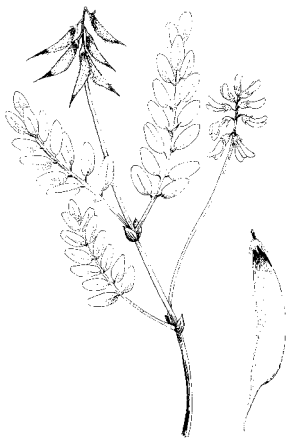
Conservation Assessment for Alpine milkvetch (Astragalus alpinus)

Photo credit: Robert H. Read



Drawing by Dorothy Semple 2003

USDA Forest Service, Eastern Region

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This Conservation Assessment compiles the published and unpublished information on the subject taxon or community; or this document was prepared by another organization and provides information to serve as a Conservation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 310 Wisconsin Avenue, Suite 580 Milwaukee, Wisconsin 53203.

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EXECUTIVE SUMMARY

Alpine milkvetch (*Astragalus alpinus* L.) is designated as a Regional Forester Sensitive Species on the Chequamegon-Nicolet and Superior National Forests in the Eastern Region of the Forest Service (R9). The purpose of this document is to provide the background information needed to prepare a Conservation Approach that will later be incorporated into forest plans as a Conservation Strategy. The Forest Service will then work cooperatively with other agencies or organizations under a formal Conservation Agreement that will include management actions to conserve the species.

Astragalus alpinus is an herbaceous perennial in the legume family. In America, it is represented by two varieties, *A. alpinus* L. var. *alpinus* and *A. alpinus* L. var. *brunetianus* Fern. This assessment will deal mostly with var. *alpinus* as the intent is to assist with management on National Forests in the Midwest. Alpine milkvetch is frequent to common through most of its wide distribution in the western U.S. and Canada but becomes rare at the edges of its range in Wisconsin, Minnesota, New Brunswick, and Utah. There are only four occurrences of this plant in the Midwest, all on National Forest System lands. It is found on gravelly riverbanks and ponds and lakeshores with fluctuating water levels. It is pollinated by bumblebees and reproduces mainly by seed. Threats to the species and its habitat include competition from exotics, shoreline development, and physical damage resulting from recreational use. Alpine milkvetch is listed as *endangered* in Wisconsin and Minnesota at the species level. Since it occurs only on National Forest lands in these states, it receives some protection. Several possible reasons for the scarcity of alpine milkvetch in Wisconsin and Minnesota are discussed and a list of needed research topics is included.

INTRODUCTION

This Conservation Assessment provides a review of currently known information regarding the status and distribution, habitat, life history, and population biology of alpine milkvetch (*Astragalus alpinus*). It is represented by two varieties in North America. *Astragalus alpinus* var. *alpinus* occurs mostly in the West with disjunct populations in the Midwest and Northeast. *Astragalus alpinus* var. *brunetianus* is found in New England and Atlantic Canada (USDA NRCS 2002). This assessment will give special emphasis to the varietal form in Wisconsin and Minnesota and the National Forests on which it occurs. This document would also have applicability in other states on the periphery of alpine milkvetch's range that currently list it or are contemplating listing. It is an administrative assessment only and does not include management direction or management commitment.

The National Forest Management Act and U. S. Forest Service policy require that Forest Service lands be managed to maintain viable populations of all native plant and animal species. A viable population is one that has the estimated numbers and distribution of reproductive individuals to ensure the continued existence of the species throughout its range within a given planning area (FSM 2670.5.22). Forest Service policy on sensitive species (FSM 2670.32) also calls for National Forests to assist states in achieving conservation goals for endemic species and to avoid and minimize impacts to species with viability concerns (USDA 2003). Alpine milkvetch is listed as *endangered* by the states of Minnesota and Wisconsin.

In addition to those species listed as endangered or threatened under the Federal Endangered Species Act, Species of Concern by U. S. Fish and Wildlife Service, or by individual states, the Forest Service also designates species that are sensitive within each region (Regional Forester Sensitive). *Astragalus alpinus* is on the Regional Forester's Sensitive Species List for the Eastern Region (R9) for the two national forests on which it occurs (Chequamegon-Nicolet and Superior). It is not listed by its varietal form although var. *alpinus* is the only variety to occur in these states. The objectives of management for such species are to ensure their continued viability throughout their range on National Forest lands, and to ensure that they do not become threatened or endangered because of Forest Service actions (FSM 2670.22).

NOMENCLATURE AND TAXONOMY

Scientific name: *Astragalus alpinus* L. var. *alpinus* (western variety)
Synonymy:

A. alpinus L. ssp. *alaskansus* Hultén
A. alpinus L. ssp. *arcticus* Hultén
A. astragalinus (Hook.) A. & D. Löve
Atelophragma alpinum (L.) Rydb.
Astragalinus astragalinus (Hook.) A. Löve & D. Löve

Scientific name: *Astragalus alpinus* L. var. *brunetianus* Fern. (eastern variety)
Synonymy: *Astragalus alpinus* L. var. *labradoricus* (DC.) Fern.

Common name: Alpine milkvetch (same common name for both varieties)

Family: Fabaceae (Legume, Pea or Bean family)

Taxon Codes: ASAL7 - *Astragalus alpinus* L. (Natural Resource Conservation Service)
PDFAB0F0D0 - *Astragalus alpinus* L. (Natural Heritage Program)
ASALA4 - *Astragalus alpinus* L. var. *alpinus* (NRCS)
PDFAB0F0D3 - *Astragalus alpinus* L. var. *alpinus* (NHP)
ASALB - *Astragalus alpinus* L. var. *brunetianus* Fern. (NRCS)
PDFAB0F0D2 - *Astragalus alpinus* L. var. *brunetianus* Fern. (NHP)

Astragalus alpinus in North America is divided into two varieties, var. *alpinus*, which is transcontinental, and var. *brunetianus* Fern. in the Northeast (Barneby 1964). This Conservation Assessment will deal mostly with the variety *alpinus* since the emphasis herein is on the Midwest. However, there will be some treatment of var. *brunetianus* because the two varieties overlap in northeastern North America.

Astragalus is the largest genus in the family Fabaceae with over 1500 species in North America and 2500 species world wide (Sanderson & Wojciechowski 1996). *Astragalus alpinus* is considered the "type" species for the genus *Astragalus* (Barneby 1964). Other variants have been described such as *A. arcticus* Bunge and *A. subpolaris* Gontascharov but the characteristics described are feebly correlated and not widely accepted (Gillett et al. 1999). This assessment will follow the respected monographer, Rupert C. Barneby and his 1964 landmark treatment of the genus *Astragalus*.

It is interesting to note that in Wisconsin, Fassett's locoweed (*Oxytropis campestris* var. *chartacea*) has grown along with *Astragalus alpinus* at the two known locations. *Oxytropis,* another large genus in the legume family with over 300 species, is considered the most closely related genus to *Astragalus* (Sanderson & Wojciechowski 1996). Fassett's locoweed is endemic to Wisconsin and federally listed as threatened. Another situation where the two species exist together is in New Brunswick, where *Oxytropis campestris* var. *johannensis* is often found with *A. alpinus* on riverbanks (Blaney 2003).

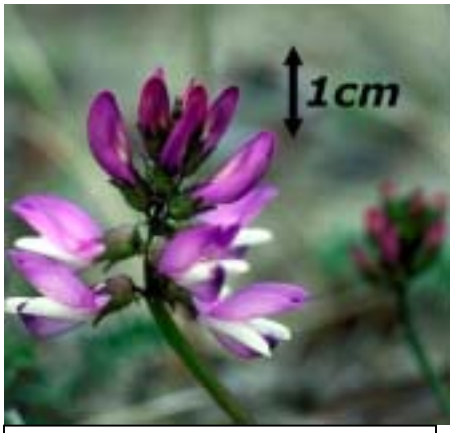

Figure 1 Flower raceme of alpine milkvetch. Note the dark calyx. *(Photo credit: Gillett et al. 1999)*

DESCRIPTION OF SPECIES

Astragalus alpinus L. var. *alpinus* is a low, weak-stemmed perennial with spreading stems arising 1-30 cm from a stout base or caudex (var. *brunetianus* tends to be only slightly taller). Though it has a wide distribution, there is little morphological variability in this species across its range (Barneby 1964). The leaves are compound with small, oblong leaflets that are hairy on both surfaces. The petioles as well as the leaf stalks are also sparsely hairy. The nodding, racemose flowers are white and purple-blue, or sometimes all white, with a definite pea-flower shape (Fig. 1).

In a patch of milkvetch the flowers dominate the scene, for they are numerous and rise above the dainty leaflets (Fig. 3). A distinguishing characteristic is the brown to blackish dark hairs that cover the calyx as well as the sickle-shaped pods. These hairs on var. *alpinus* are loosely spreading unlike var. *brunetianus*, in which they are a little shorter and almost always appressed. The pods are slightly more sickle-shaped in var. *brunetianus*. Other differences between the two varieties are noted below. (Composite descriptions from: Barneby 1964; Gleason & Cronquist 1991; Gillett et al. 1999; UC Davis 2002; Britton & Brown 1970)

Figure 2. Colony of alpine milkvetch showing the prolific flowers and rocky substrate. (Photo credit: Gillett et al. 1999)

Caudex (base): Subterranean, freely branching, or unbranched.
Stem: Glabrous, spreading, 2-25 cm high; arise from the stout caudex.
Leaves: Distributed along the stem in larger plants, opposite or semi-opposite in compact smaller plants. Entire leaf blade 1.5 – 5.5 cm long; 8-20 mm wide.
Leaflets: 15 to 25 leaflets, 3-12 mm (to 1-2 cm) long, oblong or elliptic pinnate veins; with hairs that are equally dense on both surfaces or glabrous above.
Stipules: Sheath the stem (connate); brown or green; leaf-like when young, scale-like with age.
Leaf stalk (scape): Sparsely hairy, 5-35 mm long.
Flowers: Nodding, purplish and white, axillary, pea-like 10-13 mm long in a 2-4 cm raceme that matures from bottom to top. 3-9 (11) flowers per inflorescence. (Flowers are on average a little longer in var. *brunetianus*.)

Flower stalk: 4.5-10 cm, leafless, hairy.
Petals: 5; commonly bicolored, white and purple to bluish, sometimes all white; the uppermost petal, the banner blade, is larger and broadly margined or striped; the two lower join together to form a blunt keel that is commonly darker; the two side petals, or wings are 7-11 mm long.
Ovary: pubescent; ovules 5-10 in number.
Sepals (calyx): tubular, 2 mm broad with 5 triangular lobes about 1mm long; brown to blackish looking due to loosely ascending dark hairs; persists on mature pod.
Stamens: 10.

Carpels (pods): Flat, thin-walled, pendulous, on a small (1.5-4 mm) stipe with the dorsal side grooved; 2.5-4 mm wide, 6-13 mm long with loosely ascending black or mixed black and white hairs which are 0.5 + mm in length. Darkly hairy calyx persists. Unilocular, although the suture is intruded to form a partial partition. Pods are slightly triangular in cross-section. (In var. *brunetianus* hairs of pods shorter – 0.2-0.4 mm and usually appressed; this is the one reliable character difference between the two varieties.)
Seeds: 3-5 up to 8 round seeds, 1-2 mm in diameter, yellowish.
Chromosome number: 2n= 16s

LIFE HISTORY

Reproduction and Ecology

Alpine milkvetch spreads from seed and also to some extent by the freely branching underground caudex (Gleason & Cronquist 1991). The plant initially produces a taproot, giving rise to the ascending or branching caudex (Barneby 1964). Tufts often run together into extensive clonal patches or loosely woven carpets (Smyth 1997; Barneby 1964). Alpine milkvetch is neither a fast growing nor prolifically spreading plant. Bishop and Chapin (1989) observed the natural revegetation of this species and found it to take several years to become well-established in disturbed areas. Reproductive activity starts in the second year of life (Smyth 1997).

Flowering in the Midwest begins in mid April soon after spring thaw and plants continue to produce flowers and ripen fruit through August (WDNR 2002a). It flowers and fruits profusely (Gillett et al. 1999). The flowers mature sequentially from bottom to top of the raceme (Kudo & Molau 1999). That it has a long flowering season is borne out in the Wisconsin populations. In 2000, most were in fruit in late June at one site, while plants

were in full flower in mid July at the other site. Flowering and fruit set may be dependent on favorable climate conditions each year, for no flowers or fruits were seen on July 31 in 1990 at one Wisconsin site (CNNF EO records).

The stature and length of the racemes of alpine milkvetch can vary considerably depending on the environmental conditions. Those luxuriating in moist soil along brooks or in drier soil but in partial shade, tend to be drawn out, broader leaved and more loosely flowered. When found in the harsher habitats of dry, turfy banks and in full sun, the plants are more compact (Barneby 1964). *Astragalus alpinus* is a low-growing perennial which thrives in full sun to partial shade (Ode 2003; Blaney 2002; Wooten 2003). It persists and even thrives in the very harsh habitat described above where other species cannot compete.

The flowers are very sweetly scented and produce abundant nectar. They are mostly pollinated by species of bumblebees (*Bombidae*). In an Arctic pollination study (Mosquin & Martin 1967) no flies were seen on *Astragalus alpinus*, though flies are generally considered important pollinators of arctic plants. According to Kudo and Molau in a 1999 Swedish study, it appears to be an obligate out-crosser, that is, one plant cannot produce seed from its own pollen.

Like most members of the legume family, alpine milkvetch is able to fix nitrogen from the soil with numerous root nodules. Nitrogen fixation in legumous plants involves a symbiotic relationship between a bacterium and the roots of legumes within specialized tumor-like root nodules. Twenty-one strains of two genera of Rhizobium bacteria were found in alpine milkvetch by Gillett and others (1999). It is believed that arctic rhizobia may have evolved along with arctic legumes in their environment (Prevost et. al. 1987). Since temperature limits microbial growth, these particular rhizobia are tolerant of low temperatures and may grow faster in the north than they would in southern, warmer areas (Ek-Jander in Prevost 1987). This leads to a question to be answered by further research: "Is it probable that *A. alpinus* is limited in range due to environmental limits of associated nitrogen-fixing bacteria?" *Astragalus alpinus* root nodules showed no nitrogen fixation in a study in a dry, meadow community in Norway, whereas in a sub-alpine area there was measurable nitrogen fixation (Wielgolaski 1972).

Alpine milkvetch is not known to form mycorrhizal associations with fungi. Root-fungus associations can aid the host to increase nutrient uptake and this would be especially important in some highly stressed environments such as alpine conditions where this plant grows (Treu et al. 1996). In a study of plants in Denali National Park and Preserve in central Alaska, where alpine milkvetch is very common (Carlson 2003), there were no mycorrhizal associations found on *A. alpinus* (Treu et al. 1996). This leads one to interpret that colonization of this species is <u>not</u> dependent on the seed finding suitable fungal associations.

Dispersal

The small seeds ripen in late summer and are ejected in a non-explosive manner (van der Pijl 1982 in Lind 1986) and would then be dispersed by water, wind or animal. According to Bishop and Chapin (1989), the seeds of legumes including alpine milkvetch are heavy and do not rely on wind for dispersal. Proximity to a seed source then would be important

in expansion of populations. Other authors, however, say that the seeds are dispersed by wind (Barneby 1964; Lind 1986). The flower stem elongates with maturity, carrying the pods higher than the flowers (Fig. 2). The seeds would then be more exposed to wind to scatter them longer distances, especially across snow and ice. Seeds blown over the surface of the snow collect at the bases of cliffs or talus slopes (Lind 1986). The Midwest populations today are surrounded by forest (WI & MN EO records), which would make it difficult for the species to spread to other lakes by wind. This could, however, be how alpine milkvetch was able to colonize here during the periglacial periods (Lind 1986).

The isolated populations in the Midwest and Northeast (for both varieties of *Astragalus*) limit the spread of this species. In the west, many populations occur along gravelly riverbanks (Gleason & Cronquist 1991) so seed can spread at least downriver. Sites in the Midwest are on small lakes with widely fluctuating water levels. In some years, seed may wash to other parts of the lakeshore but are restricted to that lake.

Alpine milkvetch seed may also be spread by animals or birds ingesting the seed. Predatory birds could ingest rodents that ate seed. These raptors would lack the digestive enzymes to break down the seed in the stomach of their prey (from comments by H. Iltis in Lind 1986). A researcher in the Canadian Arctic Archipelago made an interesting observation that *A. alpinus* was one of several species rarely seen except on owl perches. These perches are hills of food wastes built up around rocks upon which the owls sit to eat prey or wait for it to come along. It is possible that the seeds were ingested by prey species elsewhere and deposited by the owl in its wastes (Lind 1986). Botanist Mark Leach noted milkvetch growing on an old lodge of a muskrat (*Ondatra zibethicus*) in Wisconsin (CNNF EO records 1990). Perhaps the muskrat transported seed along with vegetation to its lodge.

Legume seeds have a hard seed coat, and propagation studies in Canada indicate that the seed needs to be scarified in order to break dormancy (Smyth 1997). This would happen naturally in its rocky, sandy substrate where wave and ice actions scratch the seed coat (USFWS 1991).

The seed produced builds up in a buried seed bank, which may be an important survival strategy. Legume seeds are known for remaining viable for a long period of time. Porsild and others (1967 in USFWS 1991) were able to grow healthy plants from arctic lupine (*Lupinus arcticus*) seeds that were 10,000 years old. Long-lived seed and a large seed bank would benefit a species in an environment where there is a high probability that suitable habitat would only be available periodically (Ralphs & Cronin in USFWS 1991). In the Midwest lakeshore populations this periodic habitat would occur during years of drought and low water levels (USFWS 1991).

HABITAT

Range-wide

The habitat of *Astragalus alpinus* throughout its range includes open, cool, mesic to dry-mesic sites on heavily scoured river terraces, lake shores, rock outcrops, turfy hillside barrens, mountain meadows, and tundra (UC Davis 2002, Gleason & Cronquist 1991). It is found on well or moderately well-drained, gravel, sand, or rock but often where there is moisture close to the surface (Wooten 2003). It grows in these habitats from near sea level

in the far north to as high as 3500 meters in the Colorado Rocky Mountains (Barneby 1964). It can be fairly common on the sites where it occurs. In the provinces of Atlantic Canada it is restricted to highly calcareous gravel and rock (Blaney 2003). Most of the literature does not mention a requirement for calcareous conditions. Barneby (1964) states that it does not have any preference to rock, but is perhaps more abundant on limestone. Cultivated legumes generally require a pH range around neutral (6-8.7).

Site Specific

The sites in Wisconsin (elevation 375 meters above sea level) occur on seepage lakes (no inlet or outlet) that rely on rain and groundwater to feed the lake. The water is moderately hard with total alkalinity of 40-60 ppm (Reinecke 2003). The soil in this region is generally considered neutral (Albert 1995), but no specific soil tests have been done on the site. The shoreline at these sites is mostly gravel-sized rock (0.5-2 cm) and some larger cobble and sand. These lakes have extensive water level fluctuations with short term, seasonal fluctuations superimposed on longer term cycles (Lind 1986). The plants are growing at one of the old high waterlines between 25 and 50 cm above the current water level of the fluctuating shore (personal observation and CNNF EO records). Bands of vegetation on the shoreline, along with stands of dead and living jack pine (*Pinus banksiana*), occur in concentric zones (Fig. 4). This is evidence of the dramatic fluctuation of the water levels. The area beyond the open beach is mixed forest dominated by jack pine, white pine (*P. strobus*), red pine (*P. resinosa*), trembling aspen (*Populus tremuloides*), red oak (*Quercus rubra*), paper birch (*Betula papyrifera*) and red maple (*Acer rubrum*).

Habitat associates in Wisconsin include: *Astragalus canadensis, Panicum lindheimeri, Panicum* sp., *Eupatorium perfoliatum, Lycopus americanus, Sisyrinchium* sp., *Hieracium aurantiacum, Potentilla anserina, P. norvegica, Polygonum* sp., *Carex scoparia, C. viridula, Juncus dudleyi, Scirpus validus, Lysymachia* sp. (native), *Verbena hastata, Oxytropis campestris* var. *chartacea, Botrychium multifidum,* and *Trifolium repens*. *Pinus banksiana, P. strobus* seedlings, and *Salix* species are found above high water (WI EO records).

Figure 3. Habitat for Alpine milkvetch in Wisconsin, showing vegetation Zone and dead trees caused by past flooding.
(Photo credit: D. Ambrose)

Habitat for the occurrences in Minnesota is very similar to Wisconsin. The plants grow on a cobbly, gravelly beach and just up into the sparse ground flora of the dry-mesic mature jack pine forest. The densest parts of the populations were in the more open and recently disturbed beach habitat of two small lakes (4 hectares and 7 hectares). Populations fluctuate widely from year to year; documented variation ranges from five stunted small clumps one year to thousands in a later year (USDA 20002.)

Habitat associates in Minnesota include: Deschampsia sp., Lysymachia ciliata, Senecio pauperculus, Aster simplex, Euthamia graminifolia, Conyza canadensis, Erigeron strigosus, and Carex sp. Blueberry and Amelanchier sp. are found nearby (MN EO records). Two other rare plant species are found in this general area: Littorella uniflora and Listera auriculata, both listed as Regional Forester Sensitive for the Superior National Forest.

An interesting phenomenon has been noted at both the Wisconsin and Minnesota sites. The lakes appear to have a complicated hydrology where the water level may actually rise during dry periods when other lakes are lowering (USDA 2000; personal observation). This difference is due to the lake's depth, bottom configuration, and relationship with the ground and surface water. Some lakes may be perched on a clay layer while one nearby is connected with the aquifer and influenced by changes in the groundwater (Hansen 2003). The Minnesota site appears to be a system of four small ponds within a 100 hectare area that are connected by the aquifer but not the surface water.

In Utah, where *Astragalus alpinus* is also listed rare, the plants occur on moist hillsides or rich humus of aspen meadows, along creeks under a fir overstory, or on rocky soil on north-facing slopes in alpine meadows (UT EO data 2003).

Ecological Classification (Bailey 1994) for the United States range of *Astragalus alpinus*

Humid Temperate Domain
Warm Continental Division
Laurentian Mixed Forest Province (probably includes Canada NE)
Western Superior Section
Northern Superior Uplands Section
Aroostook Hills & Lowlands Section (var. *brunetianus*)
Marine Regime Mountains Division (Alaska)

Dry Domain
Temperate Steppe Regime Mountains
Southern Rocky Mountain Steppe - Open Woodland -Coniferous Forest – Alpine Meadow Province
Middle Rocky Mountain Steppe – Coniferous Forest – Alpine Meadow Province
Northern Rocky Mountain Forest –Steppe – Coniferous Forest –Alpine Meadow Province
Black Hills Coniferous Forest Province

Polar Domain
Tundra Division
Tundra Regime Mountains
Subarctic Division
Subarctic Regime Mountains

NRCS Wetland Indicator Status

According to the Natural Resource Conservation Service (NRCS) system for wetland classification, alpine milkvetch occurs in Region 3, which includes Wisconsin and Minnesota (USDA NRCS 2001). In this region it is a *facultative* wetland indicator, meaning it is equally likely to occur in wetlands or in non-wetlands and the probability of its occurring in a wetland is between 34 and 66 percent. It also occurs in Regions 1, 4, 7, 8, 9 and A. In Region 1, which includes Maine, New Hampshire, and Vermont, it is a facultative upland indicator, meaning it usually occurs in non-wetlands. In region 9, which includes those occurrences in Idaho, Oregon, western Montana, Washington, and western Wyoming, *A. alpinus* is slightly less likely to be found in wetlands (closer to 34% of the time).

RANGE-WIDE DISTRIBUTION

Astragalus alpinus is circumboreal, considering the aggregate of all varieties and subspecies. It extends from the coasts of Alaska across Canada to Newfoundland Island (to about 75° N latitude), south to New England, northern Wisconsin, South Dakota, and in the western mountains to Nevada and northern New Mexico. In the Old World, the species ranges across Greenland and northern Eurasia and south in the mountains of Siberia (Alverson & Solheim 1981).

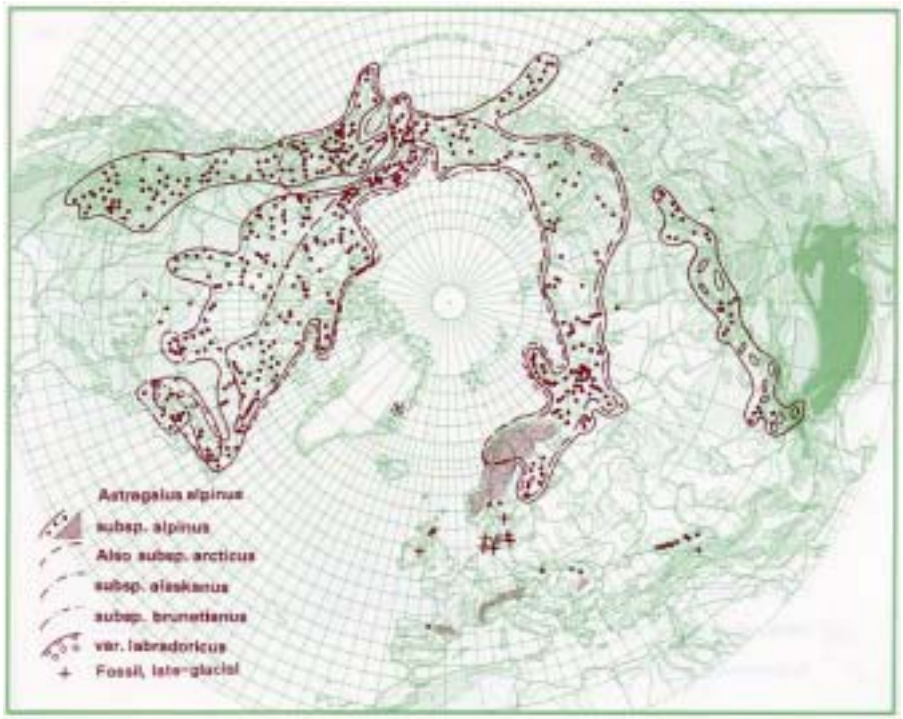

Figure 4. Map showing worldwide range of *A. alpinus. (Source: Naturhistoriska riksmuseet 1997)*

Astragalus alpinus var. *alpinus* is the only variety in the American West. Its range extends to sparse populations in Minnesota, Wisconsin, and Newfoundland Island. It is fairly common in subalpine and alpine areas of the Rocky Mountains and the Black Hills of South Dakota (Ode 2003), becoming less common on the edge of its range in Utah and northern New Mexico. In Washington, it common in the eastern Cascades but rarely collected west of the Cascade crest (Lesher 2003; Taylor & Douglas 1978), and while it is

common in the mountains of central Idaho, it does not occur in the northern part of that state (Manusco 2003).

Barneby (1964) describes *Astragalus alpinus* var. *alpinus* as disjunct in northeast Nevada, northeast Oregon, northeast Washington, the Black Hills, the Cypress Hills of southwest Manitoba, southeast Saskatchewan, and northern Wisconsin. It is widespread and abundant in Ontario in the Hudson and James Bay drainages, extending south to Lake Superior and to the north of Algonquin Park, becoming very rare and local south of the Hudson Bay lowlands (Oldham 2003). It also occurs as far east as Newfoundland Island and Labrador (Blaney 2003).

Figure 5. The range of *Astragalus alpinus* var. *alpinus* in North America *(Compiled from Barneby 1964; Gillett et al. 1999; Lind 1986; Ode 2003; Blaney 2003; Oldham 2003; Manusco 2003; Carlson 2003)*

Variety *brunetianus* only occurs in northeastern North America. There are records from southeastern Quebec, New Brunswick, Newfoundland Island, Labrador, and northern Maine (Blaney 2003; Barneby 1964). It is thought to be extirpated from a few sites along the Connecticut River in New Hampshire and Vermont (Pinkham 2003; Cairns 2003). Numerous plants were collected in New Hampshire in the late 1800's to 1926 at two sites in Sullivan and Grafton counties. Another specimen from Vermont was collected in 1896. Biologists for the New Hampshire Natural Heritage Bureau assume that the habitat where these specimens were collected still exists although the plants have not been seen in recent years (Cairns 2003).

Below are maps that compare the general range of *Astragalus alpinus* var. *alpinus* and var. *brunetianus* in North America (NatureServe 2002).

Astragalus alpinus var. *alpinus*
alpine milkvetch

Astragalus alpinus var. *brunetianus*
alpine milkvetch

STATE AND NATIONAL FOREST DISTRIBUTION

In Wisconsin the species was long ascribed to only one location in Bayfield County, in 1926 by Griscom and in 1936 by Fassett (Alverson & Solheim 1981). No other populations were found until 1992, when Forest Service botanists Donn Ambrose and Kristin Westad discovered it along with *Oxytropis campestris* var. *chartacea* on a different lake less that one kilometer from the first (CNNF EO records). Since then several other suitable lakeshore sites have been searched for both species with no success. See the Research and Monitoring section for further discussion.

In Minnesota *Astragalus alpinus* was first recorded in Lake County in 1991 about 35 kilometers from Lake Superior (USDA 2000). This is the only known occurrence in the state and is either one or two separate sites depending on how one interprets an occurrence. The site can be described as a series of small lakes in close proximity, separated by dry land, but connected by the groundwater. Milkvetch has been found on the shores of two of these. The Superior National Forest ecologists consider it to be one occurrence (Greenlee 2002; Shedd 2003) but the state lists it as two (MN EO Records). This assessment will consider there to be two occurrences. The plant colonies were more abundant on the smaller lake (4 hectares) than the larger (7 hectares) (Gerdes 2003). Minnesota's only sites are in the far north. There are, however, pollen records of the species at Wolf Creek in the central part of the state discovered by Birks in 1976 (Lind 1986). About 12,000 years ago this area would have been ice-free, treeless tundra, covered by pioneer plants while the more northern sites were still covered by ice. The area was soon colonized by spruce trees which may have eliminated the pioneer plants (Birks 1976).

The occurrence of this species in the Midwest may be related to the area's glacial history. The populations here may have thrived on the periglacial tundra in ice-free areas (refugia) and were able to recolonize the open habitats as the last glaciers retreated over 10,000 years ago. Viable seed could have survived frozen for a time or have been carried on glacial meltwater. The newly exposed glaciated areas would have been free of competition and

the habitat suited to this pioneer species. The Wisconsin location exists on what would have been the edge of Glacial Lake Grantsburg (Lind 1986; USFWS 1991).

It is unknown why alpine milkvetch has remained in small, isolated populations (see map appendix A). Its mode or method of migration may have been altered in the past as suggested by Dobberpuhl for Fassett's locoweed (USFWS 1991). Or perhaps it is just a chance rare occurrence here and has always existed in isolated patches. Lakeshore development may have wiped out populations even before they could be discovered. June Dobberpuhl, a botanist for Wisconsin Department of Natural Resources, stated that many lakes in the state appear to have suitable habitat, but to her knowledge they have never been surveyed (Spickerman 2003). It has also been speculated that it is a more recent introduction by mammal, bird, or human. This would be difficult to prove, but only one rare event may be responsible for a plant's distribution in some areas (Carlquist 1982).

RANGE WIDE STATUS

There is some confusion in the listing of alpine milkvetch because some states like Wisconsin and Minnesota list it as rare at the species level and do not use the varietal name. This author brought this to the attention of the botanist for Wisconsin's Bureau of Endangered Resources, who will consider making the name change to var. *alpinus* with the next major list revision (Anderson 2003). NatureServe 2002 lists *Astragalus alpinus* var. *alpinus* as "reported" in these two states (which could lead one to assume it is not rare there since this is also how they list species that could be common). The Eastern Region (R9) of the Forest Service also lists simply *Astragalus alpinus.* The regional rare species coordinator is aware of this problem.

Listed below and in Table 1 is the official status of both varieties of *Astragalus alpinus* with respect to federal, state or province, and private agencies. Rank is listed in bold face type followed by rank definition (NatureServe 2002).

U.S. Fish and Wildlife Service: **none** for species or its varieties (USFWS 2003)
The Global Heritage Status rank:

A. alpinus: **G5** var. *alpinus*: **G5T5** var. *brunetianus*: **G5T2T4**

Definition of G5: Secure – Common, widespread, and abundant (although it may be rare in parts of its range, particularly on the periphery). Not vulnerable in most of its range. Typically with considerably more than 100 occurrences and more than 10,000 individuals.

T-rank indicates the status of the infraspecific taxa (the variety in this case)
Definition of T5: same definition as the G-rank above
Definition of T2T4: Rank of variety is uncertain, ranging between T2: Imperiled (6-20 occurrences) and T4: Apparently secure (more than 100 occurrences)

The National Heritage Status rank:

A. alpinus and Var. *alpinus***: N?** (30 Jul 1993) Var. *brunetianus*: **N2** (01 Feb 1998)

Definition of N?: Unranked – Nation or subnation rank not yet assessed.

Definition of N2: Imperiled globally because of rarity or because of some factor(s) making it very vulnerable to extinction. Typically 6 to 20 occurrences or few remaining individuals (1,000 to 3,000) or acres (2,000 to 10,000).

The National Heritage Status rank (Canada): *A. alpinus* and Var. *alpinus*: **N?** (09 Aug 1993) Var. brunetianus: **N2N4** (01 Feb 1998)

Definition of N?: Unranked – Nation or subnation rank not yet assessed.

Definition of N2N4: Rank of variety is uncertain, ranging between N2: Imperiled (6-20 occurrences) and N4: Apparently secure (more than 100 occurrences)

U.S. Forest Service (Region 9): **Regional Forester Sensitive** for Chequamegon-Nicolet and Superior National Forests (currently listed as *Astragalus alpinus*, no variety indicated.)

Definition - The Regional Forester has identified it as a species for which viability is a concern as evidenced by: a) significant current or predicted downward trends in population numbers or density, and/or b) significant current or predicted downward trends in habitat capability that would reduce its existing distribution (FSM 2670.5.19).

Sub-national ranks (Table 1): [All sub-national (state/provincial) ranking definitions are from NatureServe 2003 National Heritage Program]

Definitions:

S1 – Critically imperiled in the sub-nation because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extirpation from the sub-nation.

S2 – Imperiled because of rarity (6-20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extirpation from the sub-nation.

S3 – Vulnerable in the sub-nation either because rare and uncommon, or found only in a restricted range (even if abundant at some locations), or because of other factors making it vulnerable to extirpation. Typically 21 to 100 occurrences.

S4 – Uncommon but not rare, and usually widespread in the sub-nation. Possible cause of long-term concern. Usually more than 100 occurrences and more than 10,000 individuals.

S5 – Secure, Demonstrably widespread, abundant, and secure in the sub-nation and essentially ineradicable under present conditions.

SX – Extirpated, element is believed to be extirpated from the subnational unit.

S? – Rank not yet assessed.

SR – Reported to occur in sub-nation but without a basis for either accepting or rejecting the report, or the report not yet reviewed locally. Some of these are very recent discoveries for which the program hasn't yet received first-hand information: others are old, obscure reports.

Table 1. Conservation status of *Astragalus alpinus* varieties in U.S. states and Canadian provinces and number of Element Occurrences (EOs).

Status	State/Province	# of EOs var. alpinus	# of EOs var. brunetianus
S1	Wisconsin - Endangered	2 (on NF)	
	Minnesota - Endangered	2 (on NF)	
	Utah – not state listed	4	
S1S2	Newfoundland Is.	6	10
S3	Maine - Special concern		37
	New Brunswick		17 (40)*
S3S5	Labrador	common	see SR
S4	Wyoming	common	
SX	New Hampshire		extirpated
	Vermont		extirpated
S?	British Columbia	common	
	Quebec	common	unknown
SR	Alaska	common	
	Colorado	common	
	Idaho	common	
	Montana	common	
	Nevada	common	
	New Mexico	common	
	Oregon	common	
	South Dakota	common**	
	Washington	common	
	Alberta	common	
	Arctic Islands	common	
	Manitoba	common	
	NW Territories	common	
	Nunavut	common	
	Ontario	common	
	Quebec	common	
	Saskatchewan	common?	
	Yukon	common	
	Labrador		reported

*For New Brunswick the number of EOs varies depending on how an occurrence is described (Blaney 2003).
** Common but restricted to the Black Hills.

POPULATION BIOLOGY AND VIABILITY

The populations at the Midwest sites are small but have persisted for a very long time, perhaps since the last glacier retreated (Lind 1986). It is unknown how many populations there were at any time in history or whether any have been lost. This makes it difficult to establish a viability outcome for alpine milkvetch in the Midwest (USDA 2000). It may well be able to survive here, barring any extreme alteration of the habitat as outlined in the threats section below.

The Minnesota sites were first discovered in 1991 by Steve Wilson. They have been checked every year or so by National Forest biologists. The *Astragalus alpinus* plants are scattered along the cobbly perimeter of two small lakes up to the edge of the jack pine forest. Number of individuals can vary considerably from year to year. Often there are only a few adult flowering plants and some tiny juveniles, but in a later year there could be a large patch of robust plants. One year, National Forest biologists estimated thousands of plants. That particular year the water was very high, flooding many of the plants, their flowers sticking above the water (Shedd 2003). As mentioned before the plant seems to be adapted to this, indeed it may even require this periodic flooding. These lakes were once used by the state for rearing fish, but biologists are unsure what affect this may have had (Shedd 2003).

Both Wisconsin occurrences consist of between 1-5 small patches at various points along the lakeshores. These patches range between 0.5-3 square meters in area usually in a narrow band. Numbers of individuals varies greatly at each patch from between 20 to several hundred although numbers were only estimated (CNNF EO records 1990-2000). When botanists surveyed one site in the early 1980s they had an initial impression of relatively few plants at one patch. This was soon dispelled when they counted 24 adult and 493 immature plants. They speculate that past estimates of population size for other sites on this same lake were likely underestimates unless careful searches were made (Alverson & Solheim 1981).

THREATS

Threats to the viability of *Astragalus alpinus* include habitat loss due to development of shoreline, mechanical damage, competition by non-native invasive plants, and hydrologic changes. Activities that significantly alter the habitat can destroy present populations and remove options for future colonization. *None of the known populations in Wisconsin or Minnesota have been lost since they were originally discovered.* Individual clumps of alpine milkvetch have disappeared in the past 6 years from one of the Wisconsin sites (personal observation). Perhaps this is due to seasonal variation in climate, recent flooding, or encroachment of competing vegetation. Monitoring will determine whether they re-establish at these locations or elsewhere on the lake. The Minnesota sites have experienced a demonstrable waning and waxing of the population over 10 years, so short-term monitoring has shown that it re-establishes itself (Shedd 2003).

PRESENT OR THREATENED RISKS TO HABITAT

Shoreline Development and Management

Lakeshore development is increasing, and with it comes the potential for habitat loss. Property owners can wipe out populations by raking, mowing, herbicide use, infilling for beaches, and grading. The shorelines in front of several homes at one of the Wisconsin lakes have been raked (personal observation). Landowners trying to establish a grass lawn may apply fertilizer which can cause enrichment of the shoreline, altering the natural habitat. The loss of the wooded buffer surrounding a lake by construction or clearcutting can increase overland sediment-laden runoff (USDA 1991). Herbicide applied to lawns and gardens can drift to other areas.

While zoning restricts some activity, there is little monitoring of shoreline alteration. Education of landowners and increased awareness of the benefits of naturally landscaped lakeshores is needed. It is quite possible that past development activities have already eliminated populations of alpine milkvetch in the Midwest and Northeast. All of the land encompassing the Minnesota occurrences is federally owned where National Forest management guidelines offer protection for rare species. One of the Wisconsin sites occurs on an 85 hectare lake with only about a third of the shoreline in federal ownership. It is unknown how many occurrences may be on this private land. Wisconsin's other site is a small, 4 hectare lake with 99% federal land.

Current Wisconsin state law does not restrict private landowners from "taking" state endangered or threatened plants on their own land. "Taking" is described as: to cut, root up, sever, injure, or carry away a listed plant (WDNR 2003b). On public land, however, these plants are protected except for certain circumstances. Lakes are considered public land up to the ordinary high water mark so populations may fall under state jurisdiction. The state is making an effort to encourage landowners to maintain a natural shoreline and only clear enough vegetation to gain an access to open water (Kearns 2003).

Recreational damage

The threat of mechanical damage to plants and habitat is great. Increased use of all terrain vehicles (ATVs) could harm populations, according to the Maine Department of Conservation (2003). Expert botanists at a Population Viability Assessment workshop for the Superior National Forest in 2000 cited ATVs as a threat to this species, especially where trails are situated near habitat (USDA 2000). Minnesota botanists have seen rutted tire tracks through one alpine milkvetch population in the early 1990s (USDA 2000; Gerdes 2003). The Forest Service set up a barrier and information sign soon after, and no ATV use of the site was observed in 2002 (Greenlee 2003). The site is visited by Forest biologists every year or so (Shedd 2003).

One of the Wisconsin lakeshores that support alpine milkvetch has received ATV activity in the past, but this diminished when the Forest Service erected a barrier and posted signs in 1995 (personal observation). ATV access to this and the second site is still possible though no damage has been noted since 1995. The second site enjoys a bit more protection because it is less accessible to the public. The closest road is gated and the current private

landowners who use this road are in favor of keeping the gate in place. Both sites are monitored at least every other year.

Competition from non-native invasive species

Natural systems invaded by non-native plants become less species-rich, threatening biodiversity and habitat quality (FICMNEW 1998). In an experiment with planting grass on disturbed alluvial sites in Alaska, areas planted with grasses inhibited or delayed the establishment and growth of native plants including *Astragalus alpinus*. These grasses competed for nutrients (Densmore 1991). Bishop and Chapin (1989) studied re-colonization of disturbed areas they refer to as "gravel pads" in Alaska. They describe interference from non-native grasses as a limitation to colonization of these disturbed areas.

Non-native species such as Canada thistle (*Cirsium arvense*), purple loosestrife (*Lythrum salicaria*), and spotted knapweed (*Centaurea biebersteinii*) occur all over northern Wisconsin and Minnesota and have the potential to crowd out native species on these open, naturally disturbed habitats (FICMNEW 1998). Purple loosestrife occurs in moist soil sites such as riverbanks and lakeshores and can tolerate dry conditions (WDNR 2002b). Although a high water table limits root development in Canada thistle, it sometimes occurs in wetlands where water levels fluctuate (WDNR 2003a). Some non-native species may be less able to compete in these sites when water levels are high, but this effect needs to be studied.

Changing Hydrology

Gravel riverbanks are a dominant habitat type in much of this species' range. Damming of rivers has destroyed populations of alpine milkvetch in New Brunswick by eliminating the beach features (Blaney 2002). There were occurrences along the Connecticut River bordering Vermont and New Hampshire that may have been extirpated as a result of hydro projects. Suitable habitat still exists, but the species has not reappeared even though Vermont is well botanized (Popp 2003).

As stated earlier, it appears at least for the eastern populations that water right under the soil surface may be important to this species. High capacity wells for agricultural irrigation or municipal use can affect lake and stream levels by lowering the aquifer if the well's 'area of influence' is near the water body. Wells within 0.25 mile of a stream can have a potential effect on stream flow (ORST 2003). The seepage lakes that support alpine milkvetch in the Midwest are in a very vulnerable situation due to their connection with the aquifer (Hansen 2003). However, none are situated near a large municipality, nor is there any agriculture in the area. Whether or not a large number of private wells around a lake could affect the water table is a question worthy of monitoring.

Disease or Predation

The small seeds ripen in late summer and are most likely a food source for wildlife. Deer and other small mammals may browse on *Astragalus alpinus* vegetation since legumes are high in nutrients. This should be an important issue for monitoring given the high deer populations in Wisconsin and Minnesota. The immediate area around the Minnesota population is an historic deer yard (Gerdes 2002). The larvae of several dipteran and lepidopteran species are known to prey on the seeds (Kudo & Molau 1999). In Finland, several butterfly and moth larvae are known to feed on this plant including arctic blue (*Agriades glandon*), alpine blue (*Albulina orbitulus*), and mountain burnet (*Zygaena exulans*) (Funet 2003).

Habitat Decline and Climate Change

As its name implies, alpine milkvetch is mainly a plant of cool, mountainous habitats. The lakeshore and streambank areas in the east that mimic these conditions are limited. Habitat is declining on the edge of the range of *A. alpinus* (Maine Department of Conservation 1999). It is a chamaephyte, or low-growing perennial (Given & Soper 1981), suggesting that snow cover is essential for winter protection of the herb. In the past 10 years or so the Midwest has experienced milder winters with years of less than average snow accumulation (NCDC 2002; personal observation). Whether this has had or will have an impact on alpine milkvetch could be determined by long term monitoring.

Various models have tried to predict the effects of global climate change, and some hypothesize that "mid-latitude to high-latitude regions in the Northern Hemisphere-areas such as the Continental United States, Canada, and Siberia-will likely warm the most" (Weier 2002). Higher average temperatures may or may not have significant effects overall on species like alpine milkvetch that have relatively large geographical ranges. However, a slight increase in temperature may be critical at a local level where milkvetch is on the southern edge of its range. In addition to higher temperature, changes in precipitation patterns and other environmental alterations connected with global warming could be even more important. In past periods of climate change species migrated or were able to recolonize following long-term glaciation and post-glacial warming (Lind 1986). With a more rapid change, this may not be possible.

Other Natural or Human Factors

Collecting

Collecting for medicinal or other uses could become another threat to the species. Alpine milkvetch is an attractive plant and has been suggested for use as groundcover (Frontier 2003). It is not known if this plant has ever been harvested for garden use in the Midwest. Some members of the genus *Astragalus* have known medicinal properties. *Astragalus membranaceus*, a native of Asia, is recommended by herbalists to strengthen resistance to viruses (Ross-Flanigan 2000). It is also used as a tonic for spleen and lung infections and for immune disorders, inflammation and cardiac disorders (McKenna et al. 2002). It is unknown if the species *A. alpinus* is harvested for any medicinal use in North America.

Small, Isolated Populations

The colonies of alpine milkvetch in the Midwest are small and isolated from the main part of the range. The Wisconsin sites are about 125 kilometers from the sites in Minnesota which are over 220 kilometers from the closest site in Ontario near Thunder Bay. Studies on lake sediments to verify the age of seeds and pollen of this species would indicate how long it has persisted here. Experts at the Population Viability Assessment speculated that it may be able to persist indefinitely in these small colonies (USDA 2000). However, if an isolated population is destroyed it may not be able to recolonize.

SUMMARY OF LAND OWNERSHIP & EXISTING HABITAT PROTECTION

The four known occurrences of alpine milkvetch in the Midwest are all on National Forest land (although there is habitat and perhaps plants on the private portions of one Wisconsin site). Both National Forests have management standards to protect rare species. Long-term viability of alpine milkvetch at the edge of its range may be dependent upon maintaining habitat on public lands. Although private landowners may be sympathetic to the survival of rare species, they may be under no obligation to protect state listed plants on their own land. It is crucial, therefore, to create and maintain havens for rare species on public land.

There are two known occurrences of alpine milkvetch on the Chequamegon-Nicolet National Forest in Wisconsin. There is no special land designation to protect these occurrences. The Forest Service put up a barrier post and a sign at a boat landing to stop ATV use of shoreline at one of the two sites. The other Wisconsin site is somewhat protected because a private landowner controls access to the lake by a gated road. Projects such as nearby logging or tree drops to enhance fish habitat on both National Forests are studied prior to implementation. These biological evaluations gauge the effects of projects on rare species. On the Superior National Forest in Northern Minnesota, the area with the two known occurrences has been identified as a potential Research Natural Area for their next Forest Plan revision (Greenlee 2003).

The National Forests in Wisconsin and Minnesota follow “Forestry Best Management Practices for Water Quality” guide. Because *A. alpinus* is often found on shorelines in the Midwest, there is a good chance that undiscovered colonies would fall within riparian protection zones typically used around lakes and therefore be protected from logging activity disturbance. The riparian management zone described for protection begins at the ordinary high water mark and continues landward a minimum of 100 feet. Following this guide, within this zone equipment would not be operated, slash would not be piled and long-lived tree species would be promoted (Holaday 1995).

This species is not known on any other National Forest in the Eastern Region. There are historical records of *A. alpinus* var. *brunetianus* in both Vermont and New Hampshire, but these populations are believed to be extirpated. Much of the White Mountain National Forest lies in Grafton County, New Hampshire, where historic occurrences of *A. alpinus* var. *brunetianus* are documented, but none of these were on National Forest lands (Williams 2003). This species was not considered for Regional Forester Sensitive listing on the White Mountain National Forest due to its extirpated status in the state (Lemieux

2003). Alpine milkvetch has never been recorded on the Green Mountain National Forest (Deller 2003). None of the three historic populations in Vermont were likely to have been from there (Popp 2003). Alpine milkvetch was dropped early in the process of Green Mountain's species viability evaluation, so it will not be listed as Regional Forester Sensitive there (Burbank 2003).

RESEARCH AND MONITORING

The populations of *A. alpinus* on the Superior and Chequamegon-Nicolet National Forests have been visited by botanists at least every other year since 1991 (Shedd 2003; Spickerman 2003; personal observation). Presence or absence of the colonies was noted as well as population estimates. Human use was observed as well as current water level and presence of non-native invasive plants. Field notes are kept on file at the Forest Supervisor's offices.

Alpine milkvetch is suitable for revegetation of subalpine and alpine disturbed soils. Smyth, (1997) used several legume species including *A. alpinus* in an experiment to reclaim unamended coal mine spoils in Canada. Seeds were collected from wild populations, cleaned and scarified (scratched with knife blade), grown in soil medium and allowed one over-wintering period on the site. They were then transplanted as seedlings in the coarse siltstone and sandstone mine spoils. *Astragalus alpinus* was one of the three most successful species, making it apparently suitable for use in revegetation with native species. Other researchers in Alberta attempted seedling transplant in oil-sands tailings with no success for *A. alpinus* (Li & Fung 1998). They attributed this to high levels of salt in these oil-sands. In another study on gravelly disturbed sites in Alaska, natural establishment of this species was successful but slow, taking over four years to become well-established (Bishop & Chapin 1989). The implications for the Midwest will be reflected in the Research and Monitoring section later.

Alpine milkvetch has been used as groundcover in gardens. It is sold as seed and according to one gardening web site, should be sown in fall when seed is ripe or in spring after seeds have been scarified (Slaby 1990). Seed is available on the internet for $2.50 for a packet of 100 seeds. It is recommended for moist soil at 7,000 to 11,500 feet elevation (Frontier 2003). It would not be advisable to use of seed obtained from an unknown source for restoration, but rather, collect it from a local genotype.

Possible reasons for the scarcity of Astragalus alpinus in Wisconsin and Minnesota

Astragalus alpinus var. *alpinus* is a rather common species through much of its large range, becoming rare at the edges, as in northwestern Wisconsin, northeastern Minnesota, Utah, and the Atlantic Provinces of Canada (Natural Heritage Program data). The variety *brunetianus* is also on the edge of its range, rare in Maine and extirpated from New Hampshire and Vermont. It might be useful to determine why alpine milkvetch is rare. This would facilitate the development of a conservation management plan. The following are possibilities for its rarity, which may suggest starting points for research and monitoring.

1) **Alpine milkvetch is a relict of past glaciation and is trapped here.** As proposed for *Oxytropis campestris,* colonies of *Astragalus* in the Midwest and east could have once been

common on the treeless tundra between glacial advances and persist today as glacial relicts along a few lakes with appropriate habitat. Norman Fassett in 1939 proposed that *Oxytropis campestris* once existed on the shoreline of Glacial Lake Grantsburg in northwest Wisconsin (USDA 1991). With limited suitable habitat, it is now restricted to a few isolated lakes.

2) **Astragalus may have lost its dispersal mechanism in the Midwest.** Clearly, plant species vary in their dispersal ability. An efficient method of dispersing its seed is not evident in *Astragalus*, and as already mentioned, the species seems locked into a few suitable isolated lake habitats. This has also been suggested for *Oxytropis campestris* (USDA 1991). There appear to be suitable lakes in Wisconsin that are similar to the known locations; why haven't they been colonized? There is evidence of dispersal in the west by free-roaming cattle, reindeer, and magpies that don't exist here. *Oxytropis campestris* seeds were found in the preserved remains of mammoths (Ridley 1930), so perhaps they ate and spread milkvetch, too. Fossil remains of both reindeer (caribou) and mammoths have been found in Wisconsin (Lind 1986).

3) The small, isolated populations in the Midwest are within the range of natural variability for this species. Alpine milkvetch can be locally common in the right habitat (Blaney 2003). It is on the edge of its range in the Midwest, where it would be expected to occur very rarely. The southern extent of this species in North America appears to correspond closely to the 80° F. isotherm where the July maximum temperature is 80 degrees (Lind 1986). It may simply not be able to survive in a warmer climate.

Research and Monitoring Priorities

This species is common in the heart of its range. Research has been done on the ability of alpine milkvetch to colonize disturbed areas and the feasibility of using it to revegetate mined areas (Bishop & Chapin 1989; Densmore 1991; Li & Fung 1998). Since the species is not at all rare where this research was carried out, it does not reflect the information needs of a rare species. The existing colonies should first be assured of protection. Below are some research needs for *Astragalus alpinus* on the edge of its range:

- **Monitor Wisconsin and Minnesota colonies.** This is already done to some degree in the Midwest since all four sites are on National Forest land where monitoring is part of the rare species program. Are they expanding, or have they filled the immediately available habitat? Are non-native invasive species or invasive indigenous species present at these sites? If so, control of the invading species may be an immediate need. Is there evidence of deer and hare browsing or herbivory by insect larvae, and what is the effect of this? Monitor the human use of the lakes, specifically all terrain vehicle use on the shore of both private and public land.

- **Survey lakes with potential habitat especially during years of low water levels.** Several suitable lakes on the Chequamegon-Nicolet were identified but most have only been searched once in the past 20 years. A quick survey of aerial photos shows 25-50+ lakes with potential shoreline habitat to the west of the National Forest in Bayfield County, Wisconsin, and these have never been thoroughly searched (Spickerman 2003). There are other small lakes in Minnesota in the immediate area of the known

populations that could be searched (Gerdes 2003).

- **Research the hydrology of known lake sites**. What is the interval of lake-level change? Compare this to other lakes in the appropriate areas of these states. Monitor the lake levels and compare the levels to plant production and location. Determine the potential for numerous water wells to affect the groundwater levels.

- **Conduct research on aspects of the biology and ecology to determine protection and management strategies necessary for long-term survival.** Collect information on population size, number of individuals, age to flowering, reproductive success, seed production, and individual lifespan. Identify pollinators and seed vectors. If colonies are spreading, is it through seed, caudex branching, or both? What are the effects of fire?

- **Ascertain conditions favorable for seed germination and establishment.** Conditions such as need for inoculant bacteria, soil types, soil nutrients and pH, moisture needs, light and shade, and other habitat requirements. Consider transplant experiments in apparently-suitable habitat using plants either from local wild populations or grown from their seed. Find nearby lakes with similar soil chemistry and morphology for future introduction efforts.

- **Determine how many extant occurrences are necessary to consider the species viable.** According to the National Heritage Program *Astragalus alpinus* is *critically imperiled* (S1) in Wisconsin, Minnesota and Utah because there are 5 or fewer occurrences in the state and possible other factors that make it vulnerable. It would still be considered *imperiled* (S2) if the number of occurrences rose to between 6 and 20 (NatureServe 2002). The results of the research in the suggestions above will help determine the number of populations, and quantity and quality of habitat necessary to make the species less vulnerable.

- **Take core samples of lake sediments to establish when Astragalus first arrived.** Although this may be expensive, it would be beneficial to find out if this plant is a recent introduction or dates back to post-glacial times.

Conclusion

Astragalus alpinus is a plant with very few occurrences and very few places with the unique habitat it requires in Wisconsin and Minnesota. It is in need of protection here as well as other states and provinces on the edge of its range. This is true for both varieties of alpine milkvetch since var. *brunetianus* is also rare within several of the jurisdictions in which it occurs. The Chequamegon-Nicolet and Superior National Forests are in an exceptional situation because they support the only occurrences of this species in the Midwest. A Conservation Approach is necessary to provide for this plant's long-term conservation, and to minimize conflict with other resource activities. Results of monitoring and research should provide managers with the data necessary to develop this approach which will later be incorporated into forest plans as a Conservation Strategy. It is likely that such a strategy will only be necessary for habitats of *A. alpinus* on the edge of its range. Initiating a strategy would involve developing goals for maintaining viability of the

species and writing management prescriptions for known sites and especially for other suitable habitat. Multiple entities both public and private would work together to conserve this species. Public education and outreach may be critical elements in efforts to protect alpine milkvetch.

Public awareness of the habitats of sensitive species and their need for protection is important for the future of this species, especially in the Midwest and other areas on the edge of its range. Perhaps lack of knowledge is as big a threat as any to this and other sensitive species. Public education efforts are crucial, especially because this habitat occurs on lands highly valued for their development and recreation potential. It is often the duty of public land stewards to reach out to private landholders in order to educate them on the needs of rare species. Together, private and public landowners can maintain critical habitat for alpine milkvetch in the Midwest.

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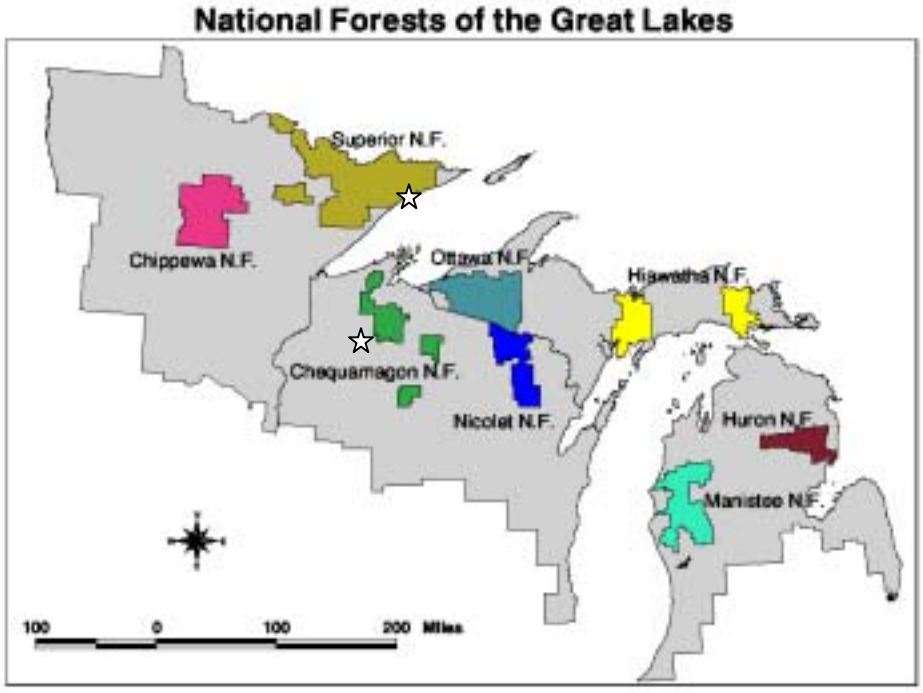
APPENDIX

☆ Element occurrences of *Astragalus alpinus* on National Forest lands in the Great Lakes states.

Chequamegon-Nicolet National Forest: ☆ = 2
Superior National Forest: ☆ = 2



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VT: Bob Popp, Information Manager/Botanist Vermont Natural Heritage Program
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WY: Tessa Dutcher, Assistant Data Manager, WY Natural Diversity Database

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