanula rotundifolia*, *Carex capillaris*, *Draba arabisans*, *Dryas integrifolia, Juniperus horizontalis, Myrica gale, Pinguicula vulgaris, Potentilla fruticosa, Primula mistassinica*, *Sagina nodosa*, *Scirpus cespitosus*, *Trisetum spicatum*, *Vaccinium uliginosum*.

APPENDIX 1D: RUSSIA

Far northeastern Asia (Chukotka Peninsula)
In a study of the snowbed plant community in far northeastern Asia, *C. scirpoidea* was found at a soil pH ranging between 5.0 and 7.8, with the optimal pH being between 6.5 to 6.9 (Razzhivin 1994). In relevés, *C. scirpoidea* occurred in areas of very snow rich habitats (>5 meters deep snow) and in moderate snow rich habitats (2-5 meters deep) (Razzhivin 1994). The species occurred in acidic soils of snow rich habitats, but at much lower frequency and cover than in calcium rich soil with calciphytes. *C. scirpoidea* was found most commonly in relevés of mesic to dry soil.

APPENDIX 2: ELEMENT OCCURRENCES

The following list includes known occurrences of *C. scirpoidea* in Michigan, Minnesota, New Hampshire, and New York. Each occurrence is considered a distinct population. Tables include county of location, last date of observation, ownership, habitat, population sizes, and associated species. "Date" is the date the occurrence was last observed. "Size" indicates the general population size as described by surveyors: large, medium, small, or historic (H: > 50 yrs since last observation). The "source" includes the record number for each element occurrence (EO) as given by the natural heritage program of the state. In addition, Michigan includes label information from specimens in the University of Michigan Herbarium (MICH). Note that Minnesota, New Hampshire, New York have subspecies *scipoidea* only. Michigan has occurrences of subspecies (ssp) *convoluta* (CO) and *scirpoidea* (SC). Key for abbreviated species names for Michigan and Minnesota are in Appendix 3.

MICHIGAN

Sources for element occurrences are: MICH (notes taken from herbarium specimens at the University of Michigan Herbarium in December 2002) and MNFI (MNFI Database 2003). MICH indicated the subspecies (ssp).

Ssp	County	Date	Owner	Size	Source	Habitat
CO	Alpena	1981		Medium (50-75 tufts)	MICH (Voss #13289), MNFI (EO #1)	On island; in crevices of limestone pavement; in open with wind exposure. **Assoc. spp:** *Solidago* spp., *Poa* sp., *Aster* spp., *Agrostis* sp.
CO	Chippewa	2001	TNC	Large "common over many acres"	MICH (McVaugh 1948, Garlitz 1988, Voss #12217), MNFI (EO #3)	On island in grassland alvar; over thin organic soil and cracks in limestone. **Assoc. spp:** JUHO, POFR, CARO, SPHE, *Artemisia* spp., ARST, COUM, SEPA, SCSC, Lichens, SHAR, *Carex* spp.
	Chippewa	1860			MNFI (EO #4)	Near or along shore of a Great Lake.
CO	Chippewa	2000	Preserve	Large	MICH (Garlitz 1990), MNFI (EO #5)	Along shore of island; in crevices of bare limestone; in interdunal wetland; in "wet cedar-fir woods". **Assoc. spp:** PRMI, SAGL, JUBA, SOHI, GEPR, TOGL, POFR, JUCO, PIRE, THOC, PIGL, BEPA, ARUV, ZYEL, CIHI

Ssp	County	Date	Owner	Size	Source	Habitat
	Chippewa	2001		Large "locally common"	MNFI (EO #6)	Along shore of island; on bedrock pavement. **Assoc. spp:** THOC, PIGL, POFR, JUCO, ABBA, CAPE, *Andropogon* spp., ARUV, SAAR, DASP, ASLA, ARST, SEPA, HADE, CARI, CAEB
	Chippewa	1985		Large "common to locally abundant"	MNFI (EO #7)	Along shore of island; on limestone pavement and "marly" cobble. **Assoc. spp:** RAAC, BRHO, ARST, *Phleum* spp., CHLE, PIGL, SAVU, CACA, CAAU, CACA
	Chippewa	1994		Large "locally abundant"	MNFI (EO #8)	Along shore of island; on thin soil of dolomite flats; spread into boreal forest. **Assoc. spp:** THOC, BEPO, ABBA, JUCO, CARI, ARUV, SHAR, CIHI, ORPU, COCA, ASMA, MACA, LIBO, CYCA, POCO, PALI, HADE
CO	Chippewa	1981		Large	MICH (Voss 15074), MNFI (EO#9)	Along shore of island; Gravel/cobble flats; Moist THOC, PIGL, LALA woods. **Assoc. spp:** CACR, CAEB, CAGA, CAVI, PRMI, SEAP, SAAR, CACO, SIMO, POAN, POFR, SEPA, ELEL
CO	Chippewa	1994	State	Large	MICH (Penskar & Ludwig 1981), MNFI (EO #11)	Along shore of island; tufts in limestone pavement; pH 8.0. **Assoc. spp:** THOC, PIST, LALA, POFR, PIGL, JUCO, JUHO, SAGL, ZIEL, DASP, SCSC, SOHO, Castilleja spp., PRMIA, SIMO, SEPA, PALI, CARO, ARST
	Chippewa	1994	State	Large "abundant, …along 4-5 miles of shoreline."	MNFI (EO #15)	Along shore of island; in cracks of dolomite bedrock. **Assoc. spp:** THOC, PIMA, PIGL, CARI, POFR, HYKA, EPRE, SAGL, DECE, CARO, PALI, PRMI, DASP, AGTR, POCO, EUGR

Ssp	County	Date	Owner	Size	Source	Habitat
CO	Chippewa	1981		Large "frequent"	MICH (Voss #15395)	Along shore of island; gravelly/cobbly flats and limestone pavement. **Assoc. spp:** CACR, CAGA, CAVI, PRMI, SEEC, SAGL, CAAR, POFR, ELEL, SEPA
	Chippewa	1988			MICH (Russ Garlitz 1988)	Along road on island; on rocky limestone ridge. **Assoc. spp:** white cedar and white birch.
SC	Delta	1982		Small	MICH (Voss #15553), MNFI (EO # 10)	On east bank of river; on a mossy, calcareous outcrop.
SC	Delta	1990		Small	MICH (Henson 1990), MNFI (EO #12)	Along north facing riverbank; in alvar habitat; cold seepy calcareous rock.
SC	Delta	1984		Medium "occa-sional"	MICH (Penskar #84251)	On southern riverbank; on moist organic substrate over dolomite. **Assoc. spp:** *Pinguicula vulgaris* and *Carex granularis*
SC	Kewee-naw	1981		Small	MNFI (EO# 2)	Along Lake Superior shore; conglomerate rock with cobble.
CO	Mackinac	1988	National Forest	Small "two clumps… 10 shoots/ clump"	MICH (Albert 1987), MNFI (EO #14)	"Fen-like habitat at edge of wet, marl pool, Northern White-cedar growing on small, elevated areas." **Assoc. spp:** AGL, SAPU, SCSC, LOKA, JUHO, *Gaylussacia* spp.
CO	Mackinac	1997	Private		MICH (Voss #16582)	Along road at edge of *Thuja occidentalis* woods in"upland transition zone" of a large northern fen (Penskar & Higman 2002) **Assoc. spp:** *Hymenoxys herbacea* (lakeside daisy), THOC
CO	Presque Isle	2002	State	Large "locally frequent"	MICH (Voss #16001), MNFI (EO #13)	Along the shore of Lake Huron; marl beach pools; cobble beach ridge; alvar and fen habitats.

MINNESOTA

County	Date	Owner	Size	Source MNNHP (2003)	Habitat
Becker	1982	State		EO #4	Moist alkaline prairie (Wet/ mesic prairie). **Assoc. spp:** GEAM, PLER
Becker	1980	TNC		EO #8	Wet/ mesic prairie. **Assoc. spp:** ANCA, THDA, MEAR
Becker	2000			EO #46	Calcareous fen. **Assoc. spp:** CAIN, CAPR, ERAN, PELA
Clay	1964			EO #1	Low meadow
Clay	1980	TNC		EO #7	Tall grass upland prairie. **Assoc. spp:** ANGE, HEMA
Clay	1980	TNC		EO #9	Moist ground, near open water. **Assoc. spp:** DAGL
Clay	1985	Private		EO #13	Wet/ mesic prairie; mowed, exotic grasses. **Assoc. spp:** SCSC, ANGE, PALA, SPHE, *Carex* spp.
Kittson	1990		Small	EO #20	Wet/ mesic prairie; mowed for hay. **Assoc. spp:** ANGE, SPHE, SONU, POPR, DECE, SOPT, SONE, HYHI, PRVU
Kittson	?	Private	Small	EO #23	Wet/mesic brush prairie, lumpy microtopography; Glacial Lake Agassiz Interbeach Area **Assoc. spp:** BEGL, SONU, SPHE, TOGL, SORI
Kittson	1991		Small	EO #24	Wet/mesic brush prairie. **Assoc. spp:** SPHE, SONU, SCSC, DECE, MURI, CYCA
Lake	2000	County		EO #43	N to NW-facing cliff; in crevices and ledges near top of a 450 ft ridge along a river; 1.5 mi to Lake Superior **Assoc. spp:** CAEB, AGSC, HUAP, HUSE, SAAI, THPH, AQCA, CARO, SOHI, FRVI
Marshall	1983	State	Medium	EO #10	Wet prairie; Sedge meadow. **Assoc. spp:** JUBA, CABU, CALA, CYCA
Marshall	1983	Private	Medium	EO #11	Narrow strip of prairie. **Assoc. spp:** CYCA, CACO, HYHI, COUM
Marshall	1984	Private		EO #12	Sedge meadow. **Assoc. spp:** CARSA, CABU, TMA

MINNESOTA

County	Date	Owner	Size	Source MNNHP (2003)	Habitat
Marshall	1991			EO #22	Wet/mesic brush prairie; seepage influenced; low shrubs 50-60% cover. **Assoc. spp:** ANGE, SPHE, SONE, BEGL, POFR
Marshall	1992	Private	Large	EO #25	Brush prairie. **Assoc. spp:** PAGL, POFR, TOGL
Marshall	1992		Medium	EO #26	Brush prairie. **Assoc. spp:** PAGL, SPPE, BEGL, CAST, SPHE, LYQU
Marshall	1992			EO #44	Wet brush prairie; seepage influenced. **Assoc. spp:** SPHE, ANGE, BEGL, POFR
Marshall	1992		Small	EO #45	Open wet prairie. **Assoc. spp:** ANGE, SPPE, SPHE, CAIN.
Norman	1988	State	Small	EO #17	Wet/ mesic prairie. **Assoc. spp:** CACO, CATE, JUIN
Norman	1988	State	Small	EO #18	Wet/ mesic prairie. **Assoc. spp:** CATE, SMST, SPHE
Penning-ton	1992	Private	Large	EO #27	Wet/ mesic prairie. **Assoc. spp:** ANGE, HERI, RUHI, EQLA
Polk	1993	State	Large	EO #3	Wet/mesic brush prairie; low alkaline area. **Assoc. spp:** CARHA, DIST, BEGL, *Salix* spp., POFR, TOGL, LYQU, GEPR, DECA.
Polk	1982	Private	Small	EO #5	Alkaline depression of low prairie (Wet/ mesic prairie); plowed up. **Assoc. spp:** CAHA, RACY
Polk	1979	TNC		EO #6	
Polk	1986	State	Small	EO #14	Wet/ mesic prairie. **Assoc. spp:** ANGE, SONU, DECE, CAIA, *Muhlenbergia* sp.
Polk	1986	Private	Small	EO #15	Fen-like, Wet/mesic saline prairie. **Assoc. spp:** CAIN, SPHE., AGTR, CAHA, POPR
Polk	1986	Private	Large	EO #16	Upland prairie; mowed for hay. **Assoc. spp:** ANGE, SONU, SPHE, MURI,PAVI, GEAF

MINNESOTA

County	Date	Owner	Size	Source MNNHP (2003)	Habitat
Polk	1993	State		EO #19	Wet/mesic saline prairie. **Assoc. spp:** CAHA, TOGL
Polk	1990	?	Small	EO #21	Wet/ mesic prairie. **Assoc. spp:** ANGE, MURI, SCSC, ZIEL, COUM, SOPT
Polk	1993	Private	Small	EO #28	Wet/ mesic prairie; near brush in shallow depression; Glacial Lake Agassiz Interbeach Area. **Assoc. spp:** MURI, ANGE, CATE, DECE, TOGL
Polk	1993	Private		EO #29	Wet/ mesic prairie in shallow swale; Glacial Lake Agassiz Interbeach Area. **Assoc. spp:** SPPE, SPHE, ANGE, SONU, TOGL, CYCA
Polk	1993	Private	Large	EO #30	Wet/ mesic prairie. **Assoc. spp:** MURI, CABU, *Deschampsia* sp. & *Andropogon* sp.; Near occurrences of PLPR
Polk	1993	TNC	Large	EO #31	Wet/mesic brush prairie. **Assoc. spp:** BEGL, SALIX SPP., POFR, MURI, DECE AND ANGE
Polk	1993	TNC	Large	EO #32	Wet/ mesic prairie; fairly well-drained soils. **Assoc. spp:** MURI, SCSC, SONU, ANGE, LIPH, RUHI, SOPT, ZIAP, HEAU, CATE, MUGL
Polk	1993	Private	Large	EO #33	Wet/ mesic prairie; Beach ridge of Glacial Lake Agassiz Interbeach Area. **Assoc. spp:** MURI, SONU, SPHE, BRKA, LYQU, CARO, ZIAP, *Liatris* sp.
Polk	1993	Private	Medium	EO #34	Wet/ mesic prairie; Base of beach ridge of Glacial Lake Agassiz Interbeach Area. **Assoc. spp:** ANGE, SONU, *Deschampsia* spp., LYQU, RUHI, PEPU, CACO, TOGL

MINNESOTA

County	Date	Owner	Size	Source MNNHP (2003)	Habitat
Polk	1993	Private	Small	EO #35	Wet/ mesic prairie; Beach ridge of Glacial Lake Agassiz Interbeach Area. **Assoc. spp:** *Deschampsia* sp., MURI, CAREX SP., SPPE, BEGL, TOGL, FRVI, *Parnassia* spp, ZIAU
Polk	1993	State		EO #36	Wet/mesic brush prairie; Bottom of beach ridge of Glacial Lake Agassiz Interbeach Area. **Assoc. spp:** BEGL, MURI, ANGE, LILI, LYQU, COST, POFR
Polk	1993	Private	Large	EO #37	Wet/mesic saline prairie; Interbeach Zone of Agassiz Lake Plain. **Assoc. spp:** MURI, *Andropogon* sp., *Deschampsia* sp., LYQU, SONE, SOPT
Polk	1993	State	Large	EO #38	Wet/mesic saline prairie; Glacial Lake Agassiz Interbeach Area. **Assoc. spp:** MURI, AN SPP, SPHE, SONU, SCSC, LYQU, GECR, SONE, ZIAP, FRVI, LICA, LILI
Polk	1993	Private	Large	EO #39	Brush prairie; At base of beach ridge in Glacial Lake Agassiz Interbeach Area. **Assoc. spp:** BEGL, MURI, *Andropogon* sp., *Deschampsia* sp., LYQU, TOGL.
Polk	1993	State	Small	EO #40	Wet/ mesic prairie; At base of beach ridge in Glacial Lake Agassiz Interbeach Area. **Assoc. spp:** SONU, MURI, SPHE
Polk	1994	State	Small	EO #41	Wet/mesic brush prairie. **Assoc. spp:** BEGL, SAGR, CABU, DECA, SPPE, TOGL, FRVI, PYVI, LYQU, SEPS, PRVU
Polk	1994	State	Medium	EO #42	Wet/mesic saline prairie. **Assoc. spp:** HOJU, DIST, JUBA, POPR, PUNU, RACY
Wilkin	1962			EO #2	Low prairie (Wet/ mesic prairie).

NEW HAMPSHIRE

Element occurrences listed in the New Hampshire Natural Heritage Inventory 2003.

NEW HAMPSHIRE

Element occurrences listed in the New Hampshire Natural Heritage Inventory 2003.

County	Year	Owner	Size	Source (NHNHI 2003)	Habitat
Carroll	1953	State	H	EO #5	1640 ft elevation.
Carroll	1987	State	Large	EO #3	2800 ft elevation; In a "deep gorge"
Coos	1908	Federal	H	EO #11	3910 ft elevation
Coos	1917	Federal	H	EO #10	3643 ft elevation
Coos	1990	Federal	Large	EO #1	>5000 ft elevation; In moss *Juncus trifidus, Salix uva-ursi, Prenanthes sp., Diapensia lapponica, Solidago sp.*
Grafton	1915	Federal	H	EO #4	>5000 ft elevation
Grafton	1939	Federal	H	EO #2	>5000 ft elevation
Grafton	1984	State	Large	EO #7	2700 ft elevation; "Seepy granite cliff." **Assoc. spp:** *Scirpus cespitosus, Geum peckii, Campanula rotundifolia, Potentilla fruticosa.*
Grafton	1991	Federal	Large	EO #9	3000 ft elevation; Associated with NNE Circumneutral Cliff Community. **Assoc. spp:** *Potentilla fruticosa, P. tridentata, Aster radula, Woodsia ilvensis,* and *Paronychia argyrocoma*.
Grafton	1999		Medium	EO #8	1920 ft elevation; "Moist, turfy ledges and cracks in east-facing calcareous cliff." **Assoc. spp:** *Muhlenbergia cf. glomerata, Eupatorium rugosum, Euthamia graminifolia, Aster cf. undulatus, Spirea alba var. latifolia, Alnus incana*

NEW HAMPSHIRE

Element occurrences listed in the New Hampshire Natural Heritage Inventory 2003.

Grafton	2000	Private	Large	EO #6	1800 ft. elevation; Calcareous cliff community; southwest aspect, in open; in thin soil; on shallow benches, in cracks in the cliff, or on overhanging ledges. **Assoc. spp:** *Quercus rubra, Diervilla lonicera, Danthonia spicata, Campanula rotundifolia, Woodsia ilvensis, Muhlenbergia sp., Aster ptarmicoi, Juniperus horizontalis*

NEW YORK

Element occurrences listed by the New York Natural Heritage Program (2003)

County	Date	Size	Habitat
Washington	1997	Large	Seepage areas on amphibolite gneiss ledges; rich oak woods. **Assoc. spp:** *Aster ptarmicoides, Potentilla arguta, Carex complanata, Deschampsia flexuosa, Bromus kalmii.*
Washington	1988	Large	Steep slope with calcareous rocky summit community in opening of woods. **Assoc. spp:** *Panicum flexile, Solidago ptarmacoides, Sorghastrum nutans, and Carex eburnea.*
Essex	1997	Large	On amorthosite cliff.
Essex	1999	Medium	Alpine meadow on thin soil over rock
Essex	1999	Small	High granite cliffs, limestone dikes. **Assoc. spp:** *Potentilla fruticosa, Trisetum spicatum, Solidago(?) hispidus, Prenanthes trifoliata, Phegopteris hexagonoptera.*
Essex	1990	Small	Thin soil on denuded gravel.

APPENDIX 3: ASSOCIATED SPECIES

Associated species of *C. scirpoidea* in a) Michigan and b) Minnesota. Following each species is a code to identify species associated with each element occurrence listed in Appendix 2.

a) Associated species of *C. scirpoidea* in Michigan

Associated species	Code	Associated species	Code
Abies balsamea	ABBA	*Halenia deflexa*	HADE
Agropyron trachycaulum	AGTR	*Hymenoxys herbacea*	HYHE
Andropogon scoparium	ANSC	*Hypericum kalmianum*	HYKA
Arctostaphylos uva-ursa	ARUV	*Juncus balticus*	JUBA
Arenaria stricta	ARST	*Juniperus communis*	JUCO
Aster laevis	ASLA	*Juniperus horizontalis*	JUHO
Aster macrophyllus	ASMA	*Larix laricina*	LALA
Betula papyrifera	BEPA	*Linnaea borealis*	LIBO
Betula populifolia	BEPO	*Lobelia kalmii*	LOKA
Bromus hordeaceus	BRHO	*Maianthemum canadense*	MACA
Campanula rotundifolia	CARO	*Oryzopsis pungens*	ORPU
Carex aurea	CAAU	*Panicum linearifolium*	PALI
Carex capillaris	CACAP	*Parnassia glauca*	PAGL
Carex castanea	CACAS	*Picea glauca*	PIGL
Carex crawei	CACR1	*Picea mariana*	PIMA
Carex crawfordii	CACR2	*Pinguicula vulgaris*	PIVU
Carex eburnea	CAEB	*Pinus resinosa*	PIRE
Carex garberi	CAGA	*Pinus strobus*	PIST
Carex granularis	CAGR	*Poa compressa*	POCO
Carex pensylvanica	CAPE	*Potentilla anserina*	POAN
Carex richardsonii	CARI	*Potentilla fruticosa*	POFR
Carex viridula	CAVI	*Primula mistassinica*	PRMI
Castilleja arkansana	CAAR	*Ranunculus acris*	RAAC
Castilleja coccinea	CACO	*Sarracenia purpurea*	SAPU
Chrysanthemum leucanthemum	CHLE	*Satureja glabella*	SAGL
Cirsium hillii	CIHI	*Satureja vulgaris*	SAVU
Comandra umbellata	COUM	*Selaginella eclipes*	SEEC
Cornus canadensis	COCAN	*Senecio pauperculus*	SEPA
Cypripedium calceolus	CYCA	*Shepherdia arvensis*	SHAR
Danthonia spicata	DASP	*Sisyrinchium montanum*	SIMO
Deschampsia cespitosa	DECE	*Solidago hispida*	SOHI
Eleocharis elliptica	ELEL	*Solidago houghtonii*	SOHO
Epigaea repens	EPRE	*Sporobolus heterolepis*	SOHE
Euthamia graminifolia	EUGR	*Thuja occidentalis*	THOC
Gentiana procera	GEPR	*Tofieldia glutinosa*	TOGL
		Zigadenus elegans	ZIEL

b) Associated species of *C. scirpoidea* in Minnesota.

Associated species	Code	Associated species	Code
Agropyron trachycaulum	AGTR	*Hypoxis hirsuta*	HYHI
Agrostis scabra	AGSC	*Juncus balticus*	JUBA
Andropogon gerardii	ANGE	*Juncus interior*	JUIN
Anemone canadensis	ANCA	*Liatris ligulistylis*	LILI
Aquilegia canadensis	AQCA	*Lilium philadelphicum*	LIPH
Betula glandulifera	BEGL	*Lithospermum canescens*	LICA
Bromus kalmii	BRKA	*Lobelia kalmii*	LOKA
Calamagrostis inexpansa	CAIN	*Lysimachia quadriflora*	LYQU
Campanula rotundifolia	CARO	*Mentha arvensis*	MEAR
Carex buxbaumii	CABU	*Muhlenbergia glomerata*	MUGL
Carex conoidea	CACON	*Muhlenbergia richardsonis*	MURI
Carex eburnea	CAEB	*Panicum lanuginosum*	PALA
Carex hallii	CAHE	*Panicum virgatum*	PAVI
Carex interior	CAIN	*Pedicularis lanceolatus*	PELA
Carex lanuginosa	CALA	*Petalostemum purpureum*	PEPU
Carex prairea	CAPR	*Plantago eriopoda*	PLER
Carex sartwellii	CASA	*Platanthera praeclara*	PLPR
Carex sterilis	CAST	*Poa pratensis*	POPR
Carex tetanica	CATE	*Potentilla fruticosa*	POFR
Castelleja coccinea	CACOC	*Prunella vulgaris*	PRVU
Comandra umbellata	COUM	*Puccinellia nuttalliana*	PUNU
Cornus stolonifera	COST	*Pycnanthemum virginianum*	PYVI
Cypripedium calceolus	CYCA	*Ranunculus cymbalaris*	RACY
Cypripedium candidum	CYCAN	*Rudbeckia hirta*	RUHI
Dactylis glomerata	CAGL	*Saxifraga aizoon*	SAAI
Deschampsia cespitosa	GECE	*Schizachyrium scoparium*	SCSC
Distichlis stricta	DIST	*Senecio pseudaureus*	SEPS
Equisetum laevigatum	EQLA	*Smilacina stellata*	SMST
Eriophorum angustifolium	ERAN	*Solidago hispida*	SOHI
Fragaria virginiana	FRVI	*Solidago nemoralis*	SONE
Gentiana affinis	GEAF	*Solidago ptarmicoides*	SOPT
Gentiana amarella	GEAM	*Solidago rigida*	SORI
Gentianopsis crinita	GECR	*Sorghastrum nutans*	SONU
Gentianopsis procera	GEPO	*Spartina pectinata*	SPPE
Helenium autumnale	HEAU	*Sporobolus heterolepis*	SPHE
Helianthus maximiliani	HEMA	*Thalictrum dasycarpum*	THDA
Helianthus rigidus	HERI	*Thelypteris phegopteris*	THPH
Hordeum jubatum	HOJU	*Tofieldia glutinosa*	TOGL
Huperzia appalachianum	HUAP	*Triglochin maritima*	TRMA
Huperzia selago	HUSE	*Zigadenus elegans*	ZIEL
		Zizia aptera	ZIAP

LIST OF CONTACTS

Information Requests

Michigan:	Michigan Natural Features Inventory, Lansing, Michigan; Jan Schultz, Forest Plant Ecologist, Hiawatha National Forest.
Minnesota:	Mary Miller, Data Management Assistant, and Sharron Nelson, Assistant Database Manager, Minnesota Natural Heritage and Nongame Research Program, St. Paul, Minnesota.
New Hampshire:	Sara Cairns, Data Manager/Biologist, New Hampshire Natural Heritage Bureau, Division of Forests and Lands, Concord, New Hampshire.
New York:	Nicholas Conrad, Information Resources Coordinator, New York Natural Heritage Program, New York State Department of Environmental Conservation, Albany, New York
Wisconsin:	Steven Spickerman, Botanist, Chequamegon-Nicolet National Forest.
Vermont:	Diane Harlow Burbank, Ecologist, Green Mountain & Finger Lakes National Forest

Review Requests

Outside the U.S. Forest Service

Professor Debra Dunlop of New England College in Henniker New Hampshire.

Within the U.S. Forest Service

Jan Schultz, Plant Ecologist, Hiawatha National Forest, Michigan
Ian Shackleford, Botanist, Ottawa National Forest, Michigan
Beverely Braden, Contracting Botanist, Hiawatha National Forest, Michigan
Shannon McKenny, Contracting Botanist, Hiawatha National Forest, Michigan