

*Conservation Assessment
for
Black crowberry (Empetrum nigrum) L.*



USDA Forest Service, Eastern Region

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Hiawatha National Forest



This document is undergoing peer review, comments welcome

This Conservation Assessment was prepared to compile the published and unpublished information on the subject taxon or community; or this document was prepared by another organization and provides information to serve as a Conservation Assessment for the Eastern Region of the Forest Service. It does not represent a management decision by the U.S. Forest Service. Though the best scientific information available was used and subject experts were consulted in preparation of this document, it is expected that new information will arise. In the spirit of continuous learning and adaptive management, if you have information that will assist in conserving the subject taxon, please contact the Eastern Region of the Forest Service - Threatened and Endangered Species Program at 310 Wisconsin Avenue, Suite 580 Milwaukee, Wisconsin 53203.

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Initial Draft

We are grateful to Carrie Sanderson, contract botanist, for her efforts in providing us with an original draft for this Conservation Assessment.

EXECUTIVE SUMMARY

Empetrum nigrum L., black crowberry, is a dwarf evergreen shrub that generally reaches 15 cm in height. Black crowberry is a subarctic, circumpolar plant. In Canada, it is found on acidic rocks, gravel, peat, and tundra. In Michigan, black crowberry is found in the Upper Peninsula and on Isle Royale National Park. On Lake Superior's southern shore, it inhabits sandstone ledges and sandy upper beaches. It also grows on *Sphagnum* hummocks in a marl swamp in Mackinac County.

Black crowberry is listed as Threatened in the State of Michigan with a G5 ranking (secure globally, though it may be quite rare in parts of its range, especially at the periphery). It is an R9 Sensitive Species on the Hiawatha National Forest in Michigan. It also occurs on the White Mountain National Forest, New Hampshire in mountains at elevations mostly between 3000-5500 feet (NH NHI 2001); it is not listed as R9 on the White Mountain National Forest. *Empetrum nigrum* is considered critically imperiled in Minnesota and Vermont. New Hampshire and New York rank black crowberry as vulnerable. Black crowberry is ranked as secure in Canada since it is primarily a species of sub-alpine climates.

Primary threats to the survival of *Empetrum nigrum* include increased levels in the water table, fire, shading, and trampling. Black crowberry is intolerant to prolonged waterlogging. Minor fires top kill black crowberry and moderate to severe fires kills underground parts close to the soil surface. Black crowberry is slow to recover following deep fires which kill the underground portion and takes many years to regenerate.

NOMENCLATURE AND TAXONOMY

Empetrum nigrum: *Empetrum*-from the Greek word *en*, upon, and *petros*, a rock, in reference to a common type of habitat of this genus. *Nigrum*- black, referring to the fruit color (Pojar & MacKinnon 1994).

Scientific name: *Empetrum nigrum*

Family: Empetraceae

Common names: black crowberry
mossberry
curlewberry

USDA plant code: EMNI

Synonyms: *Empetrum eamesii* Fern. & Weig.
E. atropurpurem (Lange) Hagerup;
E. hermaphroditicum (Lange) Hagerup.

Much of the confusion over synonyms depends on whether to separate different geographic varieties or races as distinct species or to group them together as one species. Gleason & Cronquist (1991) describe two species both with two varieties: (1) *Empetrum nigrum*, a diploid with unisexual flowers and dioecious plants; and *E. nigrum* var. *hermaphroditum*, a tetraploid with either perfect or sometimes partly unisexual flowers. (2) *Empetrum rubrum* var. *eamesii* was described with bright red fruits and short crowded ascending leaves and *E. rubrum* var. *atropurpureum* with purplish fruits and divergent leaves (Gleason & Cronquist 1991). Those who treat the *Empetrum* complex in an inclusive sense would assign our Great Lakes plants to *E. nigrum* ssp. *hermaphroditum* (Hagerup) Bocher (Voss 1985).

DESCRIPTION OF SPECIES

Empetrum nigrum is a low, creeping evergreen shrub that generally reaches 6 inches (15 cm) in height and often forms dense mats (USDA Forest Service, 1992). Young *E. nigrum* plants initially possess a strong primary root and a vertical shoot, which is later replaced by creeping lateral shoots resulting in an outspreading growth from a central point. Branches become procumbent under their own weight, and where they touch the ground adventitious roots may be produced; a dense mat of finely branched roots is eventually formed in the top 10 cm of the substratum. Root hairs are absent, but an endotrophic mycorrhiza is usually present to aid with nutrient absorption (USDA Forest Service, 1992).

STEMS: branches procumbent or decumbent, round, not winged. Prickles absent. Bark smooth, exfoliating, Branchlets very slender. Pith present, orange-yellow, round, continuous. Thorns absent. Aerial roots absent. Sap translucent, resin absent (Brooklyn Botanic Garden 1997).

LEAVES: evergreen, leathery, alternate or subopposite or whorled, 1-4 lvs per node, entire, crowded toward stem apex, divergent from stem (or reflexed), simple. Stipules absent. Blades narrowly elliptic or narrow oblong (0.3-0.5 cm long, 0.1 cm wide) strongly revolute (appearing tubular or needle-like in shape (MNFI 1985). Leaf base acute or cuneate, margin ciliate (glandular), apex obtuse, abaxial surface hairs short and unbranched, erect, sparse. Spines absent. (Brooklyn Botanic Garden 1997).

INFLORESCENCES: monomorphic, regular or, if dimorphic, female inflorescence simple, single flower, axillary. Peduncle absent. Rachis absent (Brooklyn Botanic Garden 1997).

FLOWERS: inconspicuous, formed on short shoots in the axils of the uppermost leaves, 3 merous, with 3 petal-like purplish sepals and 3 pinkish stamens (Hyland & Hoisington 1977), subtended by 3 bracts, 1 flower per inflorescence, fragrance absent, perianth of one or two whorls. Calyx present. Gynoecium syncarpous. Carpels 6-9. Stigmas 6-9, lobed. Styles not persistent, Ovary superior, placentation basal axile. Stamens 2-3. Anthers long-exserted (Brooklyn Botanic Garden 1997, Welsh 1974, Bell & Tallis 1973).

FRUITS: drupe, black or purplish-black, globose, 6-9 mm long, glabrous (Gleason & Cronquist 1991).

SEEDS: 6 to 9 seed-like nutlets, reddish-brown, ovoid or wedge-shaped, wingless, not tailed, rugose (Brooklyn Botanic Garden 1997).

Identification notes:

Black crowberry is a low, mat-forming, evergreen, heath-like shrub with needle-like linear-oblong, strongly revolute leaves. The flowers are single, tiny, pink-purple in color; the fruits are black or dark purple, berry-like drupes in the leaf axils (Chadde 1999, Soper & Heimbürger 1982).

In the Great Lakes States, there are no species that would easily be confused with *E. nigrum*. However, in the western United States and Canada, the Alaskan moss heather (*Cassiope stellerina*) and the pink mountain-heather (*Phyllodoce empetriformis*) could be confused when not in flower or fruit. Both have showy flowers and rounded capsules so are quite distinctive when mature specimens are found. The Alaskan moss heather does not have grooves on its lower leaf surface so this character can be used to distinguish the species by vegetative characteristics. Both crowberry and pink mountain-heather have grooved leaves, but *P. empetriformis* has longer leaves up to 1 cm long, rather than just 3-7mm long as with crowberry (Pojar & MacKinnon 1994).

HABITAT TYPES AND PLANT COMMUNITIES

Empetrum nigrum is a circumpolar, mid-arctic, sub-arctic plant. It withstands extremely low temperatures and will persist where other plants perish from the cold (Billington 1949). By rooting at the nodes and spreading low to the ground *Empetrum nigrum* tolerates high winds and resists uprooting (Taylor 1996). The habitat of *Empetrum nigrum* includes: bare outcrops, cedar or black spruce bogs, occasionally in peaty bogs, but more common in peaty soil along the coast or in cool alpine areas (Hyland & Hoisington 1977), sandstone ledges, open tundra, conifer forests, coastal bluffs, exposed sea cliffs, heaths (USDA Forest Service 1992), sphagnum bogs or muskegs, rocky shores, sandy bluffs, and old dune ridges (Voss 1985).

In Canada, *E. nigrum* is found on acidic rocks, gravels, peats, and tundra (Scoggan 1978). Black crowberry is found in sandy to rocky soils, glacial till, and alluvial deposits (Soper & Heimbürger 1982). In Britian, soil pH ranges from 2.5 to 7.7 (Bell & Tallis 1973). *E. nigrum* reportedly prefers a strongly acid substrate, even though it sometimes grows in areas of calcareous bedrock or mineral soil. On more calcareous sites it is normally restricted to acidic hummocks (MNFI 1985).

In Canada, *Empetrum nigrum* grows in semi-open strands between the herb field and forest or “krumholz” with other carpet-forming shrubs rooted in shallow crevices but spreading out over adjacent massive rock surfaces, sometimes with a thin, peaty, featureless soil. Although widely distributed along the north shore of Lake Superior and

locally around the southern shore of Lake Superior, *E. nigrum* is usually of limited occurrence at any one locality (Given & Soper 1981). After the boreal forest became established, several arctic-alpine species such as *Empetrum nigrum*, *Polygonum viviparum*, *Saxifraga aizoon*, and other *Saxifraga* species have been able to persist on the rocky shores where suitable habitats with cooler microclimatic conditions prevail (Soper & Maycock 1963).

Southeast of Nipigon, Ontario on Bowman Island *Empetrum nigrum* is a major constituent on rocky outcrops, and in the black spruce/balsam fir forest and krummholz. Bowman Island is home to 12 plant species of the arctic, alpine, subarctic group. Of these, *Empetrum nigrum*, *Vaccinium vitis-idaea*, and *Potentilla tridentata* were encountered in sample quadrats along the exposed shoreline indicating a tolerance for exposed rocky outcrops (Barclay-Estrup & Nuttall 1974).

Empetrum nigrum is found on the Aleutian Islands along the southwest coast of Alaska in a *Vaccinium uliginosum*-*Empetrum nigrum* coastal, wetland community. Other associates include *Erigeron peregrinus*, *Calamagrostis nutkaensis*, *Geum calthifolium*, *Pleurozium schreberi*, and *Carex anthoxantha* (Talbot & Talbot 1994).

Black crowberry is tolerant of a wide range of soil moisture conditions. It is intolerant of prolonged water logging, and on wet sites it is found in better drained areas. In Scotland, *Empetrum nigrum* was particularly characteristic of drier hummocks elevated at least 15 cm above the general bog surface (Lindsay, Riggall & Bignal 1983 *cf* Tallis 1997) and typically > 30 cm above (Ratcliffe & Walker 1958 *cf* Tallis 1997).

Black crowberry is adapted to harsh climates and it often inhabits sites exposed to wind, fog, and salt aerosols (USDA Forest Service 1992). "Site characteristics often influence black crowberry morphology: on sites with high wind exposure, black crowberry is branched and prostrate; on wet sites it is sparsely branched and has long annual growth increments; on dry sites it has branching shoots and is bushy" (Bell and Tallis 1973).

In New Hampshire, in the White Mountain National Forest *Empetrum nigrum* occurs on moderate slopes between 1900 ft and 6091 ft. with elevations of 3300-5500 being most typical (NH NHI 2001). Typical associates include *Ledum groenlandicum*, *Betula glandulosa*, *Vaccinium uliginosum* var. *alpinum*, *Vaccinium vitis-idaea*, and *Potentilla tridentata* (NH NHI 2001).

In Finland, *Empetrum nigrum* is a dominant species above 900 ft. (273 m). *Betula nana* and *Vaccinium myrtillus* are also dominant in the heath zone which occurs above the *Betula odorata* forest. *Empetrum nigrum* is more xerophytic than *Betula nana*, so the average water content of the soil may determine which species becomes more dominant in this zone. *Vaccinium myrtillus* grows in slight depressions where snow accumulates affording some protection from high winds (Leach & Polunin 1932).

Black crowberry is a dominant or codominant in a variety of different habitats. It may occur as an understory dominant in open conifer woodlands with black spruce (*Picea*

mariana), white spruce (*P. glauca*), or shore pine (*Pinus contorta* var. *contorta*). Black crowberry can dominate shrub-types with dwarf birch (*Betula nana*), willow (*Salix spp.*), and ericaceous shrubs in bogs or muskegs and on open, moist tundra (USDA Forest Service 1992).

Other commonly associated species include: paper birch (*Betula papyrifera*), quaking aspen (*Populus tremuloides*), Alaska cedar (*Chamaecyparis nootkatensis*), bog birch (*Betula glandulosa*), Labrador tea (*Ledum glandulosum* and *L. groenlandicum*), various *Vaccinium* and *Carex* species, feathermosses (*Hylocomium spp.* and *Pleurozium spp.*), lichens (*Cladonia spp.* and *Cladina spp.*), and *Sphagnum* mosses (USDA Forest Service 1992).

Successional Status: Black crowberry is a pioneer species on bare rock outcrops, on sandy blowouts, lichen-covered depressions on eskers, and in white cedar bogs (Voss 1985, USDA Forest Service 1992). In the western United States it is associated with white or black spruce climax communities (USDA Forest Service 1992). In many boreal forests, *E. nigrum* establishes in late-succession and finally dominates the ground-layer vegetation. The increased occurrence of crowberry is concomitantly associated with low species diversity, greater humus build-up, low tree seedling recruitment and diminished tree productivity (USDA Forest Service 1992). Numerous studies indicate that *E. nigrum* has allelopathic properties against seed germination of associated species. “Its phenolic compounds are released through rain, dew, and snowmelt to the soil. Phenolic effects are strongly apparent in the humus under dense clones of crowberry. For example, the fungal component of the Scots pine mycorrhizal symbiosis is strongly impaired by crowberry extracts, and this reduces nitrogen acquisition by pine seedlings” (Tybirk *et al.* 2000).

Michigan: Black crowberry grows on the rocky shores of Lake Superior and on Isle Royale National Park (Chadde 1999). Black crowberry also grows in two white cedar/black spruce bogs on the Keweenaw Peninsula (Weitzman 1984). On Lake Superior’s southern shore, it inhabits sandstone ledges at Pictured Rocks National Lakeshore (Alger County) and sandy banks in Luce County (Weitzman 1984). In rocky and sandy habitats associated shrubs include creeping juniper (*Juniperus horizontalis*), common juniper (*Juniperus communis*), green alder (*Alnus viridis*), and bearberry (*Arctostaphylos uva-ursi*) (Chadde 1999). *E. nigrum* also grows on sphagnum hummocks along with *Erigeron hyssopifolius* in a marl swamp in Mackinac County (Weitzman 1984). Associates at the swamp site include shrubby cinquefoil (*Potentilla fruticosa*), leatherleaf (*Chamaedaphne calyculata*), Labrador-tea (*Ledum groenlandicum*), small cranberry (*Vaccinium oxycoccos*).

DISTRIBUTION AND ABUNDANCE

Black crowberry, a circumpolar plant of arctic affinity, is distributed throughout Alaska, in Canada from the Yukon Territory to Labrador, Newfoundland, and Greenland (USDA Forest Service 1992). *Empetrum nigrum* dominates numerous ecosystems in boreal, sub-arctic, and arctic zones. It often dominates heathland ecosystems on acidic and nutrient poor soils when disturbance is infrequent and the climate is cool (Tybirk *et al.* 2000). In

the United States, it occurs south to the coast of Maine, in the mountains of northern New England (often at 3300-5500 ft, NH NHI 2001) and New York, the Upper Peninsula of Michigan and Isle Royale, as well as along the Pacific Coast, Oregon to northern California (Billington 1949). Black crowberry also has a wide distribution throughout Europe and Asia (USDA Forest Service 1992).

E. nigrum is common throughout Alaska including the Aleutian Islands. It is one of the most common species in heath mats to 5600 ft. (1700m) on rocky cliffs or nunataks of the Juneau Ice Field. It is widespread in arctic-alpine tundra, interior mountains, moist rocky slopes, and spruce forests along the southern coast (Viereck & Little 1972).

In Canada, *Empetrum nigrum* has been found in many localities near Lake Superior at the shoreline just above the water line of heavy storms where it inhabits on rock ledges in rock crevices. At slightly inland sites it may occur in bogs or muskegs. It is less common on sandy beaches such as the east shore near Agawa Bay partly shaded by *Pinus resinosa* and a sandy beach near Marathon in full sun with *Lathyrus japonicus* (Soper & Voss 1964).

In Minnesota, there have been recent attempts to relocate black crowberry at its original collection sites, as well as in suitable habitats on nearby islands with unsuccessful results (Coffin & Pfannmuller 1988). The University of Minnesota Herbarium lists 2 specimens from Cook County. Minnesota recent reports are for *E. nigrum*; earlier reports also included *E. atropurpureum* (E. Voss pers. comm. 2001). The collection sites for *E. nigrum* are several islands in Lake Superior. The margins of the islands consist of massive bedrock exposures; it is found on the moist ledges on the northwest end (Coffin & Pfannmuller 1988). *Empetrum nigrum* is not known from Wisconsin (NatureServe 2000).

Michigan Distribution

By 1999, there were at least 20 known sites for *Empetrum nigrum* in the Upper Peninsula of Michigan (MNFI 1999). There are nine stations on or near Isle Royale (two on the main island and seven on different islands in the Isle Royale archipelago (E. Voss pers. comm. 2001). Four stations are in Alger County, three in Luce, and two on the mainland Keweenaw Peninsula (MNFI 1985). The Hiawatha National Forest lists eight stations (covering 16 sections) in Mackinac County of which Summerby Swamp is the best known and repeatedly visited (MNFI 1999 lists as 4 occurrences). MNFI (2001b) continues to list four counties with Element Occurrences (Alger, Keweenaw, Luce, and Mackinac). Black crowberry is known from the Lake Superior shoreline in Alger County (Pictured Rocks National Lakeshore) and Luce County (east of Deer Park and near the mouth of the Two-Hearted River) (Voss 1985).

Protection Status

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

U.S. Forest Service: R9 Sensitive on Hiawatha National Forest (MI),

and occurs on White Mountain National Forest NH

Global Conservation Status Rank: G5

G5: Common, widespread and abundant globally (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.

National Conservation Status Rank: United States: N5 (Dec. 1994)

Canada: N? (Aug. 1993)

Michigan: Threatened **Minnesota:** Proposed Endangered

Wisconsin: Not known

United States: (NatureServe)

Alaska	SR	New Jersey	SR
California	S?	New York	S?
Michigan	S2	Oregon	S5
Minnesota	S1	Vermont	S1
New Hampshire	S3	Washington	SR

Canadian Province (NatureServe)

Alberta	S5	Nova Scotia	SR
British Columbia	S?	Nunayut	SR
Labrador	SR	Ontario	S5
Manitoba	S5	Prince Edward Island	S5
New Brunswick	SR	Quebec	SR
Newfoundland Island	SR	Saskatchewan	S5
Northwest Territories	SR	Yukon Territory	SR

Definition of State and Provincial Ranks:

S1 = Extremely rare; typically 5 or fewer known occurrences in the state; or only a few remaining individuals; may be especially vulnerable to extirpation.

S2 = Very rare; typically 5 between 6 and 20 known occurrences; may be susceptible to extirpation.

S3 = Rare to uncommon; typically 21 to 50 known occurrences; S3 ranked species are not yet susceptible to becoming extirpated in the state, but may be if additional populations are put at risk.

S4 = Common, apparently secure under present conditions; typically 51 or more known occurrences, but may be fewer with many large populations; usually not susceptible to immediate threats.

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? = Not enough information available to assess at this time.

LIFE HISTORY

Empetrum nigrum is a much-branched, prostrate, dwarf shrub with densely leafy shoots; elongation of its shoots proceeds monopodially from a terminal bud formed in the previous season (Shevtsova *et al.* 1995). Flower buds of *E. nigrum* are formed laterally on the current year's segments and floral initiation occurs at the end of the vegetative season, while development of berries and new branches occurs on the previous year's growth segment (Shevtsova *et al.* 1995). Flowering occurs in spring in areas of early snowmelt (May in Upper Michigan) and continues through July. Fruits mature from August to late fall and persist through the winter under snow cover (USDA Forest Service 1992).

Sexual reproduction plays a minor role quantitatively, but it has rarely been estimated. Vieno *et al.* (1993) found up to 588 viable seeds in a meter square. A recent study (Hansen 1998) in a disturbed Danish inland heath revealed up to 80 seedlings of *E. nigrum* in a meter square with a high survival rate during the first 2 years (Tybirk *et al.* 2000).

POPULATION BIOLOGY

Sexual reproduction: Black crowberry is polygamous, dioecious, or monoecious. The dark-blue to black fruit is a drupe containing six to nine nutlets. Some seeds may become established under the parent, but seedling mortality is generally high. Black crowberry seeds have been found buried beneath the soil, although only a small percent of the seeds are actually viable. Seeds were found in 71 percent of soil cores taken from plots near Great Slave Lake, Northwest Territories (USDA Forest Service 1992).

Vegetative reproduction: Sprouting from underground or basal portions is the main form of reproduction of black crowberry. In addition, adventitious roots form where procumbent branches come in contact with the ground (USDA Forest Service 1992). Vegetative propagation is more important than reproduction by seed, which seems to take place only on isolated occasions. A large colony may be derived from a single seed (Bell & Tallis 1973).

Germination: Under natural conditions low germination occurs in any one year, and the seeds lie in the ground for up to 4 years before germinating (Bell & Tallis 1973). No germination inhibitor appears to be present in the fruit; passage through the gut of a grouse does not break dormancy. Low temperature over the winter is necessary for

breaking dormancy under natural conditions. The optimum temperature for germination is 25-30 degrees Celsius. Natural conditions are more effective than any controlled cold period, probably due to wide temperature fluctuations in the natural state. Seeds that were in the field throughout the winter showed the highest germination (16%) in the following spring (Bell & Tallis 1973).

Pollination: *Empetrum nigrum* is not self-compatible (Brooklyn Botanic Garden 1997). Pollination is thought to be accomplished by wind (MNFI 1985), although claims have been made that the stigma secretes nectar to attract flies (Bell & Tallis 1973).

Dispersal: Each fruit contains 6-9 seeds. Dispersal is by animals and birds eating the fruits, so that seeds pass through the gut (Bell & Tallis 1973). Animals responsible for dispersal are birds (ravens, ptarmigans, black grouse, and gulls), foxes, lemmings, and bears (Brooklyn Botanic Garden 1997). Many fruits are not consumed, and eventually fall to the ground beneath the parent plant (Bell & Tallis 1973).

Interdependence: *Empetrum nigrum* was observed to grow better in heath plots with higher cover of dwarf shrubs. The growth of *E. nigrum* was reduced at a statistically significant level after removal of *Vaccinium uliginosum*. Since *V. uliginosum* is deciduous and *E. nigrum* is evergreen; the former may act to supply nutrients to the latter (Shevtsova *et al.* 1997).

POPULATION VIABILITY AND PROTECTION

Empetrum nigrum is tolerant of cold windy conditions, and is absent only from the most exposed summits. It is limited in the Great Lakes Region since it is naturally a more northern circumboreal plant of Canada and Alaska. Its tolerance to air pollution is considerable, and it will continue to grow next to smelters. In Straumsvik, Iceland all the dwarf shrubs except *Empetrum nigrum* have disappeared; its presence has increased from 16% to 70% (Kristinsson 1998). In northern Norway near aluminum smelters, *Calluna vulgaris* was replaced by *Empetrum nigrum* and *Salix repens* (Kristinsson 1998). Similarly, *Empetrum nigrum* is tolerant of acid rain to as low as pH 3. However “rain” at pH 3 reduced the number of berries and flower buds on the terminal shoots of *E. nigrum* affecting its reproduction potential (Shevtsova & Neuvonen 1997).

Empetrum nigrum is associated with higher organic matter accumulation in the top soil, lower pH, and lower concentrations of nitrogen. Furthermore leaching of the E horizon and coloration of the initial Bh horizon under *E. nigrum* is more pronounced suggesting a higher rate of podzolisation. Moreover, an Ah horizon beneath the H horizon indicates an increase in soil fauna activity (Emmer 1994).

The high phenolic content of *Empetrum nigrum* leaves reduces browsing and insect attacks (Tybirk *et al.* 2000). “*Empetrum nigrum* is able to dominate many northern ecosystems because it has soil forming qualities which create a closed nutrient cycle; its ericoid mycorrhiza enables it to survive in otherwise poor nutrient sites; allelopathy negatively affects competitor species; it is a long-lived species; and its phenolic compounds repel most biotic enemies” (Tybirk *et al.* 2000).

In the Upper Peninsula of Michigan, sites are at risk because this is naturally a more northern species. Most of Michigan's *Empetrum nigrum* sites are located on National Park or National Forest land. Isle Royale National Park and Pictured Rocks National Lakeshore represent long-known localities (MNFI 1985). An extensive population in Mackinac County lies within the Horseshoe Bay Wilderness Area of Hiawatha National Forest (HNF). Three other fen sites on the Hiawatha also support populations of over 100 plants (MNFI 1999). MNFI (2001a) has given one HNF site an A ranking, and another an AB rating; the others are unranked because of insufficient information on numbers and quality. The A and AB sites are considered to be viable for the long-term, medium to large populations, large habitat area, landscape relatively connected, surrounding landscape in good condition, and populations highly likely to remain viable (MNFI 2001a). Along the southern shore of Lake Superior *E. nigrum* occurs as scattered colonies; however, sites in Luce County have existed for at least a century (E. Voss pers. comm. 2001). Bell & Tallis (1973) report that a single plant may be as old as 140 years. The cedar swamp habitat in Mackinac County is less characteristic for the species, but probably it occurs here because of the cold air pockets that this landscape provides (Weitzman 1984).

POTENTIAL THREATS

General threats: Several threats exist to the survival of *Empetrum nigrum*. These include habitats with short fire intervals, increased water table levels (Bell & Tallis 1974) increased canopy closure due to alterations in timber harvesting activities, recreational activities which often result in trampling, weed introduction along logging trails or utility lines (MNFI 1985) and construction for utility lines (J. Schultz pers. comm. 2002). Also, high levels of iron and aluminum due to water fluctuation can be detrimental to the survival of *Empetrum nigrum* (Bell & Tallis 1974).

Recreational threats: In Luce County and in Pictured Rocks National Lakeshore the North Country Trail passes near *Empetrum nigrum*. In Luce County the trail is also being violated by motorized vehicles (E. Voss pers. comm. 2001).

High water table levels: Pot cultures with controlled water table levels have shown black crowberry to be intolerant of prolonged waterlogging. "The anaerobic conditions produced by a high water table probably damage the roots as a result of high carbon dioxide and hydrogen sulphide levels and impaired uptake of water" (Bell & Tallis 1974). Laboratory experiments confirmed this sensitivity, with growth of black crowberry markedly affected at water tables 0-6 cm below the surface (Tallis 1997). Under experimental conditions, heavily water logged plants ceased growth after 89 days; those subjected to an intermediate water table ceased growth at 113 days (Bell & Tallis 1974).

In general, *E. nigrum* occurs on the drier portions of mire sites. At Wybunbury Moss, in the British Isles, an *Empetrum nigrum* colony continued to decline throughout 1966, a period of high water; and by early 1967 most plants appeared dead except those at the extreme west end. During the 1968 growing season (lower water table), a considerable

amount of new growth was observed at the west end, although at the east end there were no signs of revival (Bell & Tallis 1974).

Drought sensitive: *E. nigrum* is also somewhat drought sensitive, and prefers oceanic or sub-oceanic climates in boreal regions. *Empetrum nigrum* is also very sensitive to trampling and mowing since with patches of bare ground, other species can establish and compete successfully (Tybirk *et al.* 2000).

Fire: Black crowberry is liable to top-kill by fire due to its low growth form and small stems. At many European sites *E. nigrum* is exposed to periodic fires where burning of heather is practiced. Ratcliffe (1959) and Gimingham (1964) as *cf* Bell & Tallis (1973) noted a temporary phase of abundance following controlled burning, before the re-establishment of *Calluna vulgaris* (heather). Below-ground parts of *E. nigrum* are very susceptible to fire damage because most are located near the soil surface. If fires are moderate to severe and soil temperatures are high then black crowberry is slow to recover following fire (Sinker 1962 *cf* Bell & Tallis 1973). If fire penetrates sufficiently to deeply kill the entire plant, this is often deleterious to *E. nigrum*, since this species has poor powers of reproduction from seed (Bell & Tallis 1973). In Labrador, black crowberry decreased significantly in frequency and abundance following fire. Pre-burn frequency was 61 percent, while post-burn frequency was 0 percent after 5 years. It also showed little or no recovery in 2- or 7 year-old burns in the Seward Peninsula, Alaska (USDA Forest Service 1992). Black crowberry can regenerate vegetatively following fire, but this process is slow. Normal or prefire densities may not be reached for 30-60 years (Tybirk *et al.* 2000).

Shading: Hester, Miles, and Gimingham (1991) did an experimental alteration of light intensity on plant communities beneath different ages of birch trees. *Empetrum nigrum* revealed a strong detrimental effect of shading which could lead to a rapid decline. Shading caused dramatic reductions in flowering, shoot production and dry weight of shoots (Hester *et al.* 1991). In a natural setting on Bowman Island in Ontario, many more tip shoots were produced in the open Krummholz area compared to the black spruce forest (Barclay-Estrup & Nuttall 1974). Once established, *E. nigrum* can persist under relatively low light conditions. In Western Europe, *E. nigrum* is usually associated with open habitats; it is thought that its germination is favored by light (Barclay-Estrup & Nuttall 1974).

Snow cover: Black crowberry is unable to survive severe winter temperatures without the insulating effect of snow cover. Black crowberry is also intolerant of snow cover prolonged into the spring, on account of its early commencement of growth and flowering (Bell & Tallis 1973).

Global warming: In experiments conducted in northern Finland and Sweden, *E. nigrum* responded strongly to warming by accelerated vegetative bud burst and increased shoot growth in the second and third seasons of treatment. However, increased mortality of apical meristems and the enhanced tendency of *E. nigrum* to produce a late-season flush of growth suggests that climatic warming might increase the frost susceptibility of

vegetative buds (Tybirk *et al.* 2000). In response to UV-B radiation, *E. nigrum* response was slower, but reduced growth was detectable (Tybirk *et al.* 2000).

High levels of iron and aluminum: Laboratory experiments have shown growth to black crowberry to be severely retarded at high levels of soluble iron in culture, with death occurring at 25 ppm. Aluminum toxicity is considered partly responsible for the almost total disappearance of the colony at Wybunbury Moss, Cheshire, between 1965 and 1967 (Bell & Tallis 1974). The death of *E. nigrum* at Wybunbury Moss was the result of a number of toxic effects of a high summer water table such as increased concentrations of aluminum, carbon dioxide, and hydrogen sulphide, and depleted oxygen levels (Bell & Tallis 1974).

VALUE AND USE

Importance to livestock and wildlife: Black crowberry fruits are utilized as fall and winter forage by over 40 species of songbirds, waterfowl, and upland game birds. The berries are especially important to grouse and ptarmigan. Black crowberry seeds are a major component of the red-backed vole's fall diet (USDA Forest Service 1992). Also, dense mats of black crowberry probably provide cover for small rodents and mammals (USDA Forest Service 1992).

Big game animals that browse black crowberry foliage include reindeer, caribou, and bear. Bear also eat the berries; black crowberry utilization by bear increases in summer as fruits become ripe. Occurrence of black crowberry fruits in bear scat samples increased from 5.9 percent in early spring to 12.9 percent by late summer (USDA Forest Service 1992). In Sweden, bears obtained 44-46% of their total annual energy from berries. Among berries, *Empetrum nigrum* was the most important species, followed by *Vaccinium myrtillus* (Dahle *et al.* 1998).

Nutritional value: Black crowberry in barren-ground caribou forage areas consists of 6.27 percent protein and releases energy in the amount of 5.51 kilocalories per gram. Digestibility of black crowberry has been classified as low (USDA Forest Service 1992).

Value for rehabilitation of disturbed sites: Black crowberry has been broadly successful at naturally colonizing borrow pits in the tundra regions of northwestern Canada, and may be useful in managed reclamation projects. Black crowberry has followed cottongrass (*Eriophorum spissum*) in the colonization of mined peatlands, but only after decades have elapsed. Dense black crowberry mats catch blowing soils in areas of high wind exposure, and may help stabilize the steep, rocky slopes it often inhabits (USDA Forest Service 1992).

RESEARCH AND MONITORING

Because of its circumpolar distribution, *Empetrum nigrum* has been studied extensively to determine its response to global warming, acid rain, and other air borne pollutants. Due to its ability to absorb heavy metals concentrations with little damage it has been used as a bio-indicator for the changing environmental condition.

However little research has been done where *E. nigrum* is at the southern edge of its distribution as in the Great Lakes states. Currently there is no monitoring program for *E. nigrum* at Pictured Rocks National Lakeshore or on the Hiawatha National Forest.

SUMMARY

Although black crowberry is fairly common farther north in Canada, *Empetrum nigrum* is rare in the Great Lakes Region because it is at its southern limit. It is found along Lake Superior or on hummocks in cold air pockets within marl swamps in Mackinac County. *Empetrum nigrum* has low tolerance to fire and often takes 30 to 60 years to recover. *E. nigrum* also has low tolerance to water logged conditions, and in swamps it grows on the *Sphagnum* hummocks. Once established, phenol compounds in its leaves protect it from browsing by animals, and the leaf litter helps to keep out other competing species of plants. It appears that *Empetrum nigrum* is relatively resistant to environmental changes such as acid rain, changes in UV-B radiation, global warming, and air-borne heavy metal accumulation.

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