Conservation Assessment
for
Arctic Raspberry (Rubus acaulis) *Michx.*

USDA Forest Service, Eastern Region

May 2002

This Conservation Assessment/Approach was prepared to compile the published and unpublished information on the subject taxon or community; or this document was prepared by another organization and provides information to serve as a Conservation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

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INTRODUCTION/OBJECTIVES

This Conservation Assessment was prepared to compile the published and unpublished information on Rubus acaulis Michx. (arctic raspberry or nagoonberry). This is an administrative study only and does not represent a management decision or direction by the U. S. Forest Service. Though the best scientific information available was gathered and reported in preparation of this document, then subsequently reviewed by subject experts, it is expected that new information will arise. In the spirit of continuous learning and adaptive management, if the reader has 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, Milwaukee, Wisconsin 53203.

The National Forest Management Act and USDA Forest Service policy and require that National Forest Service lands be managed to maintain viable populations of all native plant and animal species. A viable population is one that has established populations and a distribution of reproductive individuals sufficient to ensure the continued existence of the species throughout its range within a given planning area. In addition to those species listed as Endangered or Threatened under the Endangered Species Act, or Species of Concern by the U.S. Fish and Wildlife Service, the Forest Service lists species that are sensitive within each region – Regional Forester Sensitive Species (RFSS). A designation of "sensitive" affords some additional regulatory protection.

Rubus acaulis is a Regional Forester Sensitive Species (RFSS) in the Eastern Region of the National Forests. It is listed as an R9 (Region 9) Sensitive Species on the Hiawatha National Forest. As this is a Conservation Assessment for the Eastern Region, the emphasis in this document is focused on that area. However, information for Colorado and Wyoming is included also, because R. acaulis is rare in those states as well. Little to no information could be found regarding occurrences of R. acaulis in the other states/provinces where it is found, though the information that was found was included in this document.

The objectives of this document are to:
1. Provide an overview of current scientific knowledge for this species.
2. Provide a summary of the distribution and status of this species, both rangewide and within the Eastern Region of the National Forests.
3. Provide the available background information needed to prepare a subsequent Conservation Approach.

EXECUTIVE SUMMARY

Rubus acaulis Michx. (nagoonberry) is a boreal species found in northern Alaska, throughout most of Canada from the Yukon and Northwest Territories to Ontario and Quebec primarily between 50^{o} and 60^{o}N latitude. It also occurs from the mountains of British Columbia and Alberta south to the Rocky Mountains (elev. 7000-9700) of Montana, Wyoming, and Colorado. In the mid-west it grows in Minnesota, and Michigan's Upper Peninsula. Confusion has persisted as to whether R. acaulis is a species or merely a subspecies of Rubus arcticus.

Currently Rubus arcticus is described from Europe and Asia along with Alaska. Studies done on Rubus arcticus may help us understand about the life history of Rubus acaulis. The major threat in our area may be climate warming as R. acaulis is likely a remnant of colder climates; its normal range is further north in Canada.

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Herbarium and Heritage Data – We appreciate the sharing of occurrence information for this species from Heritage personnel both in the United States and Canada, along with the helpful assistance of Herbarium personnel. See Contacts section at end of report for a complete list.

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

Literature Search - We thank Laura Hutchinson of the North Central Research Library for performing initial species inquires and sending us relevant research articles, Jan Schultz, of the Hiawatha National Forest, for use of her extensive library of materials to begin to compile information on this species, Donna Peppin, a contract horticulturist, for additional literature searches at the Northern Michigan University in Marquette and Beverly Braden, a contract botanist, for additional literature searches at Michigan State University in East Lansing and the University of Michigan in Ann Arbor, and for the preparation of an initial draft of this conservation assessment.

NOMENCLATURE AND TAXONOMY

(USDA NRCS Plant profile 2001, W-20).

Order: Rosales

Family: Rosaceae

Subgenus: Cylactis

Scientific name: Rubus acaulis Michx.

USDA NRCS Plant Code: RUAC

Common names: nagoonberry, short-stemmed raspberry, dwarf raspberry, northern dwarf raspberry, arctic raspberry, northern blackberry

Synonym: Rubus arcticus ssp. acaulis Focke
Cylactis arctica (L.) ssp. acaulis W.A. Weber
Rubus arcticus var. acaulis (Michx.) Boivin
Rubus arcticus var. grandiflorus Ledeb.
Rubus arcticus ssp. stellatus var. acaulis [Michx.] B. Boi

Taxonomy notes

This species is sometimes included in the circumpolar Rubus arcticus L., from which it differs in relatively minor attributes. Narrower stipiles, single flower below the leaves, an absence of gland on the peduncles, and longer petals on R. acaulis are the distinguishing characteristics (Soper & Heimburger 1982). Rubus arcticus ssp. arcticus is described by Hultén as having 1-3 flowers, the uppermost usually overtopping the leaves; peduncles often glandular; calyx tube pubescent, petals short and broad (Hultén 1968). R. arcticus is also described as having richly flavored fruit which is used for jam and flavoring liqueur (Hultén 1968) whereas Rubus arcticus ssp. acaulis is edible but not as richly flavored (Ryynanen 1972).

Welsh (1974) commented on western varieties and subspecies, “attempts have been made to segregate R. arcticus into varieties or subspecies”. Criteria such as sepal form or pubescence, flower number and height were variable so Welsh (1974) recommended only recognizing Rubus arcticus for Alaska and western Canada. Hultén considers the complex of arcticus, acaulis, and stellatus (Alaskan bramble) to be a single species with three subspecies. Fernald (1950) recognizes the three separate species. Hultén (1968) comments on Rubus arcticus ssp acaulis “forms hybrid swarms with other subspecies of R. arcticus where ranges overlap”.
Gleason and Cronquist (1991) commented on R. acaulis, “closely related to the chiefly Eurasian R. arcticus and possibly better treated as R. arcticus var. grandiflorus Ledeb”.

When not in flower or fruit (and it rarely fruits in lower latitudes), Rubus acaulis could easily be mistaken for the vegetatively “similar” R. pubescens. Lynden Gerdes, (pers. comm. 2002),

Minnesota DNR, noted that R. acaulis "typically flowers when the bugs are really bad, so it could be overlooked since people don't loiter much in the swamps during this time."

SPECIES DESCRIPTION

Rubus acaulis is a dwarf unarmed trailing herbaceous perennial with short upright flowering branches and trifoliate leaves. Flowers are solitary and the petals are pink to red. The fruit is an edible red raspberry (Soper & Heimburger 1982). The Latin species epithet acaulis translates to stemless, in reference to the lack of a tall woody stem (Soper & Heimburger 1982).
Species Characteristics: (Chadde 1999, Soper & Heimburger 1982, Hultén 1968)

Form: Low, trailing perennial herb, flowering branches
Stem: Slender stems, trailing on the ground surface or moss; somewhat woody at the base; upright stems are to 4 inches (10cm) long without bristles or prickles.
Leaves: Leaves alternate, deciduous, and trifoliolate (sometimes 5-foliolate); upper surface shiny without hairs, underside with minutely hairy margins.
Leaflets: Terminal leaflet is stalked, the lateral pair nearly sessile, asymmetrical, often with partially developed lobe; margins are serrate with blunt forward pointed teeth.
Flowers: Branches erect with 2 or 3 leaves and a solitary terminal flower on slender, finely pubescent peduncles; June to August.
Petals: Flowers solitary, 5 petals light pink to deep rose-colored; up to 2 cm long, obviously narrowed towards the base.
Sepals: Lance-shaped to 1 cm long; calyx tube glabrous, laking glands; calyx lobes long-tapered and reflexed.
Fruits: Raspberry-like "berry" (aggregate of drupelets) about 1 cm in diameter, red, nearly globose, edible, matures July to September.

Similar species

Rubus acaulis can be distinguished by its unarmed (no prickles) stems, compound leaves of 3 to 5 leaflets and one rose colored flower. The other common dwarf raspberry in the Great Lakes states, R. pubescens has small white flowers, whip-like stems, and sharp-tipped leaflets (Newmaster et al. 1997).

Key to dwarf raspberries in the Eastern Region

(Key adapted from Soper & Heimburger 1982).
Plants low (1-3 dm); stems unarmed, turfed, erect or trailing; leaves compound with 3-5 leaflets; flowers solitary or few (2-10); fruit red.

A. "Flower stems borne singly from a long creeping stem; leaflets sharp-pointed to acuminate; flowers white to greenish, rarely pink; petals 6-10 mm long". R. pubescens
B. "Flowering stems solitary or tufted from a short, branched, perennial base; leaflets abruptly pointed to rounded; flowers pink to deep rose-colored; petals 10-20 mm". R. acaulis.

Hybrids

Apparent hybrid swarms of R. arcticus with R. acaulis and R. arcticus ssp. stellatus are reported from Alaska by Hultén (1968). R. propinqus, known from the District of Mackenzie, is thought to be a probable hybrid with R. pubescens and R. arcticus (Scoggan 1978). In Michigan, as with other places in its range, it hybridizes with R. pubescens, producing R. x paracaulis Bailey. Hybrids of this cross generally have pale pink petals and more acute leaflet tips than R. acaulis (Voss 1985). Moss and Packer (1983) add the following observations on this hybrid: it is generally larger than R. arcticus, often has stolons, with rose-colored flowers extending beyond the leaves.

GEOGRAPHIC DISTRIBUTION

Rubus acaulis is primarily a boreal species of North America. A closely related species, Rubus arcticus is known from northern latitudes in Europe (previously large natural colonies in Finland (throughout Finland, but most common between 62^{o}N and 66^{o}N), Norway (common only bordering upper portions of the fjords) and Sweden (common only along the coast) (Ryynanen 1973), Siberia (Hultén 1968), and rarely Estonia (Karp et al.1997). The arcticus group of arctic raspberries is distributed throughout sub-arctic Eurasia primarily between 60^{o} and 70^{o}N latitude in Europe and primarily between 50^{o} and 60^{o}N latitude in Asia (to 41^{o}N in China) (Ryynanen 1973). The best Eurasian location for R. arcticus is between 62^{o}N and 66^{o}N (Karp et al. 1997). In North America R. arcticus is native only to Alaska and the Yukon Territory (Hultén 1968). Plants of the R. stellatus group grow in the southern half of Alaska, the Yukon Territory, and throughout the Aleutian Islands (Hultén 1968). The combined distribution of these species forms a circumpolar belt (Ryynanen 1973).

RANGE-WIDE DISTRIBUTION

Rubus acaulis occurs from the tundra of northern Alaska, throughout most of Canada in the north-central Yukon, Northwest Territories (Great Bear Lake) to Alberta (Lake Athabasca), Saskatchewan, (Lake Mistassini) northernmost Manitoba, Ontario (south to Lake Superior), Quebec and the Gaspé Peninsula, to Labrador; not known from the Maritime Provinces (Scoggan 1978). In Canada, R. acaulis is found in Canada primarily between 50^{o} and 60^{o}N latitude (Ryynanen 1973).

Rubus acaulis is known throughout northern Ontario from Hudson Bay and James Bay south to the north shore of Lake Superior and the Lake Timiskaming region in eastern Ontario (Soper & Heimburger 1982). Soper and Heimburger's map (1982) shows over 50 occurrences, about half on the banks of rivers and streams.

In western North America it occurs from the mountains of British Columbia and Alberta south to the Rocky Mountains (elev. 7000-9700) of Montana, Wyoming, and Colorado (Grand and Park Counties) (Scoggan 1978, USGS Wyoming Field Guide W15, Fertig 2000a). In the mid-west it grows in Minnesota, and Michigan's Upper Peninsula (Chadde 1998). In Wyoming, Rubus

acaulis is known from the east slope of the Bighorn Mountains (Johnson County) and Yellowstone Plateau (Teton County). One occurrence is protected within Yellowstone National Park; J. Whipple reported it as relatively abundant. Populations in the Bighorn Range are on public lands managed for multiple uses. The Bighorn Range contains thousands of stems (unknown number of genetically distinct individuals) (Fertig 2000a).

R9 Eastern Region Distribution
(Minnesota and Upper Peninsula of Michigan)

Rubus acaulis is known from peatlands in northern Minnesota. The University of Minnesota Bell Herbarium (W-19, 2002) lists 55 specimens for Rubus acaulis from ten counties in northern Minnesota, the largest number of specimens were found from Cass, St. Louis and Lake of the Woods Counties. R. acaulis is known in Michigan only from a conifer swamp and open peatland in Schoolcraft County (Chadde 1998); it is not presently known from Wisconsin (NatureServe 2001). Emmet Judziewicz (2001) lists "Rubus acaulis as probable (50-90%) chance in cold, sphagnous conifer swamps and boreal fens, somewhere in Douglas and adjacent counties in Wisconsin".

National Forests

In Region 9, Rubus acaulis occurs on the Hiawatha National Forest (Michigan) in northern Schoolcraft county in a patterned fen within a candidate Research Natural Area (MNFI 1998). It also occurs on the Superior National Forest (black spruce swamp) and the Chippewa National Forest, both in Minnesota (University of Minnesota Herbarium 2002, W-19). In Region 2, patch sizes are listed as over 1000 stems on the Bighorn National Forest in Wyoming (Wyoming rare plant field guide, W-22).

In Region 2, Rubus acaulis occurs within the Bighorn National Forest in six subpopulations numbering several thousand stems along a 2.4 km (1.5 mile) stretch of Sourdough Creek. This is the largest known population of nagoonberry in Wyoming. Often frequency values of 50-60% of the vegetation for a 2m x 5m area were obtained with a total estimate of 51,000 to 77,000 stems. There are also two known occurrences within the Yellowstone National Park, one occurrence covers approximately 2 acres (Fertig 2000b).

HABITAT AND ECOLOGY

Rubus acaulis is primarily a boreal species. The ecology of R. acaulis includes low-elevation bogs, wet meadows and thickets at subalpine and alpine elevations (Pojar & MacKinnon 1994). In Canada and Alaska, Rubus acaulis is often found in peaty soil, moist woods, and tundra (Scoggan 1978). The habitat in Alaska ranges from subalpine to alpine in wet meadows, wet heaths, and along the edges of streams (Robuck 1989). It is described as an obligate wetland plant in the Great Lakes Region (Chadde 1998).

The European counterpoint R. arcticus grows abundantly in bogs, wet meadows, and open spruce-hardwood forests (Ryynanen 1973). In addition large populations are found in burned or

cleared areas and along streams and ditches (Holloway 1982). Common features of all habitats include little or no shade and a moist substrate with a high organic content (Ryynanen 1973). In Finland at the beginning of the century, the arctic bramble grew commonly on abandoned slash and burn (swidden) cultivations, preferring mesic sites. Now the main natural habitats remaining are roadsides and the sides of ditches (Kangasjarvi & Oksanen 1989).

Western United States

In Wyoming it prefers boggy woods and marshes at elevations of 7000-9000 feet. (Wyoming rare plant field guide W-21). On the Bighorn National Forest in Wyoming, Rubus acaulis was found along the middle reach of Sourdough Creek occurring primarily on mossy hummocks in Salix planifolia (planeleaf willow) thickets and Carex utriculata (beaked sedge) marshlands at elevations between 7400-7700 feet. Common associates in this environment included Equisetum arvense (field horsetail), Pedicularis groenlandica, (Elephant's head), Potentilla fruticosa (shrubby cinquefoil), Geum macrophyllum (large-leaved avens), and Thalictrum sparsiflorum (few-flowered meadow-rue) (Fertig 2000b). In Colorado, R. acaulis favors willow carrs and mossy streamsides at elevations of 8600-9700 feet (Colorado rare plant field guide, W-2).

Eastern Canada

Soper and Heimburger (1982) describe R. acaulis as occurring in sphagnum mats and the lichen heath of arctic meadows, in alder and willow thickets, in black spruce forest and muskeg, and on moist banks of streams and rivers. In northwestern Ontario's Thunder Bay District, Rubus acaulis is a fairly common arctic-alpine disjunct species that one would expect to find at this latitude; the other arctic-alpine disjunct species were Scirpus cespitosus, Vaccinium uliginosum, Vaccinium vitis-idaea, and Ranunculus lapponicus (Wildlands League 2001, W-23).

At another site in northern Ontario near the fringes of the boreal forest (approx. 1100 km northwest of Sudbury, Ontario) the habitat is cedar swamps with areas of deep shade where the ground remains frozen late into mid summer. Picea mariana (black spruce) and Larix laricina (tamarack) are common at the edges. Lime-rich mineral soil was transported to the Hudson Bay area by glaciers and later covered by a layer of clay-rich soil deposited by glacial lakes. Plants found here grow in a lime-rich and clay-rich, cold, moist soil. Common scrubs include swamp red currant (Ribes triste), leatherleaf (Chamaedaphne calyculata), speckled alder (Alnus incana), and slender willow (Salix petiolaris). Rubus acaulis grew in this habitat along with northern bluebells (Mertensia paniculata) and northern sweet coltsfoot (Petasites frigidus) (Northern Ontario, Bearskin and Sachigo Lake area W-14).

Rubus arcticus, a closely related species, was described from Mount Albert, the second highest mountain on the Gaspe′ Peninsula (3775 ft./1150 m). The soft, serpentine rock of the mountain is essentially a hydrated magnesium silicate, with magnesium present in sufficient quantity to be deadly to many kinds of plants. Several rare ferns (Cystopteris montana, Aspidotis densa) were found on this mountain with Adiantum aleuticum covering a large area. Plants found on the tableland or the mountain's steep sides included Arabis alpina, Arnica mollis, Rubus arcticus, Parnassia parviflora, Ranunculus allenii, R. pygmaeus, Armeria maritima subsp. sibirica, Achillea millefolium var. borealis, and Aster foliaceus (McGary 1996).

Western Canada and Alaska

The following habitat information copied from herbarium labels at the University of Michigan (2001) shows the diversity of habitats for Rubus acaulis: Alaska – wet organic soil in a ravine, in dense stands in the Brooks Range, (meadows, thickets, along creeks (Hultén 1968)); British Columbia – muskeg; Alberta – willow hummocks, boggy meadow, (boggy woods and marshes (Moss and Packer 1983); Manitoba – sandy portage in open jack pine near river (Univ. of Michigan herbarium labels 2001).

Minnesota

Rubus acaulis is known from peatlands in northern Minnesota. Water tracks composed of peat ridges and troughs known as strings and flarks are most common in the northern-most section of the state. R. acaulis was found in the Red Lake Peatland in the Glacial Lake Agassiz Region primarily in string landforms of the minerotropic fen (3 occurrences), but also in drainage ditches and hummocks of wooded islands (Wheeler & Glaser 1982). In a more thorough study of the patterned peatlands (Wright et al. 1992), R. acaulis occurred in the string landform as sparsely present in 14% of the studied plots. Strings are best developed in water tracks that have been ditched. Lynden Gerdes, a botanist for the Minnesota Department of Natural Resources (pers. comm. 2002) notes that in north central Minnesota he experienced a spectacular display of 1000's of stems in a Tamarack swamp. He said the air was remarkably sweet.

Nonforested fen landforms like those in which Rubus acaulis occurs are generally associated with a high water table and are dominated by sedges. The spring-fen channels are dominated by tussock bulrush (Scirpus cespitosus) and meagre sedge (Carex exilis). Rich fen indicators grow in this habitat including species such as Hudson Bay bulrush (Scirpus hudsonianus), grass of parnassus (Parnassia palustris) and Kalm's lobelia (Lobelia kalmii) (Glaser 1987). Dominant vegetation of strings includes Betula pumila var. glandulifera, Potentilla fruticosa, Salix pedicellaris var. hypoglauca, Carex diandra, C. cephalantha, Thelypteris palustris var. pubescens, and Viola pallens var. mackloskeyi (Wright et al. 1992).

Michigan

Rubus acaulis is known in Michigan only from a conifer swamp (Picea/Thuja/Larix) with several patterned fen openings in Schoolcraft County; (MNFI 2002, W-8). The soil is carbondale muck and peat with a pH of 7.0 to 8.0 (MNFI 2002, W-8). Heavy, waterlogged soil has built up over limestone bedrock. The underlying limestone has kept the peatland from becoming acidic (Mohlenbrock 1994). Patterned fens occur in northern regions as the result of graded terrain. Where the terrain has a gradual grade of about 2 percent, soil slides down this small gradient. When one edge of the slipping soil hooks onto something, such as a small tree or even a rock, the soil tears, forming a flark along the tear line. The distinct pattern of alternating flarks and strings becomes evident after many years of constant tearing and sliding. (Madson 1987). Mohlenbrock describes strings and flarks in Shingleton Fen as ranging from ten to one hundred feet long and one to thirty feet wide (1994).

At this latitude R. acaulis is a relic species of cold air pockets, as its normal distribution is northern Canada. It is a remnant of colder glacial periods. It rarely fruits at this location (J. Schultz pers. comm. 2002), probably because of its isolated occurrence. Out of 19 quadrats, three quadrats had one fruit (Schultz 1989). Jan Schultz noted that R. acaulis was in the poor sparsely treed swamp forest and adjacent patterned fen (Schultz 1987). Typical number of plants per quadrant were between 10-20; there were a few plots with 40-60 plants, and in 1989 one plot had over a 100 individuals (Schultz 1989). Percent cover often was about two percent, but occasionally as high as 10 percent (Schultz 1989).

The candidate Shingleton Fen Research Natural Area (cRNA) is a patterned fen with level to gently sloping topography. A patterned fen can be described as "a minerotrophic shrub-herb peatland characterized by sedge peat ridges (strings) and hollows (flarks) oriented across the slope and perpendicular to the flow of groundwater. This landform is exclusively located on sandy glacial lakebeds" (MNFI 1994). The cRNA is part of a poorly drained sand lake with reworked sands from the Lake Algonquin era, with organic soils overlying limestone, dolomite and other marine sedimentary rocks (Dorr & Eschman 1970). The soils are magnesium rich with shallow peat deposits representing 3000+ years of peat development (Comer et al. 1994). The vegetation of the cRNA varies from rich fen to poor fen to conifer swamp. Centered in a low wetland at an elevation of 785 ft. (238 m) above sea level, the cRNA reaches an elevation of 838 ft. (254m) in the north and 825 ft.(250m) in the south (HNF 1994).

This population of Rubus acaulis has been known from Voss and Henson since 1977. The individual who originally discovered this site isn't known, but D. Henson documented the occurrence in 1981 during an MNFI site survey. During the period that Jan Schultz monitored this population 1987-1989, the population remained stable. To assess the population's present health, monitoring should be repeated for several years. Associates are typical open bog plants such as Labrador-tea (Ledum groenlandicum), bog-rosemary (Andromeda glaucophylla), and slender sedge (Carex lasiocarpa), another sedge (Carex exilis) and a orchid (Arethusa bulbosa) (MNFI 1998). Scrub associates include alder-leaved buckthorn (Rhamnus alnifolia), chockberry (Aronia melanocarpa), mountain fly honeysuckle (Lonicera villosa), and bog birch (Betula pumila) (MNFI 1998).

Rangewide Protected Status (NatureServe, W-13)

Currently, the official status for Rubus acaulis Michx with respect to federal, state, and private agencies is:

U.S Fish and Wildlife Service: Not listed (None)

Global Heritage Status Rank: G5T5

U.S National Heritage Status Rank: N? (01Aug1993)

Canada Heritage Status Rank: N5 (24Oct2000)

With a global rank of G5, T5 and an U.S National rank of N?, The Nature Conservancy lists these rankings as:

N?: Ranking not assigned because of lack of information, disagreement on taxonomy, or a need to review all previously collected specimens because R. acaulis is no longer considered a subspecies.

G5,T5: Demonstrably secure globally, though it may be quite rare in parts of its range, especially at the periphery

U.S. Forest Service

Region 9 Sensitive on the Hiawatha National Forest in Michigan, where it has an Endangered state status, it occurs on Superior National Forest, and Chippewa National Forest both in Minnesota, but is not listed at risk. It is also listed as Sensitive on the Bighorn National Forest in the USFS Region 2 (Wyoming Natural Diversity Database 2002).

The Regional Forester has identified it as a species for which viability is a concern on Hiawatha National Forest 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).

State Status

Rubus acaulis is listed Endangered in Michigan (W-7), Threatened in Washington (W-22), and considered of high conservation priority (vulnerable to extirpation) in Wyoming (W-24). It is not listed in Colorado (W-2), Maine (W-6), Minnesota (W-9), Montana (W-12), or Oregon (W-15). Apparently, the Alaska Natural Heritage Program only tracks the global and state ranks, not state status, of vascular plants within Alaska that they consider rare.

State Ranks (NatureServe 2001, W-13)

Alaska	SR	**Montana**	SR
Colorado	S1	**Oregon**	SR
Maine	SR	**Washington**	SR
Michigan	S?	**Wyoming**	SR
Minnesota	SR		

Canadian Provinces (NatureServe 2001, W-13)

Alberta	SR	**Nunavut**	SR
British Columbia	S?	**Ontario**	SR
Labrador	SR	**Quebec**	SR
Manitoba	SR	**Saskatchewan**	S5
Newfoundland	SR	**Yukon Territory**	SR
Northwest Territories	SR		

S1 = Extremely rare; typically 5 or fewer known occurrences in the state; or only a few remaining individuals; may be especially vulnerable to extirpation.
S5 = Very common; demonstrably secure under present conditions.
SR = Reported from the state, but without persuasive documentation that would provide a basis for either accepting or rejecting the species.
S? = Species has not yet been ranked.

LIFE HISTORY

Pollination

The flowers of Rubus acaulis are hermaphroditic, self-incompatible, and insect-pollinated. R. acaulis fruit is similar to that of R. arcticus (arctic bramble), but with smaller and more numerous drupelets. The main pollinators, bumble bees (Bombus spp.) and honey bees (Apis melifera), are selective. For example, the pollinators preferred the white clover to the profusely growing bramble in an old field. Honeybees were very infrequent visitors in the wild in Finland (Kangasjarvi & Oksanen 1989). In Wyoming, honeybees were the only observed pollinator. Approximately 24-39% of all stems produced flowers in willow thickets compared to 23-26% of all stems in Engelmann spruce habitats (Fertig 2000b).

Pollinator movement patterns can have a great influence on the production of seeds and berries. Several pollen grains are needed for the development of full-sized berries (one for each seed). If the pollinator alights on a flower from a different clone it will be effective in depositing several pollen grains during a single visit (Yeboah & Woodell 1987 cf Kangasjarvi & Oksanen 1989). The turnover of pollen seems to be quite rapid; most of the pollen will be deposited in the first few flowers visited. Pollinators usually alight on several flowers of a single plant, and consequently, only the first few flowers visited receive effective pollen (Thomson 1986 cf Kangasjarvi & Oksanen 1989).

The great majority of flights are to the nearest neighbor (Zimmerman 1979 cf Kangasjarvi & Oksanen 1989). Therefore, adapting a planting pattern where neighboring plants belong to different clones could probably increase the berry yields in cultivation (Kangasjarvi & Oksanen 1989).

Competition for pollinators has also been observed in other self-incompatible, insect-pollinated plants, with bees clearly preferring white clover, and possibly also strawberry, to arctic bramble. However, the main flowering of white clover is later in the season than that of arctic bramble, so the competition for pollinators would only have an effect on the later yields (Kangasjarvi & Oksanen 1989). The later yields are important for the arctic bramble, since observations also indicate that more berries are produced in the later flowering period, when there are fewer flowers on a plant and insects are forced to change hosts more often (Zimmerman 1987 cf Kangasjarvi & Oksanen 1989).

In Europe observations of R. arcticus (Cernova 1959 cf Ryynanen 1973) indicate that temperatures of 2^{o} to 5^{o}C are sufficiently low to have a harmful effect on the germination of the

pollen and cause darkening of the stigma. It has also been observed that excessive radiance in the summer may dry up a large portion of the flowers of R. arcticus. In contrast with inland areas, berries are relatively abundant on plants growing beside large bodies of water. In addition, frosts seldom occur during the growing season in lakeside habitats so the flowers of early summer can successfully develop fruit (Ryynanen 1973). It is likely much of the same dynamics would be found for populations of R. acaulis growing in North America since it is a closely related species. Because R. acaulis has not been grown commercially less is specifically known about its life history.

Flowering/fruiting period/fruit production:

Chadde (1998) lists the flowering/fruiting period for Rubus acaulis in the Great Lakes Region between June and August. Jan Schultz noted the end of the 1987 blooming period in Shingleton Fen in the Upper Peninsula to be May 28 however. The flowering/fruiting period in Wyoming is mid-June to July (Fertig 2000a), and July to September in Ontario (Soper and Heimburger 1982). In Colorado it flowers from late June to early July and fruits from late July to August; however this species seldom fruits in Colorado (Colorado rare plant field guide, W-2). Rubus acaulis fruits little in lower latitudes (Lynden Gerdes, pers. comm. 2002).

In Sweden, the main bloom period takes place in late May and early June with sporadic flowers appearing until late July and beyond. The flowers are fragrant and pollinated by insects so a sheltered site is preferred. The fruit takes five to six weeks to ripen and the main harvest time is around mid-July (Simms 1996).

Fruit production of the arctic bramble in the wild is limited due to the lack of pollinators (Kangasjarvi & Oksanen 1989) and self-incompatibility (Tammisola & Ryynanen 1970 cf Holloway 1982). The growth habit of R. acaulis resembles that of strawberry with the single flower often hidden beneath the foliage (Holloway 1982); logically the low growth form with its hidden flower would make it even more difficult for pollinators to find than the upright flowers of R. arcticus. Rubus acaulis is known from just two counties in Colorado, and is noted as "seldom fruits in Colorado" (Colorado rare plant field guide, W-2); scattered occurrences would make it difficult for pollination to occur.

Factors affecting growth and fruiting

In experimental cultivations of R. arcticus, soil type does not appear to be a decisive factor affecting growth of the plant, although the species avoids heavy clays. A layer of weak humus litter was found to promote growth. Analysis of soil at sites with good yields had higher contents of Phosphorous, Copper, Zinc and Manganese than the localities with poor yields. Localities with poor yields had somewhat higher contents of Calcium and Potassium, and a slightly higher pH (Ryynanen 1973). R. arcticus has an endotrophic mycorrhizae, which plays an important role in improving the absorption of nutrients by the roots; it is not clear whether it has any direct effect on fruiting (Ryynanen 1973).

Soil moisture also affects the berry yield, since R. arcticus needs a comparatively damp substrate in order to fruit well. In the optimal growth areas for the species, a thick snow cover prevents

the species from commencing growth and flowering too early in the spring, and protects the plants from cold spells (Ryynanen 1973).

Propagation:

All species of raspberries have fruit that ripens unevenly in the summer or early fall. The fruit is an aggregate of small drupes each containing a single hard-pitted nutlet. Good seed crops occur nearly every year. Natural dispersal is mostly by birds and mammals. The fruits mature over an extended period of time. If collecting seeds for extraction, the fruits of Rubus spp. should be picked as soon as they are ripe. Seeds can be extracted by maceration and flotation. Cleaned seeds need to be dried before storage, then stored at low temperatures (Young & Young 1992). "Best emergence for Rubus spp. usually follows late summer or early fall sowing of scarified seeds. They do well sown in drill rows, covered with a thin layer of soil and the beds mulched. Germination is epigael" (Young & Young 1992).

R. acaulis seed requires stratification and is best sown in early autumn in a cold frame. Stored seed requires stratification for one month at about 3^{o}C and should be sown as early as possible in the year. When seedlings are large enough to handle, transfer to a cold frame. Plant them out to their permanent position in late spring of the following year. Divide in early spring or just before leaf-fall in the autumn (Plants for a Future 1997, W-16).

Vegetative reproduction:

R. arcticus has been able to rapidly establish itself in burnt-over areas, and meadow clearings primarily due to its rapid vegetative reproduction. Saastamoinen (1930) hypothesized that the seeds retain their viability for a considerable period, and start to germinate when the opportunity arises. It is possible that the heat in burnt-over areas provides a "shock treatment" that wakens the seeds to life (Ryynanen 1973).

Plantation growth:

Much of what is known about the life history of this group of raspberries comes from cultivation attempts of R. arcticus in Europe. In a plantation the arctic bramble will begin to bear fruit in the second year of growth. The best years are the third and fourth, and the plantation will have a lifetime of five to six years, when the plants begin to die out. The first fruits ripen at the start of July and the last at the start of September in Estonia (Karp et al. 1997). The best conditions for growth are mineral soil containing humus; avoid heavy poorly drained soils, and dry, sandy soils (Simms 1996). Optimal soil acidity is pH 4.0-5.5 (Karp et al. 1997). Plants need to be watered well in dry spells, especially when in fruit (Clime 1996). The production yield of the arctic bramble in Finland during the best years has been 40-60 kg/100m2 (Mihkiev 1988 cf Karp et al. 1997).

POPULATION BIOLOGY AND VIABILITY

Even in the main areas of distribution in Europe and the Soviet Union, the arctic bramble is becoming more rare in the wild. In Estonia it is a relic of a period of damp and cool sub-arctic climatic conditions (approximately 10,000 BC). It has been a protected species since 1958 and is included in "The Estonian Soviet Socialist Republic Red Data Book". The number of arctic brambles in Estonia have been constantly falling indicating the plant's tendency to die out gradually. In many instances its favored habitats have been drained (Karp et al. 1997). Arctic brambles are being driven from favored habitats like forest meadows by increasingly dense undergrowth because the meadows are no longer mowed. Now the arctic bramble is often shaded out by trees such as dwarf birch, grey alder, aspen and various willows. Even dense growth of Gramineae and Carex spp. can cause the arctic bramble to die out (Karp et al. 1997). Another factor that has affected the spread of the arctic bramble is the reduction in the number of forest fires, especially in Finland. These forest fires destroyed the woody competition and created more favorable growing conditions for the arctic bramble (Tammisalo 1988 cf Karp et al. 1997).

In Britain, Rubus arcticus would appear to be a relic of more favorable climatic conditions. Three or four records of the species from the area support a classification the plant as native to Britain. There are two specimens in the British Museum of Natural History from 1830 and another from 1837 (Edees & Newton 1988). Label information reads as 'gathered on the high heaths of Scotland'. R. arcticus has never been found again at any of its previous localities despite repeated searching. Records from Finland suggest that it might prove sterile in Britain, since Rubus rarely fruit at low latitudes and Britain lies south of the 59th parallel. Harley (1956) postulates that the seeds could have been brought over by winter migrating birds from Scandinavia. It seems unlikely that R. arcticus would linger more than a few years reproducing vegetatively. In Scandinavia, the winter migrant fieldfare (a Eurasian thrush) inhabits birch, pine or spruce woods near damp meadows, likely habitat for Rubus arcticus. Feeding reaches a peak just before migration so it seems possible that some seeds might reach the British Isles via their transport (Harley 1956). The limited distribution of R. arcticus in Britain could shed some light on the rarity of Rubus acaulis at similar latitudes in the United States.

In Michigan, Rubus acaulis could be a relic from more favorable climatic conditions or it might be the result of long-distance seed dispersal by migrating birds, which would lead the species to appear for awhile in areas south of its normal range; the comparison with the British populations might provide some clues as to its distribution.

The Minnesota Department of Natural Resources manages most of the peatlands occurring in the northern counties of Minnesota, the principal habitat for Rubus acaulis in the region. A plan was submitted to the legislature to protect the most significant peatlands in the State. The proposed plan recommended protecting the core zones of these peatlands as Scientific and Natural Areas, whereas the surrounding watershed protection zone would be protected by a less restrictive designation (Glaser 1987). Legislation was passed in 2001 to protect the core areas as Scientific Natural Areas (84.035 peatland protection). Certain activities are prohibited: construction of any new public drainage systems, ditching, draining, and filling, removal of peat or other industrial

minerals, and exploratory boring or removal of oil, natural gas, or metallic minerals, and commercial timber harvest (84.035 peatland protection).

POTENTIAL THREATS

Natural threats

Probably the most serious threat to Rubus acaulis in our area is the current climate and the prospect of global warming as this species prefers a colder climate. The persistence of populations in the United States is also threatened by the fact that individual plants rarely fruit at lower altitudes. J. Scultz observed that isolated plants in the Hiawatha National Forest occurrences rarely bear fruit, but instead just persist vegetatively (pers. comm. 2002). Scientists in Minnesota (J. Woehrle & J. Bach) and South Dakota (W. C. Johnson) are concerned about the effects of global warming on wetlands. It is estimated from models that if temperatures increased between 3.6^{o}F and 7^{o}F, precipitation would need to increase between 10-25 percent to maintain the current status of wetlands (Minnesota's wetlands and prairies W-11). Minnesota peatlands are especially vulnerable to climatic change because they are on the edge of western prairies, eastern hardwood forests, and northern conifer forests. The combination of a warmer, drier climate and extensive forest die-back in these areas has created prime conditions for forest fires. (Global change 1998, W-5). Less dramatic than the major changes predicted by global warming would be a shift from fen to bog habitat as the underlying ground water level dropped and precipitation became the sole water source (TNC – Sphagnum moss W-18). Warmer conditions could dry peatlands and dramatically increase the decay of plant matter releasing greenhouse gases such as carbon dioxide or methane. Eville Gorham, an ecologist at the University of Minnesota, has warned that in the worst case peatlands could burn out of control (Minnesota's Wetlands and Prairies W-11).

Snowmobile trail

On the Hiawatha National Forest there is a snowmobile trail that goes through Shingleton Fen, a candidate Research Natural Area. The snowmobile trail follows an old railroad grade that was built without culverts, causing a disruption of the drainage and resulting in the ponding of water on the west side of the grade (HNF 1994). The trail runs through the cRNA at an angle from the east boundary to the middle of the south boundary. Several rare and arctic disjunct plants grow in this bog (HNF 1994). Rubus acaulis is known from here and is the only location known for Michigan. Carex heleonastes is known only from this location in the lower 48 states. The Amerorchis rotundifolia population within the fen is perhaps the most extensive viable population left in the state (Schultz 1987). Other rare plant species found at Shingleton Fen include Drosera anglica, and Vaccinium cespitosum (HNF 1994).

Snowmobiling use is extensive in the area between Grand Marais and Munising with the possibility of hundreds of snowmobilers using the trail daily (Cornett & Dailey 2000, W-3). A combination of inadequate snow and snowmobile travel off the designated trail can create soil and vegetation damage. Possible damage may include soil compaction, an increase in frost depth within the soil, and vegetation damage or loss. During dry growing seasons ATV's leave the designated snowmobile trail and traverse the dry, open wetland, again creating resource damage (J. Schultz pers. comm. 2002). There are also unknown threats from the hydrocarbon pollutants

these two-cycle snowmobile engines leave behind in the air and the snow (Cornett & Dailey 2000, W-3). Because of potentially damaging effects efforts are needed to minimize misuse by snowmobilers and ATVs at Shingleton Fen.

Road construction and hydrological alteration

Of all previous disturbances and impacts, a logging road constructed through the Shingleton Fen cRNA resulted in the most significant alteration of the hydrology of this wetland, completely blocking drainage. Several drainage ditches were subsequently made in an attempt to remedy the water impoundment by the logging road, but it is unclear if this crude remediation was sufficient. The cRNA may have been hydrologically altered and damaged as a result of the road construction, thus potentially threatening the population of Rubus acaulis here (J. Schultz, pers. comm. 2002).

In Wyoming, on the Bighorn National Forest the Sourdough Creek watershed with the only known extant locations for Rubus acaulis is managed with a cattle grazing and timber emphasis. Cattle graze the middle reaches of the creek in late July to early August. Fishermen regularly use the middle reaches of the creek, and a trail has become established along the north side. Unofficial but semi-permanent car and trailer campsites are present along the upper reaches of the creek to the north of the Rubus acaulis populations. Initial evidence from monitoring populations along Sourdough Creek suggests that R. acaulis is surprisingly resilient to the disturbances of grazing, flooding, clear cutting, and recreation. However, given the small geographic area Rubus acaulis remains vulnerable to large scale habitat loss or disturbance (Fertig 2000b). Monitoring programs are needed to periodically assess the health of the Rubus acaulis populations. If timbering alters the flow of the creek and affects alluvial sediment loads and deposits in an area, it is reasonable to assume that populations downstream from that area would also be affected.

SUMMARY OF EXISTING HABITAT PROTECTION

Habitat protection is essential for this species within the Hiawatha National Forest. Since Rubus acaulis is not tracked in Minnesota, the health of the plants on either the Superior or the Chippewa National Forest is not readily known (J. Greenley pers. comm. 2002). After nearly a decade of research and legislative proposals for their protection, peatlands in Minnesota were recently afforded increased protection with the passage of the peatlands protection statue (84.035) (Minnesota statues 2001, W-10).

MANAGEMENT AND CONSERVATION ISSUES

Management of wild populations in the United States appears to be limited. Minnesota state heritage personnel do not track this species. It has been over 10 years since the population on the Hiawatha National Forest has been monitored, therefore long-term effects of upgrading the logging road within the candidate RNA are unknown. Initial monitoring occurred in 1987-1989, but it could take a decade or more before adverse effects might be seen due to the change in drainage as a result of the road construction in the cRNA (J. Schultz pers comm. 2002).

Rubus acaulis is a rock garden plant that can be cultivated in moist, humus soil; it tolerates somewhat drier conditions in winter. It can be propagated by fresh seed, cuttings in late summer, and layering in early spring and fall. It requires moist, humus soil, and shading in summer (Rock garden plants W-17). Fraser's Thimble Farms (W-4) in British Columbia Canada sells Rubus acaulis in 10 cm sized pots. Currently most of the growers are Canadian since Rubus acaulis is more common further north.

The accumulation of peat and regeneration of disturbed peatlands is such a slow process (only 4-16 inches of peat accumulate in the ombotrophic peatlands of Finland every thousand years) that peat mining can do irreparable harm to the ecosystem. The blanket bogs of oceanic Great Britain have slowly regenerated from ancient digging and prolonged grazing, but will most likely be unable to recover from recent large-scale onslaughts. In the British Isles the Gulf Stream moderates the climate, maintaining an even coolness throughout the year ensuring that most of the precipitation falls as rain rather than snow; often measurable precipitation occurs two out of every three days" (Crum 1988). The climate of the Great Lakes area is not as favorable for peat accumulation; the possibility of regeneration of peat in this area is unlikely. In the more favorable climates of Maine, undrained peatlands cleared of vegetation regenerate within a few years, but deep-ditched peatlands will not recover even decades after drainage. Fortunately, the peat resources in North America have not yet been exploited to a point of irreparable damage, as is the case with many of Europe's peatlands. Peat resources in Michigan have been inventoried only in part and are subject to state control only under laws regarding mineral rights. The Department of Natural Resources has neither the knowledge nor the personnel to plan for long-range controls; luckily the need in Michigan has not been great (Crum 1988). Peatland mining may therefore be less of a threat in Michigan than Minnesota.

PRACTICAL USES

The berries were eaten fresh by indigenous peoples of Alaska and central British Columbia. In Alaska, they were often mixed with cloudberries. The berries have an excellent flavor and can be eaten raw or made into jams or jellies or used for flavoring liquor (Pojar & MacKinnon 1994). In Europe, the cultivation of Rubus arcticus (arctic raspberry) as a commercial crop has become a successful enterprise. Because of its unique flavor and aroma, the arctic bramble is used in soft drinks, liqueurs, and preserves in the Scandinavian countries and the former Soviet Union.

Finding sufficient numbers of berries from the wild was increasingly difficult as favored habitat was lost to agriculture. Research on cultivation of the arctic bramble began in 1933 in Finland at the North Savo Agricultural Experiment Station at Maaninka (63^{o}N latitude) (Holloway 1982). This research was virtually abandoned during the war years and began again in the 1960's (Ryynanen 1972). Initially, wild populations were collected from throughout the country. Selection and breeding of natural strains lead to improved berries. Two cultivars, 'Mespi' and 'Mesma', were released in 1972. Because arctic bramble fruit development is dependent upon cross-pollination with another strain (R. arcticus is self-incompatible), growers needed to plant both cultivars (Ryynanen 1972). 'Mespi' was the fruit producer while 'Mesma' was used to assist pollination.

By 1982 a third cultivar 'Pima' was obtained as a result of crossing between two earlier cultivars. The yield was almost twice that of 'Mespi' (Hiirsalmi 1991), but still there were issues posed obstacles to commercially viable cultivation. Fruits are small, irregular in color, and ripen over a long period (Hall & Brewer 1989). In a further attempt to improve cultivation potential, the arctic bramble was crossed with the Alaska bramble (Rubus arcticus L. subsp. stellatus (Sm.) Boiv.) and two new cultivars were released 'Aura' and 'Astra'. Both cultivars produce higher yields than previous cultivars. The cultivars possess large, firm fruit, with a fine aroma (Hiirsalmi 1991). Both cultivars remain self-sterile (Hall & Brewer 1989).

Isolation as a field crop in Europe has made the arctic bramble more susceptible to disease. Between 1994 and 1996, large losses were reported in cultivated arctic brambles (Rubus arcticus) due to berries drying up in the middle of the growing season. Yield was often reduced by as much as 50 percent. The affected plants often exhibited interveinal, angular, purple-red lesions on their leaves (Lindqvist, Koponen, & Valkonen 1998). The causal agent was later confirmed to be a downy mildew caused by Peronospora rubi. Under cool and moist conditions, sporulation of the fungus occurs on the abaxial side of the leaves and the disease spreads rapidly. The disorder affects the vigor of shoots, leading to the malformation and desiccation of developing drupelets (Kokko et al. 1999).

RESEARCH AND MONITORING

Without the research that took place to breed better cultivars of the arctic raspberry, we would understand little about the life history and preferred growing conditions for a closely related species R. arcticus. Additional research is needed for R. acaulis to determine how similar the two species are in term of life cycle and preferred growing conditions. Research on Rubus arcticus may help us to formulate hypothesis related specifically to R. acaulis.

On the Bighorn National Forest in Wyoming, a pilot monitoring program was established in 1999 to provide information on the population trend of R. acaulis at the Sourdough Creek site. These studies were conducted to assess baseline abundance, density, and frequency of subpopulations along the Sourdough Creek. This effort yielded useful population data, but the number of plots required for statistical confidence was found to be prohibitively large. Photo plots were recommended as a useful tool for measuring changes in habitat suitability. On a 3 to 5 year cycle it was recommended that detailed notes on abundance, density, habitat preferences, and associated species should be made to determine if current patterns are being maintained (Fertig 2000b).

More monitoring data is needed before making a plan to preserve this species. Its status in other areas in the Eastern Region is fairly unclear, more occurrences could be discovered if additional suitable habitats were searched. The potential impacts in the areas where it is known to occur, such as Shingleton Fen, also need to be investigated more thoroughly.

SUMMARY

Rubus acaulis is most common in boreal Canada and Alaska. Occurrences here may be relics from glacial times. Often these relic populations do not produce fruit since pollinators do not find these isolated plants. The only known Michigan location for Rubus acaulis on the Hiawatha National Forest could be impacted by road construction, hydrological alterations and possibly snowmobile use. In general, Rubus acaulis is a poorly understood and documented species. Its need for protection has been debated because it was considered a subspecies of Rubus arcticus until recently, and its taxonomic status is still somewhat controversial. Much of what we can deduce about the life history of R. acaulis we have learned from research on the closely related Rubus arcticus, which has been grown commercially in Europe. We need additional research to understand Rubus acaulis as a separate species with its own habitat requirements.

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