



SPECIES STATUS REPORT

Hairy Braya

(Braya pilosa)

in the Northwest Territories

Status of Hairy Braya in the NWT

Species at Risk Committee status reports are working documents used in assigning the status of species suspected of being at risk in the Northwest Territories (NWT).

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ABOUT THE SPECIES AT RISK COMMITTEE

The Species at Risk Committee was established under the *Species at Risk (NWT) Act*. It is an independent committee of experts responsible for assessing the biological status of species at risk in the NWT. The Committee uses the assessments to make recommendations on the listing of species at risk. The Committee uses objective biological criteria in its assessments and does not consider socio-economic factors. Assessments are based on species status reports that include the best available Aboriginal traditional knowledge, community knowledge and scientific knowledge of the species. The status report is approved by the Committee before a species is assessed.

ABOUT THIS REPORT

This species status report is a comprehensive report that compiles and analyzes the best available information on the biological status of Hairy Braya in the NWT, as well as existing and potential threats and positive influences. Full guidelines for the preparation of species status reports, including a description of the review process, may be found at www.nwt-speciesatrisk.ca.



Environment and Natural Resources, Government of the Northwest Territories, provides full administrative and financial support to the Species at Risk Committee.

Cover illustration photo credit: James G. Harris

Assessment of Hairy Braya

The Northwest Territories Species at Risk Committee met in Behchokò, Northwest Territories on December 3, 2012 and assessed the biological status of Hairy Braya in the Northwest Territories. The assessment was based on this approved status report. The assessment process and objective biological criteria used by the Species at Risk Committee are available at www.nwt-speciesatrisk.ca.

Status: Threatened in the Northwest Territories

Likely to become endangered in the Northwest Territories if nothing is done to reverse the factors leading to its extirpation or extinction

Reasons for the assessment: Hairy Braya fits criterion (b) for Threatened

(b) – There is evidence that the range is limited and there is a decline in range, population size and habitat such that it could disappear from the Northwest Territories in our children’s lifetime

- Range is severely limited (extent of occurrence 250 km²; index of area of occupancy 64 km²).
- There are only 5 known locations, but may be more on Cape Bathurst and Baillie Islands.
- Coastal habitat is declining (10 m/year erosion) and this is expected to increase.
- Hairy Braya only exists on Cape Bathurst peninsula and Baillie Islands in the Northwest Territories, so there is no possibility of rescue from outside populations.
- The ability to expand its range is limited.
- Hairy Braya has specialized habitat requirements.
- It does not compete well with other plant species when establishing or colonizing new areas.

Threats to Hairy Braya and its habitat:

- Erosion is occurring (currently at 10 m/year) and this is expected to increase due to rising sea level.
- Salinization is affecting coastal habitat, resulting in population decline.
- There is a possibility of random events such as storm surges flooding low-lying areas where the bulk of the population occurs, leading to salinization and erosion.

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- It is assumed that there is no threat of development in this area. If there was, the status would need to be reevaluated.

Positive influences on Hairy Braya and its habitat:

- Hairy Braya is found on the calving grounds of Cape Bathurst barren-ground caribou, where there is already a high level of community concern for the area.
- It is found on Inuvialuit Private Lands with the Tuktoyaktuk Community Conservation Plan in place (category E – recommends highest degree of protection).
- The extremely remote location means there is currently little human disturbance.

Recommended measures to conserve Hairy Braya and its habitat are:

- Legally protect Cape Bathurst peninsula and Baillie Islands from industrial exploration and development;
- Check areas of potential habitat on Cape Bathurst peninsula and Baillie Islands to better describe the distribution and abundance of Hairy Braya;
- Monitor sea level change and rate of shoreline erosion on Cape Bathurst peninsula and Baillie Islands;
- Gather traditional and community knowledge and scientific information on how erosion and climate are changing Cape Bathurst peninsula and Baillie Islands;
- Provide information to the Inuvialuit Land Administration for their monitoring of land use on Cape Bathurst peninsula and Baillie Islands;
- Incorporate information on Hairy Braya in the Tuktoyaktuk Community Conservation Plan; and
- Explore the possibility and need for establishing a seed bank for Hairy Braya for further research and protection.

Executive Summary

Description

Hairy Braya (*Braya pilosa*) is a perennial plant in the mustard family (Brassicaceae). The plants are 4.5 – 12.0 cm tall arising from a tuft of basal leaves, with white flowers arranged in dense clusters. It is distinguished from other *Braya* species by its large flowers and globose (nearly spherical) fruits with very long styles.

Distribution

Hairy Braya is known to occur only in the Northwest Territories, Canada. There are approximately 13 subpopulations located on the northern portion of Cape Bathurst peninsula and on nearby Baillie Islands, in the Inuvialuit Settlement Region.

Habitat

Hairy Braya is restricted to an area that remained ice-free during the Pleistocene. Hairy Braya occurs on bluffs and dry uplands composed of calcareous sandy loam and silty clay loam soils. It apparently requires bare soils for seedling establishment. Periods of standing water, erosion, and disturbance from caribou hooves appear to be involved in creating or maintaining these bare soil habitats. These habitats appear to be quite limited on the Cape Bathurst peninsula. Patches of suitable habitat are often separated from each other by large areas of wet tundra, or by erosion or salinization. Some coastal areas southwest of Cape Bathurst are rapidly eroding, and a decrease in arctic sea ice is likely hastening the erosion of Hairy Braya habitat along the coast. Most known individuals of Hairy Braya are found inland or along protected coastal areas, in habitats that appear to be stable.

Biology

Hairy Braya is a long-lived (surviving for more than ten years) perennial plant that appears to be cross-pollinated. Its restricted distribution indicates a lack of ability to expand its distribution range. Hairy Braya likely does not compete well with other plant species. Hybridization may be occurring between Hairy Braya and Smooth Braya (*Braya glabella*), and possibly with Greenland Braya (*Braya thorild-wulffii*).

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Population

It is estimated that there are 15,000 to 20,000 plants in the 13 known subpopulations of Hairy Braya, with approximately 80% of these being mature. Subpopulations on coastal bluffs are subject to rapid erosion and are clearly at risk of declining. Trends in subpopulations on protected sections of the coast and on inland bluffs have not been determined, but the habitats themselves appear to be stable. Little is known about the population structure and demographics of the species.

Threats and limiting factors

Some coastal subpopulations of Hairy Braya are threatened by salinization and the rapid erosion of coastline habitat at a rate of about 9 to 10 m per year. Sea level is predicted to increase by 0.2 to 1.0 m over 100 years, leading to increased erosion and an increased probability of storm surges. Stochastic events such as storm surges could impact Hairy Braya, including the largest subpopulation.

Positive Influences

Due to the remoteness of Cape Bathurst peninsula, Hairy Braya faces little direct threat from human activities. The Cape Bathurst peninsula includes the calving ground of the Cape Bathurst caribou population. The Tuktoyaktuk Community Conservation Plan recommends that the area be managed to eliminate, to the greatest extent possible, potential damage and disruption.

Technical Summary

Population trends	
Generation time (average age of parents in the population)	Unknown; The species appears to be a long-lived (of at least 10-15 years) perennial.
Number of mature individuals in the NWT	The estimated number of individuals is between 15,000 and 20,000, with perhaps 80% of these (between 12,000 and 16,000) being mature.
Percent change in total number of mature individuals over the last 10 years or 3 generations	The change in numbers cannot be quantified, but the loss of some coastal subpopulations due to erosion and sea spray has undoubtedly reduced the total number.
Percent change in total number of mature individuals over the next 10 years or 3 generations	The complete loss of all at-risk coastal subpopulations would reduce the total number of mature individuals by approximately 15%.
Percent change in total number of mature individuals over any 10 year or 3 generation period which includes both the past and the future	Past changes in total numbers are not documented, but about 15% of the total number of individuals are at risk.
If there is a decline in the number of mature individuals, is the decline likely to continue if nothing is done?	The loss of coastal habitat is occurring rapidly by about 9 to 10 m per year, but when the at-risk subpopulations are gone the number of mature individuals may stabilize.
If there is a decline, are the causes of the decline reversible?	The loss of habitat due to erosion resulting from reduced sea ice, likely brought about by changing climate patterns, is not reversible, at least not within a timeframe that would prevent the expected loss of some coastal habitat.
If there is a decline are the causes of the decline clearly understood?,	Habitat loss due to coastal erosion is clearly understood.
If there is a decline, have the causes of the decline been removed?	The causes of the decline cannot be removed.

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Are there extreme fluctuations in number of mature individuals?	Unknown but unlikely.
Distribution trends	
Estimated extent of occurrence in the NWT (in km²)	The estimated extent of occurrence is approximately 250 km ² .
Index of area of occupancy (IAO) in the NWT (in km²; based on 2x2 grid)	The index of area of occupancy is approximately 64 km ² .
Number of extant locations in the NWT	There are at least 5 locations.
Is there a continuing decline in area, extent and/or quality of habitat?	The decline in habitat due to rapid rates of coastal erosion and increased sea spray over recent decades will likely continue until at-risk subpopulations are gone.
Is there a continuing decline in number of locations, number of populations, extent of occupancy and/or IAO?	The decline in number of subpopulations, locations and IAO due to rapid rates of coastal erosion over recent decades will likely continue until at-risk subpopulations are gone. This will reduce the extent of occurrence of the species.
Are there extreme fluctuations (>1 order of magnitude) in number of locations, extent of occupancy and/or IAO?	No
Is the total population severely fragmented (most individuals found within small and isolated populations)?	No
Immigration from populations elsewhere	
Does the species exist elsewhere?	No
Status of the outside population(s)	N/A
Is immigration known or possible?	No
Would immigrants be adapted to survive and reproduce in the NWT?	N/A
Is there enough good habitat for immigrants in the NWT?	N/A

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<p>Is the NWT population self-sustaining or does it depend on immigration for long-term survival?</p>	<p>The population is self-sustaining.</p>
<p>Threats and limiting factors</p>	
<p>Briefly summarize the threats and limiting factors, and indicate the magnitude and imminence for each</p>	<p>Some coastal subpopulations of Hairy Braya are threatened by salinization and the rapid erosion of coastline habitat at a rate of about 9 to 10 m per year. Sea level is predicted to increase by 0.2 to 1.0 m over 100 years, leading to increased erosion and an increased probability of storm surges. Stochastic events such as storm surges could impact Hairy Braya, including the largest subpopulation.</p>
<p>Positive influences</p>	
<p>Briefly summarize positive influences and indicate the magnitude and imminence for each</p>	<p>Due to the remoteness of Cape Bathurst peninsula, Hairy Braya faces little direct threat from human activities. The Cape Bathurst peninsula includes the calving ground of the Cape Bathurst caribou population and the Tuktoyaktuk Community Conservation Plan recommends that the area be managed so as to eliminate, to the greatest extent possible, potential damage and disruption.</p>

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Preamble

In the preparation of this species status report, an effort was made to find sources of Aboriginal traditional knowledge, community knowledge and scientific knowledge. It became apparent that documented traditional or community knowledge is not available for Hairy Braya. Therefore, this report is based almost exclusively on scientific knowledge.

Names and classification

Scientific name: *Braya pilosa* Hooker

Common names: Hairy Braya; Pilose Braya; Hairy Rockcress; Hairy Northern Rockcress; Braya Poilu

Synonyms: *Braya purpurascens* (R. Brown) Bunge ex Ledebour subsp. *pilosa* (Hooker) Hultén

Family: Brassicaceae (Cruciferae) (Mustard Family)

Life Form: Herbaceous perennial plant.



Figure 1. Photograph of Hairy Braya, by James G. Harris, 2004.

Description

Hairy Braya is a long-lived (more than ten years) perennial plant with one to 30 stems from a branched root crown. The stems are 4.0-12.0 cm long and erect (upright) to ascending (inclined upward) to almost prostrate (lying flat). The stems are leafless or with a single leaf just below the lowermost flower or fruit, and densely hairy with straight and tangled hairs. The leaves are basal (located at the base of the stem), 0.7-2.0 cm in length by 0.7-2.5 mm in width, and moderately to densely hairy. The flowers are borne in dense clusters of five to many, and have four white petals 3.7-6.6 mm long by 2.0-5.0 mm wide. The fruits are ovoid (egg-shaped) or globose (nearly spherical), 5.0-6.0 mm long by 3.0-4.0 mm wide, and pubescent (covered with short simple and 2-forked hairs). The style of the mature fruit is 1.0-2.0 mm long with a generally broadly expanded stigma. The light-brown, oblong seeds are 0.7-0.9 mm long by 0.4-0.6 mm wide (Figures 1 and 2, p.3 and p.4; Harris 1985, 2004, 2010; Harris *et al.* unpubl. data 2011).

The stems, leaves, and fruits of Hairy Braya are usually yellow-green in color, allowing the plants to be quickly and easily distinguished from the darker green and often purplish-tinged stems, leaves, and fruits of Smooth Braya (*Braya glabella*), which co-occurs with Hairy Braya in some areas.

Hairy Braya is distinguished from Greenland Braya (*Braya thorild-wulffii*) by the much larger flowers, longer styles, and more upright stems.

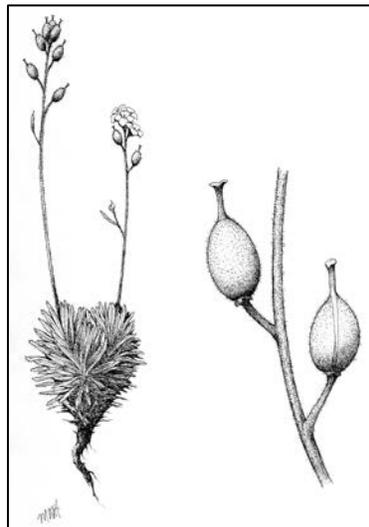


Figure 2. Illustration of Hairy Braya, by Melinda Woolf Harris.

Distribution

Continental distribution

Hairy Braya is restricted to the Northwest Territories of Canada (Hooker 1830; Harris 1985, 2004, 2010).

NWT distribution

Hairy Braya is currently known from 13 subpopulations on the northwestern portion of Cape Bathurst peninsula and on nearby Baillie Islands (Table 1, p.5 and Figure 3, p.6), an area that escaped Pleistocene glaciation (Prest 1969; Dyke *et al.* 2003). The Cape Bathurst peninsula is Inuvialuit private land under the Inuvialuit Final Agreement (Aboriginal Affairs and Northern Development Canada 1984).

The number of subpopulations of Hairy Braya was determined using definitions developed by IUCN (2008) and strategies for delimiting plant element occurrences from NatureServe (2011). Plant element occurrences (i.e. groups of Hairy Braya plants) separated from other occurrences by at least one km and isolated by unsuitable habitat are considered to be a subpopulation. The total Extent of Occurrence (EO) is approximately 249.6 km² (Figure 4, p.7), and the Index of Area of Occurrence (IAO) based on 2 km x 2 km grid squares is 64 km² (Figure 5, p.7).

Table 1. Known subpopulations of Hairy Braya. Approximate sizes of subpopulations were estimated in summer 2011 (Harris *et al.* unpubl. data 2011). Subpopulations within 1 km of northwest-facing shorelines are considered most threatened and are shown in grey. ¹Locations are based on the timeline of expected disappearance due to coastal erosion and potential flooding events (see p. 8).

Subpopulation	Estimated Number of Individuals	Location ¹
1	40	b
2	300	b
3	200	a
4	200	a
5	many hundreds	a
6	>10,000	e
7	100	e
8	100	e
9	50	c
10	many hundreds	c
11	many hundreds	c
12	many hundreds	a
13	many hundreds	d

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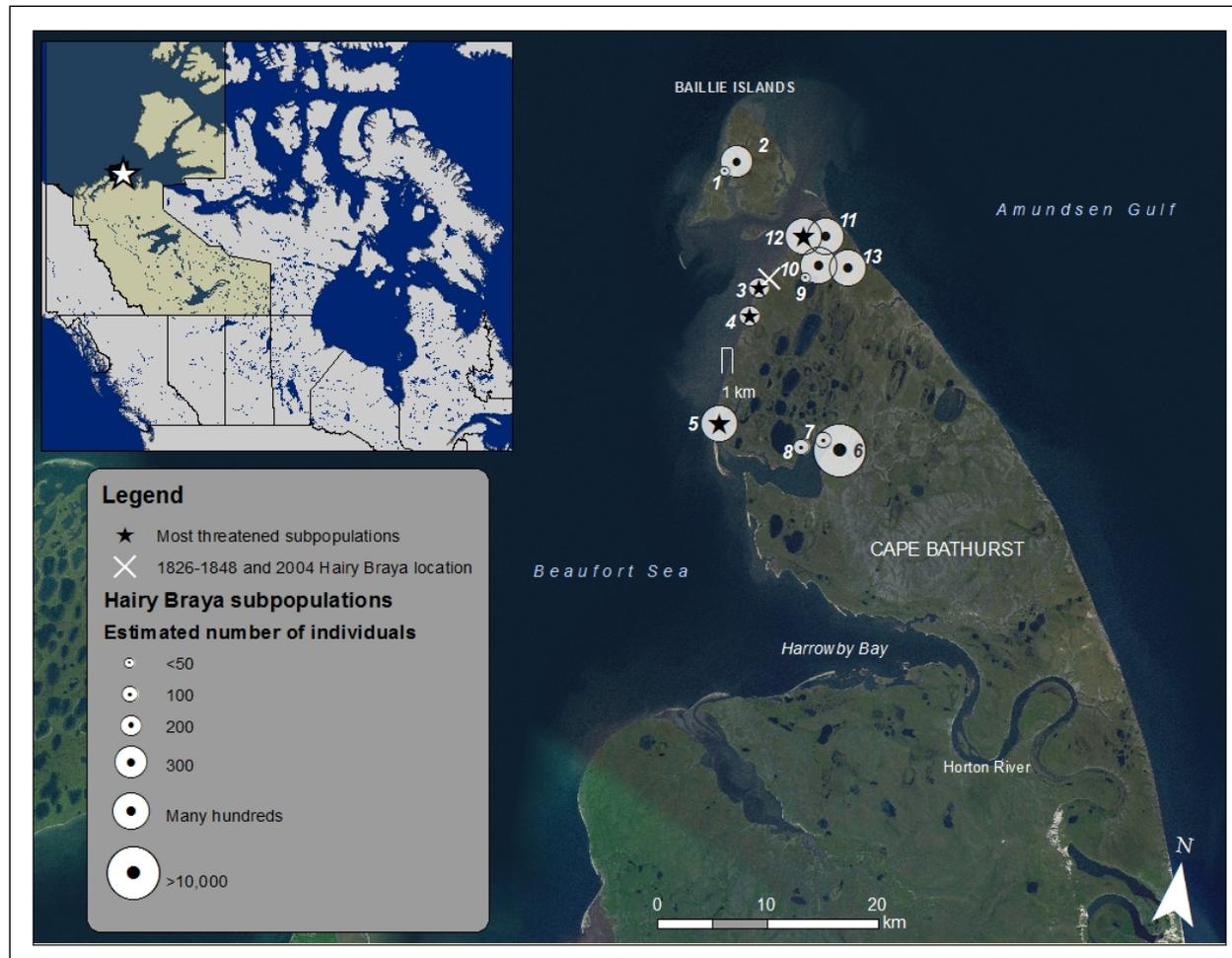


Figure 3. Distribution of Hairy Braya on Cape Bathurst peninsula and Baillie Islands, NWT. Approximate size and localities of subpopulations were estimated in summer 2011 (Table 1; Harris *et al.* unpubl. data 2011). Subpopulations marked as ‘most threatened’ are those within 1 km of northwest-facing shorelines.

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Figure 4. Extent of Occurrence (EO) of Hairy Braya. EO is calculated as the area included in a polygon without concave angles that encompasses the geographic distribution of all known populations (Species at Risk Committee 2010). Occurrences were mapped in summer 2011 to show the approximate physical extent of the populations visited (Harris *et al.* unpubl. data 2011).

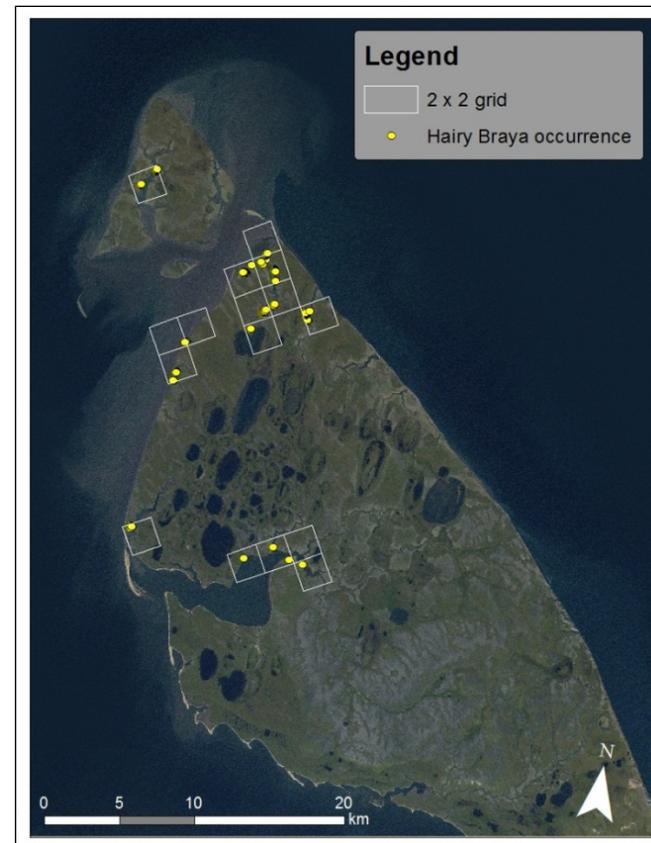


Figure 5. Index of Area of Occurrence (IAO) of Hairy Braya. The IAO is a measure that aims to provide an estimate of area of occupancy that is not dependent on scale and that can be compared across taxonomic groups. The IAO is measured as the surface area of 2 x 2 km grid cells that intersect the actual area occupied by the species (i.e., the biological area of occupancy; Species at Risk Committee 2010). Occurrences were mapped in summer 2011 to show the approximate physical extent of the populations visited (Harris *et al.* unpubl. data 2011).

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Number of locations

A location is defined as “a geographically or ecologically distinct area in which a single threatening event can rapidly affect all individuals of the taxon present. The size of the location depends on the area covered by the threatening event and may include part of one or many subpopulations. Where a taxon is affected by more than one threatening event, location should be defined by considering the most serious plausible threat” (IUCN 2008; Species at Risk Committee 2010). For Hairy Braya, the most serious threat is loss of habitat along northwest-facing shorelines (see the section on *Threats and limiting factors*, p.23). The most plausible threats for other subpopulations are less clear but may include local stochastic events due to changes in water availability (e.g., drought, flooding) or natural disturbances (see *Threats and limiting factors*, p.23). Salinization also acts on coastal subpopulations so this threat will act in advance of coastal erosion, but at an unknown rate. This threat was included as part of the coastal erosion threat in determining locations for Hairy Braya.

Based on estimated rates of coastal erosion (p. 18), all subpopulations within one km of rapidly eroding northwest-facing shorelines face extirpation within about 100 years, so all subpopulations in that zone were considered one location (location a; Table 1, p.5 and Figure 3, p.6). Subpopulations within 2 km of these shorelines face extirpation within about 200 years and were grouped as location b; subpopulations within 3 km of these shorelines face extirpation within about 300 years and were grouped as location c; and one subpopulation >3 km of these shorelines is location d. Subpopulations in low-lying areas susceptible to potential flooding events were grouped as location e. The total number of known locations was estimated at 5 but a few more are expected in other potential habitat (Carrière pers. comm. 2012) as yet unsurveyed on Cape Bathurst peninsula and Baillie Islands (see the section on *Habitat availability*, p.15). The rates of coastal erosion were estimated based on current sea level in the Beaufort Sea and on current frequencies of storms; these rates are expected to increase with rising sea levels and changes in storm events with climate change (see the section on *Habitat trends*, p.18).

Search effort

Hairy Braya was first collected in 1826, followed by subsequent collections in 1848 and 1850. All of these collections apparently came from the same site (Harris 2004). From 1850 until 2004, when the type locality of the plant was rediscovered southwest of Cape Bathurst, the species was lost to science (Harris 2004). Fieldwork conducted on Cape Bathurst peninsula in late July and

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early August of 2011 (Harris 2011) confirmed the persistence of the plant at the original site and led to the discovery of several additional subpopulations of the species. Over a four-day period approximately 60 linear kilometres in the northern portion of the peninsula were traversed on foot by J. Harris, B. Bennett, and F. Ruben. Information gathered on foot about the habitat preferences of the plant was then used for a one-day survey of surrounding areas by helicopter (Figure 6, p.10). Although several sites on the eastern coast of the peninsula as far south as the Horton River Delta were surveyed, Hairy Braya was not seen on this side of the peninsula. The available helicopter flight time was not sufficient to determine the southern limits of the plant on the western side of the peninsula; search effort on the western side was limited to north of 70.358 degrees north.

Although targeted searches for Hairy Braya since 1850 are limited to a search in 2004 (Harris 2004) and fieldwork conducted near Cape Bathurst in 2011, the fact that Hairy Braya has not been found anywhere but on Cape Bathurst peninsula and Baillie Islands is almost certainly not due to insufficient botanical exploration in surrounding areas. In addition to Porsild's significant number of collections of *Braya* between the mouth of the Mackenzie River and Cape Parry and on Banks Island, extensive botanical work has been conducted to the east of the Mackenzie River in coastal Yukon and Alaska (Bennett pers. comm. 2012). In fact, collections of other species housed in the herbaria of the Canadian Museum of Nature, Agriculture and Agri-Food Canada, the University of Alberta, the University of Alaska, the New York Botanical Garden, and the Royal Botanic Gardens at Kew, UK come from numerous places spread along the coast both east and west of Cape Bathurst (Figures 7 and 8, p.11). None of these collections include Hairy Braya from anywhere except Cape Bathurst peninsula.

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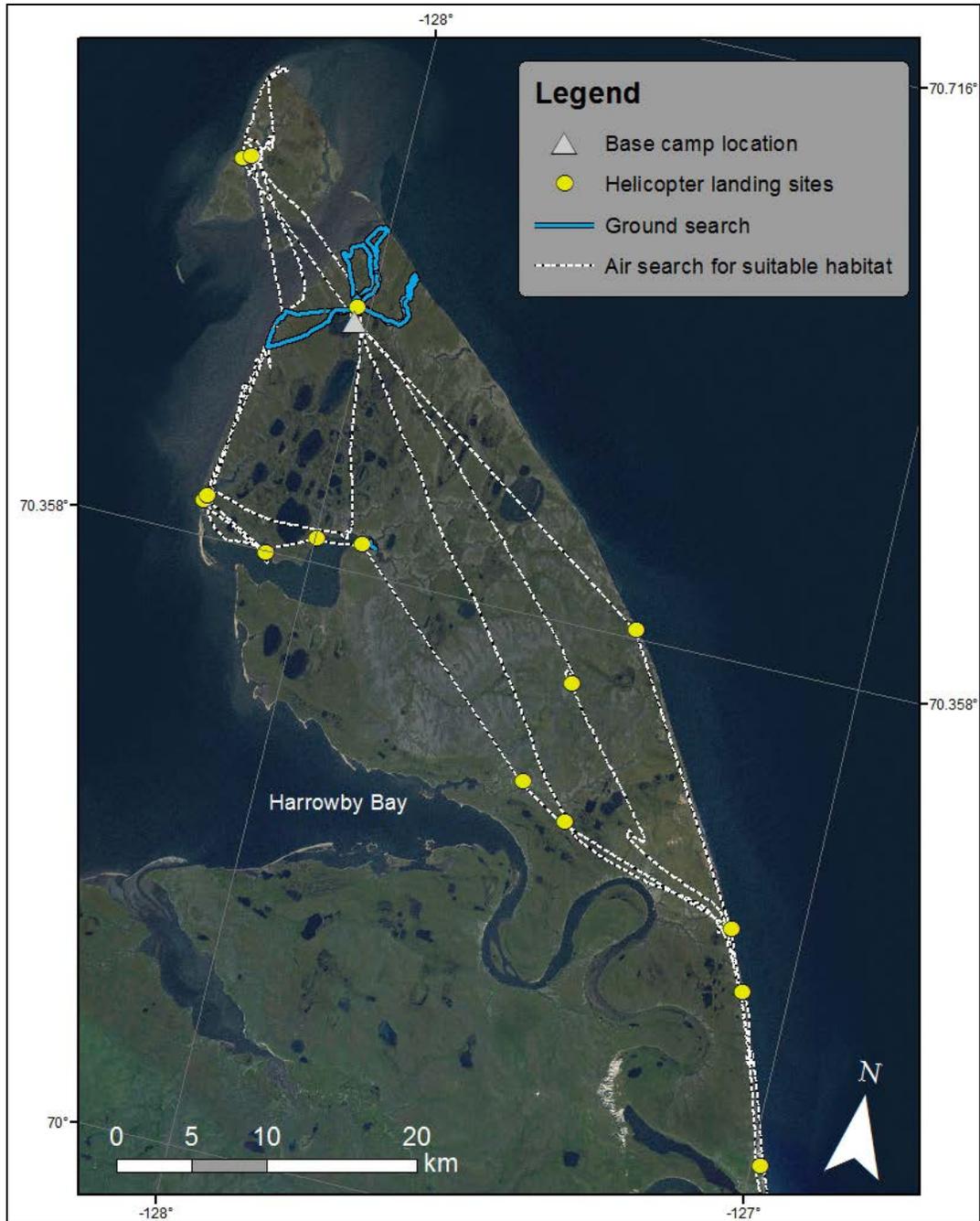


Figure 6. Search effort for Hairy Braya on Cape Bathurst peninsula and Baillie Islands in summer 2011 (Harris *et al.* unpubl. data 2011). Areas surrounding each landing site were searched on foot for the plant.

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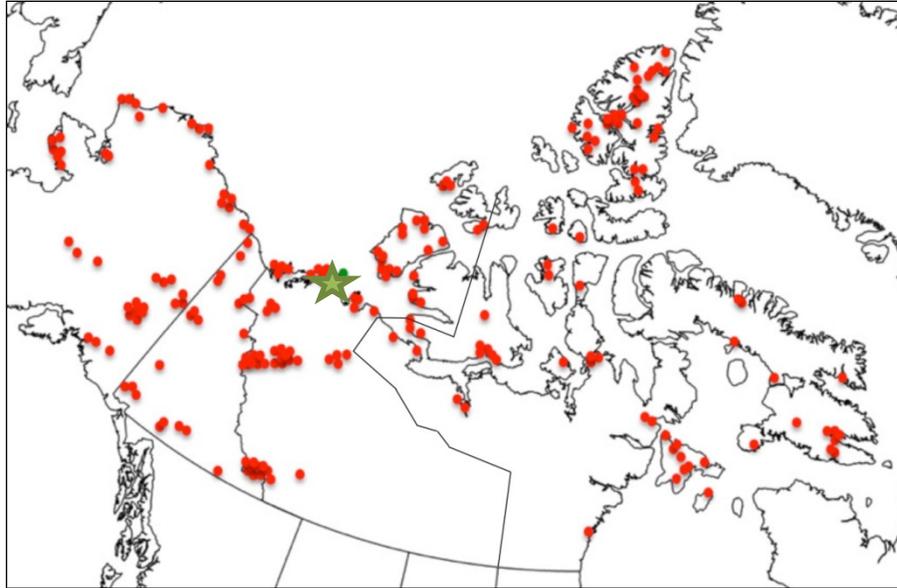


Figure 7. Hairy Braya on Cape Bathurst (green star) and other Braya collections (red dots) from Alaska, Yukon, NWT, and Nunavut (red). Map by J. Harris, adapted from Harris 1985.

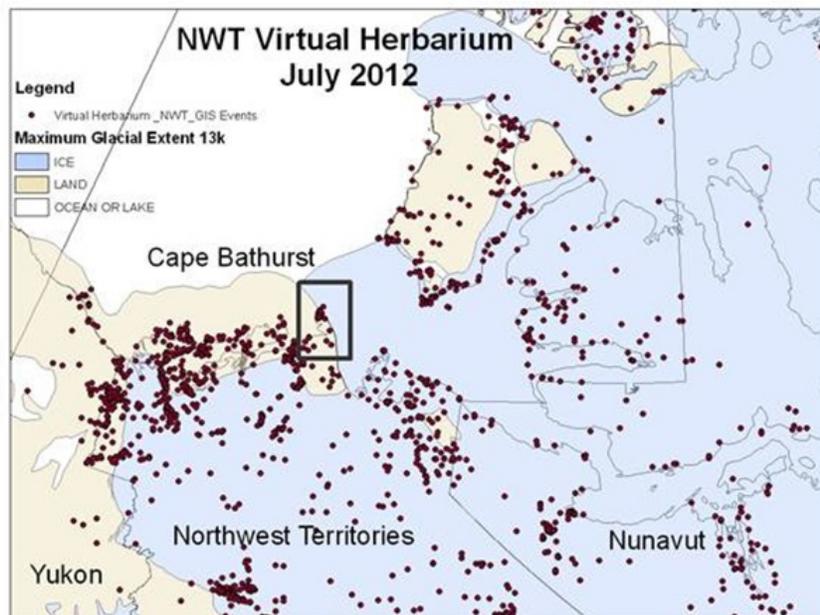


Figure 8. Collections of vascular plants in Yukon, NWT, and Nunavut (red dots), showing Cape Bathurst (rectangle) and extent of glaciation during Wisconsin maximum in northwestern North America (blue). Plant data are from NWT Virtual Herbarium (accessed July 2012) which contains label information from specimens in Agriculture and Agri-Food Canada herbarium, Canadian Museum of Nature herbarium, University of Alaska herbarium, and uncurated herbaria in Inuvik, NWT. Ice extent based on Dyke *et al.* (2003). Map by S. Carrière, Environment and Natural Resources.

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Distribution trends

Trends in the distribution of Hairy Braya are uncertain. However, because the only known populations of the plant are limited to an area that escaped Pleistocene glaciation (Prest 1969; Dyke *et al.* 2003) but which is surrounded by glaciated lands (Figure 9, p.12), range expansion is unlikely. In order to establish new subpopulations of the species on unglaciated lands, at least two rare seed dispersal events to the same area must occur to allow these apparently out-crossing plants to produce offspring. At the same time, rapid coastal erosion is occurring on the western side of the Cape Bathurst peninsula, with rates approaching 10 metres per year (Schwarz 2011). Available habitat for the species on coastlines exposed to storm surges is declining, but inland habitat, as well as some coastal habitat not subject to storm surges, appears to be stable.



Figure 9. Extent of the ice at the last glacial maximum, from Dyke *et al.* (2003).

Habitat

Habitat requirements

Hairy Braya is restricted to an area that remained ice-free during the Pleistocene (Prest 1969; Dyke *et al.* 2003; Harris 2004). The plant occurs on bluffs and dry uplands composed of calcareous sandy loam and silty clay loam soils (Figures 10 and 11, p.14). The plant communities in which Hairy Braya is found are dominated by Arctic Willow (*Salix arctica*), Entire-leaved Mountain-avens (*Dryas integrifolia*), and various grass species including Richardson's Red Fescue (*Festuca richardsonii*), Violet Wild Rye (*Elymus violaceus*), Arctic Bluegrass (*Poa arctica*), and alkali grasses (*Puccinellia* spp.) (Harris 2004, 2011). Although the Canadian National Vegetation Classification categories for this region have not yet been formalized, the habitat type falls into the Tundra: Mountain-avens/Arctic Willow working category (Bennett pers. comm. 2012).

Like other *Braya* species, Hairy Braya appears to be a poor competitor, requiring bare soil to become established. In some cases areas of bare soil occupied by Hairy Braya were the result of the erosion of coastal bluffs, and in other cases they were caused by disturbance due to caribou hooves. However, most commonly bare soils supporting Hairy Braya subpopulations appear to be the result of seasonal periods of standing water that eliminate most other plant species from small depressions in otherwise dry habitats. Percent cover measurements were taken from three Hairy Braya subpopulations in 2011. The percentages of bare soil in these three subpopulations ranged from 39% to 47% (Harris 2011). Once established, mature Hairy Braya plants can withstand some encroachment by other plant species (Harris *et al.* unpubl. data 2011).

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Figure 10. Hairy Braya habitat, photo by James G. Harris, 2011.

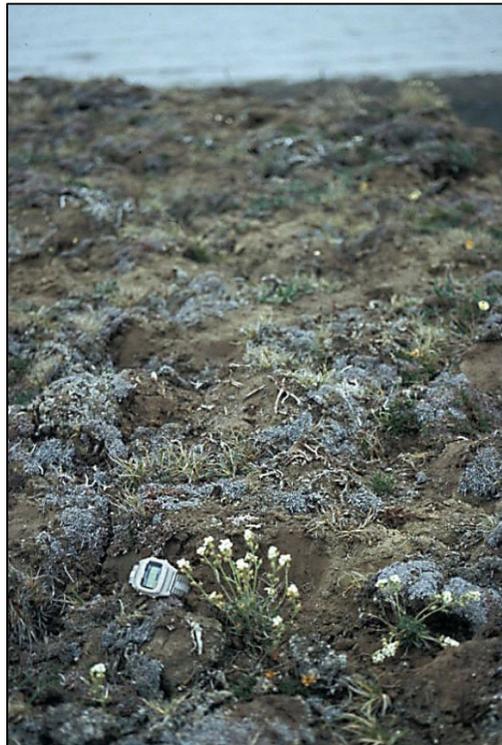


Figure 11. Hairy Braya habitat, photo by James G. Harris, 2004. Watch included for scale.

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Habitat availability

Coastal bluffs and dry uplands along streams and inlets in unglaciated areas on the western side of Cape Bathurst peninsula north of 70.358 degrees north and on Baillie Islands potentially harbour subpopulations of Hairy Braya. High-resolution satellite imagery indicates that these kinds of habitats total approximately 24.8 km² (Carrière pers. comm. 2012; Figures 12 and 13, p.16 and p.17) and a significant percentage of them were searched for the plant in 2011 (Harris 2011). Suitable habitat may also exist on the western side of the peninsula between the north side of Harrowby Bay and 70.358 degrees north, but this area has not been searched (Figure 6, p.10). Seemingly suitable habitat examined on the eastern side of the peninsula (Figure 12 (p.16), areas D and E) was not occupied by Hairy Braya (Harris 2011). This may be because the exact limits of glaciation are unclear, and it is possible that much of the eastern side of the peninsula was either glaciated, or the periglacial environment along the margins of the glaciers was not appropriate for Hairy Braya. In addition, loss of habitat due to coastal erosion of unknown rate and soot deposits from oil shale fires that have been burning along the eastern banks of the peninsula at least since 1826 (Richardson 1828) may have eliminated Hairy Braya from the area.

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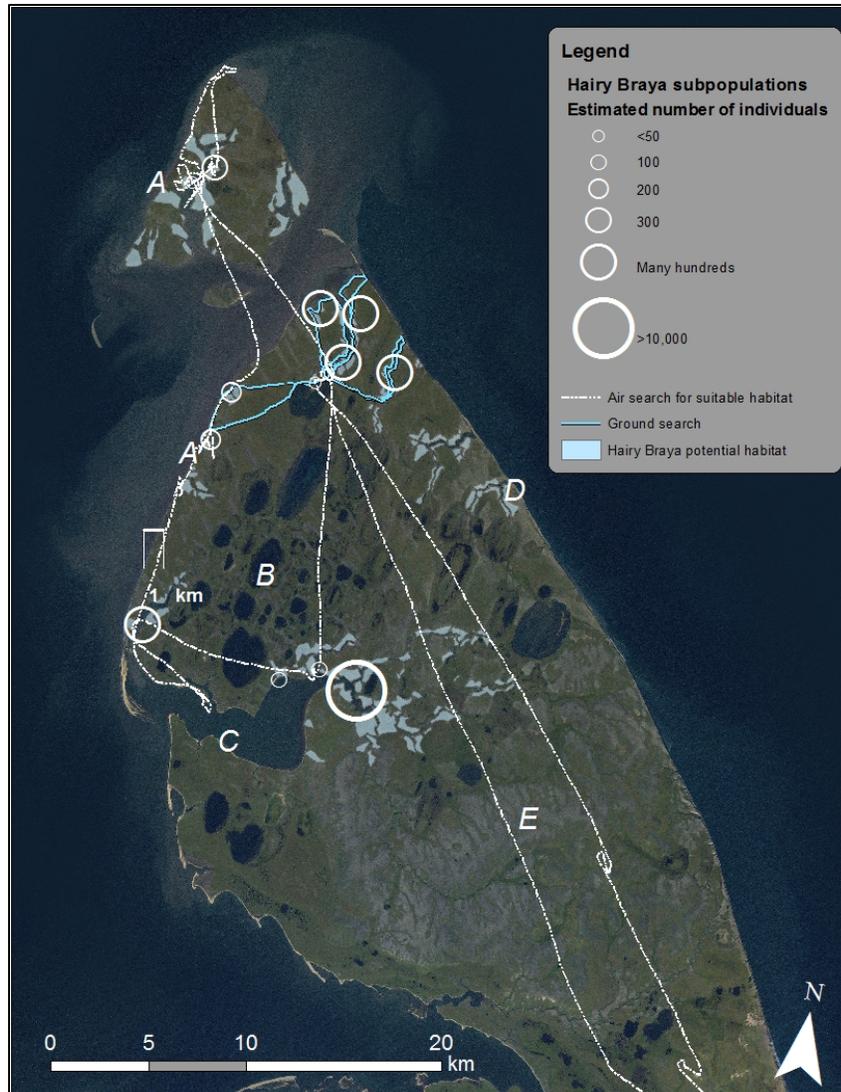


Figure 12. Potential habitat for *Braya pilosa* on Cape Bathurst peninsula and Baillie Islands. Components for potential habitat were determined during both walking (blue solid line) and helicopter (white dashed line) surveys. Components included dry land (showing blue-grey on satellite image) and close vicinity of a stream, providing some drainage in spring. Notes on map: (A) Shorelines with severe loss of habitat with measured slumping rates into the sea at about 9.5 m/yr. Additional mortality in this zone was noted due to salt sprays. Marker for 1 km corresponds to projected habitat loss over the next 100 years if rates remain constant. (B) Terrain confirmed as too wet to contain *B. pilosa*. (C) Terrain confirmed as too sandy to contain *B. pilosa*. (D) Shorelines with severe loss of habitat of unknown rate and, further south, with soot deposits due to oil shale fires along banks (Smoking Hills). (E) Inland site confirmed without *B. pilosa*. Additional dry terrain immediately west of (E) has not been visited. Satellite imagery source: ESRI, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community. For more information on this map, go to http://goto.arcgisonline.com/maps/World_Imagery.

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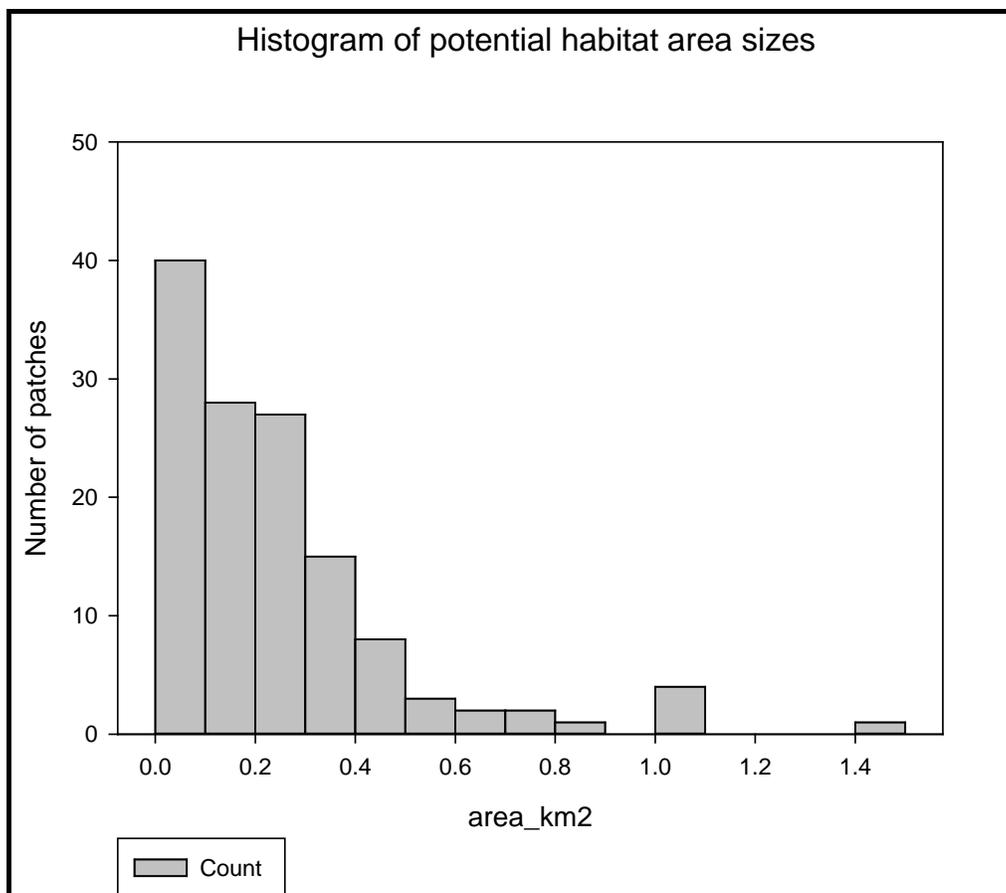


Figure 13. Potential habitat for Hairy Braya. Total area = 24.8km²; habitat patch sizes range from 0.0001 - 1.45km².

Habitat fragmentation

Habitat suitable for Hairy Braya exists as elongated bluffs and uplands along coastlines, inlets, and streams. These islands of habitat are separated from other suitable habitat by large areas of wet tundra (Figure 12 (p.16), Area B). In addition, strips of potential habitat along the coast are often fragmented by erosion or salinization due to sea spray and storm waves overtopping coastal bluffs (Figure 14 p.18; Harris *et al.* unpubl. data 2011). The ability of Hairy Braya to disperse between patches of suitable habitat is unknown, but neither the fruits nor the seeds of the plant are adapted for long-distance dispersal (see the section on *Movements*, p.22). While most Hairy Braya subpopulations are isolated from other subpopulations, they usually consist of fairly large numbers of individuals (from 100 to more than 10,000) and therefore would probably not be correctly characterized as “severely fragmented” as defined by SARC (2010).

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Figure 14. Northwest bank of Cape Bathurst with salinization mortality. Photo by Suzanne Carrière, Environment and Natural Resources, 2011.

Habitat trends

Coastal areas southwest of Cape Bathurst are rapidly eroding, with large mats of turf, some bearing Hairy Braya individuals, sliding down a steep escarpment toward the sea (Figures 15 and 16, p.19; Harris *et al.* unpubl. data 2011). The well documented decrease in arctic sea ice over the past few decades (Lindsay and Zhang 2005; Stroeve *et al.* 2007) has increased the duration and severity of storm surges (Jorgenson and Brown 2005; Jones *et al.* 2009; Lantuit *et al.* 2011) that are likely hastening the erosion of Hairy Braya habitat along the coast. Recent erosion rates have been approximately 9 to 10 metres per year over the past 38 years for some coastline areas of Cape Bathurst peninsula (Schwarz 2011). An example illustrating the rapid erosion was recently reported: a cabin and several barrels that were seen along the shoreline of Cape Bathurst in summer 2011 had fallen into the sea and disappeared just one year later (R. Gau pers. comm. 2012). The recent decline of caribou in the Cape Bathurst region (Nagy and Johnson 2006) may have also reduced Hairy Braya habitat, since at least some habitat is associated with disturbance due to caribou hooves (see the section on *Habitat requirements*, p.13); caribou numbers are now low but stable (Environment and Natural Resources 2011b).

Inland habitats of Hairy Braya, as well as habitats along coastal areas not exposed to storm surges, appear to be stable (Harris 2011). Fortunately, some individuals of the species are growing in these stable habitats.

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Figure 15. Eroding Hairy Braya habitat, photo by James G. Harris, 2004.



Figure 16. Northwest bank of Baillie Island showing melting of ice-rich permafrost and bank slumping into the Beaufort Sea. Photo by Suzanne Carrière, Environment and Natural Resources, 2011.

Biology

Life cycle and reproduction

The life cycle and reproduction of Hairy Braya have not been studied. However, although most *Braya* species are self-pollinating (Harris 1985), Hairy Braya is likely cross-pollinating (Harris 1985, 2004). Visits to Hairy Braya flowers by pollinators have not been observed in the field, but the plant has several characteristics common to out-crossing species generally (species where pollination takes place between two different flowers) (Ornduff 1969), and to out-crossing *Braya* species specifically (Harris 1985, 2004). These include: large (for the genus) and fragrant flowers (Richardson 1828; Hooker 1830; Harris *et al.* unpubl. data 2011), exceptionally long styles, rotate corollas, a relatively high frequency of abortive silicles, a low ploidy level (low number of chromosome sets in a cell) (Harris unpubl. data 2011), and a narrow distribution limited to unglaciated lands. The thick taproots, many-branched root crowns, and thick thatch of old leaves and leaf bases indicate that Hairy Braya is a fairly long-lived perennial with a generation time (average age of parents in the population) of perhaps 10-15 years.

Physiology and adaptability

No work has been done to establish the physiology and adaptability of Hairy Braya. Nonetheless, some reasonable assumptions about the species can be made. First, the extremely limited distribution of Hairy Braya strongly suggests that the species has little ability to expand its distribution range and move onto seemingly appropriate habitat in surrounding areas. Since the seeds of Hairy Braya are neither more nor less adapted for dispersal than those of other *Braya* species that are more widely distributed, the narrow distribution of Hairy Braya is probably due to the fact that out-crossing plants, as Hairy Braya is presumed to be, are not able to generate new populations from the establishment of a single individual in a new area. The rare dispersal of a seed from a self-pollinating species may produce a new population, but two rare seed dispersal events are required to establish a new population of an out-crossing species. In addition, Hairy Braya may require stable habitats over long periods of time (i.e. longer than the 15,000 years that have elapsed since the last glacial maximum) in order to establish and maintain

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viable populations. The plant's distribution pattern mirrors that of some subspecies of *B. humilis* (subsp. *maccallae* and subsp. *porsildii*), which are also out-crossing, of low ploidy level, and limited to small areas in the Rocky Mountains on or near unglaciated lands (Harris 1985).

Interactions

Species in the genus *Braya* typically do not compete well with other plant species and require bare soils (e.g. gravel bars, river banks, lake and sea shores, moraines, solifluction soils) for seedling survival (Harris 1985, 2010). It appears that most subpopulations of Hairy Braya use soils that are bare due to physical processes, such as erosion or periods of standing water (Harris *et al.* unpubl. data 2011). However, some Hairy Braya subpopulations are dependent on soil disturbance by caribou hooves to provide bare soils where seedlings can become established (Harris 2004).

The widespread Smooth Braya, which is sometimes found growing in close proximity to Hairy Braya (Harris *et al.* unpubl. data 2011), is an allopolyploid (a hybrid containing extra sets of chromosomes) that likely arose from hybridization between two *Braya* species of lower ploidy level (Warwick *et al.* 2004). The out-crossing Hairy Braya is a likely candidate for one of the parent species (Harris 1985, 2004). There is some indication from DNA sequence data (Harris unpubl. data 2011) that some crossbreeding is still occurring between Hairy Braya and nearby Smooth Braya plants.

It has long been known, based on morphology (Harris 1985) and DNA sequence data (Harris unpubl. data 2011) that Hairy Braya is most closely related to Greenland Braya, a species that is distributed primarily in Greenland and the more northerly islands in the Canadian Arctic Archipelago (Harris 2010). Greenland Braya has not previously been reported from continental North America, but the most southerly known subpopulations of the species are on the southern portions of Banks Island, 200 kilometres from Cape Bathurst. Fieldwork conducted on Cape Bathurst peninsula in 2011 (Harris 2011) indicates that the relationship between Hairy Braya and Greenland Braya needs to be reevaluated. The large number of Hairy Braya individuals observed in the field in 2011 showed a much wider range of morphological variation than previously documented in the species. Plants ranged from large-flowered, erect individuals matching previous published descriptions of Hairy Braya (Hooker 1830; Harris 1985, 2004, 2010) to

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small-flowered, decumbent (spreading horizontally) individuals strikingly similar to Greenland Braya. The morphological distinctiveness of these closely related species breaks down on Cape Bathurst peninsula.

It has been assumed (Harris 1985) that a diploid (two sets of chromosomes per cell) Hairy Braya gave rise to the tetraploid (four sets of chromosomes) Greenland Braya, and that this new polyploid species was then able to move north into high-arctic regions beyond the coast of continental North America. The highly variable subpopulations discovered on Cape Bathurst peninsula in 2011, with a significant number of individuals bearing a resemblance to the tetraploid Greenland Braya, strongly suggest that the production of polyploids from Hairy Braya is ongoing. Some preliminary chromosome data (Harris unpubl. data 2011) provides some support for this hypothesis.

A thorough genetic analysis of Hairy Braya, Smooth Braya, and Greenland Braya is required before the relationships between these species can be definitively determined and the number of pure Hairy Braya individuals can be established.

Population

Structure and rates

Little is known about the population structure and demographics of Hairy Braya. However, plants of all ages and sizes occur in every subpopulation examined in 2011 (Harris *et al.* unpubl. data 2011), indicating that seedlings are being recruited successfully.

Movements

Movements of Hairy Braya populations have not been determined. However, the fact that the species is restricted to a relatively small area of unglaciated land suggests that it is not capable of moving into surrounding areas. Although no *Braya* species have seeds adapted for long-distance dispersal, the inability of Hairy Braya to expand its range is more likely due to cross-pollination and its need for stable (i.e. unglaciated) long-term habitats (see *Physiology and adaptability*, p.20), since other *Braya* species are widely distributed in areas that were glaciated (Figure 7, p.

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11).

Abundance

Precise counts of the number of individuals (plants arising from a single root) have not been made, but estimates of the number of individual plants observed in 2011 range from about 15,000 to 20,000, with perhaps 80% of these being of reproductive age (Harris 2011). However, unraveling the complex interactions between Hairy Braya and some of its polyploid progeny, as discussed in *Interactions* (p.21), may require a significant reduction in current estimates of subpopulation sizes of pure Hairy Braya plants.

Fluctuations and trends

Subpopulations on coastal bluffs subject to rapid erosion are clearly at risk of declining (see section on *Habitat trends*, p.18). The total number of individuals in the one coastal subpopulation that was visited in both 2004 and 2011 has plummeted from several hundred to approximately 100 individuals over that seven-year period because of erosion of habitat (Harris 2004; Harris *et al.* unpubl. data 2011). It can be expected that similar subpopulations on eroding shorelines will be similarly impacted. Approximately 15% of the total number of known Hairy Braya individuals are located in these at-risk coastal habitats (Figure 12 (p.16), Area A). Trends and fluctuations in subpopulations on protected sections of the coast and on inland bluffs have not been determined, but they appeared to be stable when examined in summer 2011 (Harris *et al.* unpubl. data 2011).

There is no evidence that Hairy Braya populations typically experience extreme fluctuations in the number of mature individuals. All subpopulations include a significant proportion of mature individuals, many of them obviously several years old based on the thatches of dead leaves from previous seasons, the multi-branched root crowns, and the relatively large number of stems per plant.

Threats and Limiting Factors

The most obvious threat to Hairy Braya is a loss of habitat due to rapid erosion of coastline

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habitat. Increasing rates of coastal erosion due to a significant reduction in ice cover on the Beaufort Sea over the past few decades are well documented (e.g. Jorgenson and Brown 2005; Jones *et al.* 2009; Lantuit *et al.* 2011; Kokelj *et al.* 2012). Recent estimates of the rate of erosion of some coastline areas, based on high-resolution satellite imagery, are 9 to 10 m per year over the past 38 years (Schwarz 2011). Due to warming of the earth's atmosphere, which is expected to continue into the foreseeable future, it is expected that sea levels in the region will increase by 0.2 to 1.0 m over 100 years (Environment and Natural Resources 2011a) and protective sea ice will continue to decline (Lindsay and Zhang 2005), so coastal erosion rates will likely increase and the probability of storm surges will likely also increase. Sites along the coast are also destroyed by salinization, potentially at a greater rate than erosion itself (see *Habitat trends*, p.18).

Subpopulations in low-lying areas, including the largest subpopulation, could be susceptible to future storm surges. Other threats are not known but may include stochastic events related to local changes in habitat and disturbances.

Positive Influences

Due to the remoteness of Cape Bathurst peninsula, Hairy Braya faces little direct threat from human activities. The Cape Bathurst peninsula includes the calving ground of the Cape Bathurst barren-ground caribou population. Conservation priorities for the area have been formalized in the Tuktoyaktuk Community Conservation Plan, which states that the area includes resources of particular significance and sensitivity throughout the year, and recommends that the area “be managed so as to eliminate, to the greatest extent possible, potential damage and disruption” (TCCP 2008). Proposals for development projects may be screened by the Inuvialuit Land Administration (ILA). The ILA may require the approval of the Inuvialuit Hunters and Trappers Committees before approving project proposals, and can also attach conditions on the projects to ensure that land and resources are not harmed (TCCP 2008).

The NWT Protected Areas Strategy has identified globally rare plants (including Hairy Braya) as special features and makes this information available for use in protected areas planning and other land stewardship processes (www.nwtpas.ca).

Acknowledgements

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Collections examined

Braya pilosa has been collected four times prior to 2011: John Richardson *s.n.*, 1826, 1848; William Pullen *s.n.*, 1850; and James Harris and Daniel Taylor collection #3644, 2004. The Richardson and Pullen collections are located in the Royal Botanic Gardens Herbarium (K) at Kew, England, while the Harris and Taylor collection (and duplicates) are located at the following herbaria: Utah Valley University (UVSC), Agriculture and Agri-Food Canada (DAO), Canadian Museum of Nature (CAN), Missouri Botanical Garden (MO), New York Botanical Garden (NY), and University of Alaska (ALA). The preparer has examined all of these collections. Specimens collected during fieldwork conducted in 2011 were also examined, and these voucher specimens and duplicates will be distributed to the permanent collections listed above.

Biography of Preparer

James G. Harris received his Ph.D. from the University of Alberta in 1985 for his taxonomic and phylogenetic study of the plant genus *Braya* (Brassicaceae) in North America. His current research interests include the taxonomy, phylogenetics, and phylogeography of North American *Braya* and *Draba* (Brassicaceae) species, and the floristics of alpine regions in the Great Basin of the western United States. He is a Professor of Biology and the Director of the Herbarium at Utah Valley University, where he has been employed since 1986.

Status and Ranks

Region	Coarse filter (Ranks) To prioritize	Fine filter (Status) To provide advice	Legal listings (Status) To protect under species at risk legislation
Global	G1 - Critically imperiled (NatureServe 2004)		
Canada	N1 - Critically imperiled (NatureServe Canada 2008) May Be At Risk (Canada General Status Ranking Program 2010)		
Northwest Territories	May Be At Risk (NWT General Status Ranking Program 2011)	Threatened (SARC 2012)	To be determined
Adjacent jurisdictions not applicable			

Appendix A: Additional photographs of Hairy Braya



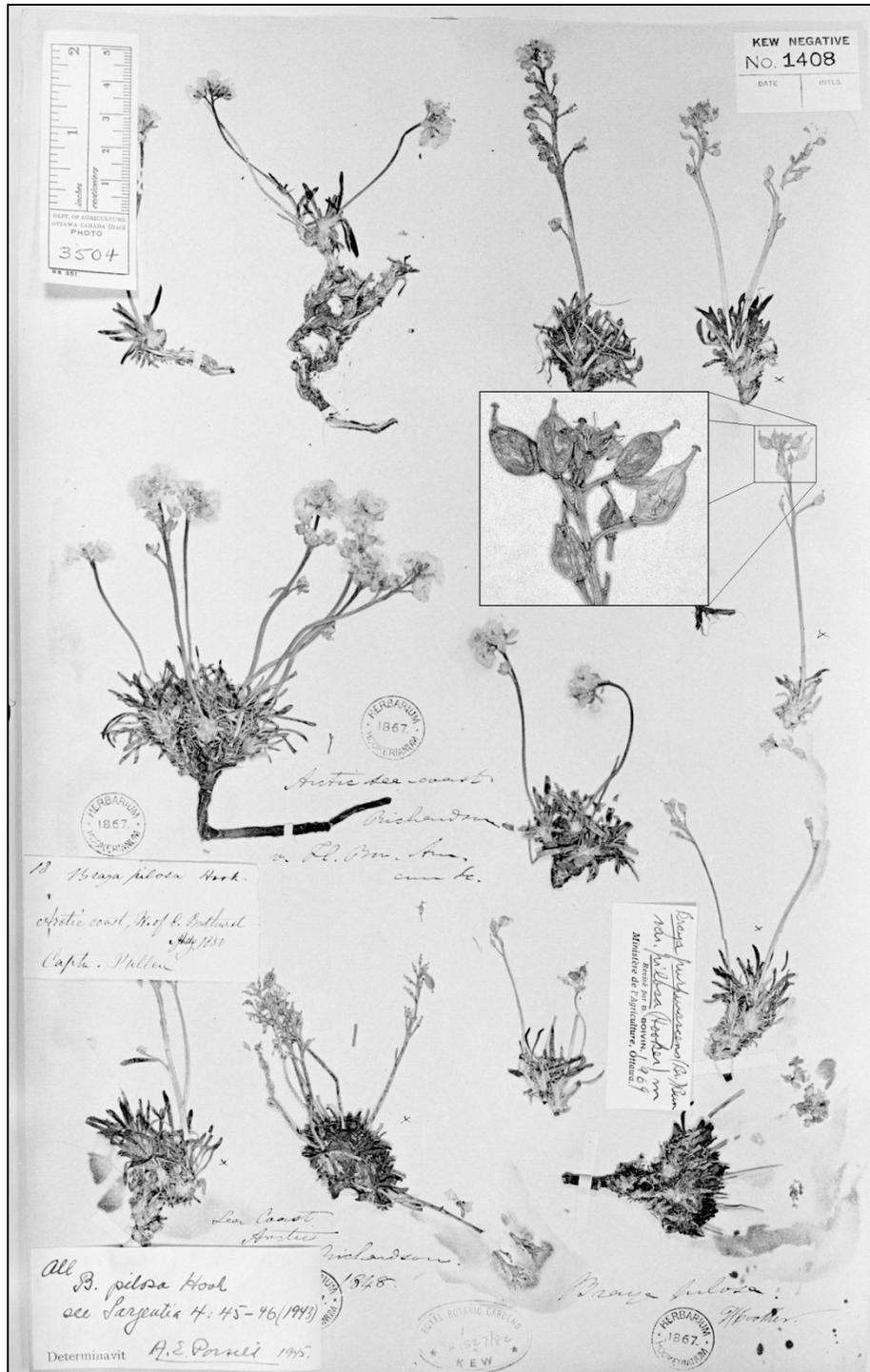
Appendix 1. Flowers and fruits of Hairy Braya, photo by James G. Harris, 2004.

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Appendix 2. Collection of *Braya pilosa* in the herbarium of Utah Valley University, photo by James G. Harris, 2004.

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Appendix 3. Type collection of *Braya pilosa*, Kew Herbarium (the annotation of one group of specimens by Boivin as *Braya purpurascens* var. *pilosa*, a combination that was never actually published, reflects a misinterpretation of the species). Photo by James G. Harris, 1984.