

Recovery Strategy for the Long's Braya (*Braya longii*) and the Fernald's Braya (*Braya fernaldii*) in Canada

Long's braya
Fernald's braya



2011

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For copies of the recovery strategy, or for additional information on species at risk, including COSEWIC Status Reports, residence descriptions, action plans, and other related recovery documents, please visit the Species at Risk (SAR) Public Registry (www.sararegistry.gc.ca).

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PREFACE

The federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996) agreed to establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada. Under the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the federal competent ministers are responsible for the preparation of recovery strategies for listed Extirpated, Endangered, and Threatened species and are required to report on progress within five years.

The Minister of the Environment and the Minister responsible for the Parks Canada Agency are the competent ministers for the recovery of the Long's Braya and Fernald's Braya, and have prepared this strategy, as per section 37 of SARA. It has been prepared in cooperation with Province of Newfoundland and Labrador.

Success in the recovery of these species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this strategy and will not be achieved by Environment Canada, or any other jurisdiction alone. All Canadians are invited to join in supporting and implementing this strategy for the benefit of the Long's Braya and Fernald's Braya, and Canadian society as a whole.

This recovery strategy will be followed by one or more action plans that will provide information on recovery measures to be taken by Environment Canada and other jurisdictions and/or organizations involved in the conservation of the species. Implementation of this strategy is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

Newfoundland and Labrador, as the primary management jurisdiction for Long's and Fernald's Braya, is in the process of developing an ecosystem based recovery plan which will include, among other things both Braya species. Once this plan is completed it will likely provide updated objectives, priorities and threats as new information will be acquired as the ecosystem plan is developed. Interested parties should contact the Newfoundland and Labrador Wildlife Division for information on the development of the ecosystem recovery plan and the implementation of the provincial recovery programs for these species.

ACKNOWLEDGEMENTS

This recovery strategy was prepared by Julie Robinson (Consulting Biologist) for Environment Canada's Canadian Wildlife Service - Atlantic Region, as well as Susan Squires (Government of Newfoundland and Labrador, Department of Environment and Conservation) and Michael Burzynski (Parks Canada Agency), on behalf of the Limestone Barrens Species at Risk Recovery Team.

The National Recovery Plan for Long's Braya and Fernald's Braya that was originally drafted in 2002 forms the basis for this document. The 2002 document was prepared by Luise Hermanutz, Marilyn F.E. Anions, Doug Ballam, Trevor Bell, Joe Brazil, Nathalie Djan-Chékar, George Gibbons, Henry Mann, John Maunder, Susan J. Meades, Wilf Nicholls, Noah Smith, and Gerry Yetman.

Environment Canada would like to recognize the efforts of the World Wildlife Fund and the Limestone Barrens Species at Risk Recovery Team (LBSARRT) for their work in the preparation of the original National Recovery Plan for Long's Braya and Fernald's Braya. The LBSARRT includes representatives from the Government of Newfoundland and Labrador, Memorial University of Newfoundland (MUN) (Biology and Geography Departments, and MUN Botanical Garden), Sir Wilfred Grenfell College, non-governmental organizations (i.e., Nature Conservancy of Canada), consultants, and interested local citizens. Provincial partners include the Government of Newfoundland and Labrador, Department of Environment and Conservation Wildlife Division and the Parks and Natural Areas Division, the Department of Natural Resources, as well as the Provincial Museum of Newfoundland and Labrador. Environment Canada would also like to acknowledge the many undergraduate and graduate students who contributed to this recovery strategy through research activities; Eddie Donato, Joni Driscoll, Shane Greene, Hilary Janes, Laura Noel, Kim Parsons, Diane Pelley, Ginette Rafuse, Julie Robinson, Jill Slater, and Susan Squires (nee Tilley).

EXECUTIVE SUMMARY

Long's Braya (*Braya longii* Fernald) and Fernald's Braya (*B. fernaldii* Abbe) are small herbaceous plants endemic to the Strait of Belle Isle ecoregion on the extreme northwest portion of the Great Northern Peninsula of insular Newfoundland. Long's Braya and Fernald's Braya were listed as Endangered and Threatened, respectively, under the Federal *Species at Risk Act* in 2003 and the Newfoundland and Labrador *Endangered Species Act* in 2002.

Long's Braya and Fernald's Braya are restricted to a narrow coastal strip of limestone barrens and are adapted to an exposed tundra-like habitat of loose, calcareous gravels with sparse vegetation cover. They occur at low densities in areas of small-scale substrate disturbance associated with cold-climate soil processes (patterned ground formation), but also pioneer in areas of human disturbance. Their present reduced distribution is the result of habitat loss caused by extensive quarrying of limestone gravel, road construction, and community development. Currently, off-road-vehicle use threatens plant survival and habitat; as do road and utility line maintenance and climate change. Plant survival and reproductive potential are also threatened by a non-native insect herbivore, the diamondback moth, and three pathogens.

Some uncertainties exist relating to the feasibility of recovery of the Long's Braya and Fernald's Braya. In keeping with the precautionary principle, a recovery strategy has been prepared as per section 41(1) of SARA, as is done when recovery is determined to be feasible. This recovery strategy addresses the uncertainties surrounding the feasibility of recovery.

The population and distribution objectives are:

For Long's Braya:

Ensure populations are viable within the current species range and establish additional populations in natural areas within the historic range from Sandy Cove to Green Island Cove by 2015.

For Fernald's Braya:

Maintain populations within the current species range and, when possible, attain self-sustaining populations.

Six broad recovery strategies and approaches have been developed to meet the population and distribution objectives and to address the limitations and threats presented in this recovery strategy.

Critical habitat is partially identified for both Long's Braya and Fernald's Braya in this recovery strategy and is based on the culmination of detailed scientific research and extensive surveying within the known range of both species.

An action plan will be posted on the SARA Registry within one year from the posting of the Recovery Strategy.

RECOVERY FEASIBILITY SUMMARY

Analysis of recovery feasibility for this species, based on the four criteria outlined by the Government of Canada (2009) demonstrates that some uncertainties exist relating to the feasibility of recovery of the Long's Braya and Fernald's Braya. In keeping with the precautionary principle, a recovery strategy has been prepared as per section 41(1) of SARA, as would be done when recovery is determined to be feasible. This recovery strategy addresses the uncertainties surrounding the feasibility of recovery.

Recovery for Long's Braya and Fernald's Braya is technically and biologically feasible as determined by the following 4 criteria (Government of Canada 2009).

1. Individuals of the wildlife species that are capable of reproduction are available now or in the foreseeable future to sustain the population or improve its abundance. – **YES**
 - Individuals of Long's Braya and Fernald's Braya capable of reproduction are available now to sustain the population throughout the species' range.
2. Sufficient suitable habitat is available to support the species or could be made available through habitat management and restoration. – **YES**
 - The Fernald's Braya occupies a larger area of coastline than the Long's Braya, within which there are many suitable areas where the species does not presently occur.
 - It is believed that the distribution of Long's Braya has probably not decreased, but simply has a naturally smaller range than the Fernald's Braya. The known and available habitat is sufficient to support the species.
3. The primary threats to the species or its habitat (including threats outside Canada) can be avoided or mitigated. - **UNKNOWN**
 - It is unknown whether all primary threats to the species or its habitat can be avoided or mitigated, such as the threat of pests, pathogens, and climate change.
 - Research is ongoing to resolve these questions.
4. Recovery techniques exist to achieve the population and distribution objectives or can be expected to be developed within a reasonable timeframe. – **YES**
 - Based on population viability analysis of the species, if the deleterious pathogens and pests to braya could be controlled or eliminated then the populations could be viable.

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1. COSEWIC SPECIES ASSESSMENT INFORMATION

Date of Assessment: May 2011

Common Name (population): Long's Braya

Scientific Name: *Braya longii*

COSEWIC Status: Endangered

Reason for Designation: Highly restricted endemic of limestone barrens with very few small populations under continued threat of habitat destruction.

Canadian Occurrence: NL

COSEWIC Status History: Designated Endangered in April 1997. Status re-examined and confirmed in May 2000 and May 2011.

Date of Assessment: May 2000

Common Name (population): Fernald's Braya

Scientific Name: *Braya fernaldii*

COSEWIC Status: Threatened

Reason for Designation: This endemic of limestone barrens occurs in low numbers and is under continued threat of habitat destruction.

Canadian Occurrence: NL

COSEWIC Status History: Designated Threatened in April 1997. Status re-examined and confirmed in May 2000.

SPECIES STATUS INFORMATION

Long's Braya and Fernald's Braya were listed as Endangered and Threatened, respectively, under the Federal *Species at Risk Act* in 2003 and the Newfoundland and Labrador *Endangered Species Act* in 2002. Both species occur exclusively within insular Newfoundland. Long's Braya and Fernald's Braya are ranked, respectively, as critically imperiled and imperiled globally, nationally and provincially (NatureServe 2009).

3. SPECIES INFORMATION

3.1 Species Description

Long's Braya and Fernald's Braya are small herbaceous perennials with fleshy basal leaves that are greyish-green to bluish. Long's Braya reaches heights of 1 – 10 cm while Fernald's Braya reaches heights of 1 – 7 cm. Both species are members of the Brassicaceae (Mustard) family. They are calciphiles (i.e. a plant that does well in alkaline soils), restricted to limestone soils, and are early colonizers of small-scale natural soil disturbances caused by frost-heaving and wind and water erosion. They have contractile taproots for secure anchorage in frost-heaved substrates and die back to the crown during winter. Further descriptive information can be found in the COSEWIC status reports for Long's Braya (Meades 1997a) and Fernald's Braya (Meades 1997b). For detailed information on species differentiation please see Parsons (2002) and Parsons and Hermanutz (2006).

3.2 Population and Distribution

Long's Braya and Fernald's Braya are highly restricted endemics of the limestone barrens of the Great Northern Peninsula of insular Newfoundland, Canada (Figure 1). Long's Braya is currently found in six isolated populations¹ between Anchor Point and Green Island Brook, spanning a distance of 26 km (Figure 2; Table 1). Each of these populations, except for Anchor Point, contains both undisturbed (natural) and human-disturbed substrate. In the 1920s, Long's Braya was collected at Green Island Cove however this population has never been relocated. Anchor Point and Shoal Cove populations were located after the production of the COSEWIC Status Report (Meades 1997a). The total global population of Long's Braya is approximately 5,500 flowering plants, 90% of which are growing on human-disturbed substrate (Hermanutz et al. 2009); this represents a decline from 7 720 plants in the 1998-2000 surveys (Hermanutz et al. 2002).

Fernald's Braya is currently found in 16 populations between Port au Choix and Burnt Cape, spanning a distance of about 150 km; however, Fernald's Braya grow almost continuously at

¹ The Sandy Cove locations as presented in this document include the Savage Point location mentioned in the COSEWIC Status Report due to its proximity to the Sandy Cove area. The six populations indicated in this report are the only populations of Long's braya recognized by the Provincial jurisdictional authority and the Limestone Barrens Species at Risk Recovery Team.

very low densities between the Watts Point Ecological Reserve and Cape Norman (Figure 3; Table 1). The southernmost location, Port au Choix, is separated from the next population to the north by about 80 km (Figure 5). Fernald's Braya has never been relocated at two historical sites - Ice Point and inland Savage Cove. The population of Fernald's Braya at the 16 main locations for 2008 is approximately 3,200 flowering plants, 91% of which are growing on human-disturbed substrate (Hermanutz et al. 2009). The census for Fernald's Braya (Table 1) is incomplete, and is based on representative samples (i.e. plots) within each of the 16 populations for which there are historic data available for comparison. This population estimate includes an additional population (Green Island Brook, containing 2 000 flowering plants) than the 1998-2000 surveys, and the COSEWIC Status Report (Meades 1997b), therefore, the original 15 Fernald's Braya populations have declined from 3 450 plants in the 1998-2000 surveys (Hermanutz et al. 2002) to 1 200 flowering plants in the 2008 survey. Additional efforts by Parks Canada have yielded a more complete assessment of the population at the Port au Choix National Historic Site (Table 2).

Table 1. A Newfoundland and Labrador Wildlife Division census of all known, current and historic, populations of Long's Braya (*Braya longii*), and an assessment of the Fernald's Braya (*B. fernaldii*) population through a census of localized plots within each known population area. Population estimates refer to flowering individuals only and are based on the most recent surveys completed in 1998-2000 (*) or 2008; DFO = Department of Fisheries and Oceans, PCA = Parks Canada Agency.

Population (current unless stated otherwise)	Latitude and Longitude	Disturbance type¹	Land Tenure²	Population estimate³
Long's Braya				
Anchor Point East	N 51.23913 W 56.78855	Natural	Provincial*	50*
Green Island Cove (Historic)	N 51.38248 W 56.58520	Natural	Provincial*	No plants located in 1998 survey ^a
Sandy Cove (Landing airstrip)	N 51.34259 W 56.68317	Both	Private/Provincial	1189
Sandy Cove (Lion's club)	N 51.34718 W 56.66381	Both	Private	273
Sandy Cove (Provisional Ecological Reserve)	N 51.34202 W 56.66944	Both	Provincial	305
Shoal Cove	N 51.35644 W 56.65438	Human-Disturbed	Provincial*	556
Yankee Point	N 51.32548 W 56.72035	Human-Disturbed	Provincial*	3226
Total				5599
Fernald's Braya				
Anchor Point East	N 51.23913 W 56.78855	Natural	Provincial*	121
Big Brook	N 51.52393 W 56.15112	Natural	Provincial*	3
Boat Harbour	N 51.59474 W 55.98836	Natural	Provincial*	20*
Burnt Cape (Provincial Ecological Reserve)	N 51.57132 W 55.74673	Human-Disturbed	Provincial	857
Cape Norman	N 51.6283 W 55.90174	Natural	DFO	46
Cook's Harbour South	N 51.59917 W 55.87323	Both	Provincial*	14
Cook's Point	N 51.61612 W 55.84664	Human-Disturbed	Provincial*	17
Four Mile Cove	N 51.49628 W 56.23619	Natural	Provincial*	40*
Green Island Brook	N 51.40092 W 56.52783	Human-Disturbed	Provincial*	2056
Ice Point (Historic)	N 51.22390 W 56.78656	Natural	Provincial*	No plants located in 1998 survey ^a

Population (current unless stated otherwise)	Latitude and Longitude	Disturbance type¹	Land Tenure²	Population estimate³
Lower Cove	N 51.54335 W 56.08153	Both	Provincial*	121*
Port au Choix National Historic Site (Port Riche)	N 50.70303 W 57.40140	Both	PCA	54
Savage Cove (Historic)	N 51.33571 W 56.70145	Natural	Provincial*	No plants located in 1999 survey ^a
Watt's Bight	N 51.5746 W 56.01046	Human-Disturbed	Provincial*	62
Watts Point (Provincial Ecological Reserve)	N 51.48010 W 56.25939	Both	Provincial	7
Watts Point South	N 51.45807 W 56.34420	Human-Disturbed	Provincial*	12
Total				3443

Disturbance type¹: Natural = plants reside on substrate that is undisturbed by human activities but is naturally disturbed via freeze-thaw cycles, Human-Disturbed= plants reside on substrate that has been disturbed by human activities, Both= plants reside on both naturally- and human-disturbed substrate; Land tenure²: Provincial= Provincial Crown Land, Provincial*=High probability that land is Provincial Crown Lands though there is a possibility that a portion of this area is privately owned, Private = private land ownership has been identified; Population estimate³ = for methodology see report by Hermanutz et al. (2009); ^asee Hermanutz et al. (2002); * = survey not completed in 2008; estimate based on survey results from 2000, see original recovery plan by Hermanutz et al. (2002)

Table 2. Parks Canada data for Port aux Choix National Historic site based on a census of flowering Fernald's Braya at four plots within the historic site¹. This effort is over and above the efforts of the Newfoundland and Labrador Wildlife Division population estimate (Table 1). These plots have no historic data for comparison.

Plot	Year	Population Estimate
Port au Choix – Plot 1	2006	81
Port au Choix – Plot 2	2007	348
Port au Choix – Plot 3	2008	201
Port au Choix – Plot 4	2009	75

1 – Parks Canada (unpublished data)

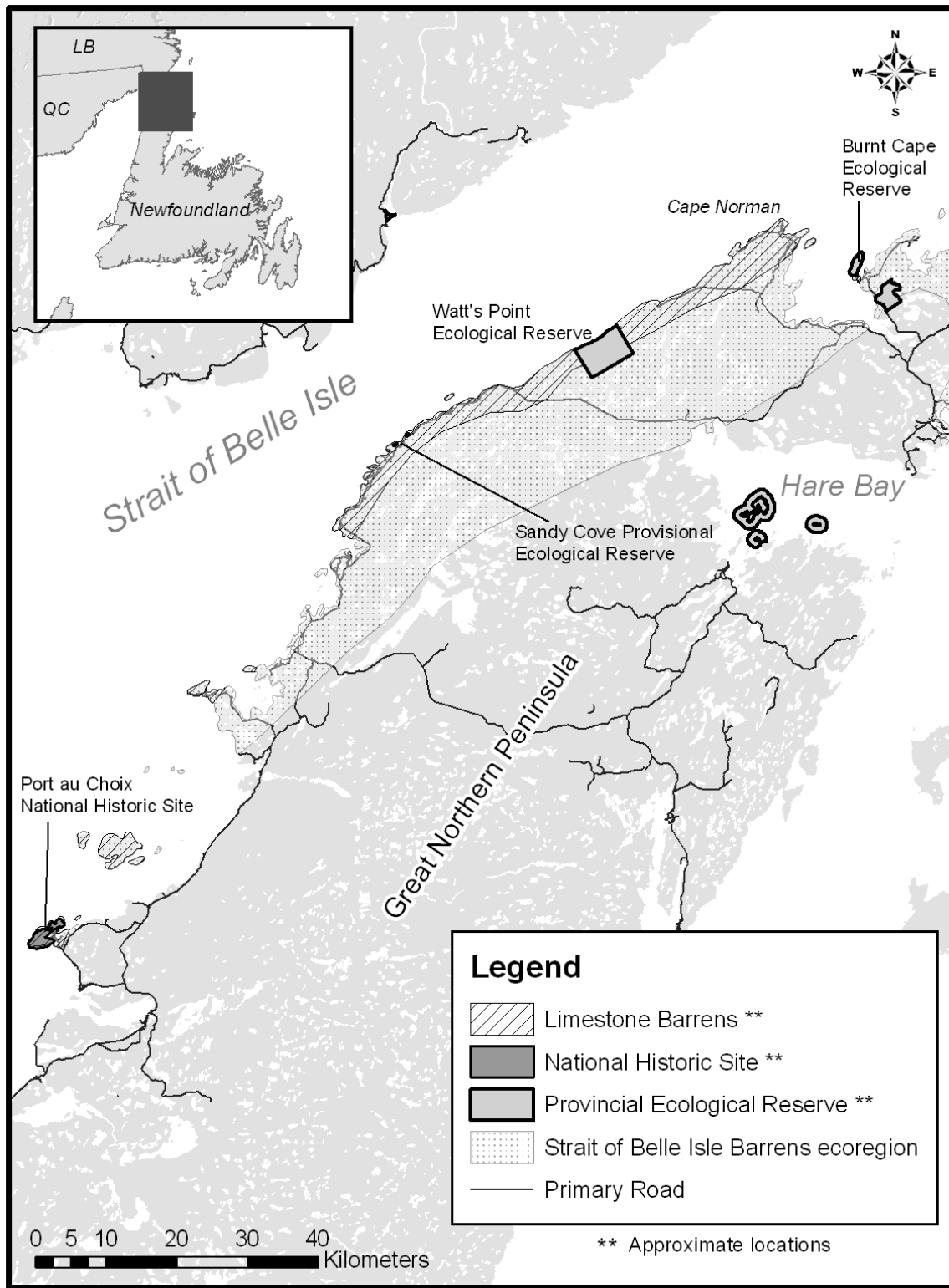


Figure 1. The limestone barrens of the Strait of Belle Isle Ecoregion, Great Northern Peninsula of insular Newfoundland (modified from Hermanutz et al. 2002)

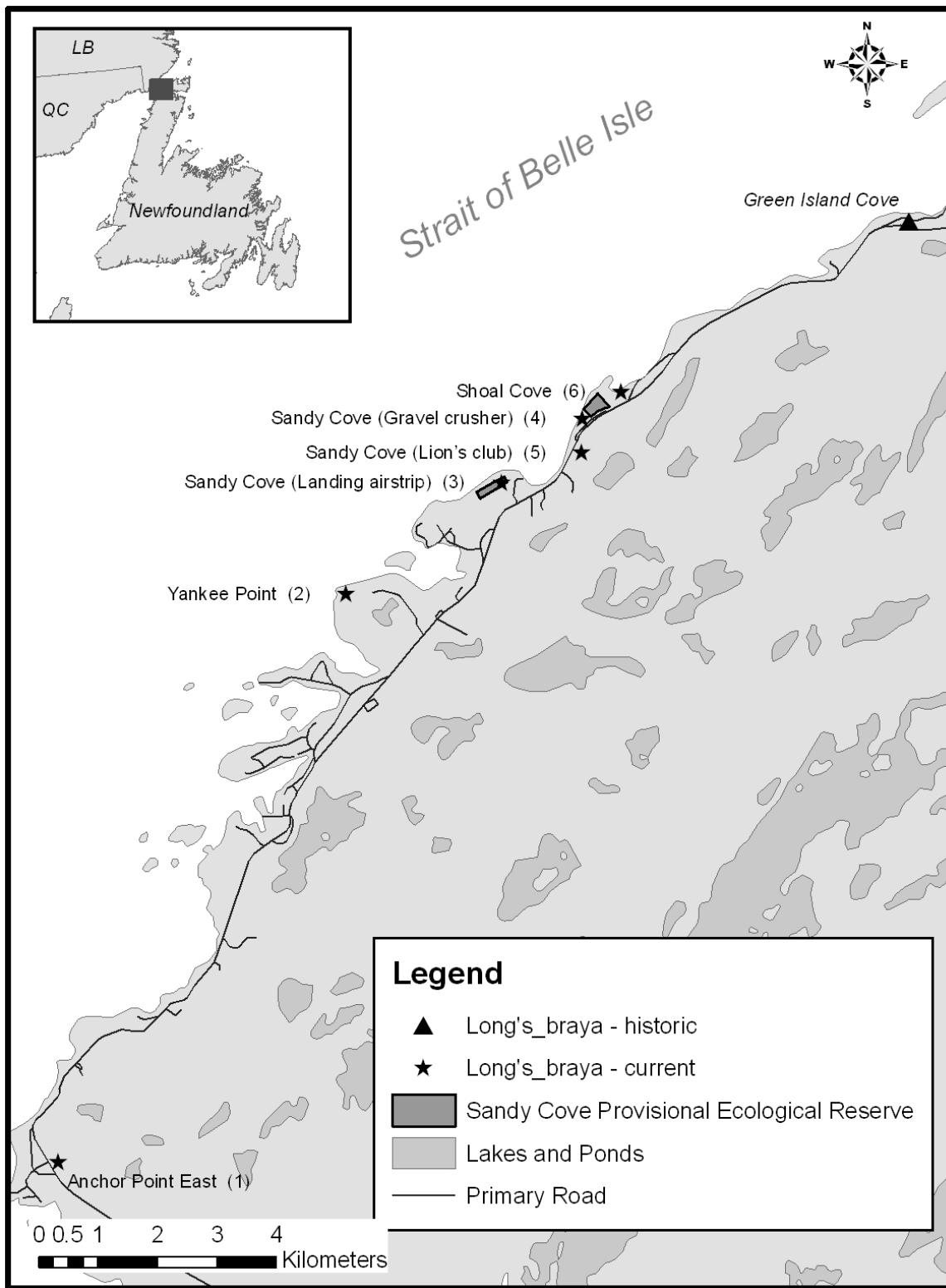


Figure 2. Historic and current distribution of Long's Braya on the Great Northern Peninsula of insular Newfoundland (modified from Hermanutz et al. 2002)

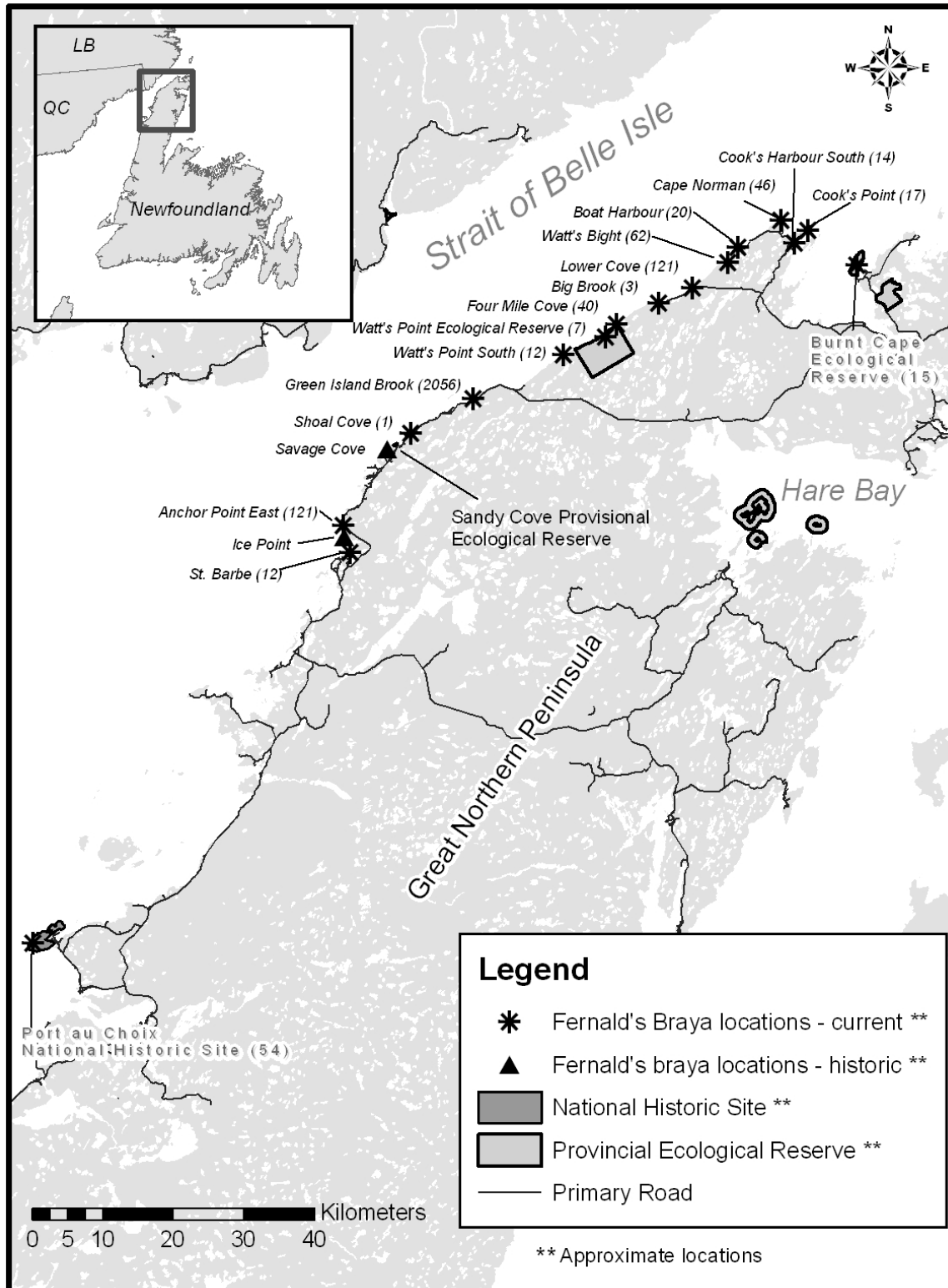


Figure 3. Historic and current distribution of Fernald's Braya on the Great Northern Peninsula of insular Newfoundland (modified from Hermanutz *et al.* 2002)

3.3 Needs of the Long's Braya and Fernald's Braya

Long's Braya and Fernald's Braya are restricted to the limestone barrens (Figure 4) on the Great Northern Peninsula of insular Newfoundland in the Strait of Belle Isle Ecoregion (Figure 1). The limestone barrens are a mixture of exposed bedrock outcrops and shallow layers of frost-shattered and sorted limestone gravel. Most areas are less than 60 m above sea level and within 1 km of the coast. Long's Braya and Fernald's Braya are adapted to the Arctic-like climatic conditions of the limestone barrens, including low temperatures, limited snowfall cover, extreme wind exposure, and heavy precipitation (Banfield 1983; Donato 2005).

Both species grow in sparse tundra-like vegetation on limestone soils and directly on bare limestone gravel. They are adapted to the natural disturbances caused by the freezing and thawing of limestone gravel substrate. In frost sorted polygons most braya live in the zone between the active central muddy cores and the relatively stable, gravel-to-cobble, vegetated rims (Noel 2000; Greene 2002). They are hardy primary colonizers of human disturbed sites but die quickly in response to shading from inanimate objects and from faster growing taller vegetation (Hermanutz and Squires unpublished data).



Figure 4: The limestone barrens at Port au Choix National Historic Site, Newfoundland. (Photo credit: Susan Squires)

The distinctiveness of the limestone barrens makes habitat specificity the most significant biological factor limiting the distribution of both species. Within the limestone barrens habitat, substrate is naturally heterogeneous, limiting the number of suitable and available microsites for seedling germination and recruitment (Noel 2000; Greene 2002). This, combined with the fact that individuals take at least one decade to reach maturity (Hermanutz and Squires unpublished data) and seeds of mature individuals only disperse an average of 50 cm (Tilley 2003), results in braya populations that are limited in size and distribution. Further, it is unknown how the cold-soil processes that shape this restricted habitat and that play an integral role in braya establishment will be affected by climate change (Slater 2005).

4 THREATS

4.1 Threat Assessment

Table 3. Long's Braya and Fernald's Braya threat classification; all threats are ranked by order of importance.

Threat	Level of Concern ¹	Extent	Occurrence	Frequency	Severity ²	Causal Certainty ³
Habitat Loss and Degradation						
Gravel extraction	High	Widespread	Current	Continuous	High	High
Off-road vehicle use	High	Widespread	Current	Continuous	High	High
Road maintenance	Medium	Localized	Current	Infrequent	Medium	Medium - High
Maintenance of utility corridors	Medium	Localized	Current	Continuous	Medium	Medium - High
Local use of barrens	Medium	Widespread	Current	Continuous	Low - Medium	Medium - High
Community expansion	Low	Localized	Current	Continuous	Low	Low
Road construction	Low	Widespread	Historic	Infrequent	High	High
Exotic Species						
Insect herbivory	High	Widespread	Current	Seasonal	High	High
Climate & Natural Disasters						
Climate change	High	Widespread	Current	Seasonal	High	Medium
Changes in Ecological Dynamics or Natural Processes						
Interspecific cross pollination	Medium	Localized	Current	Continuous	Medium	High
Natural Processes or Activities						
Microbial pathogens	High	Localized	Current	Continuous	High	High

¹ *Level of Concern: signifies that managing the threat is of (high, medium or low) concern for the recovery of the species, consistent with the population and distribution objectives. This criterion considers the assessment of all the information in the table).*

² *Severity: reflects the population-level effect (High: very large population-level effect, Moderate, Low, Unknown).*

³ *Causal certainty: reflects the degree of evidence that is known for the threat (High: available evidence strongly links the threat to stresses on population viability; Medium: there is a correlation between the threat and population viability e.g. expert opinion; Low: the threat is assumed or plausible).*

4.2 Description of Threats

4.2.1 Habitat Loss and Degradation

Gravel Extraction

On the limestone barrens, quarries were, and continue to be established for limestone aggregate that is primarily used for road construction within insular Newfoundland. Since braya were listed under the federal and provincial species at risk acts, quarry permits can only be obtained from the Province of Newfoundland and Labrador in areas where braya have not been located; however illegal quarrying has also happened. Quarrying results in habitat destruction, or severe habitat degradation by changing the frost-sorted substrate of patterned ground having coarse- and fine-grained fractions into a homogeneous shallow gravely substrate without a distinct fine-grained component (Greene 2002). Quarrying effectively removes all vegetation and most of the thin soil, and reestablishment of a native plant community at a quarried site will likely require generations if not centuries (L. Hermanutz – Memorial University, pers. comm. 2009).

Off-road Vehicle Use

Off-road vehicle damage by all-terrain-vehicles, dirt bikes, and trucks continues to be a threat throughout the limestone barrens (Rafuse 2005). Sites having substrate that has been previously modified by human activity suffer the least from off-road vehicles because the substrate is already compacted (Rafuse 2005). However, undisturbed sites are very vulnerable to off-road vehicle damage. After vehicle trampling, plants are found uprooted in tracks or have cracked leaves or stems, and the entire site may exhibit changes in hydrology due to water pooling in vehicle tracks and substrate compaction. It may take decades for these habitats to recover (Rafuse 2005).

Road Maintenance

Maintenance of the existing road infrastructure along the Great Northern Peninsula is an ongoing activity. This is a known threat to braya species. Heavy machinery operators have been directly observed to turn on limestone barren areas, and maintenance workers are known to park vehicles on the sides of roads, causing direct damage to braya populations (C. Hanel – NL Wildlife Division, pers. comm. 2009).

Maintenance of Utility Corridors

Maintenance of telephone and power lines along the Great Northern Peninsula highway (Route 430) has caused habitat destruction and braya mortality. Recent mortality in 2006 of Fernald's Braya was most severe near Cape Norman, where heavy machinery and other vehicles ran over plants causing a loss of 53% of plants tagged for long-term monitoring (17/32 tagged plants) and causing irreversible substrate damage that affects natural hydrologic patterns (Hermanutz et al. 2006).

Local Use of Limestone Barrens

For decades, communities have dumped garbage, piled wood for drying, spread nets for maintenance and drying on the limestone barrens, and used snowmobiles on braya habitat during the winter months. These activities result in direct plant mortality and removal of occupied habitat (Squires pers. comm. 2009). Stewardship initiatives have resulted in a decline in the

drying of fish nets, however wood piling for drying still occurs in the Long's Braya population at the Sandy Cove Lion's Club and the Fernald's Braya population in Green Island Brook. Due to policy and fee changes at local garbage dumps, garbage dumping may be increasing (D. House - Stewardship Co-ordinator, Limestone Barrens Habitat Stewardship Program, pers. comm. via email correspondence, 2009). Snowmobile use is of particular concern for the Fernald's Braya population near the community of Anchor Point where a well-used trail travels over an area of critical habitat. Maintenance of the snowmobile route results in substrate compaction and disturbance (D. House - Stewardship Co-ordinator, Limestone Barrens Habitat Stewardship Program, pers. comm. 2009).

Community Expansion

Large scale habitat destruction associated with community growth was in large part due to the creation of the Great Northern Peninsula highway (Route 430). The highway typically followed the settlement pattern of communities along the coast and bisected some braya populations (e.g., Anchor Point and Sandy Cove). Expansion of communities into areas in which these species reside resulted in the destruction of plants and associated habitat. This was observed in 2000 when a volleyball court was constructed adjacent to the Sandy Cove Lions Club site (L. Hermanutz – Memorial University, pers. comm. 2009).

Many of the communities within the range of these species have municipal infrastructure, such as water supplies, that tend to be located away from the community and in wilderness areas. Access to these areas for maintenance and/or expansion may result in infringements on critical habitat or sensitive areas. Also, most of the communities in this area are going through a regionalization of some services – such as solid waste disposal. This regionalizing approach will result in future changes to their operations and infrastructure needs within the area.

Road Construction

Road construction on the Great Northern Peninsula began in the late 1960s, and Highway 430 and its side roads were paved between 1975 and 1990. As well, in the late 1970s, gravel for the road to St. Anthony was removed from the limestone barrens north of Eddies Cove East, which resulted in the complete destruction of the limestone barrens at the Big Brook Barrens International Biological Programme (IBP) site. Watts Point Ecological Reserve was eventually established to protect a portion of the remaining undisturbed limestone barrens north of the original IBP site.

4.2.2 Exotic Species

Insect Herbivory

Long's Braya and Fernald's Braya, especially those populations growing on human-disturbed sites, suffer higher levels of infestation by the diamondback moth (*Plutella xylostella* L.). Diamondback moth is a global agricultural pest on members of the family Brassicaceae, and is not native to North America (Talekar and Shelton 1993). Diamondback moth larvae were first found on both braya species in 1995 (Meades 1997a, b).

From 2003 to 2006 the impacts of the diamondback moth on braya were extensively studied. After their mass immigration in early summer from overwintering sites in the southern United

States, females laid eggs on an average of 30% of the Long's Braya and 16% of the Fernald's Braya plants (Squires et al. 2009). In Long's Braya, larval feeding reduced mean seed output by up to 60%, from 10.8 - 4.3 seeds/fruit, and damaged 26% of leaves (Squires et al. 2009) (Figure 5a). Recent research indicated that plant mortality was related to the amount of leaf and fruit damage to the individual plant the year prior to death, and even two or three years before the plant dies (Squires et al. 2009). Moreover, warming climate and reduced precipitation on the limestone barrens allow the diamondback moth to produce multiple generations within one growing season, causing additive damage to braya by further reducing seed productivity, and consequently population viability (Squires et al. 2009).

4.2.3 Climate and Natural Disasters

Climate Change

A potentially important threat to the long-term persistence of Long's Braya and Fernald's Braya is climate change. The mean annual air temperature of the limestone barrens is predicted to increase by approximately 4°C over the next century (Slater 2005). This increase could alter the cold-soil processes of the limestone barrens and potentially decrease the amount of suitable substrate for both braya species. Climate change may also affect the population distribution and abundance of pathogens and diamondback moth. Survival rate of diamondback moth increases and their generation time decreases with an increase in temperature (Talekar and Shelton 1993).

4.2.4 Changes in Ecological Dynamics or Natural Processes

Interspecific Cross Pollination

Long's Braya and Fernald's Braya are closely related to each other, and to *Braya glabella* Richardson, and appear to have originated from *B. glabella* or a *B. glabella* ancestor of hybrid origin (Warwick et al. 2004). They also show mutations in the DNA, in the form of additional genetic material, and they are polyploid, i.e. they have more than two paired sets of chromosomes ($2n = 56$) (Warwick et al. 2004). Parsons (2002) found that the outliers in her breeding study were in populations at the extreme ends of each species' distribution (i.e., Shoal Cove, Watts Point, and Anchor Point), where the two species were in closest proximity to each other. At Anchor Point, Parsons (2002) found intermediate individuals that possessed characteristics of both species. These factors indicate that Long's Braya and Fernald's Braya may be able to interbreed (i.e. hybridize), and this may result in a loss of their species integrity, especially in those populations that are in close proximity to each other (Parsons 2002).

Hybridization potential is increased by human activities that mediate contact between both species, as no intermediates were observed on undisturbed habitat (Parsons and Hermanutz 2006). Long's Braya and Fernald's Braya do not suffer from inbreeding depression and therefore if hybridization occurs, hybrids might be able to persist by self-fertilization (Parsons and Hermanutz 2006).

Long's Braya and Fernald's Braya suffer from outbreeding depression (fitness is higher when individuals are crossed with individuals from the same population than when crossed with individuals from different populations), indicating that there is population differentiation among braya sites (Parsons 2002). Conservation efforts such as an *ex situ* program (Driscoll 2006)

will be designed to conserve individuals from each population in order to conserve the genetic diversity of the entire species (Parsons and Hermanutz 2006). Also, hybridization potential will be decreased by minimizing activities that cause contact between both species (Parsons and Hermanutz 2006).

4.2.5 Natural Processes

Populations of Long's Braya and Fernald's Braya resident on human-disturbed sites have higher reproductive output and grow in densities at least 10 times those found in undisturbed sites (Hermanutz et al. 2002), however human-disturbed populations are subject to higher rates of herbivory and pathogen pressure and experience altered population dynamics (i.e. individuals are less persistent - (Noel 2000)) and increased mortality rates (Squires 2010). Consequently, there is concern that human-disturbed populations may actually threaten the health and viability of undisturbed populations by acting as reservoirs from which pathogens can actively colonize undisturbed sites (Squires 2010).

Microbial Pathogens

Pathogen # 1: Flowering Stalk Pathogen of Long's Braya and Fernald's Braya

In 2003, disease symptoms were observed on Long's Braya resident on human-disturbed sites. On infected Long's Braya, one or more flowering stalks changed colour and became mouldy (Figure 5b). The symptoms always began at a single fruit, turned the fruit from green to pink to white, and moved up and down the flowering stalk until the entire stalk was white. The flowering stalk subsequently developed mould, causing the seeds within the fruits to die (Squires 2010).

By 2004, the pathogen had infected plants on four human-disturbed and two undisturbed Long's Braya sites and on one human-disturbed and one undisturbed Fernald's Braya site. Between 2003 and 2005 18% and 2% of surveyed Long's Braya and Fernald's Braya plants were infected, respectively, with the majority (66%) of infected plants growing on human-disturbed sites (Squires 2010). On average, 72% of the flowering stalks on infected plants were destroyed by the pathogen. Statistical analysis indicated that the probability of Long's Braya mortality increases if plants are infected (Squires 2010).

Pathogen # 2: *Fusarium* Pathogen of Long's Braya

In the late 1990s, species of root maggot (*Delia* spp.) were detected in the caudices of Long's Braya that were dying on human-disturbed sites (Hermanutz et al. 2002). In 2003, it was determined from newly wilted plants that the roots first rotted because they were infected with a fungus of the genus *Fusarium* (Figure 2c; Dr. George White, pers. comm.) and that infestation by *Delia* maggots is a secondary event. Two known *Fusarium* species (*F. equisetum* and *F. avenaceum* (two isolates) and one unidentified *Fusarium* species were isolated from the roots of dead Long's Braya. While it is not known which, if any, of these fungi causes Long's Braya to die, every dead wilted Long's Braya had rotten roots (Squires 2010).

All 599 Long's Braya that died between 2003 and 2005 showed the symptoms of *Fusarium* infection and subsequent feeding by *Delia* maggots and were growing on human-disturbed sites (Squires 2010). Based on population counts reported in the original Recovery Plan (Hermanutz et al. 2002), this mortality is equivalent to a loss of 8.6% of the Long's Braya population over a three-year period. While there was mortality on all the human-disturbed Long's Braya sites, the Yankee Point site lost the greatest proportion of individuals (25%) over the three-year period. The fungus preferentially infects the largest, most heavily flowered individuals, potentially causing severe reduction in reproductive output and seed bank size (Squires 2010).

Pathogen # 3: Unidentified Pathogen of Fernald's Braya

An unidentified pathogen was first recorded on Fernald's Braya at Boat Harbour in 1925 (Fernald 1950). This pathogen is thought to be a virus or bacterium, and results in leaf and flower stalk deformities and increased pubescence (Figure 5d; Hermanutz et al. 2002). The same suite of characteristics was also recorded on Fernald's Braya in Watts Point Ecological Reserve in 1995 (Meades 1997b) and in the Burnt Cape Ecological Reserve and Cape Norman in 2003. Of the surveyed Fernald's Braya at Cape Norman and in the Burnt Cape and Watts Point Ecological Reserves, an average of 27% was infected each year with the pathogen with 90% growing within human-disturbed habitat (Squires 2010). Mortality was significantly higher if plants were infected, with 35% of infected plants dying the year following infection, compared to only 18% of non-infected plants (Squires 2010).

5. POPULATION AND DISTRIBUTION OBJECTIVES

The population and distribution objectives for the Long's Braya and the Fernald's Braya are as follow:

For Long's Braya:

Ensure populations are viable² within the current species range and establish additional populations in natural areas within the historic range from Sandy Cove to Green Island Cove by 2015.

For Fernald's Braya:

Maintain populations within the current species range and, when possible, attain self-sustaining populations³.

Long's Braya have the potential for viable populations – due to the highly restricted range of the species, it is uncertain if self-sustaining populations are possible. Long's Braya has a more limited range than Fernald's Braya and have only few populations within that range. For this

² In this context, a "viable" population is one that may be management dependent for long-term persistence.

³ In this context, the term "self-sustainable" indicates populations that do not require human intervention for long-term persistence.

reason, the re-establishment of Long's Braya throughout the entirety of its known historic range is important to secure the persistence of the species over time. Population viability analyses indicate that pests and pathogens are the primary threat to this species. If these threats could be controlled or eliminated then present habitat availability would be sufficient to maintain these populations, although some habitat restoration may be needed.

For Fernald's Braya, maintenance of the populations will prevent contraction of the species range and, population levels permitting, self-sustainable populations could exist if threats are eliminated.



Figure 5: Pests and pathogens of braya. A) Leaf and fruit predation by diamondback moth (larvae) on Long's braya; B) Long's braya flowering stalk infected with an unknown pathogen (far left stalk that is pale pink) amongst uninfected stalks; and C) Long's braya infected and dying from the root fungus *Fusarium* next to a healthy Long's braya; D) Fernald's braya infected with an unknown pathogen causing flowering stalk deformities and increased pubescence. (Photo credit: Susan Squires)

6. BROAD STRATEGIES AND GENERAL APPROACHES TO MEET OBJECTIVES

6.1 Actions Already Completed or Currently Underway

Table 4. Recovery actions for Long's Braya and Fernald's Braya completed or currently in progress

Broad Strategy to Address Threats	Recovery Action	Complete / In progress
Scientific research	Determine the genetic diversity and differentiation of both braya species	Genetic research In progress Reproductive biology Complete
	Evaluate the role of seed bank in long-term persistence of each species	In progress
	Determine how disturbance affects recruitment and persistence	Complete
	Determine the long-term effect of disturbance on predation and microbial pressure on braya	Complete
	Determine optimal natural habitats for both species	Complete
	Produce a Population Viability Analysis for both species	Complete
Population monitoring	Establish permanent monitoring plots to record changes in the size and health of representative populations	Complete
	Establish total population size and distribution of both species	Complete
	Monitor population parameters at all currently identified extant locations	Completed annually
	Determine and rank health of population at each location	Completed annually
Critical habitat assessment & Protection	Assess the level of threat at each location	Complete
	Determine land ownership at each location	In progress
	Determine level of protection	Complete
	Delineate areas of occurrence	Complete
	Recommend protection for Long's Braya	Complete
	Recommend protection for Fernald's Braya	Complete
	Evaluate protection measures	Periodic
	Establish a provincial ecological reserve at Sandy Cove	In progress
	Establish a site-specific management plan for Port au Choix	Complete
Ex-situ conservation	Develop an <i>ex-situ</i> program for both species at MUN Botanical Garden	Complete
	Distribution of plants and seeds to other botanical collections	Complete
Education & Stewardship	Develop a regional education/information campaign in cooperation with applicable regional groups	Complete
	Initiate stewardship activities for all braya sites, where appropriate	In progress
	Review and evaluate stewardship and educational measures on a periodic basis	Periodic
	Ensure local participation in the delivery of recovery activities	In progress
Restoration & reintroduction	Restore Long's Braya within its historical range	In progress

6.2 Strategic Direction for Recovery

Table 5. Recovery Planning Table for Long's Braya and Fernald's Braya. Priorities are defined as: Urgent= top priority approach; Necessary = needed to evaluate and guide conservation actions; Beneficial = approach would be beneficial to the understanding of the species but not a priority.

Threat or Limitation	Priority	Broad Strategy to Recovery	General Description of Research and Management Approaches
All threats	Urgent	Monitoring	<ul style="list-style-type: none"> Periodically assess and monitor status of all populations Monitoring would include reproductive output, survival, and growth rate of the species Long-term monitoring of pest and pathogen levels within the populations
Climate Change	Necessary	Monitoring	<ul style="list-style-type: none"> Monitor climate change and assess link with population size and the occurrence of pests and pathogens
Habitat Loss & Degradation	Urgent	Habitat Management and Protection	<ul style="list-style-type: none"> Identify ownership (land tenure) of all habitat deemed necessary for the survival or recovery of both braya species Identify, develop and implement protection mechanisms and associated regulations for critical habitat on federal, provincial, and private land Develop referral system protocols and education materials for industrial/commercial operators likely to work on the limestone barrens Appropriately mark (e.g., signage, curbs) high-use habitat areas
Habitat Loss & Degradation	Necessary	Habitat Management and Protection	<ul style="list-style-type: none"> Expand Watts Point Ecological Reserve to include braya populations northward Develop and implement an off-road vehicle mitigation plan
Habitat Loss & Degradation	Beneficial	Habitat Management and Protection	<ul style="list-style-type: none"> Investigate use of landscape level planning
Habitat Loss & Degradation	Urgent	Restoration & Species Reintroduction	<ul style="list-style-type: none"> Re-establish populations of Long's Braya within its historic range by planting seed in potential substrate areas

Threat or Limitation	Priority	Broad Strategy to Recovery	General Description of Research and Management Approaches
			<ul style="list-style-type: none"> Determine and implement methods to restore human-disturbed Fernald's Braya habitat and resident population at Cape Norman
Habitat Loss & Degradation	Necessary	Restoration & Species Reintroduction	<ul style="list-style-type: none"> Determine methods (and implement these methods if time allows within the time frame of this recovery document) to restore human-disturbed Long's Braya habitat and resident populations
Insect pests & microbial pathogens	Urgent	Scientific Research	<ul style="list-style-type: none"> Identify the three microbial pathogens that negatively affect braya Further understand the impacts of insect pests and climate change on individuals and populations
Insect pests & microbial pathogens	Necessary	Scientific Research	<ul style="list-style-type: none"> Continue determining the role of the seed bank in seedling recruitment Determine genetic diversity among and within braya populations
All threats	Urgent	<i>Ex situ</i> Conservation	<ul style="list-style-type: none"> Maintain the current ex situ population at MUN Botanical Garden
All threats	Necessary	<i>Ex situ</i> Conservation	<ul style="list-style-type: none"> Evaluate the current ex situ population periodically
All threats	Urgent	Education & Stewardship	<ul style="list-style-type: none"> Erect interpretive panels at key braya sites Develop and implement Regional Communication Strategy
All threats	Necessary	Education & Stewardship	<ul style="list-style-type: none"> Establish new stewardship agreements Ensure local participation in delivery of recovery activities (e.g., Limestone Barrens Community Working Group) Reach out to enforcement agencies to further educate them on these species

6.3 Narrative to support Recovery Planning Table

Monitoring

In 2008, a demographic baseline was established and a new monitoring system was implemented (Hermanutz et al. 2009). Population and climate monitoring will continue (Donato 2005), providing recovery planners and scientists with the ability to assess the threat of insect pests, pathogens and climate change on braya and habitat.

Habitat Management and Protection

Recovery efforts will focus on completing the identification of land ownership for all critical habitat and finalizing surveys of all potential substrate areas for Fernald's Braya. Priorities will include implementing protection measures for critical habitat throughout the species' range, including federally, provincially, and privately owned land. This includes the development and implementation of an off-road vehicle mitigation plan in consultation with local communities.

Critical habitat protection will be improved by installing signs to clearly indicate critical habitat for the purpose of enforcement. The Provincial Parks and Natural Areas Division will continue to pursue an expansion of the Watts Point Ecological Reserve to the north, approval of the Sandy Cove Provisional Ecological Reserve, and establishment of an ecological reserve adjacent to the federally-owned property at Cape Norman.

Restoration and Species Reintroduction

Developing protocol and methods for the restoration of human-disturbed habitat will be important for long-term recovery. Re-establishing Long's Braya within its historical range as well as restoring degraded habitats (i.e. human-disturbed), and resident populations for both species would assist in establishing long-term viable Long's Braya populations and self-sustaining Fernald's Braya populations. Restoration of sites within the Sandy Cove area and within the Cape Norman region will be undertaken to recapture the natural landscape features and thus promote cold climate soil processes and stop changes in hydrology patterns (e.g., levelling gravel piles to restore micro-topography). The recovery value of the human-disturbed site Yankee Point will also be evaluated to determine if restoration is a feasible recovery strategy. It is important to note that human-disturbed habitat often supports higher densities of braya and, as a result, these groups of plants do not function naturally. These plants support more insect pests and pathogens than those found on undisturbed habitat (Squires 2010). Therefore, although human-disturbed habitat can be suitable substrate for braya, restoration of these habitats is vital to achieving the population and distribution objectives for both species.

Scientific Research

Much scientific research has occurred since the recovery team was formed in 1998. Currently, scientific research is needed to identify the three microbial pathogens infecting either Long's Braya or Fernald's Braya or both. Scientific research on the impacts of insect pests, pathogens, and climate change need to continue in order to fully determine the impacts of these threats.

Studies initiated under the original National Recovery Plan for Long's Braya and Fernald's Braya (Hermanutz et al. 2002), such as the investigation of seed bank longevity, will be continued until recovery is complete. Genetic testing will also be pursued to assess the threat of hybridization.

Ex situ Conservation

A representative genetic stock of seeds and living plants from all braya populations is maintained in an *ex situ* population at the MUN Botanical Garden (St. John's, Newfoundland and Labrador) (Driscoll 2006). Seeds have also been sent to the National Seed Bank (Saskatoon, SK). Both the seed bank and the live *ex situ* populations will be maintained as a failsafe in the event of an extirpation or extinction, and for use in reintroduction and restoration studies. Periodic evaluations of the living plants and seed bank will help determine needed additions to this bank from wild populations of these species.

Education and Stewardship

Local people will be encouraged to participate in recovery activities. Local input and participation will be important for the success of an off-road vehicle mitigation plan and for the value of erecting interpretive panels at key braya sites. A survey will be circulated to determine the attitudes of local people towards braya conservation. Programs and school curriculum encouraging school-aged children to be good stewards of the limestone barrens will continue and be further developed. Efforts will continue to reach out to enforcement agencies responsible for species at risk enforcement to provide resource materials and educational opportunities. The effectiveness of stewardship and education measures will be evaluated.

7. CRITICAL HABITAT IDENTIFICATION

7.1 Identification of the Species' Critical Habitat

Approach

Areas of habitat containing potential substrate for braya within the range of the Long's Braya and the Fernald's Braya was first identified from aerial photographs (Greene 2002), and subsequently assessed in the field. At that time, the habitat was designated as either *suitable substrate* (see critical habitat attributes below) or *unsuitable*. Suitable substrate areas were further surveyed for species presence and were categorized as *occupied*, if the species was observed, or *unoccupied*, if the species was not observed.

Suitable substrate areas can include both natural and human-disturbed habitat where vegetation has been removed by human activities and limestone has been exposed (Janes 1999; Noel 2000; Greene 2002; Parsons 2002; Tilley 2003). Human-disturbed habitat can be recognized by its homogenous limestone gravel that lacks a distinct fine-grained component (Greene 2002). However, it is important to note that human-disturbed habitat often supports higher densities of braya and, as a result, these groups of plants do not function naturally. These plants support more insect pests and pathogens than those found on undisturbed habitat (Squires 2010).

Therefore, although human-disturbed habitat can be suitable substrate for braya, restoration of these habitats is vital to achieving the population and distribution objectives for both species.

The location of each occupied or unoccupied suitable substrate area was mapped using a central point and a maximum radius to inscribe a circle that encompassed the entire habitat. Parts of the circle that clearly were not suitable substrate (e.g. water bodies, forest and other land cover types that appear as mapped layers within our GIS database) were removed (see Figures 6, 7, 7A, 7B, and 7C). The critical habitat within the Port au Choix National Historic Site has been further refined through more intensive ground-truthing and mapping to better reflect the critical habitat attributes on-the-ground. This is represented in Figure 7A. Within the polygons identified as critical habitat on the figures, only those areas that contain the critical habitat attributes listed below are considered to be critical habitat.

Critical habitat attributes

Critical habitat attributes for naturally occurring habitat of Long's Braya and the Fernald's Braya are as follow (Figure 8):

- limestone barrens⁴
- vegetation cover less than 10 cm in height
- vegetation rarely exceeding 50%
- substrate characterized by angular boulders, rocks, and pebbles, often in a fine grained sediment matrix
- substrate can be sorted by frost action in a circular or stripped pattern

Critical habitat attributes for human-disturbed habitat of Long's Braya and Fernald's Braya are as follow (Figure 9):

- limestone barren⁴
- vegetation cover less than 10 cm in height
- natural habitat transformed to a homogeneous gravelly substrate without a distinct, fine-grained component – can include abandoned roadways, ATV trails, and quarries



Figure 8: Example of naturally occurring habitat of Long's braya and Fernald's braya. (Photo credit: Susan Squires)



Figure 9: Example of human-disturbed habitat of Long's braya and Fernald's braya. (Photo credit: Susan Squires)

⁴ For the purposes of this document, 'limestone barrens' is defined as a mixture of exposed limestone bedrock outcrops, thin layers of frost-shattered limestone gravel, and shallow limestone soils with sparse tundra-like vegetation.

Identification of critical habitat

Critical habitat for Long's Braya is all suitable substrate within the known historical range of the species regardless of the presence of plants. Rationale for this designation is twofold: 1) there is so little habitat left for recovery; and 2) part of the life cycle of this species is hidden, i.e. long-lived seeds can lay dormant in the soil (i.e. a seedbank), therefore plant residency alone is not a sufficient criterion to assess species occupancy. Potential substrate is available for Long's Braya between Shoal Cove and Green Island Brook (see Figure 6). More studies are needed to complete the identification of critical habitat for Long's Braya in this area. These areas may be needed to meet the population and distribution objectives for this species.

Fernald's Braya is more widespread, and critical habitat for this species is identified as all the areas classified as suitable occupied substrate and mapped as per the methodology described above in the Approach section. Areas classified as suitable unoccupied substrate were not identified as critical habitat as they are not considered necessary to meet the population and distribution objectives for this species. More studies are needed to complete the identification of critical habitat for Fernald's Braya - there are still potential substrates that have not been verified in the field for suitability.

There are no locations where both species share the same portion of critical habitat, however critical habitat areas for both species are adjacent to each other near the communities of Anchor Point, Shoal Cove, and Green Island Brook. The critical habitat for the Long's Braya and Fernald's Braya is mapped in the Figure 6 and the Figure 7 series of maps, respectively.

7.2 Schedule of studies to identify critical habitat

Critical habitat identification techniques have been explained in this document, however neither Long's Braya nor Fernald's Braya have complete critical habitat identification. There are areas of potential habitat (i.e. potential substrate) within the range of Long's Braya. These areas have yet to be fully surveyed, but are expected to contain habitat capable of supporting a re-established Long's Braya population. Additionally, further actions are required to more completely understand the distribution of Fernald's Braya throughout the limestone barrens of the Great Northern Peninsula (Table 6).

Table 6. Schedule of Studies

Description of Activity	Outcome/Rationale	Timeline
Finalize surveys of potential substrate within the range of Fernald's Braya to verify occupancy.	Identification of additional critical habitat for Fernald's Braya.	By 2013
Complete surveys of potential substrate within the historic range of Long's Braya to verify occupancy.	Identification of additional critical habitat for Long's Braya.	By 2013

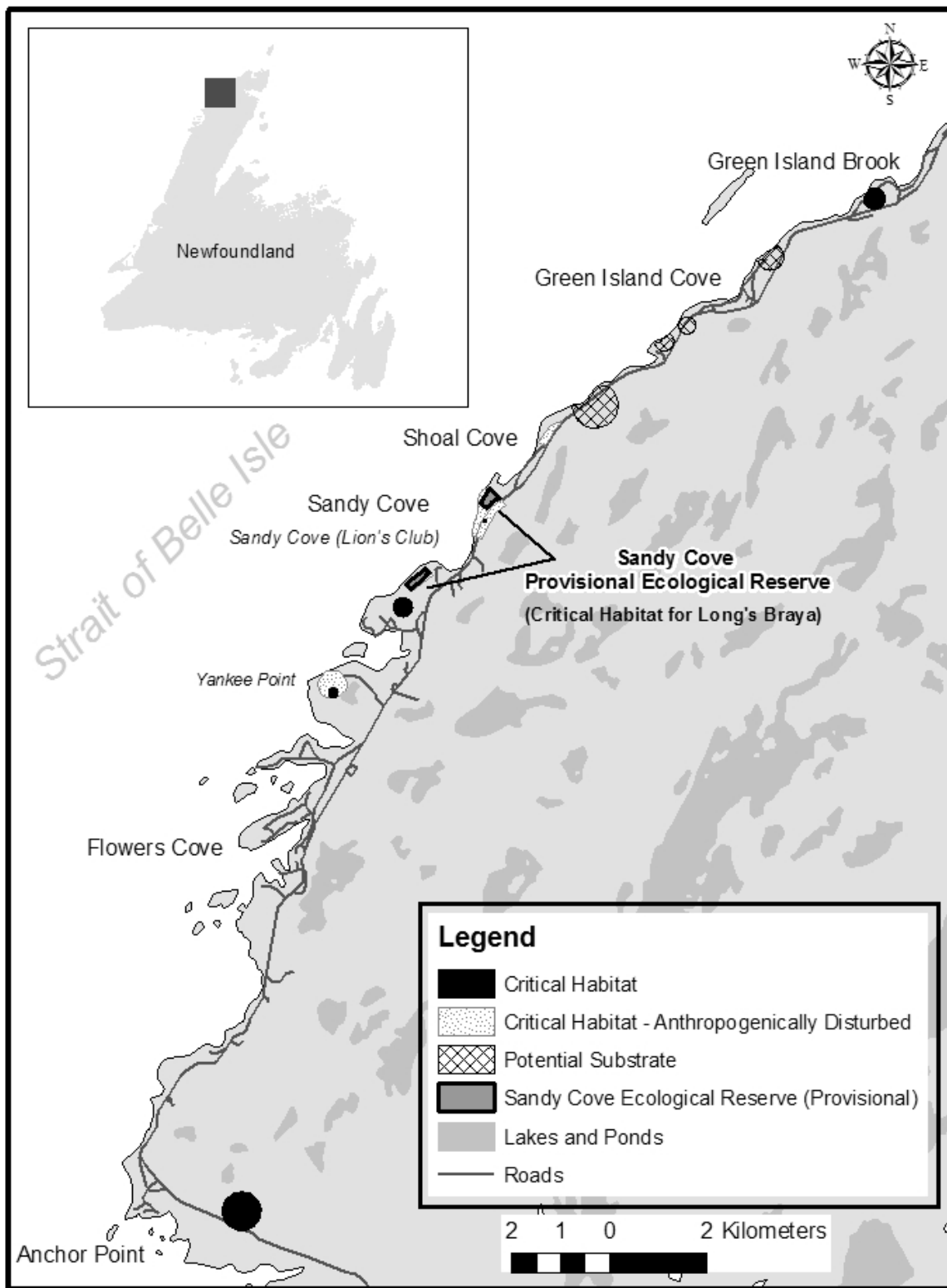


Figure 6: Map showing locations of critical habitat for the Long's Braya (*Braya longii*), throughout its historic range, from Anchor Point to Green Island Cove, on the limestone barrens of the Great Northern Peninsula of insular Newfoundland.

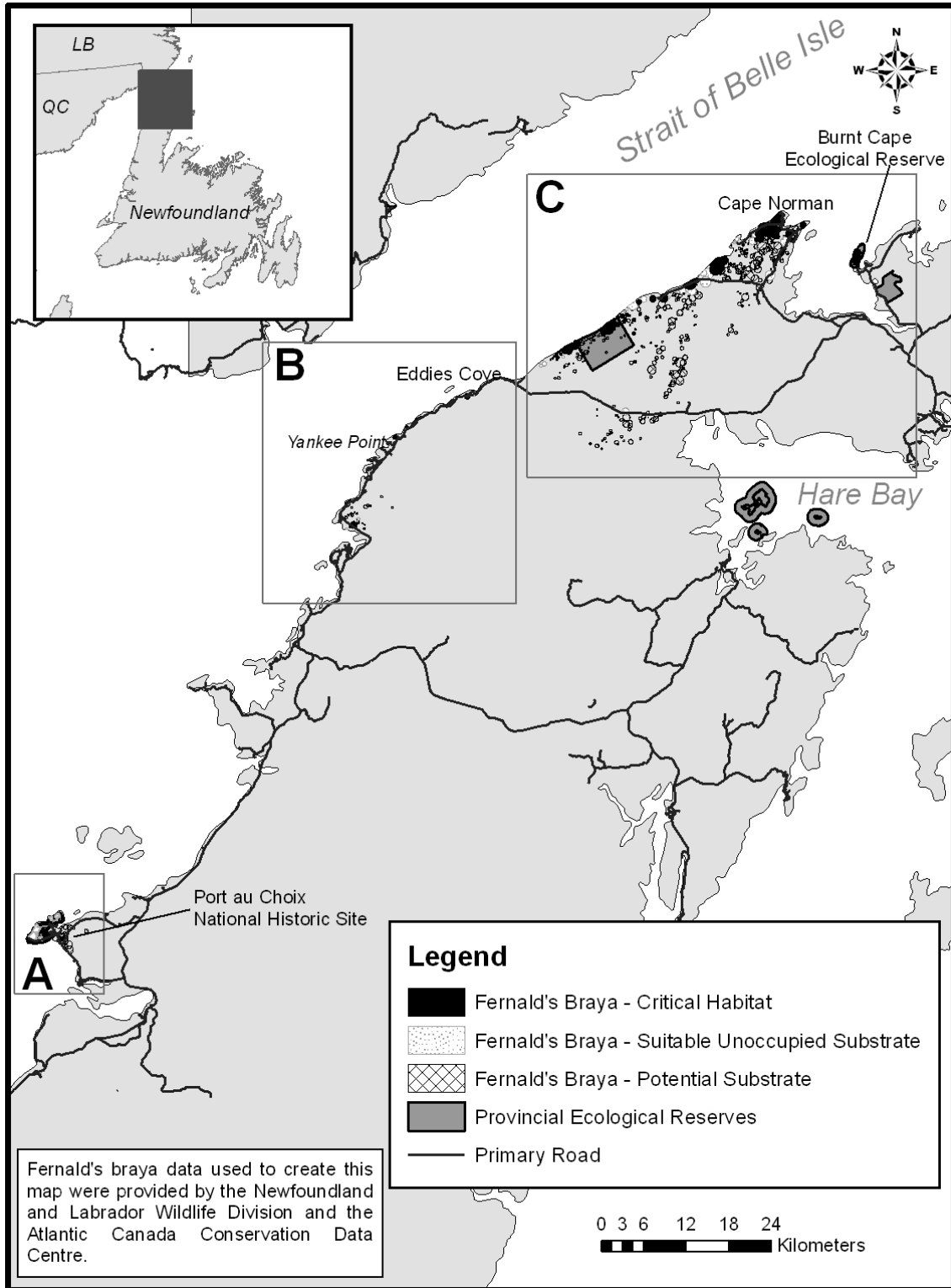


Figure 7: Map showing locations of critical habitat for the Fernald's Braya (*Braya fernaldii*), throughout its historic range, from Point Riche Peninsula (Port au Choix) to Burnt Cape Ecological Reserve, on the limestone barrens of the Great Northern Peninsula of insular Newfoundland.

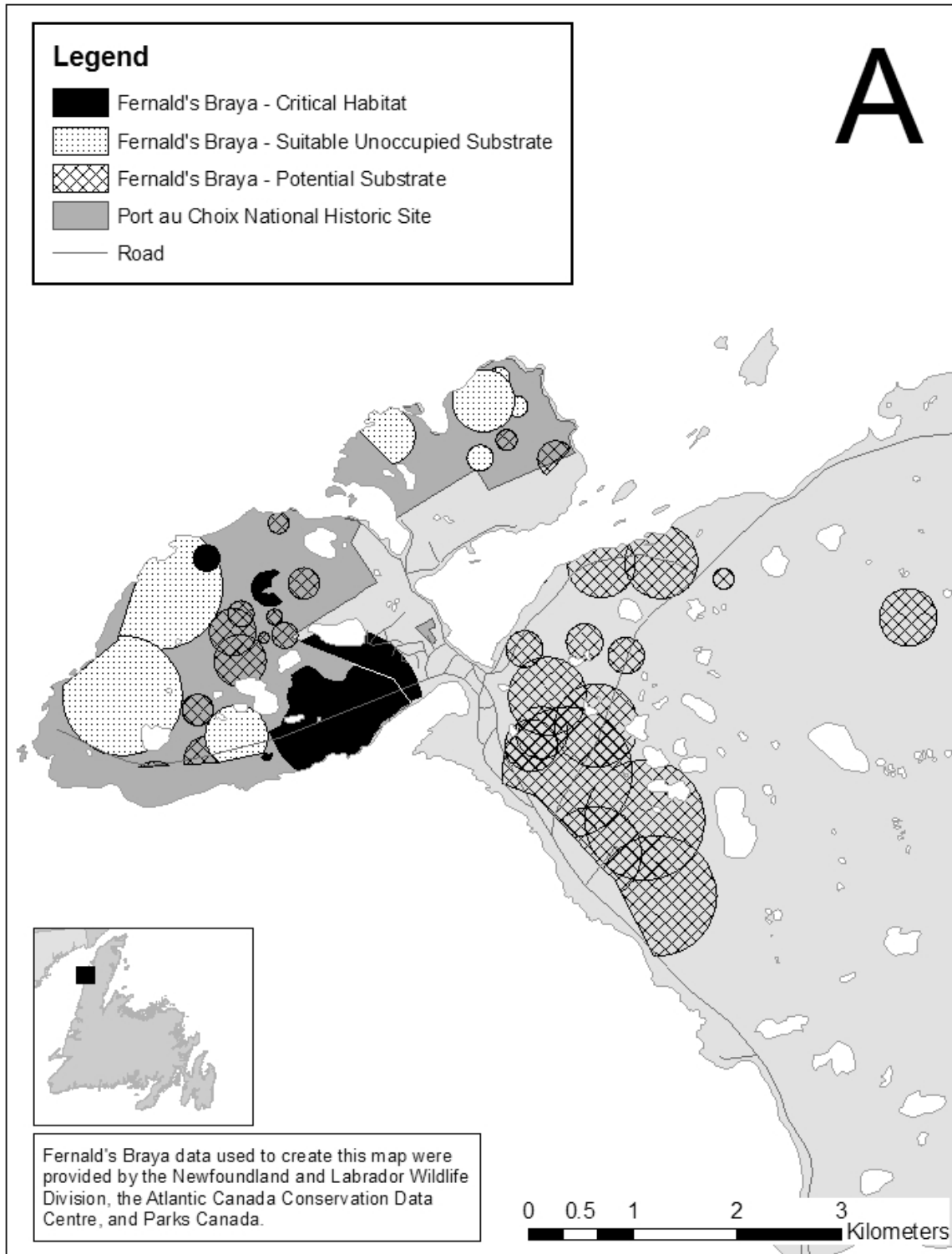


Figure 7A: Map showing locations of critical habitat for the Fernald's Braya (*Braya fernaldii*) at Port au Choix National Historic Site (Parks Canada Agency), on the limestone barrens of the Great Northern Peninsula of insular Newfoundland.

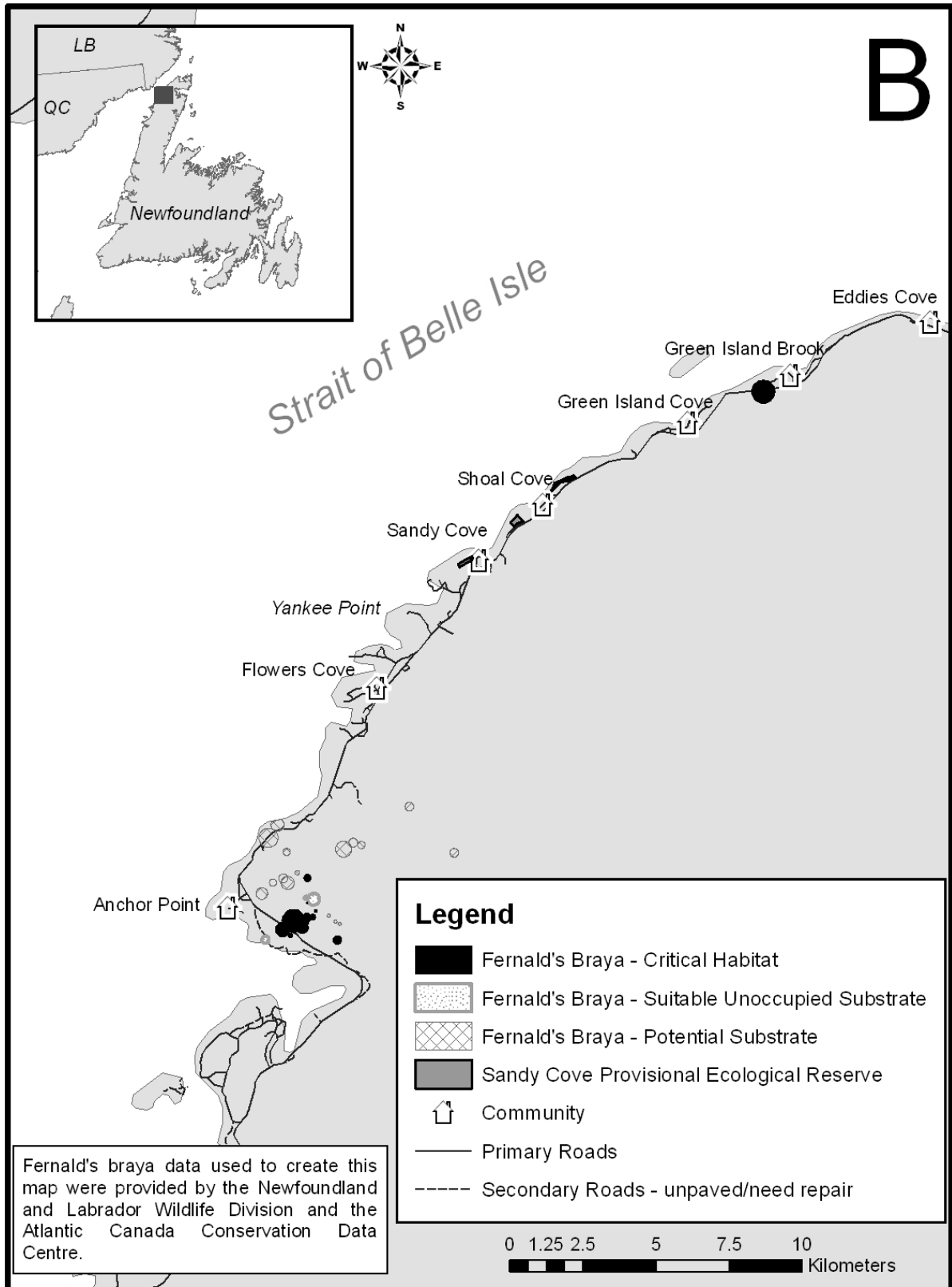


Figure 7B: Map showing locations of critical habitat for Fernald's Braya, from Anchor Point to Green Island Brook, on the limestone barrens of the Great Northern Peninsula of insular Newfoundland.

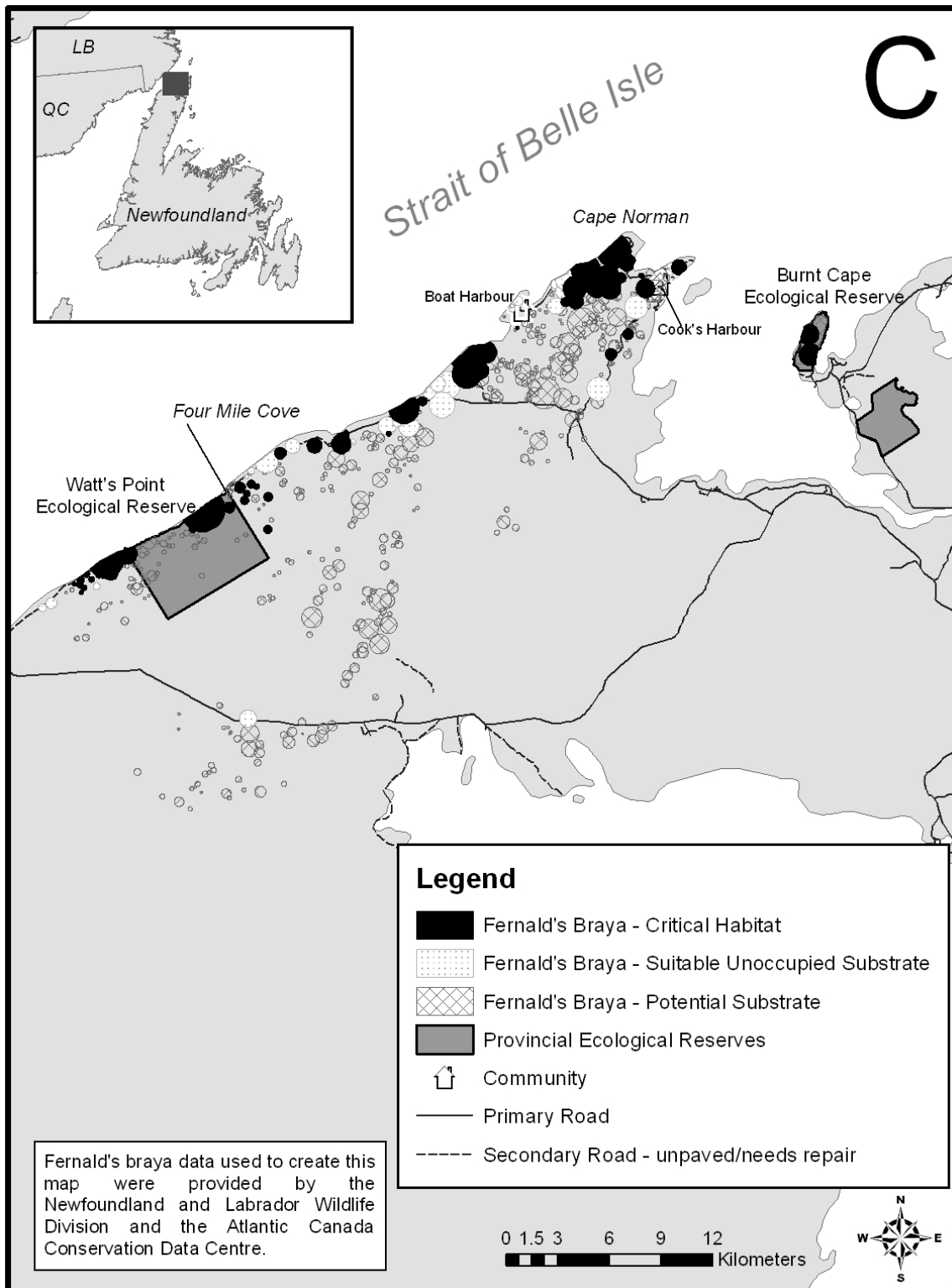


Figure 7C: Map showing locations of critical habitat for the Fernald's Braya, from Watts Point Ecological Reserve to Burnt Cape Ecological Reserve, on the limestone barrens of the Great Northern Peninsula of insular Newfoundland.

7.3 Activities Likely to Result in the Destruction of Critical Habitat

Examples of activities likely to result in the destruction of critical habitat for the Long's Braya and Fernald's Braya include, but are not limited to the following activities:

- 1) The removal of vegetation and/or the organic layer can result in destruction or critical habitat. Specific examples include commercial or industrial activities such as limestone gravel excavation, quarrying, drilling and road construction. Other local activities include the development of recreational trails for eco-tourism purposes. It should be noted that these activities occur infrequently but result in a significant loss of habitat.
- 2) Substrate compaction and substrate damage (e.g. limestone shattering) that affects normal root function, seedling recruitment, and natural hydrologic patterns. Specific examples capable of causing compaction and substrate damage include inappropriate maintenance of roads, utility corridors, and service lines, recreational use of off-road vehicles, and the placement of temporary or permanent structures. It is important to note that even a single pass of an off-road vehicle (e.g. all-terrain vehicle or dirt bike), especially when substrate is wet, can cause enough compaction to result in the temporary loss of habitat function.
- 3) Any activity on critical habitat that may result in the disturbance or alteration of the habitat in such a way as to reduce the quality of habitat by removing substrate or damaging components of the plant community. Specific examples include the laying out of fish nets or other fishing equipment, wood piling, the collecting of rock or plants for horticultural purposes, the collecting of fossils, allowing any domestic animal to run at large, picnicking or camping, the depositing of waste material, and the introduction of plants or animals non-native to the limestone barrens.

All of these activities can have severe impacts on habitat that is critical to the persistence of the species and can result in direct plant mortality and population decline.

8. MEASURING PROGRESS

The following performance measures will be used to evaluate the progress and success of recovery efforts. Performance measures apply to both species unless stated otherwise.

- No destruction or degradation of critical habitat observed throughout the range of both species'.
- All known populations of Long's Braya are maintained at viable population sizes, while all known populations of Fernald's Braya are maintained at self-sustaining sizes.
- The number of Long's Braya populations reintroduced into natural areas within the species' historic range, from Sandy Cove to Green Island Cove.
- Trends in population health, size and abundance, as well as impacts of pests and pathogens to braya populations are detected over time.

9. STATEMENT ON ACTION PLANS

An action plan will be posted on the Species at Risk Public Registry within one year from the posting of the Recovery Strategy.

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Appendix 1 – Effects on the Environment and Other Species

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision-making.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that strategies may also inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts upon non-target species or habitats. The results of the SEA are incorporated directly into the strategy itself, but are also summarized below in this statement.

This recovery strategy will clearly benefit the environment by promoting the recovery of Long's Braya and Fernald's Braya. The potential for the strategy to inadvertently lead to adverse effects on other species was considered. The SEA concluded that this strategy will clearly benefit the environment and will not entail any significant adverse effects. The reader should refer to the following sections of the document in particular: Needs of Long's Braya and Fernald's Braya (section 3.2) as well as Broad Strategies and Approaches to Recovery (section 6).

Appendix 2 – Limestone Barrens Species at Risk Recovery Team and Associates

Recovery Team:

- Luise Hermanutz, Memorial University of Newfoundland, Department of Biology (Co-Chair)
- Susan Squires, Newfoundland and Labrador (NL) Department of Environment and Conservation (Wildlife Division (WD)) (Co-Chair)
- Douglas Ballam, Nature Conservancy of Canada, Program Manager
- Trevor Bell, Memorial University of Newfoundland, Department of Geography
- Michael Burzynski, Parks Canada Agency
- Jeri Graham, NL Department of Environment and Conservation (Parks and Natural Areas Division (PNAD))
- Claudia Hanel, NL Department of Environment and Conservation (WD)
- Dulcie House, Limestone Barrens Habitat Stewardship Program Manager
- John Maunder, Curator Emeritus of Natural History, Provincial Museum of NL
- Wilf Nicholls, Memorial University of Newfoundland, Botanical Garden
- Dale O'Leary, NL Department of Natural Resources (Natural Resources (NR))
- Leah Soper, NL Department of Natural Resources (NR)
- Millie Spence, Parks Canada Agency
- Geneva Woodward (Sandy Cove)
- Gerry Yetman, NL Department of Environment and Conservation (WD)

Associated specialists:

- Peggy Dixon, Agriculture and Agrifoods Canada
- Peter Deering, Parks Canada Agency
- Tina Leonard, NL Department of Environment and Conservation (PNAD)
- Henry Mann, Botanical consultant, Memorial University of Newfoundland (Professor Emeritus)
- Anne Marceau, Parks Canada Agency
- Susan Meades, Botanical consultant
- Diane Pelley, Atlantic Canada Conservation Data Centre and Memorial University of Newfoundland, Department of Biology
- Cathy Regular, NL Department of Environment and Conservation (WD)
- Jonathan Sharpe, NL Department of Environment and Conservation (WD)
- Peter Thomas, Canadian Wildlife Service (Atlantic Region)

Community working group members:

- Lynn Dempster, Economic Development Officer, Innovation, Trade, and Rural Development
- Tamsey Laing (North Boat Harbour)
- Carolyn Lavers (Port au Choix)
- Barbara Pike, Alternate member (Port au Choix)
- Elizabeth Smith, Alternate member (Raleigh)
- Denise White, Economic Development Officer, Innovation, Trade, and Rural Development
- Madeline White, Alternate member (Sandy Cove)
- Geneva Woodward (Sandy Cove)