

*Conservation Assessment*  
*for*  
*Bigelow's Sedge (Carex bigelowii) Torr.*



*Photo credit: John Maunder*

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*This Conservation Assessment was prepared to compile the published and unpublished information on the subject taxon or community; or this document was prepared by another organization and provides information to serve as a Conservation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.*

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## **EXECUTIVE SUMMARY**

*Carex bigelowii* Torr., otherwise known as Bigelow's sedge, is a perennial forb of the sedge family. It is a turf-forming species that reproduces primarily through clonal growth. The distinctive dark brown flower spikes appear in June and July, and are wind-pollinated. Mature fruit form during August and September.

There are no taxonomic issues with *Carex bigelowii*, and accurate identification is fairly easy since the plants are distinctive. Identification can be confirmed by a number of technical features, but people who are not familiar with sedge keys and terminology may have difficulty with descriptions in technical manuals.

The species is somewhat common in the alpine communities of New Hampshire, and is less abundant in Maine, New York, and Vermont. It is known from more than a dozen different community types, though it is not dominant species in many of them. Most of these communities are rare at the state level.

*Carex bigelowii* is a circumboreal species, and is found in the mountains of the western United States as well as in the Northeast. It is ranked S3 and is known from at 18 extant occurrences in New Hampshire, most of which lie within the White Mountain National Forest. It is ranked S2 in Maine, with 12 extant occurrences. In Vermont, it is ranked S1 and there are 4 extant occurrences, one of which is from the Green Mountain National Forest. It is on the Green Mountain National Forest's Regional Forester's Sensitive Species list. It is ranked S2 in New York and is known from 11 extant occurrences, all of which are within Adirondack Park.

The main threat to *Carex bigelowii* is loss of individual plants and suitable habitat due to recreational activities. Direct trampling, soil compaction, and soil erosion all result from hiker foot traffic and off-trail wandering. Air pollution, acid rain, and global warming may have long-term effects on the viability of the species and its alpine habitats. Current regulations are not effective at controlling threats from recreational use or from environmental changes due to human activities.

Currently, only the populations on Vermont's alpine peaks are managed under active conservation programs. The Green Mountain Club is responsible for summit stewardship programs and revegetation projects on a few mountains. Management plans are in place for some of the lands on which *Carex bigelowii* occurs, but there is little in the way of active conservation in Maine, New Hampshire, and New York. Since *Carex bigelowii* is widespread in alpine habitats, it may be a good indicator species that can reflect the overall health and integrity of the alpine system in the Northeast.

## **ACKNOWLEDGEMENTS**

I owe many thanks to Lisa St. Hilaire, who wrote the initial literature review of *Carex bigelowii* for the White Mountain National Forest and Green Mountain National Forest. Her excellent writing and organization of information served as the basis for much of the following document. I reorganized and rewrote sections that were similar to those in the literature review, and cited the original sources, so I rarely cite Lisa's work directly, but I could not have written this document without her. Thanks are due to Diane Burbank of the Green Mountain National Forest; Sara Cairns, Bill Nichols, and Dan Sperduto at New Hampshire Natural Heritage Bureau; Heather Root for directing me to Pete Antos-Ketcham at the Green Mountain Club; Stacy Lemieux of the White Mountain National Forest; Bob Popp and Jodi Shippee at Vermont Nongame and Natural Heritage Program; Don Cameron and Emily Pinkham at Maine Natural Areas Program; Alice Schori at the Appalachian Trail Conference; Steve Young at New York Natural Heritage Program. Thanks especially to MaryBeth Deller, my contracting officer at the Green Mountain National Forest.

## **INTRODUCTION**

*Carex bigelowii* is a perennial forb of the sedge family. Plants may live for many years, and reproduce sexually through flowers and fruit and asexually through clonal growth. The species is somewhat common in the alpine communities of New Hampshire, and is less common in Maine, New York, and Vermont. *Carex bigelowii* is easily identifiable due to its turf-forming clonal habit and distinctive dark brown flower spikes.

*Carex bigelowii* is a circumboreal species, and is found in the mountains of the western United States and in the Northeast. It is ranked S3 in New Hampshire, S2 in Maine, S1 in Vermont, and S2 in New York. It is on the Green Mountain National Forest's Regional Forester's Sensitive Species list.

This assessment includes sections on taxonomy, life history, and population biology. There is an extensive section that describes alpine and subalpine habitats in the Northeast. Occurrence information for Maine, New Hampshire, Vermont, and New York is included in the Distribution and Status section. The last sections cover threats to the species, conservation and management activities, land ownership and habitat protection, and research and monitoring activities.

This assessment is designed to concentrate on occurrences within the Green Mountain National Forest, since it is the national forest in Region 9 with *Carex bigelowii* on the Regional Forester's Sensitive Species list. Since the alpine zone in the Northeast is found in New York, Maine, New Hampshire, and parts of Vermont that are not within the Forest, those areas are included as well. Similar assessments are being written for *Juncus trifidus*, *Agrostis mertensii*, and *Vaccinium uliginosum* as well. These species share similar habitats in the Northeast and are widespread enough to serve as good indicators of the overall health of the alpine system.

## **NOMENCLATURE AND TAXONOMY**

*Carex bigelowii* Torr. ex Schwein. was named in 1824. Synonyms include *Carex rigida* var. *bigelowii* (Torr. ex Schwein.) Tuck., *Carex rigida* ssp. *bigelowii* (Torr. ex Schwein.) Steffen, *Carex bigelowii* ssp. *hyperborea* (Drej.) Bocher, *Carex bigelowii* ssp. *rigida* (Good.) W. Schultze-Motel, *Carex hyperborea* Drejer, *Carex vulgaris* var. *hyperborea* (Drejer) Boott, *Carex rigida* Gooden., *Carex rigida* ssp. *inferalpina* (Laest.) Gorodk., and *Carex consimilis* Holm (BNAP 1998), (MOBOT 2001). The name *Carex concolor*, an arctic species, has been misapplied to specimens in the Northeast (Gleason and Cronquist 1991).

*Carex bigelowii* forms a circumpolar complex with a number of morphologically similar taxa (Murray 1994), but there are no issues with identifying *Carex bigelowii* in the Northeast (SVE Panel 2002).

## **DESCRIPTION OF SPECIES**

*Carex bigelowii* is a member of the Cyperaceae (sedge family). It is a rhizomatous perennial, 1-4 dm high. The stems are surrounded by the dried-up leaf-bases from the previous year. The leaves are 2-6 mm wide. The terminal spike of the inflorescence is staminate and 0.5-2 cm, usually long-pedunculate. The lower 2 or 3 spikes are pistillate, cylindric, and 0.5-3.5 cm. The lowest spike is short-peduncled while the middle spike(s) is usually sessile. The inflorescence bracts do not have a sheath and the lowest bract is usually shorter than the inflorescence. The pistillate scales are dark brown and may have a pale midvein. They are elliptic to obovate, obtuse, and conceal the perigynia. The perigynia are pale green to purple, ovate to obovate, 2.1-2.8 mm, and minutely apiculate. There are two stigmas and the achene is lenticular (Gleason and Cronquist 1991). The yellow stamens are long and conspicuous against the brown scales when the plant blooms.

## **LIFE HISTORY**

*Carex bigelowii* is a perennial sedge that can form turfs or mats through rhizomatous growth. Its roots extend down to 80 cm in the soil (Bliss 1966). Clonal growth is its primary means of reproduction (Callaghan 1976). A genet may consist of a single large plant with many ramets (clones), or of several plants (ramets) due to the decomposition of the rhizome and/or fragmentation (Jonsson *et al.* 1996). A study of *Carex bigelowii* in Norway analyzed the longevity and behavior of each shoot, or tiller, on the rhizomes of a given plant. A tiller was more likely to bloom the more leaves it had, with 100% floral initiation in tillers with 36-40 leaves. After a tiller bloomed, it died, but tillers that did not bloom could live for 4 years. Tillers produced on the same plant have different grow

rates depending on how many leaves the parent plant had at the time of tiller initiation and on how many other tillers were produced at the same time (Callaghan 1976).

In the spring, plants use stored energy reserves to initiate growth and flowering (Hadley and Bliss 1964). Only the newer shoots of a plant accumulate photosynthetic carbohydrates (Jónsdóttir and Callaghan 1989 and 1990 in Jonsson *et al.* 1996). Older shoots supply water and nutrients to young tillers (Jónsdóttir and Callaghan 1990 in Sonesson and Callaghan 1991). Since the roots are perennial (Kummerow and Ellis 1984), roots on older parts of the rhizome can still be important for supplying nutrients. Carbohydrates made during the summer are stored in the rhizomes (Hadley and Bliss 1964). Cold periods during the summer months can decrease the amount of stored carbohydrates (Fonda and Bliss 1966 in Billings and Mooney 1968), potentially decreasing the number of successful new shoots and flowers in the next year.

*Carex bigelowii* can photosynthesize at low light levels and at low temperatures, making it the most efficient and dominant species at some locations (Hadley and Bliss 1964). The optimal temperature for photosynthesis appears to be between 10 and 20°C on Mt. Washington in New Hampshire (Bliss 1966).

The flowers of *Carex bigelowii* are wind-pollinated and are self-compatible, but self-pollination is limited by the anthers shedding their pollen before the stigmas are receptive (protandry) (Jonsson *et al.* 1996). *Carex bigelowii* initiates shoot elongation and flowering in late May and early June (Bliss 1966). Roots and shoots can grow when their temperature is 2°C (Kummerow and Ellis 1984). Plants bloom from early June to late July and fruit from early August to early September (Young 1992). Seeds of *Carex* may be eaten by insects or birds (Martin *et al.* 1951).

A range of chromosome numbers has been recorded for *Carex bigelowii*. Gleason and Cronquist (1991) report  $2n = 76-80$ , Faulkner (1972 in Jonsson *et al.* 1996) reports  $2n = 68$  or  $70$ , and Löve and Löve (1975 in Vavrek *et al.* 1991) call it a polyploid with  $2n = 68-71$ .

## **HABITAT**

*Carex bigelowii* is common in boreal or alpine bogs, tundra, meadows, and solifluction lobes (Vavrek *et al.* 1991). In the Northeast, it is found on rocky ledges and alpine mountain meadows (Gleason and Cronquist 1991). It occurs primarily in the dry/mesic heath meadow system of alpine communities in New Hampshire, which includes an array of *Carex* meadows, strong heaths, *Diapensia*, fell fields, and barren rock (SVE Panel 2002). The dry/mesic heath meadow system is located on unconsolidated gravel-stony soils, is associated with stony areas and convex landforms that are more exposed, and is limited by elevation (SVE Panel 2002). The dry/mesic heath meadow system forms a large and widespread patch matrix in the Presidential Range of the White Mountains in New Hampshire. Lesser summits have these systems in small patches (SVE Panel 2002). *Carex bigelowii* is typically found on flatter areas of this association that are wetter, have

thicker soils, or are somewhat sheltered versus areas that are more exposed. *Carex bigelowii* can also be found in the snowbank/wet meadow/streamside community system, bare subalpine rock summits, and alpine/subalpine bogs, but is not usually found in the krummholz associations (SVE Panel 2002). *Carex bigelowii* appears to be limited to places where there is a winter snow accumulation of at least one to two inches, which is sufficient to cover the ground-level meristems (Tiffney 1972).

The soils on Mt. Washington are quite acidic, with a low availability of exchangeable cations, and are deficient in nitrogen (Bliss 1966). It is likely that most of the soils in alpine regions in the Northeast share these characteristics. These soils tend to have good drainage, but stay moist due to fog and precipitation (Bliss 1966).

Specific alpine community types include: 1) dwarf heath-graminoid alpine ridge (Gawler 2001); 2) alpine meadow (Vermont); 3) alpine heath snowbank, 4) Bigelow's sedge meadow, 5) sedge-rush-heath meadow, 6) dwarf shrub-bilberry-rush barren, 7) alpine herbaceous snowbank meadow (Sperduto and Cogbill 1999); 8) *Diapensia* alpine ridge (Gawler 2001); 9) *Diapensia*-azalea-rosebay dwarf shrubland, 10) *Diapensia*-bilberry heath, 11) wet alpine/subalpine level and sloping bog (Sperduto and Cogbill 1999). Many of these community types are ranked S1 or S2 in New England states (see St. Hilaire 2002 for more details on ranks). Alpine communities are significantly shaped by cold winter and cool spring and summer temperatures, a short growing season, almost constant and frequent high-speed winds, snow and ice scour, frost heaving, and desiccation. Soils tend to be thin and acidic, with low nutrient availability and dry to mesic conditions.

1) The dwarf heath-graminoid alpine ridge is the most common community type above treeline in Maine. It occurs on exposed windswept ridges, and ranges from dry in exposed areas to moist in protected patches. The vegetation is a mixture of dwarf evergreen shrubs and herbs, with total cover from 35-65%. The most abundant herbs are *Carex bigelowii* and *Juncus trifidus*. In one variant, *Carex bigelowii* forms carpets and is dominant, with sparse heath shrubs and herbaceous species (Gawler 2001).

2) Alpine meadows are found on open, exposed ridgetops at elevations above 3500 feet in Vermont. In these locations, high winds, frequent fog, abundant precipitation, low temperatures, and frequently intense solar radiation are prevalent. The soils are thin and primarily organic, in low pockets and in areas where the bedrock breaks into small fragments through freezing and thawing, allowing soil accumulation. The plant associations in this community are determined by environmental stresses, soil depth, and moisture. Sedge meadows form a mosaic with low shrub communities, areas of lichen-covered bedrock, and occasional trees in protected pockets. This community is characterized by many arctic species. *Vaccinium uliginosum*, *Empetrum nigrum*, and *Vaccinium boreale* are the dominant shrubs, with *Salix uva-ursi*, *Salix pyrifolia* also present. Herbaceous species may include *Agrostis mertensii*, *Asplenium viride*, *Carex atratiformis*, *Carex bigelowii*, *Deschampsia flexuosa*, *Diapensia lapponica*, *Dryopteris fragrans*, *Empetrum nigrum*, *Hierochloe alpina*, *Huperzia appalachiana*, *Juncus trifidus*, *Luzula parviflora*, *Maianthemum canadense*, *Minuartia groenlandica*, *Poa fernaldiana*,

*Potentilla tridentata*, *Prenanthes boottii*, *Smilacina trifoliata*, and *Solidago cutleri* (Thompson and Sorenson 2000).

3) The alpine heath snowbank community is located in the lee of rocks and ledges or just above continuous krummholz where snow accumulates and typically does not melt until May. Soils in this community tend to be well-drained, with a pH from 4.0 to 4.6 (Bliss 1963). The community is characterized by *Vaccinium uliginosum*, *Vaccinium angustifolium*, *Vaccinium vitis-idaea*, *Carex bigelowii*, and *Juncus trifidus*, supports *Ledum groenlandicum*, *Empetrum nigrum*, *Vaccinium cespitosum*, *Loiseleuria procumbens*, and occasionally *Arctostaphylos alpina* (Sperduto 1993). *Phyllodoce caerulea* and *Harrimanella hypnoides* can be found in this community (Sperduto and Cogbill 1999). Herbaceous associates include *Cornus canadensis*, *Maianthemum canadense*, and *Trientalis borealis*, and *Cetraria islandica* is frequently present. These communities form dense mats 4 to 12 inches deep, with 91-96% plant cover (Bliss 1963, 1966).

4) Bigelow's sedge meadow is generally the dominant but variable alpine meadow community of higher alpine peaks. Krummholz is sparse or absent. The community is dominated by *Carex bigelowii*, with small amounts of *Minuartia groenlandica* and dwarf heaths, and is found at 4300-6000 feet.

5) The sedge-rush-heath meadow is typically found on west and north exposures from 4800-5500 feet and is characterized by mixtures of *Carex bigelowii*, *Juncus trifidus*, dwarf heath and other shrubs (Sperduto 1993). *Minuartia groenlandica* and *Vaccinium vitis-idaea* are present, and total plant cover averages 72% (Bliss 1963). At lower elevations rush-heath mixtures with less sedge are a prominent variant (Sperduto and Cogbill 1999). *Carex bigelowii* is more prominent at higher elevations, while *Juncus trifidus* is more prominent at lower elevations. Other species present include *Potentilla tridentata* and *Cetraria islandica*. Some examples have much exposed rock and may grade into a fellfield community (Sperduto 1993). At elevations above 5600 feet on Mt. Washington, the community is characterized by *Juncus trifidus*, *Vaccinium vitis-idaea*, and *Potentilla tridentata*, with *Carex bigelowii* and *Minuartia groenlandica* decreased in importance. In more exposed areas, *Diapensia lapponica* is common, while *Vaccinium uliginosum* is more prevalent in areas with greater snow cover (Bliss 1963). Soils in this habitat have pHs ranging from 4.1 to 4.7 (Bliss 1963).

6) The dwarf shrub-bilberry-rush barren is found in exposed situations, from 3400 to 4800 feet. It is the most common alpine community type in the Presidential Range, covering extensive areas. This community is usually located within a few hundred feet of timberline (Bliss 1963). Some winter snow may accumulate, but it melts early (Sperduto 1993). It is dominated by *Vaccinium uliginosum*, *Vaccinium vitis-idaea*, *Juncus trifidus*, with scattered dwarf shrubs, particularly *Empetrum atropurpureum*, *Potentilla tridentata*, and the occasional *Diapensia lapponica* and *Betula minor*. *Carex bigelowii* and *Juncus trifidus* have a lower abundance here than in sedge-rush-heath meadows (Sperduto and Cogbill 1999). This community type has local variations. On the upper solifluction terraces at higher elevations, like Mt. Washington's Alpine Garden,

*Minuartia groenlandica*, *Scirpus cespitosus*, and *Agrostis mertensii* are important. On nearby Boott Spur and Bigelow Lawn, large stone rings with wind-exposed diaspensia communities at their centers are surrounded with dwarf shrub heath-rush or sedge-rush-dwarf shrub heath on the more stable and protected flanks. In areas where the soils are moister in summer, there is an increase in the importance of *Carex bigelowii*, so that it dominates, or is co-dominant with *Juncus trifidus* (Bliss 1963). Soils in this community have pHs that range from 4.1 to 4.6 (Bliss 1963).

7) The alpine herbaceous snowbank meadow is a type of snowbank meadow community that may be associated with seepage zones and that has more herbs than heaths (Sperduto and Cogbill 1999). Snowbank meadow communities are characterized by deep accumulations of snow that melt late and are typically adjacent to krummholz clumps on east and southeast facing slopes, as well as in the lee of rocks. They are usually found below 5800 feet and are floristically richer than those found at higher elevation but may lack some true alpine species. These communities tend to have thick organic soils, and well-decomposed peat provides an important source of nutrients (SVE panel 2002). Soil pH values range from 4.0 to 4.6 (Bliss 1963). Lower elevation snowbank communities may include *Dryopteris spinulosa*, *Rubus pubescens*, *Amelanchier bartramiana*, *Spiraea latifolia*, *Streptopus roseus*, *Betula minor*, and *Betula nana* (Bliss 1963, 1966; Sperduto 1993). Plants of higher elevation snowbank communities (5300-6100 feet) include *Vahlodea atropurpurea*, *Salix herbacea*, *Geum peckii*, *Vaccinium uliginosum*, *Carex bigelowii*, *Solidago macrophylla*, *Houstonia caerulea*, *Phyllodoce caerulea*, *Harrimanella hypnoides*, *Castilleja septentrionalis*, *Phleum alpinum*, *Oxyria digyna*, *Luzula spicata*, *Luzula parviflora*, *Viola palustris*, *Veronica alpina* var. *unalaschensis*, *Vaccinium cespitosum*, *Maianthemum canadense*, *Coptis groenlandica*, *Clintonia borealis*, *Cornus canadensis*, and *Veratrum viride*. Total plant cover in snowbank communities averages 91-94%, (Bliss 1966).

8) The Diapensia alpine ridge in Maine has patchy alpine vegetation in which matted evergreen shrubs and a few herbs are scattered among boulders or in bedrock pockets. Cushions of *Diapensia* are the dominant feature, but *Vaccinium uliginosum* is also common. The cover of herb species is usually less than 20%, and graminoids such as *Carex bigelowii* and *Juncus trifidus* are typically more abundant than forbs. This community is found in very exposed and windswept areas above treeline, with plants growing in gravelly substrate among fractured rocks (Gawler 2001).

9) The Diapensia-azalea-rosebay dwarf shrubland of New Hampshire is found on exposed wind blown situations with considerable bare ground where winter snow cover is slight or absent (4400-5500 feet elevation). Diapensia communities are characterized by the lowest percent plant cover of alpine communities (48-51%), a dominance of cushion plants, and a limited cover of lichens and mosses. Freeze-thaw cycles are prevalent, as are active soil polygons (patterned soil movement due to freeze-thaw cycles) (Bliss 1963). Dominant species include *Diapensia lapponica*, *Juncus trifidus*, *Rhododendron lapponicum*, *Loiseleuria procumbens*, and *Vaccinium uliginosum*. Other species may include *Solidago cutleri*, *Salix uva-ursi*, *Agrostis mertensii*, and *Minuartia groenlandica*.

10) The Diapensia-bilberry heath community represents less diverse Diapensia heaths and is found at lower elevations (4000-4600 feet) (Sperduto and Cogbill 1999). Both Diapensia communities have soil pHs between 4.2 and 4.6 (Bliss 1963).

11) In New Hampshire, the wet alpine/subalpine level and sloping bog community is included in the broader classification of subalpine bogs and subalpine heath snowbanks, which are sloping and level peatlands from 2900 to 4000 feet, occurring in concavities on ridges and on slopes where a combination of poor drainage and abundant precipitation, and/or self-maintaining *Sphagnum* mats contribute to peat accumulation. The soil is a thick organic layer, with a pH between 4.2 and 4.7 (Bliss 1963). Lowland bog plants are the primary species, but subalpine or alpine species can also be found (Sperduto and Cogbill 1999). *Carex bigelowii* is prevalent, with lesser amounts of *Scirpus cespitosus*, *Vaccinium uliginosum*, *Vaccinium vitis-idaea*, *Vaccinium oxycoccus*, *Eriophorum spissum*, and *Kalmia polifolia*. Moss species include *Dicranum bergeri*, *Sphagnum fuscum*, *Sphagnum girgensohnii*, *Aulacomnium turgidum*, and *Drepanocladus uncinatus* (Bliss 1963). Wet alpine/subalpine level and sloping bog communities are usually level or slightly sloping peatlands and occur above 3500 feet. They have a patchy distribution, and are restricted to little strips on major subalpine ridges (SVE panel 2002). They tend to be permanently saturated. *Sphagnum capillifolium*, *Sphagnum fuscum*, *Sphagnum rubellum*, *Sphagnum russowii*, and *Sphagnum lescurii* dominate, with subalpine species such as *Empetrum nigrum*, *Vaccinium uliginosum*, and *Rubus chamaemorus*. *Vaccinium oxycoccus* and *Eriophorum vaginatum* are also present (Sperduto and Cogbill 1999). In sites with more alpine exposures at higher elevations, *Carex bigelowii*, *Geum peckii*, and *Betula glandulosa* may be present (Sperduto 1993).

In New York, the Natural Heritage Program (2004) lists its habitat as alpine ridges, meadows, and openings in krummholz. The three community types that correspond to these descriptions according to Edinger et al. (2002) are alpine meadow, alpine krummholz, and spruce-fir rocky summit, and they are described below.

12) The alpine meadow is a meadow community that is similar to arctic tundra. Alpine meadows occur above timberline (about 4900 ft or 1620 m) on the higher mountain summits and exposed ledges of the Adirondacks. This community consists of a mosaic of small grassy meadows, dwarf shrublands, small boggy depressions, and exposed bedrock covered with lichens and mosses. The flora includes arctic-alpine species that are restricted (in New York) to these meadows, as well as boreal species that occur in forests and bogs at lower elevations. The soils are thin and organic, primarily composed of sphagnum peat or black muck. The soils are often thoroughly wet because they can be saturated by atmospheric moisture from fog. Characteristic species of the grassy meadows include *Scirpus cespitosus*, *Carex bigelowii*, *Calamagrostis canadensis*, *Hierochloa alpina*, *Deschampsia flexuosa*, *Luzula parviflora*, *Juncus trifidus*, *Potentilla tridentata*, *Cornus canadensis*, *Minuartia groenlandica*, and *Prenanthes nana*. Characteristic species of the low shrublands are *Vaccinium uliginosum*, *Chamaedaphne calyculata*, *Ledum groenlandicum*, *Betula glandulosa*, *Empetrum nigrum*, *Rhododendron lapponicum*, *Diapensia lapponica*, and *Salix uva-ursi*. On a few mountains there are distinctive patches of low shrublands consisting of dwarf birches including *Betula*

*glandulosa*, *Betula minor*, and stunted *Betula cordifolia*. Characteristic species of the small boggy depressions include the peat mosses *Sphagnum nemoreum* and *Sphagnum fuscum*, *Eriophorum vaginatum* var. *spissum*, *Kalmia polifolia*, and *Vaccinium oxycoccos*. Rock outcrops that are relatively undisturbed by trampling are covered with arctic-alpine lichens such as map lichen (*Rhizocarpon geographicum*) and may have scattered cushions of *diapensia*. This community is very sensitive to trampling because of the thin, often saturated soils and the very slow growth rate of the vegetation in the stressful alpine environment.

13) The alpine krummholz community is a dwarf woodland dominated by *Abies balsamea* that occurs at or near the summits of the high peaks of the Adirondacks at elevations of 3500 to 4900 ft (1067 to 1494 m). Approximately 85% of the canopy consists of *Abies balsamea*; common associates include *Betula cordifolia* and *Picea mariana*. Less common are *Picea rubens*, *Juniperus communis*, *Larix laricina*, and *Thuja occidentalis*. The trees form dense stands of stunted trees; at the uppermost elevations below timberline the trees are under 5 ft (1.5 m) tall, with branches extending to the ground (i.e., there is no self-pruning of lower branches), and an average dbh of 3 in (7.6 cm). The groundlayer is densely shaded; the groundcover consists of a thick carpet of mosses, with scattered lichens and herbs. Characteristic herbs include *Cornus canadensis*, *Solidago macrophylla*, *Oxalis acetosella*, *Coptis trifolia*, and *Maianthemum canadense*.

14) The spruce-fir rocky summit is a community that occurs on cool, dry, rocky ridgetops and summits where the bedrock is non-calcareous (such as anorthosite, quartzite, or sandstone), and the soils are more or less acidic. The vegetation may be sparse or patchy, with numerous rock outcrops and rock slides. The species have predominantly boreal distributions. Characteristic trees include *Picea rubens*, *Abies balsamea*, *Sorbus americana*, and *Betula cordifolia*. *Tsuga canadensis* may be an associate in examples in the Catskill Mountains. The shrub layer includes sapling canopy trees along with *Vaccinium angustifolium* and *Vaccinium myrtilloides*. Characteristic herbs include *Campanula rotundifolia*, *Potentilla tridentata*, *Solidago spathulata* ssp. *randii*, *Solidago macrophylla*, *Deschampsia flexuosa*, *Cornus canadensis*, *Aster acuminatus*, and *Oryzopsis pungens*. There are usually many mosses and crustose lichens growing on rock outcrops. This community type is not fully understood and more data are needed.

The alpine and subalpine habitats in which *Carex bigelowii* occurs overlap with the habitats of *Juncus trifidus*, *Agrostis mertensii*, and *Vaccinium uliginosum*, for which conservation assessments have also been written. Surveys in the alpine zone should include these species as well, since they are likely to be found with *Carex bigelowii*.

## **DISTRIBUTION AND ABUNDANCE**

*Carex bigelowii* is a circumboreal species and is found south to New Hampshire, Vermont, and New York, and west to Alaska (Gleason and Cronquist 1991). It could be considered disjunct in New England and New York, since there are no other close

populations. Although it is at the southern edge of its range, this edge is relatively wide (SVE Panel 2002).

*Carex bigelowii* is abundant in several different kinds of alpine communities. In New Hampshire, it is found covering acres in the Presidential Range. In smaller patches of alpine habitat, especially in Maine, Vermont, and New York, it is less abundant.

### ***Summary of Maine Occurrences***

There are sixteen occurrences in the Maine Natural Areas Program's database (2001). Four of these are historical and four have not been officially observed since 1984. There are eight occurrences which have been seen more recently. None of the sixteen occurrences is on land owned by the White Mountain National Forest. The occurrences are mostly from alpine and subalpine habitats, but one report has been assigned to a location that is at too low an elevation to be considered subalpine.

**ME .002 (T3 R10 WELS, Piscataquis County)** – This occurrence was last observed on August 12, 2000, in Baxter State Park. It is ranked A, and occurs at 4700 feet. It is widespread and one of the most important elements in the sedge meadow communities above treeline. There were thousands of ramets in leaf and with mature fruit in 2000, over several square miles of area. Associated species include *Diapensia lapponica*, *Solidago multiradiata*, *Huperzia appalachiana*, *Minuartia groenlandica*, and *Hierochloa alpina*. The area is owned by the Bureau of Parks and Lands.

**ME .003 (Riley Township, Oxford County)** – This occurrence was first recorded in 1990, when fewer than 10 plants were seen. It was last observed on September 6, 1997. It is ranked B and is in the Appalachian Trail Corridor in the Mahoosuc Range. The elevation is 3700 feet. Plants occur on the East Peak, the West Peak, and two lesser balds, one along a relatively new trail. Population counts correspond to the bald on the newer trail. In 1997, there were approximately 150 plants. Associated species include *Juncus trifidus*, *Scirpus cespitosus*, *Minuartia groenlandica*, and *Agrostis mertensii*. Hiker use of the trails threatens plants, and one rare species may already have been lost from this location. The trail was poorly planned, travels directly through rare plant populations, and is causing serious erosion in places. The area is owned by the Bureau of Parks and Lands.

**ME .004 (Grafton Township, Oxford County)** – This occurrence was last seen on June 25, 2001. Plants grew in more than 12 separate patches in extensive lawns on exposed ridges. Five percent of the plants were in bud or in flower. Associated species included *Picea rubens*, *Minuartia groenlandica*, *Juncus trifidus*, *Vaccinium uliginosum*, *Ledum groenlandicum*, *Kalmia angustifolia*, *Scirpus cespitosus*, *Vaccinium vitis-idaea*, and *Empetrum nigrum*. It is ranked C and is at 3800 feet. Hiker traffic is causing erosion that directly threatens the *Carex bigelowii* population. The site is in the Appalachian Trail Corridor in Grafton Notch State Park and is owned by the Bureau of Parks and Lands.

**ME .005 (Sandy River Plt., Franklin County)** – This occurrence was last observed on July 10, 1996. Thousands of plants occurred in mats in open areas across the alpine ridge and peaks. Associated species included *Vaccinium uliginosum*, *Empetrum nigrum*, *Vaccinium angustifolium*, *Ledum groenlandicum*, *Minuartia groenlandica*, *Diapensia lapponica*, and *Juncus trifidus*. The population is ranked A and is in the Appalachian Trail Corridor. The elevation ranges from 3600 to 4116 feet.

**ME. 006 (Carrabassett Valley, Franklin County)** – This occurrence was first observed in 1985, when one patch of about 100 plants was seen. It was last seen in June 1991. Two vigorous subpopulations were seen in a mosaic of alpine and krummholz vegetation. The population is at the base of a communications building of a ski resort, and is ranked D because of erosion and trampling. Associated species include *Vaccinium uliginosum*, *Vaccinium vitis-idaea*, and *Juncus trifidus*. The elevation is 4000 feet.

**ME .007 (Mt. Abram Township, Franklin County)** – This occurrence was first recorded in 1985, when a patch of thousands of plants was found growing near a fire tower. It was last seen on July 28, 1997. No details were taken at that time. *Carex bigelowii* occurs in boulder-strewn sedge meadows with *Juncus trifidus* and *Ledum groenlandicum*. The elevation ranges from 4020 to 4049 feet. The population is ranked CD because of heavy hiker traffic. The area is owned by paper companies.

**ME .008 (Dead River Township, Somerset County)** – This historical occurrence was last observed in 1980. It was searched for in 2002 but not found. It is in the Appalachian Trail Corridor and the area is owned by the Bureau of Parks and Lands. The elevation is 3700 feet. There is heavy hiker traffic here.

**ME .009 (Mt. Katahdin Township, Piscataquis County)** – This occurrence was last observed on July 26, 1994. It was noted as being all over around the rocky shore of a pond. It is in Baxter State Park.

**ME .010 (T3 R10 WELS, Piscataquis County)** – This occurrence was last observed on July 17, 1984, on an open slide on the southwest side of a mountain. It is considered extant and is at 3260 feet in Baxter State Park.

**ME .011 (T3 R10 WELS, Piscataquis County)** – This occurrence was last observed on July 18, 1984 and is considered extant. A few plants were seen in flower on a small bald. The site is at 3500 feet and is in Baxter State Park.

**ME .012 (T4 R10 WELS, Piscataquis County)** – This occurrence was last observed on June 9, 1984, and is considered extant. It was in open alpine areas around and below the summit. This site is at 4143 feet in Baxter State Park.

**ME .013 (T3 R10 WELS, Piscataquis County)** – This occurrence was last observed on June 9, 1984. It is considered extant and occurred in a very small open summit area at 3700 feet. This area is in Baxter State Park.

**ME .014 (Jackman, Somerset County)** – This historical occurrence was last seen on August 2, 1918, on the summit of a mountain.

**ME .015 (Grafton Township, Oxford County)** – This historical occurrence was last seen on September 20, 1919. The report is from a mountain in the Appalachian Trail Corridor.

**ME .016 (T28 MD, Hancock County)** – This historical occurrence was last seen in September 1896. Maine Natural Areas Program (2001) references a specimen (#11076) at NHA, and gives the location as Black Cap Mountain, town unspecified, in Hancock County. There are two Black Cap Mountains in Hancock County, and a third just over the county line in Eddington. They are all around 1000 feet in elevation. A specimen in the MAINE herbarium, collected by the same collectors during the same month and year, bears the number 1107b. No county or town is given, and the label merely says “Orono and vicinity.” If these represent the same collection, which seems likely, Blackcap Mountain in Eddington is the most probable location. It is currently a forested hill with houses on it, and is hardly suitable habitat for *Carex bigelowii*.

**ME .017 (Dead River Township, Somerset County)** – This occurrence was observed on September 4, 2002, and is ranked B. Over 100 plants were found, with 10% reproductive and mature fruit present. The habitat is a dwarf heath graminoid alpine ridge community. The plants were found growing in gravel with *Vaccinium uliginosum* at 4060 to 4100 feet elevation. Hikers pose a potential threat to this population.

### *Summary of New Hampshire Occurrences*

There are twenty-five occurrences in the New Hampshire Natural Heritage Bureau’s database (New Hampshire Natural Heritage Inventory 2001). Twenty-three occurrences are from the White Mountain National Forest. One occurrence is owned by an educational institution, and one occurrence is in a State Forest. Seven occurrences are historical, which leaves 18 extant.

**NH .001 (Sargents Purchase, Coos County)** – This historical occurrence is based on an herbarium specimen from 1888. It was collected from a ravine on Mt. Washington, at 3643 feet, in what is now the White Mountain National Forest.

**NH .002 (Thompson & Meserves, Coos County)** – This historical occurrence from Mt. Washington is based on an 1887 herbarium specimen. This location is in the White Mountain National Forest.

**NH .003 (Sargents Purchase, Coos County)** – This historical occurrence from Mt. Washington is based on an herbarium specimen from 1907. This location is in the White Mountain National Forest.

**NH .004 (Franconia, Grafton County)** – This occurrence was last observed in 1990, when it was ranked A. It was widespread along several summits and ridges. This site is in the Appalachian Trail Corridor and is monitored by the Appalachian Trail Conference. There are 4 unprocessed reports from this area at New Hampshire Natural Heritage Bureau. The area is in the White Mountain National Forest.

**NH .006 (Sargents Purchase, Coos County)** – This occurrence was last observed on June 27, 1990. It was dominant in the herb layer. No detailed notes were taken. The elevation is 5020 feet, and this location is in the White Mountain National Forest.

**NH .007 (Sargents Purchase, Coos County)** – This occurrence was first observed in 1990, when it was noted as widespread and abundant, with vigorous growth and flowering. Associated species included *Potentilla tridentata*, *Diapensia lapponica*, *Vaccinium uliginosum*, and *Juncus trifidus*. It was last observed on July 6, 2001. It is ranked A, and is found in varying concentrations at several locations. The elevation is 5250, and this site is along a popular trail in the White Mountain National Forest. Hikers pose a threat through trampling and picking alpine plants.

**NH .008 (Orange, Grafton County)** – This occurrence was last observed in 2003. It is presently considered historical but will be reranked after New Hampshire Natural Heritage Bureau processes the 2003 report. Plants were observed in two patches. The first was north of a fire tower, in bare gravel at the edge of a seasonal pool, at 3100 feet. More than 1000 plants grew in a swath of about 120 square feet, and were of normal vigor with immature fruit. *Sibbaldiopsis tridentata* was the only associated species. Plants are injured by being trampled and sat on, and this population has decreased in size over the years. The summit is bare due to a fire, and is a popular hiking destination. The second patch is at 3060 feet, along a trail that leads to the summit. Hundreds of stems grew in an area approximately 10 feet by 3 feet. The plants were very short and 20% were reproductive. Associated species included *Carex capitata*, *Sibbaldiopsis tridentata*, *Vaccinium vitis-idaea*, and *Betula papyrifera*. This occurrence is in Cardigan Mountain State Forest.

**NH .009 (Benton, Grafton County)** – This occurrence was observed and ranked B in 1990. It was last observed on October 6, 2002. Many clumps were observed along a trail. Associated species included *Potentilla tridentata*, *Minuartia groenlandica*, *Deschampsia flexuosa*, *Vaccinium uliginosum*, *Vaccinium vitis-idaea*, *Agrostis borealis*, *Juncus trifidus*, and *Achillea millefolium*. Hiker traffic is heavy and disturbance and erosion occur despite scree walls. The elevation ranges from 4600 to 4800 feet. The site is partly privately owned and partly in the White Mountain National Forest.

**NH .010 (Franconia Grafton County)** – This occurrence was last observed in 1990, when it was ranked CD due to limited habitat. There is about an acre of habitat on an exposed rocky alpine area. *Agrostis mertensii* also occurs here. The location is in the Appalachian Trail Corridor and is monitored by the Appalachian Trail Conference. It is at 4360 feet and is in the White Mountain National Forest. Hiker traffic poses a threat to this population.

**NH .011 (Franconia, Grafton County)** – This occurrence was last seen on August 7, 1990, when it was ranked CD due to a small habitat area. There is a rocky alpine summit of less than 1 acre, with a typical assemblage of alpine species, at 4900 feet. No population details were recorded. *Vaccinium uliginosum* also occurs at this site, which is in the White Mountain National Forest along the Appalachian Trail. Hiker traffic is heavy.

**NH .012 (Chandlers Purchase, Coos County)** – This occurrence was last observed on September 2, 1990. It was ranked A and was widespread and vigorous on the summit of a mountain. Associated species included *Diapensia lapponica* and *Juncus trifidus*. The elevation is 4280 feet, and this occurrence is in the Presidential Range-Dry River Wilderness Area of the White Mountain National Forest. Hiker traffic is heavy, as this location is along the Appalachian Trail.

**NH .013 (Beans Grant, Coos County)** – This occurrence was last observed on July 7, 1989, and was ranked CD due to limited habitat. Fifty to 100 ramets were seen in a small exposed alpine area at 3910 feet. Associated species included *Diapensia lapponica*, *Juncus trifidus*, *Potentilla tridentata*, *Empetrum nigrum*, *Minuartia stricta*, *Solidago cutleri*, and *Agrostis mertensii*. This site is in the White Mountain National Forest.

**NH .014 (Low & Burbanks Grant, Coos County)** – This occurrence was last seen on July 16, 1990. It was in a ravine at 5020 feet. *Vaccinium uliginosum* and *Agrostis mertensii* also occur at this site. This location is in the White Mountain National Forest.

**NH .015 (Thompson & Meserves, Low & Burbanks Grant, Coos County)** – This occurrence was last observed on July 17, 1990. No details were taken. This location is a series of peaks along the Appalachian Trail, at 4820 feet, and is in the White Mountain National Forest.

**NH .016 (Thompson & Meserves, Coos County)** – This occurrence was last seen on July 17, 1990, when it was ranked A. It was abundant on a lawn on the south slope of a mountain in the White Mountain National Forest.

**NH .017 (Thompson & Meserves, Low & Burbanks Grant, Coos County)** – This occurrence was last observed on July 17 1990, when it was ranked A. Population data were not collected. The habitat was an alpine bog, with *Eriophorum spissum*, *Scirpus cespitosus*, and *Carex bigelowii*. The elevation was 4900 feet. This location is in the White Mountain National Forest, and hiker education is needed to keep hikers out of the bog.

**NH .018 (Sargents Purchase, Coos County)** – This occurrence was last seen on June 27, 1990. No detailed notes were taken. The habitat is exposed boulder talus, and *Carex bigelowii* is a dominant species, along with *Diapensia lapponica*. The elevation is 5900 feet and this site is in the White Mountain National Forest.

**NH .019 (Sargents Purchase, Coos County)** – This occurrence was last seen on June 28, 1990. Plants were noted as widespread and vigorous, with many flowering and some with maturing fruit. The population is ranked A, and is at 5400 feet. Hiker traffic is not considered much of a threat at this White Mountain National Forest location.

**NH .020 (Shelburne, Coos County)** – This occurrence was last observed on October 7, 1990, when it was ranked CD. The area is a matrix of heath associations, subalpine bogs, and krummholz with open rock exposures. The elevation is 3640 feet. Hiker traffic poses a threat at this location in the White Mountain National Forest.

**NH .021 (Beans Grant, Coos County)** – This occurrence was observed in 1990, but no details were recorded. The habitat is dominated by *Diapensia lapponica*, *Juncus trifidus*, and *Vaccinium uliginosum*. The elevation is 4185 feet, and the site is in the White Mountain National Forest.

**NH .022 (Low & Burbanks Grant, Coos County)** – This historical occurrence was last observed in 1901. It was on a mountain, at 4725 feet, in the Appalachian Trail Corridor in the White Mountain National Forest.

**NH .023 (Thompson & Meserves, Coos County)** – This historical occurrence was collected in 1884, 1901, and 1902, and was last observed in 1903. The location is in the White Mountain National Forest.

**NH .024 (Sargents Purchase, Coos County)** – This historical occurrence was seen in 1933, in a gulf on the southeastern side of Mt. Washington. The location is in the White Mountain National Forest.

**NH .025 (Sargents Purchase, Coos County)** – This historical occurrence was collected in 1853, 1878, 1882, and 1895, and was last seen in 1901. It was at 6280 feet in Mt. Washington State Park in the White Mountain National Forest.

**NH .026 (Sargents Purchase, Coos County)** – This occurrence was last observed on August 7, 1999, along a trail into a gulf. Plants were locally abundant over an area of 100 square yards, and had mature fruit. The habitat was an open, south-facing alpine ridge. Associated species included *Salix argyrocarpa*, *Salix planifolia*, *Geum peckii*, *Solidago macrophylla*, *Phegopteris connectilis*, *Vaccinium uliginosum*, and *Coptis trifolia*. The elevation was 4194 feet, and this location is in the White Mountain National Forest.

### *Summary of Vermont Occurrences*

There are four extant occurrences in Vermont, one of which is on land owned by the Green Mountain National Forest (Vermont Nongame and Natural Heritage Program, 2001).

**VT .001 (Underhill, Chittenden County)** – This occurrence was first observed in 1875. In 1990, it was noted as widespread in alpine meadows from the Forehead to Adam’s Apple, and most common on the exposed western side. It was scattered across the entire ridge. It was last observed in 1994. Four long-term transects were established, each with 10 one-meter quadrats. The first site had *Carex bigelowii* in 8 quadrats, the second had it in 4 quadrats, the third had it in 7 quadrats, and the fourth had it in all 10 quadrats. The elevation is approximately 4000 feet, and the occurrence is ranked A. The area is owned by the Vermont Department of Forests, Parks, and Recreation, and by the University of Vermont.

**VT .002 (Huntington, Chittenden County)** – This occurrence was first recorded in 1981, and it was noted that there were good populations. In 1987, *Carex bigelowii* lawns were in good condition near the summit. It was last observed on August 9, 2001. Plants were noted as scattered throughout the summit in alpine meadows. The habitat is New England Alpine Community at 3800 feet. This occurrence is ranked E and is owned by the Vermont Department of Forests, Parks, and Recreation.

**VT .003 (Worcester, Washington County)** – This occurrence was last seen on August 12, 1985, when there was one plant with 150 shoots in feeble condition. It was searched for on August 8, 2000, but was not found. It is possible that the hiking trail was rerouted to avoid the population. The plant grew with *Abies balsamea*, *Nemopanthus mucronatus*, and *Deschampsia flexuosa*. The habitat was Northern New England rocky summit/krummholz at 3400 feet. The occurrence is ranked D and is owned by the Vermont Department of Forests, Parks, and Recreation.

**VT .004 (Lincoln, Addison County)** – This occurrence was last monitored in September, 2002 (M. Deller personal communication). Plants grew in scattered clumps on small alpine outcrops. The habitat was a half-acre of alpine tundra community and subalpine fir-heath krummholz, with a mosaic of bare rock, stunted balsam fir, low heaths, and mats of low herbaceous vegetation. The elevation is 4000 feet. The occurrence is ranked D because of the small population size and its proximity to hiker traffic. The area is owned by the Green Mountain National Forest. Thompson (1991) comments that *C. bigelowii* is the dominant vascular plant on this summit, and that though the alpine tundra habitat is very small compared to other areas in Vermont, it is nonetheless highly significant and needs careful management.

### ***Summary of New York Occurrences***

There are 11 extant occurrences and one historical occurrence in New York (New York Natural Heritage Program 2004). All the occurrences are in Adirondack Park. Occurrences may be ranked from A to D (A being best) based on population size, available habitat size, population quality, and population defensibility. Occurrences ranked F are considered likely to be extirpated, but need further surveying.

**NY .001 (North Elba, Essex County)** – This occurrence was first surveyed on June 18, 1986, and was last seen in June 2001. There was a fairly large population in grassy areas and at the edges of rock outcrops in an alpine meadow. Associated species included *Scirpus cespitosus*, *Hierochloe alpina*, and *Potentilla tridentata*. The elevation is 4950 feet. This occurrence is ranked AB and is in the High Peaks Wilderness Area of Adirondack Park.

**NY .002 (Keene, Essex County)** – This occurrence was last observed on June 20, 1981. In 1981, there were approximately 1000 plants in an alpine meadow at the summit, growing with *Juncus trifidus*. The elevation was 4920 feet. This occurrence is ranked AB and is in the High Peaks Wilderness Area of Adirondack Park.

**NY .003 (Keene, Essex County)** – This occurrence was first surveyed on June 19, 1990, and was last seen on September 15, 2002. Plants grow in degraded alpine meadows at and just below the summit, at 5300 feet. Associated species include *Juncus trifidus* and *Hierochloe alpina*. This occurrence is ranked BC and is in the High Peaks Wilderness Area of Adirondack Park. It is owned by the New York State Department of Environmental Conservation. Trampling is a problem at this location.

**NY .004 (Wilmington, Essex County)** – This occurrence was last observed and surveyed on July 21, 1999. Hundreds of plants were seen growing on south-facing ledges below the summit but above timberline, and along the trail to the summit. The habitat is alpine meadows on thin soil over rocks and alpine krummholz community at 4860 feet elevation. Associated species include *Juncus trifidus*, *Salix uva-ursi*, and *Minuartia groenlandica*. This occurrence is ranked A and is in Adirondack Park.

**NY .005 (Newcomb, Essex County)** – This occurrence was first surveyed on July 28, 1988, and was last observed on August 2, 2001. Population data were not available. The habitat was alpine meadow on rocky bluffs at the summit. The elevation was 4710 feet. This occurrence is ranked Extant and is in the High Peaks Wilderness Area of Adirondack Park.

**NY .006 (North Elba, Essex County)** – This occurrence was first surveyed on July 21, 1989, and was last observed on July 31, 2001. Plants were scattered over most of the alpine zone, which occurs in patches among rock outcrops. The elevation is 4475 feet. The occurrence is ranked C and is in the High Peaks Wilderness Area of Adirondack Park.

**NY .007 (Keene, Essex County)** – This occurrence was last observed on July 25, 1998. Plants grew on the summit ridge, which was mostly bare rock with a narrow strip of alpine meadow and scattered krummholz. Associated species included *Vaccinium uliginosum* and *Scirpus cespitosus*. The elevation was 4695 feet. This occurrence is ranked Extant and is in the High Peaks Wilderness Area of Adirondack Park. The area is severely impacted by hikers.

**NY .008 (Newcomb, Essex County)** – This occurrence was first surveyed on July 28, 1988, and was last observed on August 2, 2001. Population data were not available. The habitat is a very small alpine zone at 4470 feet. The occurrence is ranked Extant and is in the High Peaks Wilderness Area of Adirondack Park.

**NY .009 (Keene, Essex County)** – This occurrence was observed in 1988. Plants are found scattered across the alpine zone of a few summits. The alpine zone is extensive (19 acres) and occurs at 4775 feet. This occurrence is ranked C because it is a small population despite the excellent available habitat. It is in the High Peaks Wilderness Area of Adirondack Park and is owned by the New York State Department of Environmental Conservation.

**NY .010 (Keene, Essex County)** – This occurrence was first surveyed on August 23, 1988, and was last observed on June 23, 2001. Plants grew in a small alpine zone on the west and south sides of a small summit at 4530 feet elevation. This occurrence is ranked Extant and is in the High Peaks Wilderness Area of Adirondack Park.

**NY .011 (Keene, Essex County)** – This occurrence was surveyed on August 12, 1988, and was last observed on August 16, 2001. Population data were not available. The habitat is alpine meadow and krummholz on two summits, at 4760 feet. This occurrence is ranked extant and is in the High Peaks Wilderness Area of Adirondack Park.

**NY .012 (North Elba, Essex County)** – This occurrence is based on a citation from a 1924 checklist. Habitat was surveyed in 1990 but no plants were found. This occurrence is ranked F and is in the High Peaks Wilderness Area of Adirondack Park.

## **STATUS**

*Carex bigelowii* has a global rank of G5. It is ranked S1 in Vermont, S2 in Maine and New York, and S3 in New Hampshire. Table 1 below lists ranks for North American states and provinces.

**Table 1. Status of *Carex bigelowii* in North America (NatureServe 2001).**

<b>RANKED as S1, S2 or LISTED as T or E by State</b>	<b>RANKED as S3-S5 or S? or SU</b>	<b>RANKED as SR or SRF</b>	<b>RANKED as SH or SX</b>
Maine (S2, SC): 12 extant and 4 historical occurrences	New Hampshire (S3): 18 extant and 7 historical occurrences	Alaska, Colorado, Idaho, Wyoming (SR)	Ontario (SH)
Vermont (S1): 4 extant occurrences	British Columbia (S3)	Labrador, Newfoundland Island (SR)	
New Mexico (S2?)	Manitoba (S3)	Northwest Territories, Nunavut, Yukon Territory (SR)	
New York (S2): 11 extant occurrences and 1 historical occurrence	Montana (SU)	Quebec (SR)	
New Brunswick (S1)			
Saskatchewan (S1)			

In Vermont, *Carex bigelowii* is on the Green Mountain National Forest Regional Forester's Sensitive Species list. It is only known from 4 occurrences in Vermont, and the Green Mountain National Forest occurrence is very degraded. If habitat is protected, *Carex bigelowii* may persist in the Green Mountain National Forest. Without protection, the population and the habitat will probably be lost (SVE Panel 2002). In Maine it is a species of special concern.

In New Hampshire, it is doing well in the Presidential Range, but has been degraded in other alpine areas (SVE Panel 2002). The dry/mesic heath meadow system is doing fine although it is likely to be degraded in areas of high traffic and on lesser summits where its extent is less extensive. Snowbank communities have a similar outcome. They are not greatly impacted by trails in the Presidential Range, but may be heavily impacted in other areas. It is expected that recreation impacts will increase, but so will public awareness, which may mitigate recreation impacts. Winter campers are expected to have the largest impact on snowbank areas near Appalachian Mountain Club huts. Off-trail

hiking in Mt. Washington's Alpine Garden and Tuckerman's Ravine could lead to the extirpation of rare species populations if off-trail hiking prohibitions are not enforced (SVE Panel 2002). *Carex bigelowii* is not on the White Mountain National Forest Regional Forester's Sensitive Species list.

New England Plant Conservation Program ranks *Carex bigelowii* as Division 3, indicating that it is a locally rare taxon which may be common in parts of New England, but has one or more occurrences of biological, ecological, or possible genetic significance (Brumback and Mehrhoff *et al.* 1996).

## **POPULATION BIOLOGY AND VIABILITY**

*Carex bigelowii* uses clonal growth as its primary means of reproduction (Callaghan 1976). A plant, or genet, may consist of a single large plant with many connected shoots (ramets or clones), or of several plants (unconnected ramets) due to the decomposition of the rhizome and/or fragmentation (Jonsson *et al.* 1996). *Carex bigelowii* is protandrous, which means that the anthers of the male flowers shed pollen before the stigmas of the female flowers are receptive. Theoretically this should prevent self-pollination, but because a plant can become fragmented or have ramets growing in slightly different microhabitats, it is possible for ramets to be self-fertilized by other ramets (Jermy and Tutin 1968 in Vavrek *et al.* 1991).

The reproductive strategy of *C. bigelowii* is opportunistic (Callaghan 1976). In the spring, many vegetative ramets are initiated. If environmental conditions are favorable, and the parent plant has enough reserves, ramets develop and colonize new ground. If conditions are unfavorable, some or all of the ramets abort (Callaghan 1976). This could reduce the fitness of subsequent generations, since only the newer shoots of a plant accumulate photosynthetic carbohydrates (Jónsdóttir and Callaghan 1989 and 1990 in Jonsson *et al.* 1996). Older shoots supply water and nutrients to young tillers (Jónsdóttir and Callaghan 1990 in Sonesson and Callaghan 1991).

Nutrient availability can be a limiting factor in alpine soils, but *Carex bigelowii* has some mechanisms that give it an advantage. Since the roots are perennial (Kummerow and Ellis 1984), older parts of the rhizome can supply nutrients to areas of the plants that are growing or reproducing. Since the plants grow via rhizomes, which extend in a more or less straight line, each area of soil is exploited by only one tiller of one generation. The tiller of the next generation exploits a new area of soil, usually some distance from the former generation as a result of rhizome elongation. Each area of soil is exploited by a tiller for a maximum of four years, though the roots of the tiller may persist after the above-ground shoot has died. The directional growth of the tillers allows *Carex bigelowii* to grow over areas of extremely low nutrient levels and avoid competition between tillers of the same ramet (Callaghan 1976).

A study of *Carex bigelowii* in Norway analyzed the longevity and behavior of each shoot or tiller on the rhizomes of a given plant. A tiller was more likely to bloom the more

leaves it had, with 100% floral initiation in tillers with 36-40 leaves. After a tiller bloomed, it died, but tillers that did not bloom could live for 4 years. Tillers produced on the same plant have different growth rates depending on how many leaves the parent plant had at the time of tiller initiation and on how many other tillers were produced at the same time (Callaghan 1976). The mortality rate of young tillers is very high, but it decreases as the tillers reach the 16 to 20 leaf stage. Tillers die after they have produced flowers. Tillers that have lived for several years without flowering show an increased mortality rate due to natural senescence. Less than 1% of tillers live to the final age class (36-40 leaves per tiller). In contrast, tillers show the highest degree of vegetation immediately before maturity (Callaghan 1976). The life span of the average individual tiller is about two years (Jónsdóttir and Callaghan 1988 in Vavrek *et al.* 1991). One study found that the majority of rhizome systems survived for less than 20 years (Kershaw 1962 in Vavrek *et al.* 1991) but it is not known how many years a genet may live through its multiple ramets (Vavrek *et al.* 1991). *Carex bigelowii* clones have a relatively slow growth rate and may live for many years through successive tiller generations (Jonsson *et al.* 1996).

Vegetative reproduction in *Carex bigelowii* is more efficient than sexual reproduction (Callaghan 1976). Sexual reproduction requires a lot of energy, both in the form of stored energy and nutrients to initiate flowering shoots and in resources accumulated during the growing season. Fewer than 20% of the younger ramet generations flower and produce seed (Jonsson *et al.* 1996).

*Carex bigelowii* produces viable seed, and Alaskan studies have shown seed to be present in seed banks (Jonsson *et al.* 1996, Gartner *et al.* 1983). Some seeds may germinate the same year they are produced, but the majority have dormancy requirements (Billings and Mooney 1968, Gartner *et al.* 1983). In an Alaskan study, first-year seedlings had a mortality rate of 13% in the growing season, due to surface runoff and frost action (Gartner *et al.* 1983).

Populations of *Carex bigelowii* may be limited by unsuitable habitat. If tillers end up on soil that is too dry or exposed in the winter, they may die or be unable to cross into new habitat. Disturbance may limit populations as well, though it can recolonize exposed areas after disturbance has ceased (SVE Panel 2002). Ketchledge *et al.* (1985) indicate that *Carex bigelowii* is highly resistant to trampling by hikers, and is usually the last species in highly degraded areas. However, persisting is not the same as thriving, and *Carex bigelowii* does not do well with disturbance (SVE Panel 2002). Seeds germinate successfully in disturbed areas (McGraw and Vavrek 1989).

## **POTENTIAL THREATS AND MONITORING**

### **Present or Potential Risks to Habitat or Range**

Hiker traffic is a threat to a number of alpine areas, especially those that are small and on heavily visited peaks. Hikers can trample plants to death, causing them to lose their soil-

retaining capabilities. Foot traffic can also loosen soil, which is then washed or blown away. Soils do not recover quickly in the alpine zone, and habitat can decrease at a rapid rate. Some habitats are more sensitive than others. Erosion and disturbance are the major limiting factors to the alpine/subalpine bog association. This habitat erodes very quickly, as evidenced by a trail in the Mahoosuc Mountains that has been worn down to bare rock through three-quarters of a meter of peat. Hikers who explore alpine bogs can cause great damage (SVE Panel 2002).

The heath snowbank/wet meadow/streamside/wet shrub ravine system has a patchy linear distribution that may be more vulnerable to disturbance, and its hydrology may be affected by disturbance (SVE Panel 2002). The snowbank/wet meadow/streamside community system may be negatively affected by hiking, winter camping, and late winter/spring use. Current management allows camping in alpine areas with more than one foot of snow, and areas in the snowbank/wet meadow/streamside community system have the best potential for making snow caves. This draws recreational use to the habitat and may affect the snowbank system. Snow use in general probably has a minor effect, but snow cave digging may have a large effect (SVE Panel 2002).

The dry/mesic heath meadow system is threatened by trampling along trails and on ridges and peaks where hikers wander in search of a good view (SVE Panel 2002). Heavy recreational use also threatens alpine plants on Camel's Hump (Zika 1993). Extensive *Carex* meadows have been degraded due to trampling, especially in Vermont (SVE Panel 2002). Likewise, hiker traffic has severely degraded habitat on Mt. Marcy (Ketchledge and Leonard 1984).

Global warming and acid deposition may be a threat to the dry/mesic heath meadow system, though the threat is not known at this time and is likely minor compared to other factors such as hiker pressures. The alpine/subalpine bog association is threatened by hydrological changes, such as the drought conditions that have been present in parts of the White Mountain National Forest in recent years (SVE Panel 2002). Air pollution, including ground-level ozone, may damage plants in the alpine zone. In Newfoundland, *Carex bigelowii* is limited by high summer temperatures (Damman 1965).

### **Commercial, Recreational, Scientific or Educational Over-utilization**

*Carex bigelowii* is not threatened by commercial, scientific, or educational activities. It is threatened by recreational over-use, which negatively impacts its habitat, as well as individual plants. See Habitat Threats above for a discussion of recreational issues.

### **Disease or Predation**

No threats due to disease or predation have been identified for *Carex bigelowii* in the Northeast. It does provide food and shelter for animals, but does not appear to be negatively impacted.

### **Inadequacy of Existing Regulatory Mechanisms**

*Carex bigelowii* is not a protected species in Maine or New Hampshire. Though it is on the state list in Maine, it is not afforded any protection (D. Cameron, Maine Natural Areas Program, personal communication). Small populations could easily be lost due to recreational impacts. There are no regulations that restrict recreational impacts, except in Maine's Baxter State Park, where access is somewhat restricted. In Vermont, species that are state listed as Threatened or Endangered are protected from "taking" (picking, digging up, etc.) without a permit (R. Popp, Vermont Nongame and Natural Heritage Program, personal communication). However, *Carex bigelowii* is not state listed, and the protection from taking does not include protection from trampling by hikers. On peaks in the Green Mountain National Forest, there are no regulations that prohibit camping above treeline, an activity that could negatively impact plants and habitat. However, campfires are prohibited at Mt. Abraham (USDA Forest Service 1987). In New York, plants on the state list are protected from "taking" without the landowner's permission (New York Natural Heritage Program 2004). Plant protection laws can be very difficult to enforce.

In addition, there are no regulatory mechanisms that protect habitat. Efforts are being made in the White and Green Mountains to educate hikers and limit hiker impacts, but there are very few regulations that are effective at preventing habitat loss. Off-trail hiking prohibitions in parts of the White Mountain National Forest are not adequately enforced. Regulations that allow winter camping in the Presidential Mountains may be detrimental to snowbank communities. Federal regulations governing air pollution and air quality are also not effective at preventing damage to alpine plants and ecosystems from ozone and other pollutants.

#### **Other Natural or Human Factors Affecting Continued Existence of Species**

There is some concern over the impact of dogs on alpine vegetation in Vermont. No other factors have been identified for *Carex bigelowii*.

#### **SUMMARY OF LAND OWNERSHIP AND EXISTING HABITAT PROTECTION**

In Maine, occurrences are on land owned by the Bureau of Parks and Land, Baxter State Park, or private individuals and companies. A few occurrences are in the Appalachian Trail Corridor. Habitat in Baxter State Park and in the Appalachian Trail Corridor is protected from development, though not from recreational impacts. Land owned by the Bureau of Parks and Land is managed for multiple uses, including recreation, wildlife, and timber. Their dominant use system is designed to keep intensive management activities away from areas with rare species and backcountry recreational usage (Maine Bureau of Parks and Land 2004). Land owned by private individuals and companies is assumed to be without protection.

All but two of the New Hampshire occurrences are within the White Mountain National Forest. One is on land owned by an educational institution and the other is in a State Forest. The White Mountain National Forest is managed for multiple uses, including

timber harvesting. Populations that are within the Appalachian Trail Corridor are afforded protection from non-recreational uses. Since *Carex bigelowii* grows above treeline in many locations, in areas where the primary use is recreational, it is relatively protected from non-recreational pressures. The State Forest is managed by the New Hampshire Division of Forests and Lands and by the New Hampshire Division of Parks and Recreation. The mountain summit is managed for recreation. The occurrence that is on privately owned land is also managed for recreation.

In Vermont, one occurrence is on land owned by the Green Mountain National Forest. The other occurrences are on land owned by Vermont Department of Forest, Parks, and Recreation and the University of Vermont. Since *Carex bigelowii* is on the Green Mountain National Forest Regional Forester's Sensitive Species list, any activities near the occurrence should maintain protection for the plants. There is also a summit steward at the Green Mountain National Forest site who encourages people to stay off the alpine vegetation. The Vermont Department of Forests, Parks, and Recreation lands are protected from development. Land classified as natural areas are managed for protection of rare species and habitats and for recreational purposes (Vermont Forests, Parks, and Recreation 2004). University of Vermont allows multiple uses of its land but cooperates with state agencies to protect the alpine habitat. Vermont's alpine summits are heavily used by hikers, and also are used by radio stations and ski resorts. Illegal ski trails tend to be a problem. These may not threaten *Carex bigelowii*, but they illustrate that effective habitat protection can be limited.

In New York, all occurrences are in Adirondack Park. Adirondack Park is a combination of public and private lands that is managed for multiple uses, including water conservation and timber management. Some areas are designated as wilderness or as for outdoor recreation. All public lands are managed by the state, and there is a management plan for the whole Park. The Adirondack Park Agency is responsible for managing the Park (Adirondack Park Agency 2004). It is not clear which occurrences in Adirondack Park are on public lands, and it is not clear what the management strategy for the alpine areas is. Two occurrences in the Park are on land owned by the New York State Department of Environmental Conservation. Since the Department of Environmental Conservation is responsible for setting and enforcing environmental laws, including New York's protected plants legislation, it is assumed that populations of *Carex bigelowii* on Department of Environmental Conservation lands are afforded protection. Again, recreational uses are heavy, and ski resorts expansion may threaten some occurrences.

## **SUMMARY OF EXISTING MANAGEMENT ACTIVITIES**

There are no existing management activities in Maine, New Hampshire, or the White Mountain National Forest. The National Forests have management plans in place or are in the process of developing them. The Appalachian Trail Conference monitors rare plants within its corridor and tries to protect rare plants during trail work. The SVE Panel (2002) mentioned active management monitoring at sites in Franconia, but provided no information as to what the management entailed, when it was conducted, or who was in

charge of the project. There may be management activities in Adirondack Park, on lands owned by the New York Department of Environmental Conservation, and on lands owned by Vermont Forests, Parks, and Recreation. There are management plans in place for their lands, but no information on management activities was available through those agencies' websites or through data provided by Natural Heritage Programs. Current management activities in Vermont appear to be restricted to periodic monitoring by the Green Mountain National Forest and the conservation activities of the Green Mountain Club. See below for details.

## **PAST AND CURRENT CONSERVATION ACTIVITIES**

In Maine, New Hampshire, Vermont, and New York, *Carex bigelowii* is tracked by state Natural Heritage Programs, and may be tracked by New England Plant Conservation Program task force members in New England. Signs aimed at educating visitors about the fragility of the alpine zone are present on various peaks in Maine, New Hampshire, Vermont, and New York. Alpine revegetation projects have been carried out at a small scale in the Adirondacks (Ketchledge *et al.* 1985), but may not be occurring presently.

The Green Mountain Club is responsible for a number of conservation activities. Summit caretakers are present on Mt. Mansfield, Camel's Hump, and Mt. Abraham from the end of May to mid-October to educate visitors about alpine habitats and plants. Trail crews work to keep trails well-defined with blazes and cairns, and construct scree walls to protect vegetation. Summit caretakers also use string to mark off areas that are being revegetated, and position wooden signs that ask people to stay off revegetated areas at ground level, where they can be easily seen. Illegal trails and areas used repeatedly for picnicking or view seeking are revegetated. The Green Mountain Club's conservation activities are limited by a lack of funds to pay caretakers and varying regulations for lands owned by different agencies.

## **RESEARCH AND MONITORING**

### **Existing Surveys, Monitoring and Research**

In Maine, there is no regularly scheduled monitoring for *Carex bigelowii*. Plants are surveyed or monitored in New Hampshire and the White Mountain National Forest, but the species is not of high priority. The Appalachian Mountain Club monitors vegetation and rare species around its huts, but *Carex bigelowii* is not a targeted species. In New Hampshire, other surveys in the alpine area are carried out by New England Plant Conservation Program task force members, although those surveys tend to target the rarest alpine species, and by Plant Conservation Volunteers, who are overseen by the New England Wild Flower Society. The Appalachian Trail Conference last conducted surveys within its trail corridor in 1990, and *Carex bigelowii* populations were ranked according to their condition (A. Schori, Appalachian Trail Conference, personal communication). The SVE Panel (2002) mentioned monitoring in Franconia, but did not

specify which group is responsible for the monitoring actions. There appears to be no present research on *Carex bigelowii* in New Hampshire or Maine.

In Vermont, monitoring and surveys are conducted by Vermont Nongame and Natural Heritage Program botanists and by Plant Conservation Volunteers. There is no regular scheduling for surveying activities (B. Popp, Vermont Nongame and Natural Heritage Program, personal communication). There are several long-term study transects that have been set up on Mt. Mansfield to monitor vegetation changes.

In New York, monitoring and surveys are conducted by New York Natural Heritage Program botanists. There have previously been revegetation studies in the alpine zone of the Adirondacks, but there may not be any current studies.

### **Survey Protocol**

Each state's Natural Heritage Program has its own form for surveys, but all the forms are designed to gather the same basic information. Location, population size, habitat, and threats are all important. New Hampshire's old form asked for detailed information on habitat (community type, associated species, slope, aspect, position, soil hydrology), population data (number of ramets or genets if countable, occurrence area, plant health, population structure, phenology, reproductive evidence), and a map, but the newer form is less complex. Forms generally also ask for ratings of four aspects of the element occurrence – quality, condition, viability, and defensibility.

In New Hampshire and Vermont, Plant Conservation Volunteers, as well as state botanists, may survey plants. Plant Conservation Volunteers are trained to identify plants and are then assigned certain occurrences to survey. They may also send in information about new populations that they discover. New England Plant Conservation Program monitoring groups use state Heritage reporting forms and collect GPS data points for each population. New Hampshire occurrences within the Appalachian Trail corridor were surveyed by members of New Hampshire Natural Heritage Bureau. Maine relies on state botanists, as does New York, but both will accept occurrence data from what Maine terms "rogue botanists." Reporting forms are available on-line. Ideally, each field report would contain comprehensive data, but detailed observations are frequently lacking. Thoroughly surveying a population is time-consuming and may not be feasible for large populations. Sometimes a botanist does not realize that a species is of particular interest, and so it is only noted in passing.

The Green Mountain National Forest has a survey protocol that involves photographs along transects at set locations, followed by analysis using a grid overlay. However, time and funding for data analysis are often not available (M. Deller, personal communication).

### **Research Priorities**

Information is needed on the disturbance dynamics of the dry/mesic heath meadow system. Information is needed on the dry/mesic heath meadow system of lower elevation peaks as they may receive heavier recreational impacts (SVE Panel 2002). The patches of alpine communities on the lower elevation peaks are small and isolated, and the percentage of the lower summit areas impacted by recreation is much higher than in the large alpine blocks on the higher summits (S. Lemieux, USFS-White Mountain National Forest, personal communication).

Monitoring of the snowbank/wet meadow/streamside/wet shrub ravine system, and specific sites such as Mt. Washington's Alpine Garden, is needed to determine the effects of winter camping and other recreational uses (SVE Panel 2002). Information is available for compilation (SVE Panel 2002).

There is a need for information regarding the processes that distinguish the different community types within this snowbank/wet meadow/streamside/wet shrub ravine system (SVE Panel 2002). There is also a need for information on the patterns of distribution of communities within the snowbank/wet meadow/streamside/wet shrub ravine system (SVE Panel 2002).

## **REFERENCES**

- Adirondack Park Agency. 2004. Available at: [http://www.apa.state.ny.us/About\\_Park/more\\_park.html](http://www.apa.state.ny.us/About_Park/more_park.html) (Accessed May 5, 2004).
- Billings, W. D. and H. A. Mooney. 1968. The ecology of arctic and alpine plants. *Biological Reviews* 43: 481-529.
- Bliss, L. C. 1963. Alpine plant communities of the Presidential Range, New Hampshire. *Ecology* 44: 678-697.
- Bliss, L. C. 1966. Plant productivity in alpine microenvironments on Mt. Washington, New Hampshire. *Ecological Monographs* 36: 125-155.
- BNAP, Biota of North America Program. 1998. A Synonymized Checklist of the Vascular Flora of the United States, Puerto Rico, and the Virgin Islands. Full Text Index—July, 1998. Available: <http://www.csd1.tamu.edu/FLORA/b98/check98.htm>. (Accessed July 25, 2002).
- Brumback W. E., L. J. Mehrhoff, R. W. Enser, S. C. Gawler, R. G. Popp, P. Somers, D. D. Sperduto, W. D. Countryman, and C. B. Hellquist. 1996. Flora Conservanda: New England. The New England Plant Conservation Program list of plants in need of conservation. *Rhodora* 98: 233-361.
- Callaghan, T. V. 1976. Growth and population dynamics of *Carex bigelowii* in an alpine environment. *Oikos* 27: 402-413.

Damman, A. W. H. 1965. The distribution patterns of northern and southern elements in the flora of Newfoundland. *Rhodora* 67: 363-392.

Edinger, G. J., D. J. Evans, S. Gebauer, T. G. Howard, D. M. Hunt, and A. M. Olivero (editors). 2002. *Ecological Communities of New York State*. Second Edition. A revised and expanded edition of Carol Reschke's *Ecological Communities of New York State*. (Draft for review). New York Natural Heritage Program, New York State Department of Environmental Conservation, Albany, New York. Found online at: [http://www.dec.state.ny.us/website/dfwmr/heritage/Draft\\_ECNY2002.htm](http://www.dec.state.ny.us/website/dfwmr/heritage/Draft_ECNY2002.htm)

Gartner, B. L., F. S. Chapin III, and G. R. Shaver. 1983. Demographic patterns of seedling establishment and growth of native graminoids in an Alaskan tundra disturbance. *Journal of Applied Ecology* 20: 965-980.

Gawler, S. C. 2001. *Natural landscapes of Maine: a classification of vegetated natural communities and ecosystems*. Maine Natural Areas Program, Department of Conservation, Augusta, Maine.

Gleason, H. A. and A. Cronquist. 1991. *Manual of vascular plants of northeastern United States and adjacent Canada*, 2<sup>nd</sup> edition. The New York Botanical Garden, Bronx, New York.

Hadley, E. B. and L. C. Bliss. 1964. Energy relationships of alpine plants of Mt. Washington, New Hampshire. *Ecological Monographs* 34: 331-357.

Jonsson, B. O., I. S. Jónsdóttir, and N. Cronberg. 1996. Clonal diversity and allozyme variation in populations of the arctic sedge *Carex bigelowii* (Cyperaceae). *Journal of Ecology* 84: 449-459.

Ketchledge, E. H. and R. E. Leonard. 1984. A 24-year comparison of the vegetation of an Adirondack mountain summit. *Rhodora* 86: 439-444.

Ketchledge, E. H., R. E. Leonard, N. A. Richards, P. F. Craul, and A. R. Eschner. 1985. *Rehabilitation of alpine vegetation in the Adirondack Mountains of New York State*. USDA Forest Service, Northeastern Forest Experiment Station, Research Paper NE-553.

Kummerow, J. and B. A. Ellis. 1984. Temperature effect on biomass production and root/shoot biomass ratios in two arctic sedges under controlled environmental conditions. *Canadian Journal of Botany* 62: 2150-2153.

Maine Bureau of Parks and Land. 2004. Available at <http://www.state.me.us/doc/parks/programs/prl.html> (Accessed May 5, 2004).

Maine Natural Areas Program (MNAP). 2001. *Element Occurrence Summary*. Maine Department of Conservation, Augusta, Maine, USA.

Martin, A. C., H. S. Zim, and A. L. Nelson. 1951. American wildlife and plants: a guide to wildlife food habits, the use of trees, shrubs, weeds, and herbs by birds and mammals of the United States. McGraw-Hill Book Company, Inc., New York. Dover books also issues a reprint of this title.

McGraw, J. B. and M. C. Vavrek. 1989. The role of buried viable seeds in arctic and alpine plant communities. Pages 91-105 in M. A. Leck, V. T. Parker, and R. L. Simpson, editors. Ecology of Soil Seed Banks. Academic Press, Inc., San Diego, California.

MOBOT, Missouri Botanical Garden web site. 2001. Available at:

<http://mobot.mobot.org/W3T/Search/vast.html>

Murray, D. F. 1994. Floristics, systematics, and the study of arctic vegetation—a commentary. *Journal of Vegetation Science* 5:777-780.

NatureServe: An online encyclopedia of life [web application]. 2001. Version 1.5. Arlington, Virginia. The Association for Biodiversity Information. Available: <http://www.natureserve.org/>. (Accessed: October 22, 2001).

New Hampshire Natural Heritage Inventory (NHNHI). 2001. Element occurrence summaries. DRED-Division of Forests and Lands, Concord, New Hampshire, USA.

New York Natural Heritage Program. 2004. New York State Department of Environmental Conservation. Albany, New York, USA.

Sonesson, M. and T. V. Callaghan. 1991. Strategies of survival in plants of the Fennoscandian tundra. *Arctic* 44: 95-105.

Sperduto, D. 1993. Alpine/subalpine tundra formation of New Hampshire, DRAFT 3/24/93. New Hampshire Natural Heritage Inventory.

Sperduto, D. D. and C. V. Cogbill. 1999. Alpine and subalpine vegetation of the White Mountains, New Hampshire. New Hampshire Natural Heritage Inventory, Concord, New Hampshire. Submitted to the USDA Forest Service, White Mountain National Forest, Laconia, New Hampshire.

St. Hilaire, L. 2002. Literature review of *Carex bigelowii*. Prepared for the White and Green Mountain National Forests.

SVE Panel. 2002. Green Mountain National Forest/White Mountain National Forest species viability evaluation expert panel notes on alpine plants. Panel held: May 13-15, 2002, Rutland, Vermont.

Thompson, E. 1991. Inventory and monitoring of rare plants and natural communities: Mount Abraham, Lincoln, Addison County, Vermont. Report prepared for Vermont

Nongame and Natural Heritage Program and United States Forest Service, Green Mountain National Forest.

Thompson, E. H. and E. R. Sorenson. 2000. Wetland, Woodland, Wildland: A guide to the natural communities of Vermont. Published by The Nature Conservancy and the Vermont Department of Fish and Game. Distributed by University Press of New England, Hanover and London.

Tiffney, W. N., Jr. 1972. Snow cover and the *Diapensia lapponica* habitat in the White Mountains, New Hampshire. *Rhodora* 74:358-377. USFS ref # 9179-32, hard copy with *Diapensia lapponica*.

USDA Forest Service. 1987. Land and Resource Management Plan for the Green Mountain National Forest. Available at Green Mountain National Forest's Supervisor's Office, 231 North Main Street, Rutland, Vermont.

Vavrek, M. C., J. B. McGraw, and C. C. Bennington. 1991. Ecological genetic variation in seed banks. III. Phenotypic and genetic differences between young and old seed populations of *Carex bigelowii*. *Journal of Ecology* 79: 645-662.

Vermont Department of Forests, Parks & Recreation (Vermont Forests, Parks, and Recreation). 2004. Available at: <http://www.state.vt.us/anr/fpr/> (Accessed May 5, 2004).

Vermont Nongame and Natural Heritage Program (VNNHP). 2001. Element Occurrence Summary. Department of Fish and Wildlife, Waterbury, Vermont, USA.

Young, S. M., editor. 1992. New York rare plant status list. New York Natural Heritage Program, New York State Department of Environmental Conservation, Latham, New York.

Zika, P. F. 1993. Historical species loss in the alpine zone of Camels Hump, Vermont. *Bulletin of the Torrey Botanical Club* 120: 73-75.

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## **Appendix I:**

### **An Explanation of Conservation Ranks Used by The Nature Conservancy and Natureserve**

The conservation rank of an element known or assumed to exist within a jurisdiction is designated by a whole number from 1 to 5, preceded by a G (Global), N (National), or S (Subnational) as appropriate. The numbers have the following meaning:

- 1 = critically imperiled
- 2 = imperiled
- 3 = vulnerable to extirpation or extinction
- 4 = apparently secure
- 5 = demonstrably widespread, abundant, and secure.

G1, for example, indicates critical imperilment on a range-wide basis — that is, a great risk of extinction. S1 indicates critical imperilment within a particular state, province, or other subnational jurisdiction — i.e., a great risk of extirpation of the element from that subnation, regardless of its status elsewhere. Species known in an area only from historical records are ranked as either H (possibly extirpated/possibly extinct) or X (presumed extirpated/presumed extinct). Certain other codes, rank variants, and qualifiers are also allowed in order to add information about the element or indicate uncertainty.

Elements that are imperiled or vulnerable everywhere they occur will have a global rank of G1, G2, or G3 and equally high or higher national and subnational ranks (the lower the number, the "higher" the rank, and therefore the conservation priority). On the other hand, it is possible for an element to be rarer or more vulnerable in a given nation or subnation than it is range-wide. In that case, it might be ranked N1, N2, or N3, or S1, S2, or S3 even though its global rank is G4 or G5. The three levels of the ranking system give a more complete picture of the conservation status of a species or community than either a range-wide or local rank by itself. They also make it easier to set appropriate conservation priorities in different places and at different geographic levels. In an effort to balance global and local conservation concerns, global as well as national and subnational (provincial or state) ranks are used to select the elements that should receive priority for research and conservation in a jurisdiction.

Use of standard ranking criteria and definitions makes Natural Heritage ranks comparable across element groups; thus, G1 has the same basic meaning whether applied to a salamander, a moss, or a forest community. Standardization also makes ranks comparable across jurisdictions, which in turn allows scientists to use the national and subnational ranks assigned by local data centers to determine and refine or reaffirm global ranks.

Ranking is a qualitative process: it takes into account several factors, including total number, range, and condition of element occurrences, population size, range extent and area of occupancy, short- and long-term trends in the foregoing factors, threats, environmental specificity, and fragility. These factors function as guidelines rather than arithmetic rules, and the relative weight given to the factors may differ among taxa. In

some states, the taxon may receive a rank of SR (where the element is reported but has not yet been reviewed locally) or SRF (where a false, erroneous report exists and persists in the literature). A rank of S? denotes an uncertain or inexact numeric rank for the taxon at the state level.

Within states, individual occurrences of a taxon are sometimes assigned element occurrence ranks. Element occurrence (EO) ranks, which are an average of four separate evaluations of quality (size and productivity), condition, viability, and defensibility, are included in site descriptions to provide a general indication of site quality. Ranks range from: A (excellent) to D (poor); a rank of E is provided for element occurrences that are extant, but for which information is inadequate to provide a qualitative score. An EO rank of H is provided for sites for which no observations have been made for more than 20 years. An X rank is utilized for sites that are known to be extirpated. Not all EO's have received such ranks in all states, and ranks are not necessarily consistent among states as yet.