2021

Recovery Plan

Limestone Barrens Species at Risk

Prepared by the Limestone Barrens Species at Risk Recovery Team

Department of Fisheries, Forestry and Agriculture
Forestry and Wildlife Branch

Newfoundland Labrador

What is the *Endangered Species Act*?

The *Endangered Species Act* was enacted in 2001 to ensure that species at risk of extinction in Newfoundland and Labrador, as well as their residence and habitat critical to their survival and recovery, receive protection. Furthermore, the *Endangered Species Act* ensures that efforts to recover these species are initiated. This legislation applies to species, sub-species and populations that are native to the province, but does not include marine fish, bacteria, or viruses. It also does not apply to introduced species, except in extraordinary circumstances. The *Endangered Species Act* fulfills the province's commitments to the *Accord for the Protection of Species at Risk*. The *Species at Risk Act*, was enacted in June 2003 as the federal government's contributing piece of legislation to the Accord.

What is recovery?

For species at risk of continued population decline or extinction, such as those listed in the *Endangered Species Act* as endangered, threatened, or vulnerable, recovery is the process by which its population decline is stopped, stabilized, and reversed. This occurs when a threat to the whole population or individuals is removed or reduced. A species is not considered to be recovered, and thereby removed from the *Endangered Species Act*, until its long-term persistence in the wild is secured. It is possible that a species will always be considered rare. This typically occurs when the species is restricted to an extremely unique or uncommon habitat or habitat loss has been extensive. For each species listed as endangered or threatened a recovery team is put in place to oversee the recovery process and write a recovery plan. For each species listed as vulnerable a management plan is written to guide the recovery process.

What is a recovery plan?

A recovery plan outlines the goals and actions deemed necessary by the recovery team to protect and recover the species and identifies the main threats to the species' recovery. Section 23 of the *Endangered Species Act* outlines the required content of and the process for developing recovery plans. It states that a recovery plan will identify the necessary measures for the recovery of a species, a species' critical and recovery habitat (if appropriate), and a schedule for the implementation of the plan. Depending on the status of a species, a recovery plan has to be developed within one to two years after the species is designated under the *Endangered Species Act*. Recovery plans are reviewed regularly and updated as necessary.

To effectively present the recovery and management needs of species that occur in the same place or share habitats recovery plans may be multi species, ecosystem based and/ or include the management actions for species listed as Vulnerable.

What's the next step?

Implementing the plan! Many people work towards implementing the recovery and management actions outlined in recovery documents, including the members of a recovery team itself, who meet regularly to discuss the recovery of the species. Approximately 100 people participate on recovery teams and working groups around the province, and act as provincial representatives on national recovery teams. Recovery team members are representatives of indigenous governments and organizations, species experts, stewardship practitioners, community members, work with resource industries, conservationists, land managers, as well as representatives from municipal, provincial, and federal governments. Each play a significant role in the implementation of the recovery plan. Success in species conservation and recovery depends on the commitment and cooperation of many different people and requires all responsible jurisdictions, as well as all Newfoundlanders and Labradoreans, to work together to support and implement management plans.

Disclaimer

This recovery document is a multispecies plan that presents actions to support the management and recovery of species that are of provincial and national conservation concern. The plan was developed by the Limestone Barrens Species at Risk Recovery Team to meet legislated requirements under the Newfoundland and Labrador *Endangered Species Act*. This recovery plan applies only to provincial and private land and as such focuses primarily on presenting information and actions for individuals and populations which occur on lands of provincial jurisdiction. Where protection currently exists on federal lands, this will also be identified for information purposes.

The goals and actions identified in a recovery plan are based on the best existing knowledge and are subject to modifications resulting from new findings and revised objectives. They do not necessarily represent the official positions of the governmental or non-governmental organizations, or individuals, involved. Implementation of the actions identified in this document ultimately depends on the ongoing program priorities and budgetary constraints of the participating individuals, groups, organizations, jurisdictions, and agencies.

For more information, contact:

Forestry and Wildlife Branch
Department of Fisheries, Forestry and Agriculture
192 Wheeler's Road
Corner Brook, NL
A2H 7S1
Web site: www.gov.nl.ca

COVER PHOTOGRAPHS

Limestone Barrens - Dr. Susan Squires - Department of Fisheries, Forestry and Agriculture
Fernald's Braya - Diane Pelley
Barrens Willow - John Maunder
Mackenzie's Sweetvetch - Claudia Hanel - Department of Fisheries, Forestry and Agriculture
Wooly Arnica - Claudia Hanel - Department of Fisheries, Forestry and Agriculture

RECOMMENDED CITATION

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AUTHORS

This recovery plan was prepared by the Limestone Barrens Species at Risk Recovery Team with technical authorship by Corrina Copp and Claudia Hanel. The Limestone Barrens Species at Risk Recovery Team (Appendix A) holds the authorship of this document and provided extensive input and editorial review.

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RESPONSIBLE JURISDICTIONS

Government of Newfoundland and Labrador
Government of Canada

DEDICATION

Our continued dedication to the Limestone Barrens is inspired by the work of Joe Brazil, without whom this Province would not have an Endangered Species Act, and the people of the Limestone Barrens, who call this unique habitat home and whose kindness makes much of our work possible.

- Limestone Barrens Species at Risk Recovery Team

EXECUTIVE SUMMARY

Globally, limestone is very widely distributed. Notable areas of limestone habitat exist in Ireland, the United Kingdom, Estonia, and Sweden. Within Canada, notable limestone habitats include the “alvars” of Manitoba, Ontario, the limestone islands of the Mingan Archipelago in Québec, and the “limestone barrens” of Newfoundland and Labrador. The limestone barrens of the Island of Newfoundland make up less than 1% of the island’s area, and are divided into a northern and a southern region. They are founded upon a mixture of exposed calcareous bedrock outcrops, thin layers of frost-shattered calcareous gravel, and shallow calcareous soils, and are characterized by sparse, frost-disturbed vegetation.

The substrate is nutrient poor and naturally heterogeneous, characterized by angular boulders, cobbles, and pebbles in a fine-grained sediment matrix. On the limestone barrens, frost action, wind, soil erosion, and copious precipitation, continuously shape the limestone rock.

The primary vegetation type on the limestone barrens is islands of vascular plants distributed within areas of exposed substrate. Limestone barrens plants demonstrate adaptations to the nutrient deficient substrates, low temperatures, strong winds, and a relatively short growing season. These adaptations include cushion-like growth forms; woolly coverings of stems, buds, and leaves; cup-shaped flowers that rotate to face the sun; and dark coloured leaves that absorb more heat. Given the fundamental connection between climatic conditions and the complex dynamics of the limestone barrens, climate change may adversely affect the persistence of the species at risk in this habitat.

The limestone barrens ecosystem is a “biodiversity hotspot”; the harsh habitat has created a niche for arctic-alpine types of plants that require and/or tolerate high calcium and magnesium levels, and are adapted to low nutrient levels. Of the approximately 300 species of vascular plants considered to be rare to the Island of Newfoundland, about 10% are specific and unique to the limestone barrens. Of these, four are listed under the federal *Species at Risk Act*, and six are listed under the provincial *Endangered Species Act*. While the flora of the limestone barrens is well known, other elements of its biodiversity are relatively poorly understood.

Despite the uniqueness of the limestone barrens ecosystem, a significant component of the northern portion, has been degraded by human use. The substrate and vegetation have undergone large-scale disturbance, due to road and building construction, housing development, quarrying, oil and gas development, and the use of motorized vehicles. Human-degraded habitats contain homogeneous gravel substrates that do not exhibit patterning or sorting, are missing a distinct fine-grained component, and have low plant species diversity, and are often invaded by non-native plants.

There is an urgent need to immediately mitigate of further landscape degradation, preserve remaining the limestone barrens and restore critical ecosystems and habitats, to ensure the recovery of species at risk.

The purpose of this recovery plan is to establish a series of goals, objectives, and actions necessary to ensure the long-term persistence of the species at risk of the limestone barrens as self-sustaining viable species throughout their current and, where possible, historical ranges in Newfoundland and Labrador. To this end, the following five goals have been identified:

Goal 1. Reduce gaps in our understanding of limestone barrens biotic and abiotic (physical) factors that affect species at risk long-term persistence and recovery including future range shifts.

Goal 2. Restore damaged limestone barrens habitats, prioritizing areas designated as critical and/or recovery habitat.

Goal 3. Develop stewardship, education, and outreach strategies to address threats to the limestone barrens and recovery of limestone barrens species at risk.

Goal 4. Implement habitat and species protection mechanisms to ensure conservation of limestone barrens and species at risk.

Goal 5. Investigate funding opportunities to complete listed recovery goals and collaborate with research institutions, community organizations, etc., to promote the conservation of limestone barrens.

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ECOSYSTEM INFORMATION

The limestone barrens of the Island of Newfoundland are a mixture of exposed calcareous bedrock outcrops, thin layers of frost-shattered calcareous fragments or gravel, and shallow calcareous soils with sparse, frost-disturbed vegetation (Environment Canada 2012). In some areas these exposures of largely bare substrate are associated with substantial areas of calcareous heath and/or transition zones to surrounding forest, talus slopes, meadows, or wetlands, which are also considered to be part of the greater limestone barrens ecosystem.

DISTRIBUTION

Global

Globally, limestone is widely distributed; however, the total area of treeless landscapes with exposed limestone in temperate to boreal climates, is very limited. Limestone barrens thus constitute a globally rare habitat.

Figure 1. The Burren of County Clare, Ireland. (Photo: Wikipedia Commons 2011).

Significant areas of limestone barrens also exist in the United Kingdom, Estonia and Sweden, as well as in North America, although only 3% of the original area of this habitat remains intact within the United Kingdom (Anon 2001). The importance of these rare habitats is recognized throughout the United Kingdom, where limestone pavement barrens are legally protected by Limestone Pavement Orders and Areas or Sites of Special Scientific Interest (ASSI/SSSIs) to conserve wildlife and geology (Limestone Pavement Conservation 2013).

A notable area of limestone barrens is “The Burren” in County Claire, Ireland (Figure 1). The Burren region encompasses 363 km^2, of which 318 km^2 is protected within Natural Heritage Areas (NHAs), under the updated *Wildlife Amendment Act* (2000) and 20 Special Areas of Conservation (SACs) under the European Union (EU) Habitats Directive (Burrenbeo 2020). Over 630 species of flowering plants and ferns, representing more than 70% of the native Irish flora, have been recorded as growing within The Burren (https://burrenbeo.com/the-burren/natural-heritage/flora/) (Burrenbeo 2020).

National

Within Canada, the most significant temperate or boreal limestone habitats, other than the “limestone barrens” of Newfoundland and Labrador, are the alvars of Ontario.

Alvars are lakeshore occurrences of flat limestone or dolomite bedrock that are covered in grass or savannah-like vegetation, or are otherwise sparsely vegetated (Alvar Working Group 1999; Reschke et al. 1999). Alvar soils are shallow and prone to seasonal drought and flooding. Canadian alvars also occur in Quebec, Manitoba and the Northwest Territories (Catling et al. 2014, Enns et al. 2020).

Provincial

In Newfoundland, limestone barrens occur along the island’s west coast in two disjunct regions (Figure 2): “the northern region” and “the southern region”.

The northern region is limited to a long, narrow, and fragmented strip of land on the west coast of the Great Northern Peninsula (Hermanutz et al. 2002) (Figure 2). It lies almost completely within the Strait of Belle Isle Barrens Ecoregion with a small outlier in the Northern Peninsula Forest Ecoregion (Coastal Plain Subregion). The northern limestone barrens represent less than 0.1% (~50km^2) of land area of the Island of Newfoundland.

The northern limestone barrens are generally low in elevation, mostly less than 30 m above sea level, and only small summit areas on St. John Island and at Burnt Cape lie above 60 m. At the tip of the Great Northern Peninsula, south of Cape Norman, an area of approximately 36 km^2 is almost entirely comprised of limestone barrens. The barrens in this area are very large and separated by ponds, wetlands, and narrow, more densely vegetated valleys that may form natural barriers to the dispersal of some plant species.

The southern limestone barrens region is even less extensive. Geographically, it includes the western, southern, and central portions of the Port au Port Peninsula, as well as the summit plateau of Table Mountain located just east of the Peninsula (Figure 2). The region lies within the Western Newfoundland Forest Ecoregion (Port au Port Subregion) (Burzynski et al. 2016).

Most of the southern barrens are located on the flanks and summits of broad, rounded hills and are mostly above 150 m in elevation. They are separated by valleys with heath, meadow, or woodland vegetation. Some of these valleys are very steep-sided, nearly impenetrable ravines. Due to their topographic position, the southern barrens are semi-alpine in nature, generally drier than the northern barrens and rarely associated with wetlands.

Additional areas of exposed consolidated or unconsolidated limestone, such as cliffs, scree slopes, small outcrops, river gravels, karsts, and marls exist both on the Island of Newfoundland and in southern Labrador.

These other limestone areas are ecologically different, as they do not experience significant soil disturbance processes. While some of the species at risk covered in this recovery plan do inhabit such sites, at least to a minor extent, they support quite different species assemblages and species at risk.

The geographically restricted, distinctive climatic, geological, and biological characteristics of the Newfoundland limestone barrens make habitat specificity the significant limiting factor in the distribution of associated rare species.

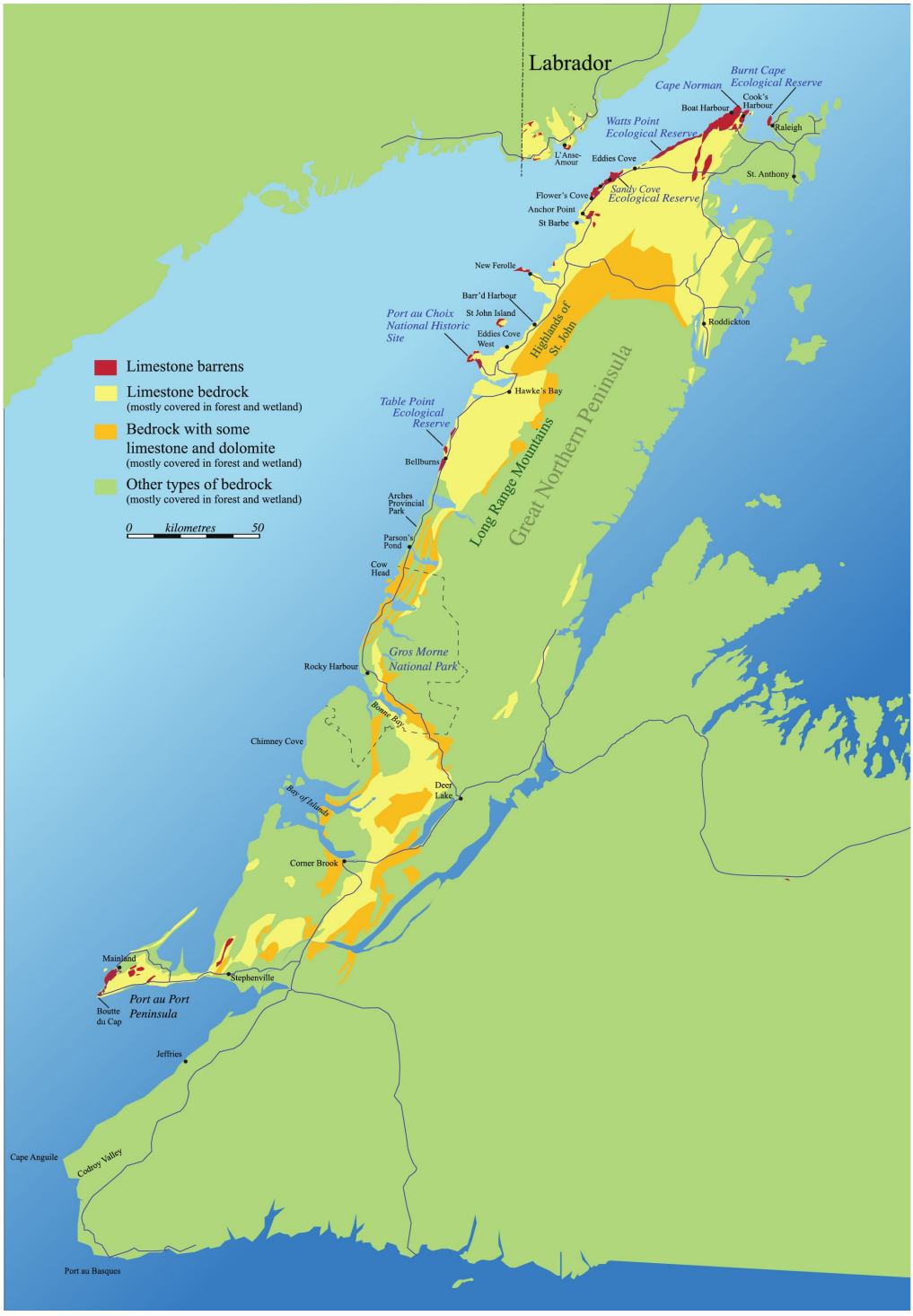

Figure 2. Distribution of limestone and dolomite bedrock (yellow and orange), illustrating the rarity of exposed limestone barrens (red) in Newfoundland and Labrador. (Map: M. Burzynski 2021).

HABITAT

Geology

The limestone barrens of western Newfoundland are treeless outcrops of basic sedimentary rocks. These outcrops are mainly composed of the minerals calcite and aragonite (calcium carbonate) and the mineral dolomite (calcium magnesium carbonate) (Grant 1967; Janes 1999). For simplicity, both of these carbonate rocks will be referred to as “limestone” in this document. Limestone forms through the deposition and lithification of the calcitic remains of marine organisms and through direct precipitation of dissolved calcium carbonate. Dolomite forms when water conditions such as oxygen levels, temperature, and saturation make it possible for dissolved magnesium to replace some of the calcium in limy sediments. The resulting dolomite is slightly more resistant to dissolution by mild acids, such as in rainwater. Western Newfoundland’s barrens range in composition from 100% limestone to 100% dolostone. Many of the carbonate rocks also contain vaying amounts of chert (microcrystalline silica), iron oxide, and aluminium oxide (DeGrace 1974). All of these components affect the weathering of the rock and the formation of soil (M. Burzynski, pers. comm.).

Limestone is soluble in acidic water, such as rain (which is mildly acidified by carbonic acid), as well as more acidic solutions such as river water and soil runoff. The ready solubility of limestone leads to the development of karst topography (caves, sinkholes, and karren), which is common within the limestone barrens (Grant 1987).

The limestone of western Newfoundland was deposited between 520 and 460 million years ago during the Cambrian to Middle Ordovician periods (Plummer et al. 2007) in warm, shallow marine environments along the edge of the ancient Iapetus Ocean. These limestones were not deposited in one continuous sequence, but during several separate events. Due to their different ages, and the physical conditions prevailing during their formation, the various Newfoundland limestone formations contain different assemblages of fossils, including gastropods (Figure 3), trilobites, nautiloids, bryozoans, brachiopods, and algal mounds such as thrombolites. (Limestone Barrens Species at Risk Recovery Team 2008). Large thrombolites occurs in the community of Flowers Cove on the Great Northern Peninsula.

The limestone deposits found in present day Newfoundland were repeatedly modified during periods of tectonic uplift, and most recently by the effects of dramatic crustal depression and rebound as glacial ice masses repeatedly accumulated and melted during the multiple glacial advances of the Quaternary Glacial Period (2.6 million years ago to present).

Figure 3. Fossil of a gastropod on the limestone barrens. (Photo: S. Squires 2005).

Because each ice advance erased all or most of the evidence of the glaciation that preceded it, only

the evidence of the most recent glaciation is preserved in most areas. In Newfoundland, the most recent glacial episode was the Late Wisconsinan, which reached its peak about 18,000 years ago and ended about 10,000 years ago.

During the Late Wisconsinan, the entire area encompassed by the limestone barrens was covered and scoured by coalescing ice sheets – in the north, by a portion of the southeastern edge of the Laurentide ice sheet, which crossed the Strait of Belle Isle, and further to the south, by smaller ice caps spreading atop the Long Range Mountains and the Topsails (Grant 1987; Batterson and Liverman 2000). The glaciers eroded bedrock and deposited glacial sediment (mostly “till” derived from the underlying bedrock).

As the glaciers melted, water that had previously been held in the ice sheets returned to the oceans. Coupled with the depression of the Earth’s elastic crust, originally caused by the weight of the overlying glacial ice, this significant increase in ocean volume led to dramatically higher relative sea levels, still evidenced today by the elevation of the clearly-marked “maximum marine limit” (the maximum elevation at which evidence of postglacial sea level can be detected). Primary evidence of the “maximum marine limit” includes marine sediments (sand, gravel and mud), marine features (raised beaches), and marine fossils (mostly shells) (Liverman 1994).

All of the northern barrens but virtually none of the higher elevation southern barrens presently lie below this “maximum marine limit”, which, is about 150 m above modern sea level at the tip of the Great Northern Peninsula and in southern Labrador, but decreases southward, along the west coast, to about 140 m a.s.l. at Port au Choix, to 60 m a.s.l. at Corner Brook, and to 45 m a.s.l. at Stephenville.

The massive weight of the thick Laurentide Ice Sheet lobe depressed the northern portion of the Great Northern Peninsula far more than relatively thin montane ice sheets flowing off the heights of the Island depressed the rest of Newfoundland. This has meant that the deeply depressed northern tip of the peninsula has taken far longer to rebound than other parts of the Island. Whereas the northern tip of the Great Northern Peninsula is still rising after being depressed into the mantle by the continental ice sheet, everything south of Hawke’s Bay is starting to sink slightly (Batterson and Liverman 2010). Isostatic rebound is similar to a rapidly unloaded boat, the boat will rise, then fall slightly, then rise somewhat less, then fall less, until the water surface is stable. Hawke’s Bay is the “fulcrum” of this see-saw, which is caused by the displacement of semi-liquid magma within the Earth’s mantle. If there were no change in absolute sea level, the post-glacial rising of land caused by isostatic rebound would be perceived by an observer as the falling of sea level in that area, even though sea level world wide had not changed at all. However, absolute sea level is now rising around the world as human-induced climate change warms the planet and melts polar ice. Relative sea level rise is a complex interaction between isostatic rebound and changes in absolute sea level. Depending on the rate of rising of falling the land and the rate of increase in absolute sea level, different places along the shore of western Newfoundland will have different relative sea-level curves. The importance of this is that

anthropogenic changes in absolute sea level will probably have a much greater impact on the sinking shoreline of limestone barrens south of Hawke's Bay than it will on the rising shoreline of northern barrens.

Since deglaciation, the erosion of bedrock surfaces has continued as a result of weathering by water, freeze-thaw, and wind abrasion. The effects of weathering on the various combinations of limestone and dolostone has resulted in the different sediment depths and growing characteristics of today's barrens and in an abundance of patterned ground (Figures 4 and 5).

Figure 4. Jointed blocks on terraced ridges of the limestone barrens at Cape Norman. (Photo: S. Squires 2005).

Climate

The northern limestone barrens are located in the Strait of Belle Isle Barrens Ecoregion, with a small outlier in the Northern Peninsula Forest Ecoregion (Damman 1983). The area falls within the Northern Peninsula climate zone, and is heavily influenced by the cold waters of the Labrador Current (Banfield 1983). The climate is described by Hare (1952) as Arctic-like. The average annual temperature of this ecoregion is 2.5°C (Bell 2002). Summers are cool and short with the average frost-free season lasting about 120 days. Annual precipitation is 760 to 950 mm, with 300 to 400 mm of this falling as snow (Banfield 1983). Extensive sea ice persisting near the coast at least until June can retard the arrival of spring more severely than elsewhere in Newfoundland. While severe snow drifting occurs in the winter, the generally flat landscape does not generally allow the accumulation of deep snow beds capable of supporting a specialized snowbed flora (Damman 1983).

The southern limestone barrens, located in the West Coast climate zone, have a similarly cool climate with a mean annual temperature of 4.4°C. In contrast to the northern limestone barrens, the climatic conditions of the southern limestone barrens seem to be somewhat more influenced by elevation. The Port au Port Peninsula experiences approximately 140 to 150 frost-free days annually; however, the number of frost-free days in areas of higher elevation, where most of the southern limestone barrens are found, probably experience a lower number of frost-free days. Annual precipitation for the area is approximately 750 mm, of which 300 mm falls as snow (Greenlee and Heringa 1984).

Substrate Composition and Processes

On the limestone barrens, frost action, wind, soil erosion, and high levels of precipitation continuously shape the limestone bedrock and the exposed soils derived from it. Limestone is soluble in water, and water drains easily into the natural joints and crevices. As water freezes into ice, it increases in volume, and fractures the limestone. The result is a landscape with a variety of microhabitats; primarily shallow frost-shattered substrate and exposed bedrock outcrops scattered among tundra-like heaths, but also rock cracks (grykes), natural limestone scree, and peaty-sandy accumulations (Banfield 1983; Donato 2005; Boland 2014).

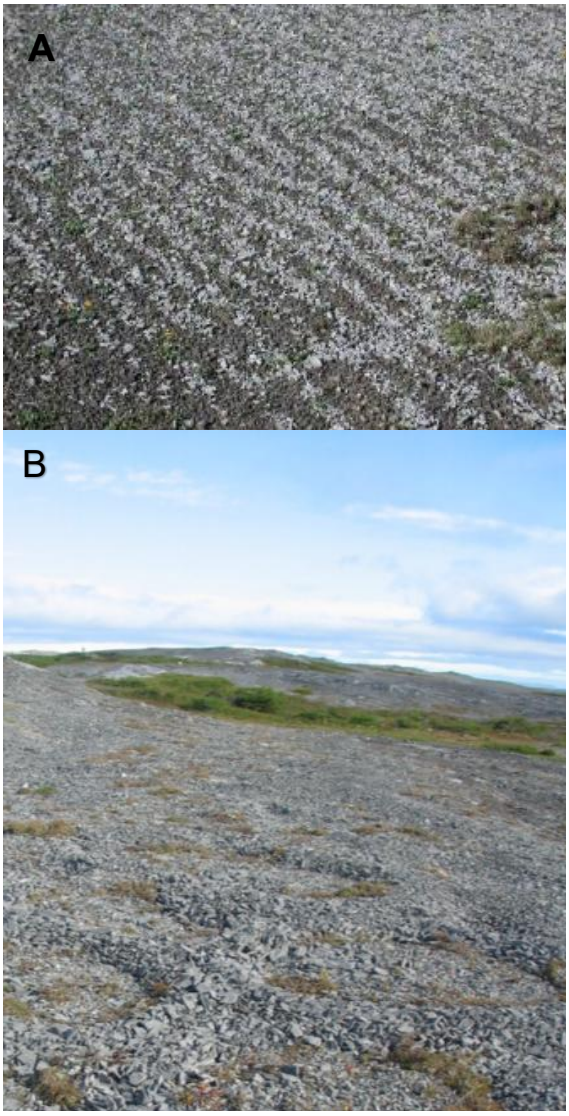

Figure 5. A) Patterned ground: stone stripes at Port au Choix National Historic Site and B) sorted circles at Burnt Cape Ecological Reserve. (Photos: S. Squires 2005).

The substrate suitable for plant colonization is nutrient poor, shallow, and naturally heterogeneous, characterized by angular boulders, cobbles, and pebbles in a fine-grained sediment matrix. At Sandy Cove and Anchor Point, the texture of unsorted substrates was composed of 60-70% silt/clay,15-20% gravel, plus rock fragments (Greene 2002; Environment Canada 2012; Copp 2014).

Frost action on the limestone barrens has led to the formation of patterned ground, such as sorted stripes and sorted circles (Figure 5) in areas where a variety of particle sizes, including a fine fraction, are present. The scale of patterned substrate ranges from 0.25 to 3 m in diameter (Greene 2002). Active frost polygons in soils derived from limestone are found as far south as the Port au Port Peninsula (Wildlife Division, unpublished data).

Frost-sorted microsites account for between 3 and 7% of the barrens area at Sandy Cove Airstrip and Anchor Point (Greene 2002), and less than 10% at the abandoned quarry adjacent to the Sandy Cove Ecological Reserve (Copp 2014). In addition, unsorted microsites comprise an additional 6% at each (Greene 2002). However, on the majority of the northern barrens and the southern barrens the percentage of frost-sorted substrate, unsorted substrate and rock have yet to be evaluated.

Habitat Types

The Newfoundland limestone barrens ecosystem exhibits a continuum of plant cover, ranging from sparsely to completely vegetated.

Open Limestone Barrens

Open limestone barrens are defined by vegetation less than 10 cm in height that cover less than 50% of the substrate and are readily identified in air photos (Noel 2000, Greene 2002). Most of the vegetation cover of open barrens is aggregated into islands made of woody heath species (see below). However, plants intolerant of competition that are adapted to exposure and substrate disturbance caused by frost action, are the most characteristic. Open limestone barrens are the preferred habitat of three of the endangered, endemic species, Fernald's Braya (*Braya fernaldii*), Long's Braya (*Braya longii*), and Barrens Willow (*Salix jejuna*), as well as the Low Northern Rockcress (*Braya humilis*). Due to the presence of the three endemic species and their early recognition as species at risk, this habitat type has been the most thoroughly studied.

Abundant coarse fragments, coupled with intense frost action in substrate with a finer fraction, limit the number of suitable and available microsites for seedling germination and survival for the endemic Braya species (Noel 2000; Greene 2002). In areas with particularly severe frost action, few plants can survive (Figure 6).

Figure 6. Open barrens with extremely active frost sorting on the Port au Port Peninsula. (Photo: C. Hanel 2016).

Where the frost action in the substrate is tolerable, species such as Dwarf Hawksbeard (*Askellia pygmaea*), Glacier Sedge (*Carex glacialis*), and Snowy Cinqufoil (*Potentilla nivea*) grow in the bare substrate. W.J. Meades (1983) classified the vegetation of open limestone barrens on the Great Northern Peninsula into a plant association, which he referred to as "rock garden heath".

Often the majority of the vegetation islands are comprised of mat-forming low shrubs such as Creeping Juniper (*Juniperus horizontalis*) and White Mountain Avens (*Dryas*

*integrifolia s*ubsp. *integrifolia*). The low shrubs are important because they collect snow and dead plant matter, increasing the soil moisture and organic content. However, parts of the shrubs and the thin organic layer in the vegetation islands can be abraded or eroded by wind and precipitation (Figure 7). As a result, the islands are dynamic and can grow, shrink, and shift over time.

Figure 7. Heath erosion in Port au Choix National Historic Site. (Photo: M. Burzynski 2003).

Limestone Heath

Open limestone barrens are often interspersed with or surrounded by a shrub-dominated heath, in particular Crowberry (*Empetrum* spp.) heath (Figure 8). Heath is also often transitional to tuckamore (low stunted conifers more widely known as krummholz) or upper beach vegetation. Several types of Crowberry heath from the Great Northern Peninsula were described by Meades (1983), who noted that the presence of salt-tolerant species decreased, and the thickness of the organic soil increased, with increasing distance from the ocean. He determined that the veneer of organic matter covering the limestone substrate had a very low nutrient retention capacity and was acidic, especially near the surface.

This woody vegetation type supports several species of dwarf Willow (*Salix* spp.), as well as rare herbaceous plants, such as Velvet Bells (*Bartsia alpina*), Pendant Pod Oxytrope (*Oxytropis deflexa*) and Fiery Lousewort (*Pedicularis flammea*). Near the shore Crowberry is more dominant and further inland Willows become more dominant (Meades 1983).

Figure 8. Crowberry/willow heath at Cape Norman. (Photo: A. Voitk 2014).

Of the species at risk covered in this plan, Mackenzie's Sweetvetch (*Hedysarum boreale* var. *mackenziei*), Griscom's Arnica (*Arnica griscomii*), and Wooly Arnica (*Arnica angustifolia* subsp. *tomentosa*) are most closely associated with heath habitats. However, the latter three species also occasionally inhabit bare substrate and vegetation islands in open barrens, and the two Arnica species are sometimes

associated with alpine summits, as well as ledges and talus of low cliffs. Bodin's Milkvetch (*Astragalus bodinii*) grows at the interface between heath and upper beach.

Figure 9. Clint and gryke landscape at White Rocks Trail, Flower's Cove. (Photo: M. Burzynski 2010).

Grykes

A third habitat type can be found within "grykes" (i.e. natural joints in the limestone pavement that have been widened and deepened through dissolution by flowing groundwater. Also spelled "grike") (Figure 9). These are sheltered from wind, they are shady and moist, and they fill with snow in the winter. Typical plants include shrubs (mostly willows, *Salix* spp.) and herbs (e.g. Naked Miterwort (*Mitella nuda*) and Kidneyleaf Violet (*Viola renifolia*)), as well as ferns such as Fragile Fern (*Cystopteris* fragilis) and Green Spleenwort (*Asplenium viride*).

Limestone Barren – Wetland Transition

In some areas of the Great Northern Peninsula, limestone barrens grade into fens or other intermittently or permanently wet areas. Meades (1983) described one variant as a series of peat hummocks inhabited by shrubs and stunted conifers interspersed with pools, which are inundated after rainfall but are dry during most of the growing season. However, the full variety of these interfaces between limestone barrens and wetlands or aquatic habitats has not been well documented. The natural habitat of the Oval-leaved Creeping Spearwort (*Ranunculus flammula* var. *ovalis*) in the Port au Choix area is transitional between limestone barren and wetland and is characterized by areas of open, intermittently wet, sparsely vegetated pockets of silty or gravelly limestone substrate interspersed with raised ridges and hummocks (Figure 10).

Figure 10. Transition area between limestone barren and wetland near Port au Choix, NL. The low-lying areas of relatively bare limestone substrate between the shrub- and sedge-covered hummocks are inundated seasonally and after heavy rains. (Photo: C. Hanel 2015).

Snowbed Meadow

A fifth habitat type, which cannot be considered a "true" limestone barren, is the snowbed meadow, a community dominated by grasses or forbs often surrounded by heath or tuckamore (Figure 11). This is just one of the habitat types bordering limestone barrens and outcrops, occupying depressions and

ravines, which provide shelter and accumulate moisture. These areas collect snow blown from the surrounding open barrens or outcrops, but the snow cover does not persist long enough for snowbed specialist species, such as Herb Willow (*Salix herbacea*), to colonize.

Snowbed meadows are common on the Port au Port Peninsula and are an important habitat for Lindley's Aster (*Symphyotrichum ciliolatum*), which also occurs in heath and sometimes in forested areas.

Figure 11. Snowbed meadow in the central Port au Port Peninsula. These meadows are moister and more sheltered than the surrounding limestone barrens but have a shorter snow-free season. (Photo: C. Hanel 2015).

Threats to Habitat

Habitat Loss and Substrate Degradation

Approximately 30% of the northern limestone barrens has been degraded by human activities (Squires 2010) and a lesser percentage of the southern limestone barrens has also been similarly affected. The substrate and vegetation has undergone large-scale disturbance due to road and building construction, housing development, quarrying, and the use of motorized vehicles (Environment Canada 2012). Human-degraded habitats often contain homogeneous gravel substrates that do not exhibit patterning or sorting, are missing a distinct fine-grained component, and have low plant species diversity (Greene 2002; Rafuse 2005; Robinson 2010) (Figure 12).

In the northern barrens, habitat loss and degradation increased sharply between 1968 and 1990 when limestone was removed from multiple gravel quarries for the construction of Route 430 – the modern highway that bisects some limestone barrens habitats (Janes 1999;

Figure 12. A comparison of A) natural limestone barrens substrate at Sandy Cove Ecological Reserve (Photo: S. Squires 2004), and B) human-degraded limestone barrens at Sandy Cove quarry. (Photo: L. Hermanutz, 2016).

Hermanutz et al. 2002). Bulldozers were frequently used to push surrounding surface gravels towards the surveyed road centre line to create the road surface, damaging many kilometres of habitat on either side of the road corridor (J. Maunder, pers. comm.). In other parts of the limestone barrens, utility operators and municipalities have used limestone gravel to level land, to support utility poles, and/or to build roads.

In the southern barrens major disturbance commenced when a Cold War early-detection radar–surveillance part of the Pinetree Line was constructed by the United States Air Force on top of Table Mountain in 1951. The station was decommissioned in 1971 and in the following decades the buildings were dismantled and hazardous waste, including contaminated soil, was remediated. The site continues to be occupied by communications towers and other infrastructure operated by the Coast Guard, NavCanada and others (Tilley et al. 2005). More recent habitat losses and disturbances on the nearby Port au Port Peninsula have been caused during the course of [1] the construction of a paved road linking the communities of Cape St. George and Mainland, [2] the construction of several smaller gravel roads, [3] the cutting of seismic testing lines, as well as [4] oil drilling and limestone gravel extraction.

Most of the species at risk (Long's Braya, Fernald's Braya, Low Northern Rockcress, Wooly Arnica, Mackenzie's Sweetvetch, Oval-leaved Creeping Spearwort, and Barrens Willow) are capable of recolonizing degraded limestone patches from nearby natural habitat (Squires 2010, Wildlife Division, unpublished data). However, abiotic limitations including substrate moisture, particle composition, and thermal regime, prevent long-term viable establishment of some rare species, such as Braya species (Janes 1999).

A more recent study on the northern barrens has shown that degraded quarry sites were still only partly recolonized 45 years after the last human disturbance (Figure 13). Bare substrate remained dominant, covering 68-90% of the ground, and the main re-colonizers were native species, such as Seaside Plantain (*Plantago maritima*), mosses, and grasses, but the original vegetation at the time of quarrying did not recolonize. Two aggressive non-native species, Coltsfoot (*Tussilago farfara*) and Dandelion (*Taraxacum officinale*) have invaded the Sandy Cove area as a result of the human disturbance (Mason 2014).

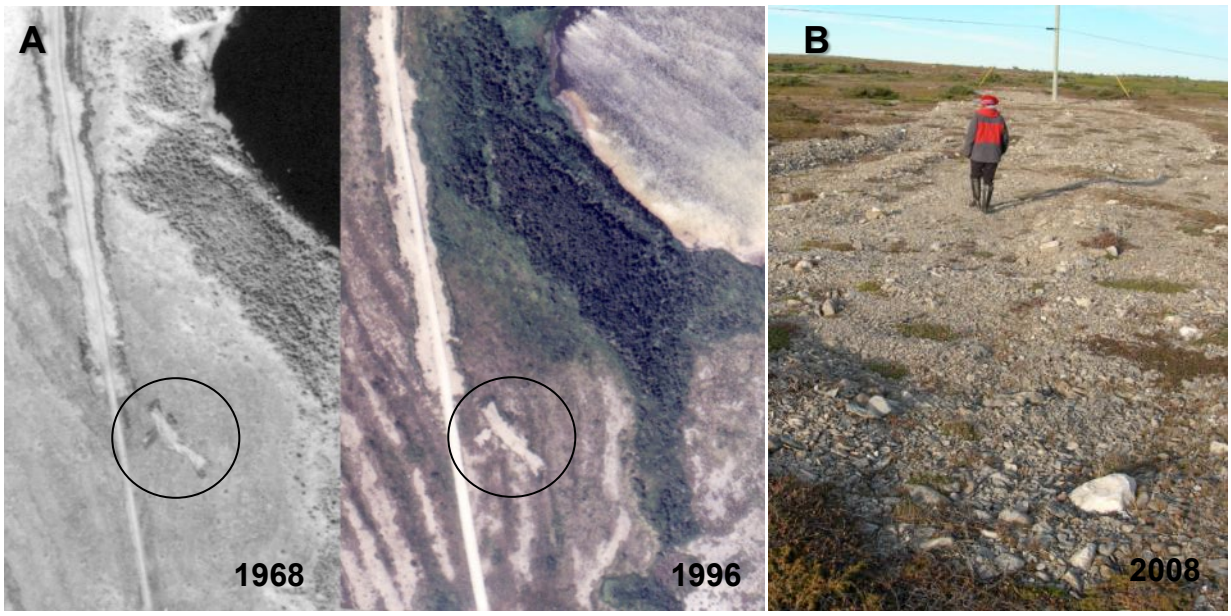

Figure 13. Limited recovery of an area scraped by a bulldozer during road construction at Port au Choix. A) aerial photographs depicting a bulldozer scraped area B) photo of the area outlined in the aerial photographs demonstrating lack of recovery after 40 years. (Photos: M. Burzynski).

Some activities previously considered to be major threats to limestone barrens habitat, such as community expansion, road construction, quarrying, utility maintenance, and other land developments, have largely been mitigated through regulation and stewardship in areas with species at risk. However, the legacy of many of these activities will remain unless these sites are successfully restored to functioning limestone barrens. Illegal or uncontrolled activities affect less land area but still present a source of continued degradation and loss of habitat, even in protected areas (Table 1). The greatest current threat is the off-road vehicles of all types; a problem on both the northern and southern barrens (Table 1; Figure 14).

Figure 14. Although blocked off, this dirt track at Cape St. George through Critical Habitat for Mackenzie's Sweetvetch continues to be used by ATVs. (Photo: A. Voitk 2014).

Table 1. Risk levels of threats (High, Medium, Low, NA) associated with human activities that have degraded limestone barrens, and continue to cause negative impacts, which include: scale of the activity, current regulatory environment, mitigation efforts, and level of risk to species at risk: Fernald's Braya (FB), Long's Braya (LB), Barrens Willow (BW), Mackenzie's Sweetvetch (MS), Bodin's Milkvetch (BM), Low Northern Rockcress (LNR), Oval-leaved Creeping Spearwort (OCS), Lindley's Aster (LA), Griscom's Arnica (GA), and Wooly Arnica (WA).

Land Use Activity	Scale	Regulation	Legal Requirements/Current Mitigation Efforts *	Current Risk (H-high, M-medium or L-low, NA-not applicable)									
				FB	LB	BW	MS	BM	LNR	OCS	LA	GA	WA
Off-road vehicle use	widespread	regulated/ illegally occurring	• Off-road vehicle use is prohibited in all designated protected areas • Stewardship	H	H	H	M	H	L	H	L	L	M
Gravel or limestone extraction	widespread	regulated/ illegally occurring	• Permit required • Prohibited in a designated protected areas • Signage in select areas • Reviewed within Sensitive Wildlife Areas	H	H	M	L	M	L	M	H	L	M
Construction and Maintenance of roads	widespread	regulated	• ESA Permit required in vicinity of plant occurrences • Environmental Assessment • Prohibited in all designated protected areas • Reviewed within Sensitive Wildlife Areas	M	M	H	M	L	M	L	L	L	L
Construction and maintenance of utility corridors	widespread	regulated	• ESA Permit required in vicinity of plant occurrences • Reviewed in Sensitive Wildlife Areas	M	M	H	NA	NA	H	NA	L	NA	NA
Garbage dumping	localized	regulated/ illegally occurring	• Prohibited outside of designated sanitary landfill sites • Stewardship	M	M	M	L	L	L	M	L	L	L
Staging areas to cut and pile wood	widespread	regulated/ illegally occurring	• Permit required • Stewardship	M	M	M	NA	NA	NA	M	L	L	M
Staging areas to dry nets	localized	unregulated	• Stewardship • Selection of suitable alternative sites	L	L	NA	NA	NA	NA	NA	NA	NA	NA

Staging areas to store boats and vehicles, etc.	localized	unregulated	• Signage • Stewardship	M	NA	NA	NA	NA	NA	NA	NA	NA	NA
Construction and maintenance of recreational corridors and infrastructure	localized	regulated	• ESA Permit required in vicinity of plant occurrences • Reviewed within Sensitive Wildlife Areas	L	L	M	L	NA	NA	NA	NA	L	L
Tourism	localized	unregulated	• Stewardship	M	M	M	L	L	L	L	NA	L	L

***** At Port au Choix National Historic Site of Canada and Gros Morne National Park of Canada all of these activities are prohibited or regulated to prevent impacts on species at risk under various federal acts including the Canada *National Parks Act*, the *Species at Risk Act*, and/or the *Impact Assessment Act*. In Sandy Cove, Watts Point and Burnt Cape Ecological Reserves all of these activities are prohibited or regulated under the provincial *Wilderness and Ecological Reserves Act*.

Climate Change and Habitat

The functioning of the limestone barrens and their rare plants are influenced by climate; specifically by air and soil temperature and by the amount and pattern of precipitation. The restricted and fragmented distribution of appropriate limestone barrens substrate on the landscape, and limited seed dispersal capabilities of some species at risk limit the ability of species to move with changing climate (Tilley 2003). Climate change, in combination with existing habitat fragmentation, is expected to decrease ecosystem resilience to perturbations, such as pests and severe weather events (Jump and Penuelas 2005).

As the ecology of the limestone barrens depends upon an Arctic-like climate, warming trends are likely to be potentially detrimental. Climate warming may increase the size and abundance of woody vegetation, expansion of invasive species, disturb the moisture balance and cold soil processes, and affect the growth of the species at risk themselves, as well as their pollinators, pests, and pathogens. For example, species at risk may be increasingly threatened by insect pests whose generation time decreases with increases in temperature (Talekar and Shelton 1993; Squires et al. 2009).

The mean annual air temperature in the area of the northern limestone barrens is predicted to increase by approximately 4°C over the next century (Slater 2005). By 2070, daily maximum air temperatures for Newfoundland limestone barrens are predicted to rise by 2.3-3.0°C in summer and 3.5-4.5°C in winter, with the larger increases expected in the area of the northern limestone barrens. Mean daily air temperature and daily minimum temperature are predicted to follow similar patterns (Finnis 2018). The number of growing degree days is similarly predicted to increase (Slater 2005). Recent modeling by Finnis (2018) resulted in predictions of increases of 250 growing degree days near the tip of the Great Northern Peninsula and increases of nearly 400 growing degree days on the Port au Port Peninsula within the next 50 years. The number of frost-free days is expected to increase by 45-60 days in areas with limestone barrens. These increases in heat may increase height of shrubs that will negatively affect rare plants as many, such as the three endemic plants, are shade intolerant.

Provincial climatic projection studies completed in 2018 provide additional support for changes in climatic factors over the course of the 21st century. For example, the daily mean temperature in St. Anthony during the months of June, July, and August is expected to rise from 13.0°C in the 20th century to 15.7°C by 2041-2070, and to 17.7°C by 2071-2100. During the same months, the daily mean precipitation is expected to rise from 2.5 mm in the 20th century to 3.5 mm by 2041-2070, and to 3.6 mm by 2071-2100 (Environment, Climate Change and Municipalities 2018; Finnis 2018).These projections indicate that the climate of the Limestone Barrens will drastically change.

Warming winter temperatures are predicted to increase spring and fall freeze-thaw frequency and reduce secondary heave duration, which is required for frost sorting and

can eject plants from the substrate (Perfect et al. 1988; Henry 2008; Jefferies et al. 2009; Copp 2014). It is unknown how this change will affect periglacial landscape features, although it is predicted to hinder frost sorting (Hjort and Luoto 2009). It is possible that frost patterned areas will fossilize as in the Mingan Archipelago National Park, where relict polygons remain but freeze-thaw cycles are no longer sufficient to churn the soil (M. Burzynski, pers. comm.).

In combination with increased air temperatures, this change in frequency and duration of frost heave may negatively affect recruitment and persistence of primary colonizers and disturbance-adapted species of the open barrens, especially endemics such as Long's and Fernald's Braya. Less soil movement may result in increasing competition favouring the development of later successional stages and species such as Crowberry, White Mountain Avens, and Willows, and allow formerly open barrens habitat to develop towards Crowberry heath (Perfect et al., 1988).

Precipitation changes are more uncertain than temperature increases, but increases in precipitation of approximately 5% are expected throughout the year. For areas from Plum Point northward, precipitation increases of approximately 25% in the summer months are predicted to occur. Precipitation events are expected to become more intense throughout the year, but mostly during fall and winter months near the tip of the Great Northern Peninsula (Finnis 2018). For example, projections suggest that extreme precipitation events will become more intense in St. Anthony. On a 24-hour basis, a 1-in-100 year storm is expected to bring 97 mm of precipitation by mid-century, an increase from the current climate's 78 mm (23% growth). Increased snow may also promote shrub growth and encroachment. No predictions were made about wind speeds, which affect snow distribution, and the effect that precipitation changes will have on the limestone barrens is largely unknown.

Sea level rise is probable around the coast of Newfoundland in the future. On the northern portion of the Great Northern Peninsula, projected sea level rise due to climate change is partly mitigated by continued rising of the landmass due to isostatic rebound, resulting in predict rises of 30 cm by 2049 and 80 cm by 2099 (Batterson and Liverman 2010). This predicted sea level rise is less than for the remainder of the island of Newfoundland, but several populations of species at risk in low-lying coastal sites, such as Bodin's Milkvetch at Cooks Point, and Long's Braya at Sandy Cove, could potentially be impacted.

BIODIVERSITY

Plants

The limestone barrens of insular Newfoundland are one of Canada's key areas for endemic vascular plants (Enns et al. 2020). The vascular flora of the limestone barrens contains many species typically found in arctic or alpine tundra, as well as a number of

boreal species. On the island of Newfoundland, both the southern and northern limestone barrens are hotspots for vascular plant biodiversity. Of the nearly 300 species considered to be rare on the island, about 15% are predominantly found in limestone barrens. However, they may occasionally grow in other open calcareous habitats, such as rocky summits, cliff ledges, talus slopes, and coastal heath (Wildlife Division, unpublished data, CESCC 2016). These plants are arctic-alpine or boreal species that are adapted to high calcium and magnesium levels and low soil fertility. At least five moss species of arctic-alpine affinity found in Newfoundland limestone barrens are rare (R. Belland, pers. comm., CESCC 2016).

Three of the plant species at risk – Long's Braya, Fernald's Braya, and Barrens Willow – are endemic to the Island of Newfoundland, meaning they are found nowhere else in the world. Griscom's Arnica is only slightly more widespread, with the entire world population being located around the Gulf of St. Lawrence, on the island of Newfoundland and in Québec. Endemism is extremely rare in boreal biomes, making these species especially unusual.

Vertebrates and Invertebrates

The limestone barrens are also an important habitat for a number of avian and mammal species, including several species at risk. Species listed under both the provincial *Endangered Species Act* and the federal *Species at Risk Act* have been observed using the barrens. Short-eared Owl (*Asio flammeus*) forages for small mammals on the open barrens and have been observed hunting on the limestone barrens of the Northern Peninsula (Schmelzer 2005; S. Garland, pers. comm.). Other species at risk, including Newfoundland Gray-cheeked Thrush (*Catharus minimus minimus*) and Peregrine Falcon (*Falco peregrinus*) have been observed using the barrens at Burnt Cape Ecological Reserve near Raleigh and at Port au Choix (Mactavish 2001).

Rare plant species, such as those occurring on the limestone barrens, are often associated with equally rare and unique moth species that are closely tied to their food source. Moth and butterfly (Lepidoptera) collections have been made in the Burnt Cape and Watts Point areas, and preliminary data suggest that newly recorded species for the province occur at these sites (G. Pohl, Canadian Forest Service, pers. comm.).

Land and freshwater molluscs are being studied in the limestone barrens region, as part of a wider provincial study, by John Maunder and Ronald G. Noseworthy. Among their many discoveries is the only known Newfoundland occurrence of the tall "column snail" (*Columella columella* sensu lato – taxonomy still under revision), from the limestone barrens near the lighthouse at Cape Norman (J. Maunder, pers. comm.).

Fungi, Lichens, and Soil Organisms

Figure 15. *Helvella corium*, a mushroom found on limestone barrens in the Burnt Cape Ecological Reserve (Photo: A. Voitk 2010).

Systematic examination of macrofungi has occurred only in the Burnt Cape Ecological Reserve, which has been visited twice by groups of mycologists. Over a dozen of the mushroom species found there had never before been found elsewhere in the province (Foray NL 2010, 2012). The lichens of open limestone barrens, heath and other habitats have also been studied at Cape Norman and within the Burnt Cape and Watts Point Ecological Reserves. Compared with coastal sites without limestone between Raleigh and St. Anthony, most of the limestone sites had a higher number of species. The southern part of Burnt Cape had the largest number of unique species not found at any of the other sites (James Lendemer, pers. comm.). However, no final analysis of the significance of the lichen flora of the limestone barrens is currently available because status ranking has been hampered by a lack of data (Canadian Endangered Species Conservation Council 2016). Soil organisms were also the focus of two separate pilot studies but no results are available to date (Dirk Krueger, pers. comm., Steve Harris, pers. comm.).

ECOLOGY

Plant Adaptations

While some plant species growing in limestone barrens are ‘soil indifferent’, others have various degrees of affinity for calcium, such as the ‘calcicoles’ (plants that generally grow on basic substrates rich in calcium carbonate), and ‘calciphiles’ (plants that require soil with a high pH). These plants have developed mechanisms that allow them to flourish in such basic habitats lacking soluble iron and phosphorus essential for growth (Figure 16). Seedlings of vascular plant species of limestone soils exude higher concentrations of complex organic acids that make phosphorus and iron, both in limited supply in limestone soils, more soluble (Tyler and Ström. 1995).

The plants of the limestone barrens are variously able to tolerate high winds, a cool, short growing season, and frost-heaving. Adaptations include cushion-like growth forms, woolly coverings of stems, buds, and leaves, cup-shaped flowers that rotate to face the sun, and dark coloured leaves that absorb more heat. Plants with these adaptations are often slow-growing, long-lived, and intolerant of shade and competition.

Figure 16. A) White Mountain Saxifrage (*Saxifraga paniculata* subsp. *laestadii*), a plant that excretes excess calcium through specialized pores in the leaf-tips (Photo: J. Maunder 2002), and B) Common Butterwort (*Pinguicula vulgaris*), a plant that absorbs nutrients from invertebrates that are digested in its modified leaves (Photo: J. Maunder 2001).

Many species, such as the Net-veined Willow (*Salix reticulata* subsp. *reticulata*), Barrens Willow, and Mackenzie's Sweetvetch, survive the harsh conditions by growing very slowly and/or spreading horizontally along the ground (Figure 17). Based on experimental seeding trials in natural habitats, both Braya species appear to be long lived (over 20 years; Squires and Hermanutz, unpublished data).

Long's Braya, Fernald's Braya, and Low Northern Rockcress each have contractile taproots for secure anchorage in frost-heaved substrates. Contractile taproots are able to pull the heaved plants back into the soil, making them well adapted to small-scale natural soil disturbances caused by frost, wind and water erosion.

Figure 17. A Common Juniper (*Juniperus communis*) destroyed by an off-road vehicle and later found to be 253 years old by counting tree rings (Photo: M. Burzynski 2006).

To maximize reproductive output in a short growing season, the flowering time of both Long's and Fernald's Braya is strongly linked to the date of snowmelt (Donato 2005). Physical characteristics of Long's Braya were found to be correlated with temperature; increasing temperatures were correlated with smaller basal diameter, longer leaves and flowering stalks, and more fruit per stalk (Belbin 2013).

SPECIES AT RISK INFORMATION

LEGAL STATUS, EXISTING PROTECTION, AND IDENTIFICATION OF CRITICAL HABITAT

To date, 10 limestone barrens plants have been listed under the provincial *Endangered Species Act*. The first four species listed are also listed under Schedule 1 of the federal *Species at Risk Act.* See individual species summaries (Appendix B) for specific details on each species and their listing:

Table 2. Legal status of plant species included in the NL Recovery Plan for Limestone Barrens Species at Risk, under the provincial *Endangered Species Act* and federal *Species at Risk Act*.

Species	Legal Status	
	Endangered Species Act (Provincial)	***Species at Risk Act*** (Federal)
Barrens Willow (*Salix jejuna*)	Endangered	Endangered
Fernald's Braya (*Braya fernaldii*)	Endangered	Endangered
Long's Braya (*Braya longii*)	Endangered	Endangered
Griscom's Arnica (*Arnica griscomii* subsp. *griscomii*)	Endangered	Threatened
Low Northern Rockcress (*Braya humilis*)	Endangered	Not listed
Mackenzie's Sweetvetch (*Hedysarum boreale* subsp. *mackenzii*)	Endangered	Not listed
Bodin's Milkvetch (*Astragalus bodinii*)	Threatened	Not listed
Oval-leaved Creeping Spearwort (*Ranunculus flammula* var. *ovalis*)	Endangered	Not listed
Wooly Arnica (*Arnica angustifolia* subsp. *tomentosa*)	Endangered	Not listed
Lindley's Aster (*Symphyotrichum ciliolatum*)	Endangered	Not listed

Plants of the limestone barrens remain a high priority for species assessment agencies, including the Species Status Advisory Committee (SSAC) and the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), due to their rarity and the restricted area of the limestone barrens.

Existing Protection

The individuals of the 10 species at risk covered in this plan, and much of their known habitat, as well as many unsearched patches of the limestone barrens ecosystem, are conserved or protected through a variety of legal and management tools. These include various provincial acts (i.e. *Endangered Species Act, Wilderness and Ecological Reserves Act, Environmental Protection Act*, *Crown Lands Act*, *Quarry Materials Act*), various federal acts and regulations (i.e. *Species at Risk Act, Canada National Parks Act*, *National Historic Parks General Regulations*, *Impact Assessment Act*) as well as a variety of stewardship agreements and land management techniques (i.e. the identification of Sensitive Wildlife Areas in the NL Land Use Atlas) that do not have legal ramifications.

Protection of Individuals

According to the provincial *Endangered Species Act*, Section 16(1), a person shall not disturb, harass, injure, or kill an individual of a species designated as threatened, endangered, or extirpated on provincial and private lands.

Similarly, under the federal *Species at Risk Act*, Section 32(1), no person shall kill, harm, harass, capture, or take an individual of a wildlife species that is listed as extirpated, endangered, or threatened on federal lands.

Disturbance or destruction of the species at risk or their Critical Habitat is prohibited within protected areas through regulations prohibiting damaging activities, such as the use of motorized vehicles or equipment, removal or disturbance of substrate, organisms, or any other natural object, development of infrastructure, disposal of garbage, etc.

Protected Areas and Existing Critical Habitat

In the northern limestone barrens, varying proportions of the population and habitat of all species at risk, with the exception of Bodin's Milkvetch, are captured within provincial or federal protected areas. None of the three species at risk in the southern barrens – Mackenzie's Sweetvetch, Low Northern Rockcress, and Lindley's Aster – are currently found within an existing protected area, as to date no such areas have been designated.

Provincial Lands

To protect two populations of Long's Braya, one of the most restricted and at-risk species within this plan, a provisional Ecological Reserve was established at Sandy Cove under the provincial *Wilderness and Ecological Reserves Act* in 2007 and was given full Ecological Reserve status in 2013 (Government of NL 2013). This protected area complements the Burnt Cape Ecological Reserve (Government of NL 2000) and the Watt's Point Ecological Reserve (Government of NL 1990) to the north, which protect Fernald's Braya. Barrens Willow is currently protected within the Watts Point Ecological Reserve.

Provincial Critical Habitat Orders

While provincial Critical Habitat has been identified for most of the species at risk (Appendix B), legal Critical Habitat orders as outlined in section 28 of the *Endangered Species Act* have not yet been established to protect habitat on provincial Crown Land for any of the limestone barrens plant species at risk.

Federal Lands

The Parks Canada Agency protects Fernald's Braya and Griscom's Arnica, as well as the provincially listed Wooly Arnica and Oval-leaved Creeping Spearwort at Port au Choix National Historic Site of Canada. Occurrences of Griscom's Arnica and Wooly Arnica are also protected in Gros Morne National Park of Canada (Parks Canada, 2007). All of these species at the two sites are managed under various federal acts and regulations, listed above.

The Department of Fisheries and Oceans (DFO) owns and manages the property where Fernald's Braya and Barrens Willow occur, listed both federally and provincially. DFO properties include the Cape Norman lighthouse near Cook's Harbour, Big Brook Wharf in Big Brook, and two properties near Port au Choix: the Port au Choix Range Rear and a portion of the Point Riche Road.

Public Works and Government Services Canada (PWGSC) owns and manages the majority of the provincially-listed Low Northern Rockcress habitat on Table Mountain. PWGSC has been notified that the Low Northern Rockcress occurs on its property and the agency is enabled by SARA legislation to take measures to ensure that on-site work does not jeopardize the species.

Federal Critical Habitat Orders

Critical Habitat is defined under the federal *Species at Risk Act* (SARA) as the habitat that is necessary for the survival or recovery of a listed wildlife species, and that is identified as the species' Critical Habitat in the recovery strategy or action plan for the species. This differs from the provincial *Endangered Species Act*, where Critical Habitat and recovery habitat are defined as separate entities.

Federal Critical Habitat for Fernald's Braya is identified in the SARA Action Plan for the Long's Braya (*Braya longii*) and the Fernald's Braya (*Braya fernaldii*) in Canada (ECCC 2018). This Critical Habitat is protected on federal land by the Critical Habitat of the Fernald's Braya (*Braya fernaldii*) Order put in place in 2021(https://species-registry.canada.ca/index-en.html#/documents/112) (Figures 18 & 19).

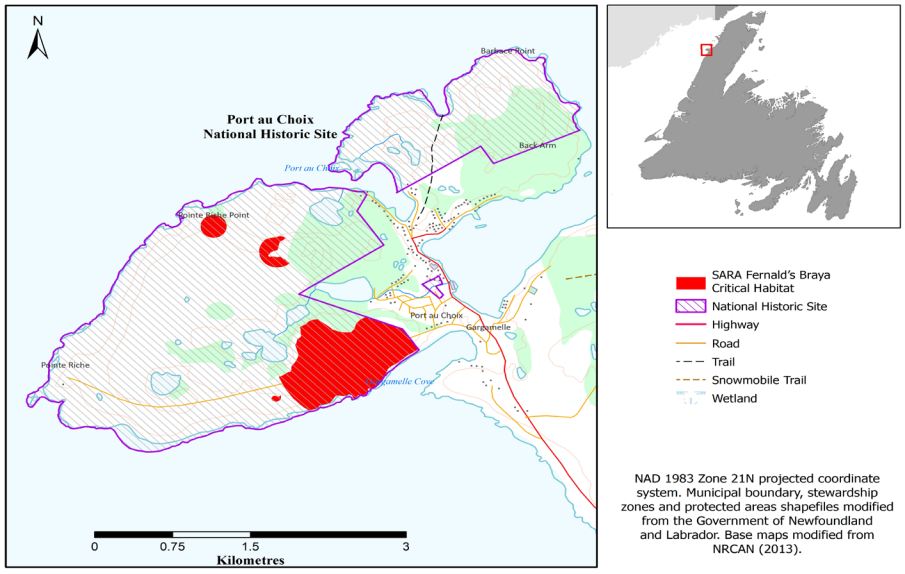

Figure 18. Critical Habitat for Fernald's Braya on federal land, protected by a *SARA* Critical Habitat Order.

Critical Habitat for Barrens Willow is identified in the SARA Action Plan for the Barrens Willow (*Salix jejuna*) in Canada (ECCC 2018), and is protected on federal land by the Critical Habitat of the Barrens Willow (*Salix jejuna*) Order put in place in 2019 (https://species-registry.canada.ca/index-en.html#/documents/1827) (Figure 19).

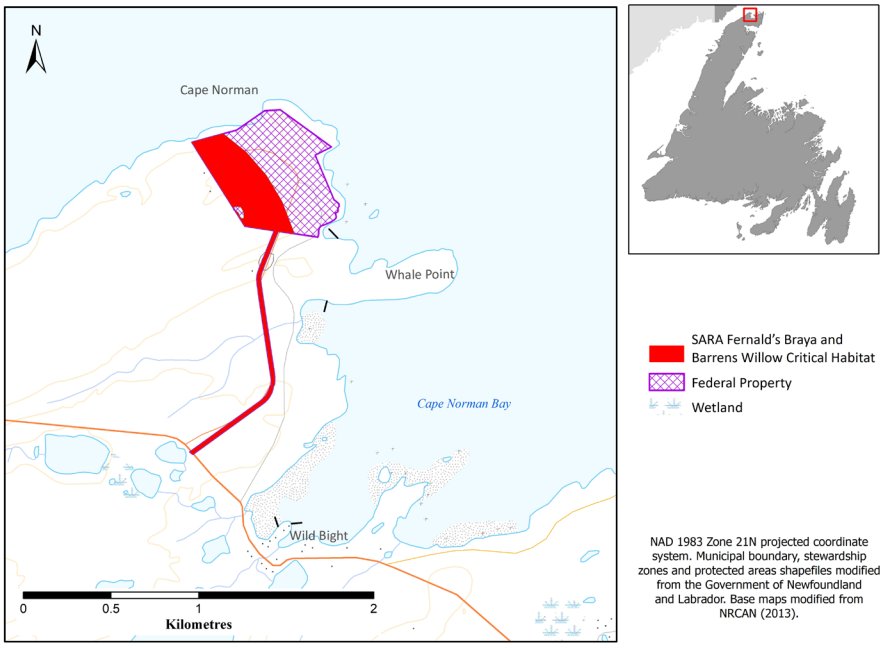

Figure 19. Critical Habitat for Fernald's Braya and Barrens Willow on federal land, protected by a *SARA* Critical Habitat Order.

Stewardship Agreements

Stewardship agreements have been established to help conserve limestone barrens habitat and species through the Limestone Barrens Recovery Program (LBRP) and the provincial government's stewardship program; however they do not offer legal protection. In 2002, stewardship agreements were signed with the Municipality of Flower's Cove, Straits Elementary School in Flower's Cove, and the landowners of the Sandy Cove Airstrip to conserve valuable limestone barrens habitats within the town's municipal boundaries. In 2009, a stewardship agreement was also signed with the Town of Port au Choix (Figure 20) and St. Theresa's Elementary School in Port au Choix. Since then, both elementary schools have amalgamated with other schools (now, Canon Richards Memorial Academy and French Shore Academy) (Town of Port au Choix, 2010). Although the stewardship agreements were not transferred to the amalgamated schools at the time, the LBRP is currently pursuing the matter.

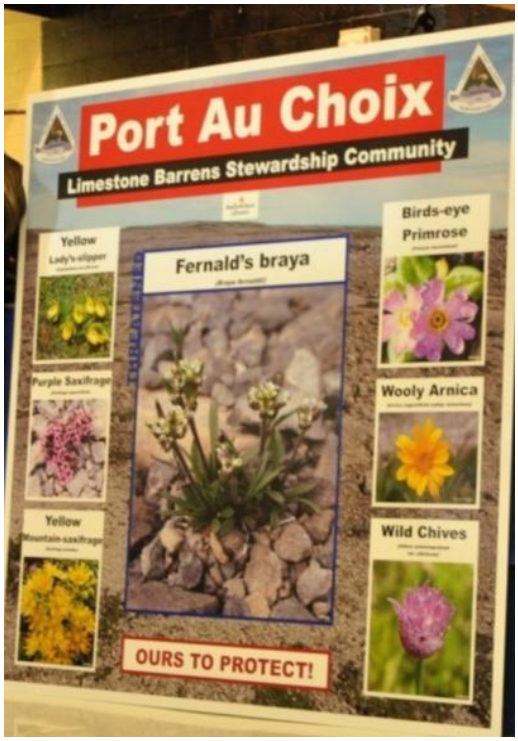

Figure 20. Roadside sign presented to the Town of Port au Choix at the 2009 signing of a Stewardship Agreement. (Photo: D. House 2009).

Land Management

Polygons containing provincial Critical Habitat, suitable habitat and potential habitat, previously identified for all 10 limestone barrens plant species at risk, have been designated as Sensitive Wildlife Areas on the Provincial Land Use Atlas (Appendix B). Although not associated with legal protection, this designation triggers a thorough review of the land use proposal (e.g. developments, roads, quarries, etc.) by NL Department of Fisheries, Forestry and Agriculture ecologists during the provincial environmental assessment and land use referral process. The review may place conditions on land use activities, such as surveys and/or mitigations to halt or reduce negative effects on species at risk or their habitat.

All areas of suitable limestone habitat identified by Greene (2002; see section below) for Long's Braya, Fernald's Braya, and Barrens Willow in the area between Port au Choix and the tip of the Northern Peninsula were designated as Sensitive Wildlife Areas on the provincial Land Use Atlas, regardless of whether any species listed under the *Endangered Species Act* were present or absent. It was anticipated that some of the unsurveyed areas would harbour listed species, therefore these areas of unsurveyed potential habitat were also designated as Sensitive Wildlife Areas. These Sensitive Wildlife Areas remain unchanged through the 2019 Critical Habitat identification update and are included on the new provincial Critical Habitat maps (Appendix B). These Sensitive Wildlife Areas are intended to be updated in the future.

Critical Habitat for Species at Risk on the Northern Limestone Barrens

Under the Newfoundland and Labrador *Endangered Species Act*, section 28, an area of land may be protected by order as critical or recovery habitat of a designated species (extirpated, endangered, threatened, or vulnerable). The *Endangered Species Act* defines Critical Habitat as habitat critical to the survival of a species and recovery habitat as that which is necessary for the recovery of a species. Given the very restricted distribution of each of the limestone barrens plant species at risk, all areas of occurrence are considered to be habitat critical to the survival of the species, but has not yet been designated.

There is currently no provincial recovery habitat identified for species on the limestone barrens under the *Endangered Species Act.* However, any recovery habitat identified in the future will be in addition to Critical Habitat identified in this recovery plan. Critical Habitat on provincial and private land for seven of the 10 plant species in this recovery plan has been developed using the legal definition in the *Endangered Species Act*. The seven species include: Long's Braya, Fernald's Braya, Barrens Willow, Griscom's Arnica, Wooly Arnica, Bodin's Milkvetch, and Oval-leaved Creeping Spearwort. Any Critical Habitat on federal land, developed under the federal *Species at Risk Act,* is previously described in the Existing Protection section of this plan.

A first effort to identify critical and recovery habitat for Long's Braya, Fernald's Braya, and Barrens Willow was made by the Limestone Barrens Species at Risk Recovery Team between 2000 and 2002. Areas containing potential (limestone) substrate were identified from aerial photographs, assessed in the field as suitable or unsuitable, and surveyed for each species (Greene 2002). The occupied habitat areas were identified as Critical Habitat. In 2002 digitizing the outline of each area of potential habitat was not feasible. For mapping purposes, the centroid of each habitat patch was found to create a circle with a radius that encompassed the entire habitat patch. However, the outer circumference of the circles did not conform to any of the ecological boundaries of the habitat.

As the circle-derived areas on the maps represented only a very rough approximation of the actual Critical Habitat, a more accurate approach based on the classification of satellite imagery was developed in 2019. This replaces the Critical Habitat for Fernald's Braya, Long's Braya and Barrens Willow that was based on the work in 2002 and extends it to the Fernald's Braya reintroduction site at Brig Bay, and the more recently discovered Fernald's Braya population north of Bellburns. It also forms the basis of Critical Habitat for Griscom's Arnica and Wooly Arnica. Refer to Appendix B for maps depicting 2019 Critical Habitat for each species at risk on provincial and private land.

Sentinel satellite imagery has been classified into areas of either limestone barren or not limestone barren. The limestone barren areas were buffered by 20 m due to the use by some limestone barrens species of the heath habitat surrounding open barrens, and to the edge effect of the relatively large pixels. Refer to Table 3 and 4 for habitat types that were included in, or excluded from, Critical Habitat delineation. Removal of anthropogenic and misidentified features was done manually as this could not be automated. All patches with species at risk plants present were considered Critical Habitat. In some cases, minor boundary modifications were necessary to include all accurate occurrence points. For those species where all occurrences were not adequately captured, or where the buffered polygons produced during the 2019 classification were not accurate due to cloud cover, etc., Critical Habitat was modified manually using detailed remote-sensed imagery to include all known occurrences within boundaries of the Critical Habitat.

Table 3. Types of habitat that are specifically included in, or excluded from, the Critical Habitat polygons for five species at risk derived from classified Sentinel satellite imagery of the northern barrens. Any other habitats not specifically mentioned are included. Vegetation heights refer to the average height of the vegetative plant parts, which is often exceeded by flowering stalks and sometimes scattered taller plants.

Species	Included in Critical Habitat	Excluded from Critical Habitat *
<u>Open barrens species:</u> Barrens Willow Fernald's Braya	• open gravel barrens dominated by limestone and/or dolomite, may be sorted, unsorted, or homogenized (anthropogenically disturbed) with a varying silt fraction, dry to intermittently wet	• low heath more than 5 m from any open barren • heath taller than 5 cm

	• frost polygons or other frost patterned ground, especially intermediate zones • low heath (dwarf-shrub dominated vegetation patches or mats) less than 5 cm tall within 5 m of open barrens • limestone/dolomite outcrops or pavement with small silt/gravel pockets or cracks filled with silt/gravel • roadsides, road shoulders and former roadbeds • disturbed areas on limestone/dolostone with at least small patches of bare silt/gravel, such as gravel mounds, areas around utility poles, etc. • walking trails	
<u>Open barrens+heath edge species:</u> Long's Braya Wooly Arnica	As above, but also including slightly taller heath with an average vegetation height to 10 cm, within 30 m of open gravel barrens.	• heath more than 30 m from any open barren
<u>Open barrens+heath edge+cliff species:</u> Griscom's Arnica	• open gravel barrens (as above) • disturbed areas on limestone/dolostone (as above) • low heath less than 10 cm tall • limestone/dolomite cliffs and outcrops and associated ledges and talus	• intermittently wet areas

* The following are excluded from Critical Habitat for five species: waterbodies and marl areas of along their shores; streams; wetlands without exposed limestone/dolomite silt/gravel, such as peatlands; areas of limestone pavement without at least small accumulations of silt/gravel; meadows or other continuous herbaceous vegetation; heath taller than 10 cm; tuckamore/krummholz; forested areas; beaches and other coastal areas with strong salt influence or dominated by halophytic vegetation.

Table 4. Types of habitat included and excluded for two species at risk on the northern barrens whose Critical Habitat polygons were not derived from satellite image classification, but centred on known occurrences.

Species	Included in Critical Habitat	Excluded from Critical Habitat
<u>Intermittently wet barren species:</u> Oval-leaved Creeping Spearwort	• small or large intermittently wet limestone/dolomite barrens with some silty, gravely or muddy substrate • can be disturbed or natural	• dry limestone/dolomite barren, including rock barren • wetlands without exposed limestone/dolomite silt/gravel, such as peatlands

	• can be interspersed with, or surrounded by, peat hummocks	
Coastal heath barren species: Bodin's Milkvetch	• low heath up to 5 cm tall • upper beach near transition to heath • disturbed areas, such as ATV trails, with vegetation mostly lower than 5 cm	• shoreline vegetation dominated by halophytes • shoreline rocks • intertidal area • vegetation taller than 5 cm

A summary of the 2019 provincial Critical Habitat identification process follows. For a detailed version of this process, refer to the technical NL Limestone Barrens Critical Habitat Identification document (Wildlife Division, in prep.).

This new analysis is not applied on federal land due to differences in the provincial and federal definitions of Critical Habitat as well as difference in the processes and mechanisms of protection. As such, federal Critical Habitat for Long's and Fernald's Braya can be found in the SARA Action Plan for the Long's Braya (*Braya longii*) and the Fernald's Braya (*Braya fernaldii*) in Canada (ECCC 2018). Federal Critical Habitat for Barrens Willow can be found in the SARA Action Plan for the Barrens Willow (*Salix jejuna*) in Canada (ECCC 2018).

Critical Habitat for Species at Risk on the Southern Limestone Barrens

The provincially listed species on the Port au Port Peninsula and on Table Mountain (Lindley's Aster, Mackenzie's Sweetvetch, and Low Northern Rockcress) were not included in the previous identification of Critical Habitat. Maps showing buffered occurrences of these species are found in Appendix B.

Similar methods for classifying suitable habitat from satellite imagery will be employed for Low Northern Rockcress and Mackenzie's Sweetvetch. Lindley's Aster is only marginally a limestone barrens species. While it is sometimes found in heath islands and strips associated with open gravel and rock barrens it can sometimes be found >1 km from these. It is also found in moist meadows, openings in wooded areas and shorelines.

RECOVERY GOALS, OBJECTIVES, AND ACTIONS

The purpose of this recovery plan is to establish a series of goals, objectives, and actions necessary to ensure the long-term persistence of ten vascular plant species at risk inhabiting limestone barrens throughout their current and, where possible, historical ranges in Newfoundland and Labrador. Ranges of these species may shift in response to predicted environmental changes: however, no modelling has been done to explore future distributions. To this end, the following five broad goals have been identified along with the objectives and actions listed (in Table 5) and detailed below:

> Goal 1. Reduce gaps in our understanding of limestone barrens biotic and abiotic (physical) factors that affect species at risk long-term persistence and recovery including future range shifts.
>
> Goal 2. Restore damaged limestone barrens habitats, prioritizing areas designated as critical and/or recovery habitat.
>
> Goal 3. Develop stewardship, education, and outreach strategies to address threats to the limestone barrens and recovery of limestone barrens species at risk.
>
> Goal 4. Implement habitat and species protection mechanisms to ensure conservation of limestone barrens and species at risk.
>
> Goal 5. Investigate funding opportunities to complete listed recovery goals and collaborate with provincial and federal government agencies, research institutions, community organizations, etc., to promote the conservation of limestone barrens.

Reduction of information gaps

Reducing the gaps in our knowledge of biotic and abiotic factors affecting long-term persistence of the limestone barrens plants has already played a key role in the recovery of these species. Research conducted on three endemic plant species at risk of the northern limestone barrens in the last two decades has vastly improved the identification of Critical Habitat and threats, as well as habitat restoration and ex-situ techniques for these species. While a portion of this work has also benefitted the seven more recently listed plant species, many questions about all 10 species remain. Ongoing research on the genetic delineation of the Braya species will enable management to determine how to best manage the species and restoration efforts. Further genetic analyses of clonal spreading species such as Barrens Willow are necessary to help understand population size and changes.

Our ability to identify and implement recovery actions in support of rare plant conservation within the limestone barrens is still limited by our lack of knowledge of some aspects of the biology and ecology, and how climate change will affect future

species range distribution. In particular, a better understanding of life strategies, genetics, distribution, long-term population trends, habitat requirements, plant responses to environmental change, and the relative impact or importance of threats, will enable the targeting of recovery actions towards factors that can be influenced. To re-assess the population status and future prognosis for species at risk, monitoring programs tracking plant abundance, size, and health of representative populations with appropriate techniques must be established or continued for all limestone barrens plant species at risk. Developing a more comprehensive understanding of the species diversity of the limestone barrens will inform habitat protection decisions by identification of keystone and umbrella species, as well as potential actions targeted towards enhancing beneficial species and reducing damaging pests or pathogens.

Many of the land uses and activities threatening the limestone barrens (Table 1) are currently managed or prohibited, but some ongoing threats and new damaging land uses, as well as newly degraded sites, are occasionally identified. Ongoing research and monitoring is required to identify new threats, as well as how all threats may interact with each other to affect habitat integrity and the long-term persistence of the species at risk.

Restoration of habitat

Many accessible limestone barrens have been degraded, and an estimated 30% of sites known to support Long's Braya and Fernald's Braya have been affected, although some areas are less affected than others (Squires 2010). The vast majority of the Oval-leaved Creeping Spearwort population grows on degraded substrate, as do smaller portions of the populations of Barrens Willow, Lindley's Aster and Low Northern Rockcress, Mackenzie's Sweetvetch, and Wooly Arnica (Wildlife Division, unpublished data).

An early attempt at restoration of a Fernald's Braya site at Burnt Cape failed because organic material from heath cover was raked over the area, which made it possible for grasses to colonize and outcompete Fernald's Braya. During later restoration efforts in the small portion of the Sandy Cove Ecological Reserve near the airstrip, six rock piles from quarrying activities were removed by students (Figure 21), by hand, and used to fill quarry test pits but the substrate composition was not changed.

Between 2011 and 2013 Copp (2014) developed experimental restoration protocols in a degraded former quarry site adjacent to Sandy Cove Ecological Reserve to inform the larger restoration planned for the area. The project included modeling the pre-existing site beach ridge contours, as well as analyses of soil composition, chemistry, temperature, frost action, and vegetation in several types of degraded and natural limestone barrens habitats. Experimental plots were established to determine what mixture of substrates would best mimic native substrate in composition and functioning. Long's Braya seeds from the site, along with several other native seeds were planted into the experimental plots and emergence, growth, survival, and reproduction was monitored.

Since the Critical Habitat of Long's Braya is extremely limited in distribution and a large proportion is degraded, a larger restoration effort was carried out in 2016 using protocols developed by Copp (2014) in the same degraded quarry adjacent to the Sandy Cove Ecological Reserve with funding from ECCC Habitat Stewardship Program. The intention is that once restored, the area will be included in the Sandy Cove Ecological Reserve. Large areas of the quarry were reshaped to original contours with the help of local companies, and Long's Braya from the *ex situ* seed bank, along with other native limestone barrens plant species collected on site were seeded. The evaluation of the effectiveness of the habitat restoration project has been monitored yearly. Annual monitoring has been funded by ECCC Community Nominated Priority Places and the provincial government (2019-2021). Tracking of seeded plots of Long's Braya and other species along with substrate parameters and processes, shows that the protocols used have been successful in restoring habitat and species. The restoration has successful reintroduced Long's Braya with other plants showing for the first time that optimal habitat for these rare species can be brought back from the brink. A priority list of degraded Critical Habitat is being developed to begin to restore these areas as funds become available. Funding must be secured to continue monitoring after the current funding runs out to determine if the restoration has produced self-sustaining populations of the species at risk and to continue restoration of important habitats to make populations resilient to new threats such as climate change.

It is currently not known whether the protocols and targets suitable for Long's Braya could also successfully restore degraded Critical Habitat for Barrens Willow or other species preferring open limestone barrens. Species of substantially different habitat types, such as Lindley's Aster and Oval-leaved Creeping Spearwort for example, would probably require different approaches because site features other than the availability of nutrient-poor open barrens characterize their Critical Habitat. For Oval-leaved Creeping Spearwort, an absence of competing species and an optimal level of moisture are probably essential, while Lindley's Aster seems to require at least a sparse cover of heath or herbaceous plants. Habitat preferences and processes of these species are only partially understood, and for both species there is a potential danger of hybridization with closely related taxa. Due to the high costs of site restoration there is a need for prioritization of both species and sites.

Stewardship, education, and outreach

For many decades, communities have used the barrens for disposing of garbage, piling wood for drying, spreading nets for maintenance and drying, and as off-road vehicle and snowmobile routes. Stewardship initiatives have resulted in a decline in the drying of fishnets, however wood piling still occurs in some areas. Snowmobile and off road vehicles, such as ATV use, is of particular concern. Random use and well-established formal and informal trails travel over areas of Critical Habitat of species at risk, resulting in degradation of habitat, plant damage or loss, and the introduction of invasive species. Therefore, the development of mitigations and guidance for off-road vehicle use is

necessary in combination with increased awareness of residents and development of a conservation ethic.

Schools throughout the northern limestone barrens have been promoting conservation actions and responsible attitudes and behaviours towards limestone barrens habitats and plant species at risk, and continue to be an important avenue to educate the public about the importance of responsible off-road vehicle use on the limestone barrens. Since the commencement of the Limestone Barrens Recovery Program (previously the Habitat Stewardship Program) in 2001, the Program Manager and partners have worked together with local citizens and groups to ensure successful implementation of education campaigns as well as on-the-ground stewardship activities, such as site restoration (Figure 21). A similar program of student engagement would be very beneficial for the southern limestone barrens, where few local residents are aware of the unique ecosystem and species at risk near their communities. Ecotourism is another activity capable of causing damage to individuals and habitat of limestone barrens species at risk and for all limestone barrens, and is being addressed by working with local communities to promote sustainable tourism activities.

Figure 21. Restoration of a small-scale disturbance (a quarry test pit) at the Long's Braya Sandy Cove Airstrip site (Photo: D. House 2009).

Mechanisms for protection

To reduce further habitat degradation, Critical Habitat must be protected. Limestone barrens are found on federal, provincial, municipal, and private property, within protected areas, on natural, undisturbed substrate, and on substrate affected by a wide variety of anthropogenic activities. The linear coastal distribution of this habitat and its sparse and patchy occurrence within this range, combined with complex land use and ownership issues, makes protecting the limestone barrens, particularly the Critical Habitat of species at risk, a challenge. While many damaging activities are now managed or prohibited, many limestone barrens, including those harbouring plant species at risk, currently have no effective protection.

Protection mechanisms for both the habitat and species must be implemented at all levels to ensure conservation of limestone barrens species at risk. Identification of critical and recovery habitat, establishment of Critical Habitat orders, facilitation of enforcement, establishment and support for protected areas, and municipal stewardship agreements can all be used in combination for conservation while considering the needs of land users.

Funding opportunities

Projects undertaken to understand, conserve, and protect limestone barrens habitat, its rare floral inhabitants, and its unique geomorphology have been funded and supported by several partners and funding agencies. However, current funding sources are dwindling and highly uncertain at both provincial and federal levels, impeding current and future research, management, protection, and conservation of this important ecosystem. The government will be unable to meet its mandate under the ESA without additional funding. Sources of funding need to be continually pursued, how this will be carried out is unknown. In addition, opportunities for all levels of government, community, and indigenous groups to collaborate need to be identified and used to further conservation of the limestone barrens ecosystem.

Table 5. Recovery goals, objectives, and actions for Limestone Barrens Species at Risk.

Recovery Goal & Objective	Recovery Action
Goal 1: **Reduce gaps in our understanding of Limestone Barrens biotic and abiotic (physical) factors that affect species at risk long-term persistence and recovery.**	
Objective 1.1. Research species interactions that affect recovery of limestone barrens species at risk	Action 1.1.1. Determine whether pollinators are needed for seed production, and what species affect the dispersal and predation of seeds.
	Action 1.1.2. Study negative impacts of pests and pathogens on limestone barrens species at risk to develop mitigation/management strategies and how relationship may change with changing climate.
	Action 1.1.3. Determine how substrate structure, soil processes, and chemistry may affect limestone barrens species at risk.
	Action 1.1.4. Monitor cold-soil processes to determine how freeze-thaw cycling and frost action may be affected by climate change.
	Action 1.1.5. Determine historical and future spatial and temporal vegetation change of intact limestone barrens and how that might change with the climate.
Objective 1.2. Determine population trends and demographic rates of limestone barrens species at risk and how climate change may affect persistence and recovery	Action 1.2.1. Establish permanent monitoring programs for each limestone barrens species at risk to determine population trends, biodiversity changes, and monitor bioclimatic factors within permanent plots to determine trends in growth and reproduction.
	Action 1.2.2. Survey potential habitat of each limestone barrens species at risk to better determine population size and distribution.
	Action 1.2.3.

	Improve species identification, delineation of individual genotypes, and hybridization for Barrens Willow, Fernald's Braya, Long's Braya, Lindley's Aster, Bodin's Milkvetch, and Oval-leaved Creeping Spearwort using genetic technology, where necessary.
	Action 1.2.4. Determine the basic biology, habitat processes and limiting factors for recently listed limestone barrens species at risk.
Goal 2: **Restore damaged limestone barrens habitats, prioritizing areas designated as critical and/or recovery habitat.**	
Objective 2.1: Develop and implement scientifically-based protocols to restore and monitor damaged limestone barren sites in northern and southern limestone barrens	Action 2.1.1. Determine the percentage of limestone barrens habitat that remains intact and the percentage that is degraded across the listed species' ranges.
	Action 2.1.2. Prioritize degraded lands according to the need for restoration for limestone barrens species at risk and restore as funds become available.
	Action 2.1.3. Monitor recently restored limestone barren sites to evaluate the success of restoration efforts.
	Action 2.1.4. Monitor Shoal Cove trench (NL Hydro) for invasive native and non-native species and recolonization of natural vegetation.
	Action 2.1.5. Monitor and remove invasive native and non-native species invasion into Critical Habitat.
Objective 2.2. Restore/establish limestone barrens species at risk populations using augmentations, re-introductions, and translocations, where necessary to ensure long-term persistence, where appropriate.	Action 2.2.1. Use population augmentation, re-introductions and translocation where necessary, and monitor upon completion.
	Action 2.2.2. Experimentally test and determine appropriate methods for habitat restorations and reintroductions for newly listed limestone barrens species at risk identified in this document, and monitor when completed.
Objective 2.3 Maintain an *ex-situ* conservation program	Action 2.3.1. Maintain an *ex situ* live plant and/or seed bank collection of limestone barrens species at risk at the Memorial University Botanical Garden.

Goal 3: **Develop stewardship, education and outreach strategies to address threats to the limestone barrens and recovery of limestone barrens species at risk.**	
Objective 3.1: Mitigate community level threats to the limestone barrens habitat and associated species at risk	Action 3.1.1. Document the current level of threat posed by community-level land-use activities on Critical Habitat for species at risk.
	Action 3.1.2. Appropriately mark and maintain (e.g. with signs, markers) high-use areas of Critical/Recovery Habitat to discourage activities that cause habitat degradation and limestone barrens species at risk damage.
	Action 3.1.3. Continue to identify and engage individuals/groups that use Critical Habitat (such as sawmillers, woodpilers, NL Snowmobile Federation, motorised vehicles, industries, etc.) and provide users with information on species at risk and the NL *Endangered Species Act*. Integrate this into stewardship programs to build and foster relationships with local communities.
	Action 3.1.4. Work with local communities to develop and implement an off-road vehicle mitigation plan in and around Critical Habitat for limestone barrens species at risk.
	Action 3.1.5. In partnership with the Province, engage the ecotourism sector with workshops and the production of a sustainable tourism guidance document.
	Action 3.1.6. Work with communities to determine storage alternatives for boats, motorhomes, vehicles, etc., that do not affect limestone barrens species at risk.
	Action 3.1.7. Develop and deliver to service providers and heavy equipment operators “best practice” educational materials and maps that describe how work can be carried out in a way that minimizes disturbance to limestone barren Critical Habitat.
	Action 3.1.8. Determine the current number of quarry operators with active permits, and ensure the accurate mapping of existing and proposed quarries within limestone barren Critical and Recovery habitat. Work with quarry operators and the Quarry Division (Mines) to disseminate information on limestone barren Critical Habitat, distribution of limestone barrens species at risk, and the NL *Endangered Species Act* legislation applicable to them.
Objective 3.2.	Action 3.2.1.

Use stewardship and education programs aimed at schools and the general public in Northern and Southern limestone barrens to minimize or remove human threats	Erect and maintain interpretive panels that display information about limestone barrens species at risk biology, population status, and Critical Habitat conservation and restoration efforts at limestone barren sites.
	Action 3.2.2. Produce and update educational materials about all species at risk and their Critical Habitats, and disseminate these materials to schools and other outlets. Extend the educational stewardship to the southern limestone barrens.
	Action 3.2.3. Engage the local communities and indigenous groups in restoration activities, as appropriate.
	Action 3.2.4. Hold workshops as needed, inviting indigenous groups, land managers, owners, and users of limestone barrens to engage and share information addressing potential impacts on limestone barrens habitat and species at risk and strategies to minimize such impacts.
	Action 3.2.5. Evaluate the effectiveness of existing school and general public stewardship and education measures.
	Action 3.2.6. Regularly update the limestone barrens outreach material such as posters, website, social media, etc.
	Action 3.2.7. Encourage and support community events that foster community pride, celebrate the limestone barrens as a community resource, to promote a conservation ethic.
	Action 3.2.8. Create a parallel version of the Limestone Barrens Community Working Group with representatives from the Port au Port Peninsula and area surrounding Table Mountain.
	Action 3.2.9. Design and implement an awareness campaign on the Port au Port Peninsula based on experiences from the Northern Peninsula.
Goal 4: **Implement habitat and species protection mechanisms to ensure conservation of limestone barrens and species at risk.**	
Objective 4.1. Implement provincial and federal protection mechanisms to conserve limestone barrens,	Action 4.1.1. Determine land ownership of limestone barren areas with species at risk occupancy and seek appropriate habitat protection mechanisms. Identify land owners in Critical Habitat or with residences close to listed species, and inform them about the species at risk, and if appropriate, pursue stewardship agreements.
	Action 4.1.2.

particularly areas identified as Critical Habitat.	Identify critical and recovery habitat for all limestone barrens species at risk, and ensure that all new areas identified as critical and recovery habitat for limestone barrens species at risk are designated as Sensitive Wildlife Areas by the Government of Newfoundland and Labrador until an appropriate level of legal protection is established.
	Action 4.1.3. Recommend to the responsible Minister the establishment of Critical Habitat orders under the NL *Endangered Species Act* to protect critical and recovery habitat for species at risk within the limestone barrens.
	Action 4.1.4. Support the establishment of provincial protected areas to conserve the limestone barrens, specifically the expansion of Watt's Point Ecological Reserve, establishment of Ecological Reserves at Cape Norman, Cape St. George, Mainland, and on St. John Island.
	Action 4.1.5. Support the management of federally owned property to conserve the limestone barrens and resident species at risk.
	Action 4.1.6. Continue to pursue stewardship agreements with local municipalities, and update existing agreements as new species at risk are listed, as appropriate.
	Action 4.1.7. Encourage communication between all federal, provincial, and municipal agencies that have land-use management or permitting responsibilities for populations of plant species at risk and associated Critical Habitat.
Objective 4.2. Support enforcement initiatives that protect the limestone barrens and species at risk.	Action 4.2.1. Erect and maintain enforcement signage around the habitat of listed species throughout the limestone barrens and ecological reserves. Update the signage reflecting changes in legislation and regulations.
	Action 4.2.2. Identify appropriate enforcement and ensure proper training of those responsible for limestone barrens, Critical Habitat, and the NL *Endangered Species Act.* Discuss how to best enforce the legislation and regulations and any subsequent Critical Habitat orders
	Action 4.2.3. Ensure that contact information for enforcement is readily available to communities and all involved in limestone barrens management.
	Action 4.2.4. Ensure that the Limestone Barrens Species at Risk Recovery Team is informed about incidents relating to limestone barrens species at risk and their Critical Habitat that are reported to enforcement officers and any enforcement actions taken.

	Action 4.2.5. Ensure that enforcement officers are made aware of any development permits issued in or near limestone barrens species at risk Critical Habitat and any conditions associated with the work.
Goal 5: **Investigate funding opportunities to complete listed recovery goals and collaborate with provincial and federal government agencies, research institutions, community organizations, etc., to promote the conservation of limestone barrens.**	
Objective 5.1. Find funding and collaborations with other agencies and groups to support conservation actions.	Action 5.1.1 Identify and apply for funding to support research, education and stewardship of limestone barrens and the species at risk.
	Action 5.1.2 Work with national and international groups to raise awareness of limestone ecosystems.

Table 6. Implementation schedule of the actions required to meet recovery objectives for the Limestone Barrens Species at Risk in Newfoundland and Labrador during the next five years (2021-2025).

Recovery Action	Priority (High, Medium, Low)	Species Affected	Completion Date (2021 to 2025)
Action 1.1.1. Determine whether pollinators are needed for seed production, and what species affect the dispersal and predation of seeds.	L	All	2025
Action 1.1.2. Study negative impacts of pests and pathogens on limestone barrens species at risk and how relationships may change with changing climate to develop mitigation/management strategies.	H	All	2023
Action 1.1.3. Determine how substrate structure, soil processes, and chemistry may affect limestone barrens species at risk.	L	All	ONGOING (in restoration site)
Action 1.1.4. Monitor cold-soil processes to determine how freeze-thaw cycling and frost action may be affected by climate change.	M	All	ONGOING
Action 1.1.5. Determine historical and future spatial and temporal vegetation change of intact limestone barrens and how that might change with the climate.	H	All	2025
Action 1.2.1. Establish and implement permanent monitoring programs for each limestone barrens species at risk to determine population trends, biodiversity changes, and monitor bioclimatic factors within permanent plots to determine trends in growth and reproduction.	H	All	ONGOING
Action 1.2.2. Survey potential habitat of each limestone barrens species at risk to better determine population size and distribution.	H	All	ONGOING
Action 1.2.3. Improve species identification, delineation of individual genotypes, and hybridization for Barrens Willow, Fernald's Braya, Long's Braya, Lindley's Aster, Bodin's Milkvetch, and Oval-leaved Creeping Spearwort using genetic technology, where necessary.	H	Barrens Willow Long's & Fernald's Braya Lindley's Aster Oval-leaved Creeping Spearwort	ONGOING-2025
Action 1.2.4. Determine the basic biology, habitat requirements, processes and limiting factors for recently listed limestone barrens species at risk.	H	Griscom's & Wooly Arnica, Oval-leaved Creeping Spearwort, Bodin's Milkvetch,	ONGOING

Recovery Action	Priority (High, Medium, Low)	Species Affected	Completion Date (2021 to 2025)
		Mackenzie's Sweetvetch, Lindley's Aster	
Action 2.1.1. Determine the percentage of limestone barrens habitat that remains intact and the percentage that is degraded across listed species' ranges.	H	All	2023
Action 2.1.2. Prioritize degraded lands according to the need for restoration for limestone barrens species at risk and restore as funds become available.	H	All	2021
Action 2.1.3. Monitor recently restored limestone barren sites to evaluate the success of restoration efforts.	H	Long's Braya	ONGOING
Action 2.1.4. Monitor Shoal Cove trench (NL Hydro) for invasive and non-native species and recolonization of natural vegetation.	M	Fernald's Braya	ONGOING
Action 2.1.5. Monitor and remove invasive native and non-native invasion into Critical Habitat.	M	All	ONGOING
Action 2.2.1. Use population augmentation, re-introductions and translocation where necessary, and monitor upon completion.	H	Long's & Fernald's Braya, Barrens Willow, Griscom's Arnica	ONGOING
Action 2.2.2. Experimentally test and determine appropriate methods for habitat restoration and reintroductions for newly listed limestone barrens species at risk, and monitor when completed.	M	Oval-leaved Creeping Spearwort, Lindley's Aster, Griscom's & Wooly Arnica, Bodin's Milkvetch	ONGOING
Action 2.3.1. Maintain an *ex situ* live plant and/or seed bank collection of limestone barrens species at risk at the Memorial University Botanical Garden.	H	All	ONGOING
Action 3.1.1. Document and monitor the current level of threat posed by community-level land-use activities on Critical Habitat for species at risk.	H	All	2025
Action 3.1.2. Install and maintain (with signs, markers) high-use areas of Critical/Recovery Habitat to discourage activities that cause habitat degradation and limestone barrens species at risk damage.	H	All	ONGOING
Action 3.1.3.	H	All	2024

Recovery Action	Priority (High, Medium, Low)	Species Affected	Completion Date (2021 to 2025)
Continue to identify and engage individuals/groups that use Critical Habitat (such as sawmillers, woodpilers, NL Snowmobile Federation, motorised vehicles, industries, etc.) and provide users with information on species at risk and the NL *Endangered Species Act*. Integrate this into stewardship programs to help build and foster relationships with local communities.			
Action 3.1.4. Work with local communities to develop and implement an off-road vehicle mitigation plan in and around Critical Habitat for limestone barrens species at risk.	H	All	2024
Action 3.1.5. In partnership with the Province, engage the tourism sector with workshops and the production of a sustainable tourism guidance document.	M	All	2024
Action 3.1.6. Work with communities to determine feasible storage alternatives for boats, motorhomes, vehicles, etc., that do not affect limestone barrens species at risk.	M	Fernald's Braya, Oval-leaved Creeping Spearwort, Wooly Arnica	ONGOING
Action 3.1.7. Develop and deliver to service providers and heavy equipment operators "best practice" educational materials and maps that describe how work can be carried out in a way that minimizes disturbance to limestone barren habitat.	M	Barrens Willow, Long's & Fernald's Braya, Low Northern Rockcress, Mackenzie's Sweetvetch, Lindley's Aster	ONGOING
Action 3.2.1. Erect and maintain interpretive panels that display information about limestone barrens species at risk biology, population status, and Critical Habitat conservation and restoration efforts at limestone barren sites.	H	Barrens Willow, Long's & Fernald's Braya, Mackenzie's Sweetvetch, Griscom's & Wooly Arnica	ONGOING
Action 3.2.2. Produce and update educational materials about all species at risk and their Critical Habitats, and disseminate these materials to schools and other outlets. Extend the educational stewardship to the southern limestone barrens.	H	All	ONGOING
Action 3.2.3. Engage the local communities and indigenous groups in restoration activities, as appropriate.	M	Long's & Fernald's Braya, Oval-leaved Creeping Spearwort, Wooly Arnica	ONGOING
Action 3.2.4. Hold workshops as needed, inviting indigenous groups, land managers, owners, and users of limestone barrens to engage and share information	H	All	ONGOING

Recovery Action	Priority (High, Medium, Low)	Species Affected	Completion Date (2021 to 2025)
addressing potential impacts on limestone barrens habitat and species at risk and strategies to minimize such impacts.			
Action 3.2.5. Evaluate the effectiveness of existing school and general public stewardship and education measures.	H	All	2023
Action 3.2.6. Regularly update the limestone barrens outreach material such as posters, website, social media, etc.	H	All	ONGOING
Action 3.2.7. Encourage and support community events that foster community pride, celebrate the limestone barrens as a community resource, to promote a conservation ethic.	H	All	ONGOING
Action 3.2.8. Create a parallel version of the Limestone Barrens Community Working Group with representatives from the Port au Port Peninsula and area surrounding Table Mountain.	H	Mackenzie's Sweetvetch, Low Northern Rockcress, Lindley's Aster	ONGOING
Action 3.2.9. Design and implement an awareness campaign on the Port au Port Peninsula and areas surrounding Table Mountain based on experiences from the Northern Peninsula.	M	Mackenzie's Sweetvetch, Low Northern Rockcress, Lindley's Aster	2024
Action 4.1.1. Determine land ownership of limestone barren areas with species at risk occupancy and seek appropriate habitat protection mechanisms. Identify land owners in Critical Habitat or with residences close to listed species, and inform them about the species at risk, and if appropriate, pursue stewardship agreements.	M	Long's & Fernald's Braya, Lindley's Aster	2024
Action 4.1.2. Identify critical and recovery habitat for all limestone barrens species at risk, and ensure that all new areas identified as critical and recovery habitat for limestone barrens species at risk are designated as a Sensitive Wildlife Areas by the Government of Newfoundland and Labrador until an appropriate level of legal protection is established.	H	All	ONGOING
Action 4.1.3. Recommend to the responsible Minister the establishment of Critical Habitat orders under the NL *Endangered Species Act* to protect critical and recovery habitat for species at risk within the limestone barrens.	H	All	2022/ONGOING

Recovery Action	Priority (High, Medium, Low)	Species Affected	Completion Date (2021 to 2025)
Action 4.1.4. Support the establishment of provincial protected areas to conserve the limestone barrens, specifically the expansion of Watt's Point Ecological Reserve, establishment of Ecological Reserves at Cape Norman, Cape St. George, Mainland, and on St. John Island.	H	Fernald's Braya, Barrens Willow, Griscom's Arnica, Mackenzie's Sweetvetch	ONGOING
Action 4.1.5. Support the management of federally owned property to conserve the limestone barrens and resident species at risk.	H	Fernald's Braya, Barrens Willow, Low Northern Rockcress, Griscom's & Wooly Arnica	ONGOING
Action 4.1.6. Continue to pursue stewardship agreements with local municipalities, and update existing agreements as new species at risk are listed, as appropriate.	M	Oval-leaved Creeping Spearwort, Long's & Fernald's Braya, Barrens Willow, Wooly Arnica, Lindley's Aster, Low Northern Rockcress, Mackenzie's Sweetvetch	ONGOING
Action 4.1.7. Encourage and facilitate communication between all federal, provincial, and municipal agencies that have land-use management or permitting responsibilities for populations of plant species at risk and associated Critical Habitat.	H	All	ONGOING
Action 4.2.1. Erect and maintain enforcement signage around the habitat of listed species throughout the limestone barrens and ecological reserves. Update the signage reflecting changes in legislation and regulations.	H	All	ONGOING
Action 4.2.2. Identify appropriate enforcement and ensure proper training of those responsible for limestone barrens, Critical Habitat, and the NL *Endangered Species Act.* Discuss how to best enforce the legislation and regulations and any subsequent Critical Habitat orders	H	All	ONGOING
Action 4.2.3. Ensure that contact information for enforcement is readily available to communities and all involved in limestone barrens management.	H	All	ONGOING
Action 4.2.4. Ensure that the Limestone Barrens Species at Risk Recovery Team is informed about incidents relating to limestone barrens species at risk and their	H	All	ONGOING

Recovery Action	Priority (High, Medium, Low)	Species Affected	Completion Date (2021 to 2025)
Critical Habitat that are reported to enforcement officers and any enforcement actions taken.			
Action 4.2.5. Ensure that enforcement officers are made aware of any development permits issued in or near limestone barrens species at risk Critical Habitat and any conditions associated with the work.	H	All	ONGOING
Action 5.1.1 Identify and apply for funding to support research, education and stewardship of limestone barrens and the species at risk.	H	All	ONGOING
Action 5.1.2 Work with national and international groups to raise awareness of limestone ecosystems.	M	All	2025

Table 7. Recovery actions for the limestone barrens species at risk that have been completed or are currently in progress. These actions were compiled from a previous recovery plan prepared by the Limestone Barrens Species at Risk Recovery Team (formerly the Braya Recovery Team) (Hermanutz et al. 2002).

Recovery Approach	Recovery Action	Reference(s)/ Documents/ Responsible Parties (if available)
Scientific research	Determine the genetic diversity and differentiation of Long's Braya and Fernald's Braya (*in progress*)	Parsons 2002; Parsons and Hermanutz 2006; Roncal and Hermanutz, ongoing
	Determine the ability for unoccupied habitat to support Long's Braya and Fernald's Braya	Tilley 2003
	Evaluate the role of seed bank in long-term persistence of each Long's Braya and Fernald's Braya	Hermanutz et al. 2009
	Determine how disturbance affects recruitment and persistence of limestone barrens species at risk (*In progress*)	Noel 2000; Rafuse 2005; Robinson 2010; Copp 2014; Robinson and Hermanutz 2015; Mason 2014; Dart 2013
	Determine the long-term effect of disturbance on predation and microbial pressure on Long's Braya and Fernald's Braya	Squires et al. 2009; Squires 2010
	Determine the role and impact of pests and pathogens on long term persistence of limestone barrens species at risk (*in progress*)	Hermanutz, Hillier, De la Bastide, Finston, ongoing
	Determine optimal natural habitats for Long's Braya and Fernald's Braya (In progress)	Noel 1999; Greene 2002
	Produce a Population Viability Analysis for both Long's Braya and Fernald's Braya	Squires 2010
	Determine the genetic variation within and among Barrens Willow populations, to assess whether hybridization is occurring, and determine the extent of clonal growth within all populations.	Martinez and Good 2011
	Describe differences in Barrens Willow life history strategy between undisturbed natural populations and human disturbed populations in order to develop site-specific protection regulations, if required	Robinson 2010; Robinson and Hermanutz 2015
	Prepare identification keys, descriptions and illustrations to improve identification of willows in the field once an acceptable definition of an "individual" Barrens Willow plant is established	Robinson 2010; Robinson and Hermanutz 2015
	Determine the age of willow, birch, balsam fir, junipers, black and white spruce, and larch using tree cores, dead wood, or cookies to assess whether preliminary results indicating tree ages of 100-300 years is consistent across the range of tree species and the geographic boundaries of the limestone barrens	M. Burzynski, pers. comm.
	Outline potentially suitable limestone barrens habitat in the northern limestone barrens from air photos	Greene 2002
	Determine life history of Mackenzie's Sweetvetch	Zheng 2011
	Determine temperature sensitivity of Long's Braya to predict effects of future climate change on endemic endangered species	Belbin 2013
	Determine and inventory limestone barrens biodiversity (*In progress*)	Meades 1990; Mactavish 2001; Lendermer; Larson et al. 2000; Hynes 2004; Djan-Chékar & Hanel 2004; Foray NL 2012;

Population monitoring	Establish permanent monitoring plots to record changes in the size and health of representative populations of each species (*In progress*)	Hermanutz et al. 2009; Province, ongoing
	Establish total population size and distribution of all limestone barrens species at risk (*In progress*)	Hermanutz et al. 2009; Province, ongoing
	* Monitor population parameters at all currently identified extant locations	Hermanutz et al. 2009; Province, ongoing

Critical habitat assessment & Protection	Assess the level of threat at each location (*In progress*)	CNPP
	Determine level of protection (*In progress*)	Critical habitat maps (see Appendix B)
	Delineate areas of occurrence (*In progress*)	Critical habitat maps (see Appendix B)
	Recommend protection for Long's Braya and Fernald's Braya	Critical habitat maps (see Appendix B)
	Establish SWAs for all currently listed limestone barrens species at risk (*In progress*)	ILUC
	Establish an ecological reserve at Sandy Cove	Government of Newfoundland and Labrador 2013
	Establish a site-specific management plan for Port au Choix	Drafted, M. Burzynski
	Establish an ecological reserve at Burnt Cape	Meades 1995; Government of Newfoundland and Labrador 2000
Ex-situ conservation	Develop an *ex-situ* program for all species at the Memorial University Botanical Garden	Driscoll 2006; Walsh and Boland, ongoing
	Distribute seeds to long-term seed banks	Deemed redundant
Education & Stewardship	* Develop a regional education/information campaign in cooperation with applicable regional groups	
	Initiate stewardship activities for all Braya sites, where appropriate	
	* Review and evaluate stewardship and educational measures on a periodic basis	
	* Ensure local participation in the delivery of recovery activities	
	* Supply schools with education material such as the Limestone Barrens Guidebook, limestone barrens wildflower poster, etc.	
	* Continue to update the limestone barrens website	J. Maunder; www.limestonebarrens.ca
	* Develop interpretive materials for communities and tourists	Flowers Cove, Port au Choix NHS, Cape Norman; Burzynski & Marceau, ongoing
	Create an updated version of the limestone barrens guidebook	Burzynski et al., 2016
Restoration & reintroduction	Restore Long's Braya within its historical range	
	Given change in the status of Fernald's Braya look towards implementing habitat restoration strategies	
	Determine restoration protocols for degraded Long's Braya habitat (In progress)	Copp 2014; C. Copp, Hermanutz & Squires
	Level out limestone rock overburden piles at the Airport site	S. Squires, D. House & Local Green Teams
	Re-introduction of Barrens Willow, Long's Braya and Fernald's Braya into unoccupied, historically and currently occupied Critical Habitat	Tilley 2003; Pelley 2011

* Denotes those recovery actions which will always be ongoing.

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APPENDIX A

LIMESTONE BARRENS SPECIES AT RISK RECOVERY TEAM MEMBERS

(at time of document release)

Dr. Kathleen Blanchard	Intervale Associates Inc.
Michael Burzynski	Species Expert
David Chambers	NL Dept. of Fisheries, Forestry and Agriculture
Shelley Garland (co-chair)	NL Dept. of Fisheries, Forestry and Agriculture
Jeri Graham	NL Dept. of Environment, Climate Change and Municipalities
Claudia Hanel	NL Dept. of Fisheries, Forestry and Agriculture
Dr. Luise Hermanutz (co-chair)	Dept. of Biology (retired) Memorial University, St. Johns
Dulcie House	Limestone Barrens Recovery Program Manager, Memorial University
Paul Knaga	Canadian Wildlife Service, Environment and Climate Change Canada
Julia Lawlor	Nature Conservancy of Canada
Holly Lightfoot	Parks Canada Agency
John Maunder	Curator of Natural History (retired), Provincial Museum of Newfoundland and Labrador (now The Rooms Provincial Museum)
Jonathan Sharpe	NL Dept. of Fisheries, Forestry and Agriculture
Elizabeth Smith	Community Member
Dr. Susan Squires	Species Expert

Community Working Group Members, Frequent Contributors, and Former Team Members

Joe Brazil	Lynn Dempster	Corrina Copp
Nathalie Djan-Chekar	Philemena Dempster	Brent Sellars
George Gibbons	Tamsey Laing	Dr. Krista Baker
Henry Mann	Carolyn Lavers	Todd Boland
Sue Meades	Elizabeth Smith	Peter Deering
Dr. Wilf Nichols	Denise White	Anne Marceau

Noah (Tiny) Smith
Gerry Yetman
Kathy St. Laurent
Dale O'Leary
Tim Walsh
Madeline White
Tina Leonard
Geneva Woodward
Rick Ploughman
Peter Thomas
Carson Wentzell
Sylvia Gould
Dr. Darroch Whitaker

Students

James Harris
Sabine Dietz
Edward Donato
Julie Robinson
Kunjin Zheng
Laura Noel
Ginette Rafuse
Garry Dart
John Kennard
Marika Karolyo
Joni Driscoll
Paul Sokoloff
Corrina Copp
Shane Greene
Jill Slater
Agnes Mason
Dr. Susan Squires
Kim Parsons
Sami Rehman
Diane Pelley
Hilary Janes
Anne Marie Hynes
Shane Belbin

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Memorial University
Endangered Species Recovery Fund – WWF and Environment & Climate Change Canada
Habitat Stewardship Program, Environment & Climate Change Canada Species at Risk Program
Community Nominated Priority Places – Environment & Climate Change Canada
Metcalf Foundation
Patrons of Limestone Barrens
Parks Canada
Department of Fisheries, Forestry and Agriculture
Department of Tourism, Culture, Industry and Innovation
NL Legacy Nature Trust (NLLNT)
NL Hydro
NL Arts Council

APPENDIX B

Species Details & Critical Habitat Maps

Maps in this section only show Critical Habitat and plant occurrences on provincial and private land. For further information on the Critical Habitat and occurrence of these species on federal land please contact the appropriate federal management agency.

Figure B1. Long's Braya (*Braya longii*). (Photo: S.E. Squires 2008).

Long's Braya (*Braya longii*) is a small herbaceous perennial in the Brassicaceae (Figure B1) with fleshy, dark-green to purplish, narrowly spoon-shaped leaves clustered into basal rosettes. Flowering stems reach a height of 1 to 10 cm and its inflorescence is a dense cluster of four-petalled white flowers that elongates during fruit (Meades 1997a). Fruit are glabrous (hairless), elongated pods bearing rounded seeds without special dispersal mechanisms. Long's Braya is a calciphile with a contractile taproot.

<table>
<tr><td colspan="2">Common name: Long's Braya</td><td colspan="2">Scientific name: Braya longii</td></tr>
<tr><td colspan="2">Provincial Listing (ESA):
Endangered</td><td colspan="2">Federal listing (SARA): Endangered</td></tr>
<tr><td>Global:
G1 Critically Imperilled
(NatureServe)</td><td colspan="2">National:
S1 Critically Imperilled Canadian Endangered Species Conservation Council 2016)</td><td>Provincial:
S1 Critically Imperilled (Canadian Endangered Species Conservation Council 2016)</td></tr>
<tr><td colspan="2">SSAC assessment history: NA (only assessed by COSEWIC)</td><td colspan="2">COSEWIC assessment history: Endangered (1997), Endangered (2000), Endangered (2011)</td></tr>
<tr><td colspan="4">Reason for designation: Highly restricted endemic of the limestone barrens with very few populations; in continued decline from natural and human threats.</td></tr>
<tr><td colspan="4">Newfoundland and Labrador occurrence: Long's Braya is very restricted to a tiny portion of the limestone barrens of the Great Northern Peninsula of Newfoundland, a 10 km strip centered on Sandy Cove (COSEWIC 2011). There is a historical record from Green Island Cove.</td></tr>
<tr><td colspan="4">Canadian & Global occurrence: Other than on the Island of Newfoundland, Long's Braya is not found anywhere else in Canada or the world.</td></tr>
<tr><td colspan="4">Legal protection: Endangered Species Act (NL), Species at Risk Act (Federal).</td></tr>
<tr><td colspan="4">Distribution: Long's Braya's very limited range has not been extended since 2000, nor has the known area of occupancy been substantially refined (COSEWIC 2000, Wildlife Division, unpublished data). A large proportion of the habitat of the species is degraded or artificially created. Several refinements have occurred to the distribution of the species as reported by COSEWIC (2012).</td></tr>
<tr><td colspan="4">Best population estimate: 4000-8000 mature (flowering) individuals, with lower numbers more likely, based on census counts of 7,720 in 1998 and 5,500 in 2008 (Hermanutz et al. 2009; COSEWIC 2011). Both of these census counts likely captured</td></tr>
</table>

at least 90% of the population. Ratios of vegetative to reproductive individuals in monitoring plots varied widely among years and sites, but averaged 15:1, leading to an estimate of 64,000 to 128,000 individuals (Wildlife Division, unpublished data).

Trends: Permanent plot-based long term monitoring suggests there are substantial natural, local fluctuations in population size, but that in degraded habitat overall declines are both larger and more frequent. Anthropogenic activity has resulted in the destruction of four monitoring plots since 2008, one of them in a protected area (Wildlife Division, unpublished data).

Relevant biological information: Primarily autogamous (self-fertilizing), potential for outcrossing low but higher than for Fernald's Braya (Parsons and Hermanutz 2006). Plants take 3-5 years to flower, and mature plants do not necessarily flower every year; species can transition between flowering and non-flowering in subsequent years. The species has a long-lived seed bank, with seed living for more than 10 years (Hermanutz, unpublished data).

Natural stressors and limiting factors: Long's Braya is shade intolerant. Competition by taller plants, as well as frost heave, are the main stressors, with soil erosion by rain splash and local periodic inundation less common. (Wildlife Division, unpublished data). There is evidence of potential hybridization with Fernald's Braya at both the north and south end of the population (Parsons and Hermanutz 2006).

Threats to the species:

Land use: Off-road use of road vehicles, ATV use, utility maintenance, unauthorized quarrying, tourist traffic, illegal garbage dumping.

Pests: Diamondback Moth (*Plutella xylostella*) herbivory has caused increased plant mortality and reduced reproductive output but attack severity fluctuates highly from year to year (Hillier 2020, unpublished data, Squires 2010, Squires et al. 2009, Wildlife Division, unpublished data).

Pathogens: Over 30 species of fungi have been detected on Braya plants, not all of them pathogens, with the vast majority of them encountered only once or twice, or in single years. More common species detected regularly over the summer include: *Alternaria* spp., *Boeremia/Phoma* group, *Colletotrichum* sp., *Fusarium* sp., *Stemphyllium vesicum*. The following are known plant pathogens or parasites: *Boeremia exigua*, *Botrytis cinerea*, *Sclerotinia sclerotiorum* and *Colletotrichum* sp. In addition, several others such as *Alternaria* sp., *Cladosprorium herbarum*, *Fusarium* sp., and *Phoma* sp. are pathogens or saprobes (De La Bastide and Finston 2021, unpublished data). Climate change is likely to alter the rates of infection by pathogens and infestation of pests.

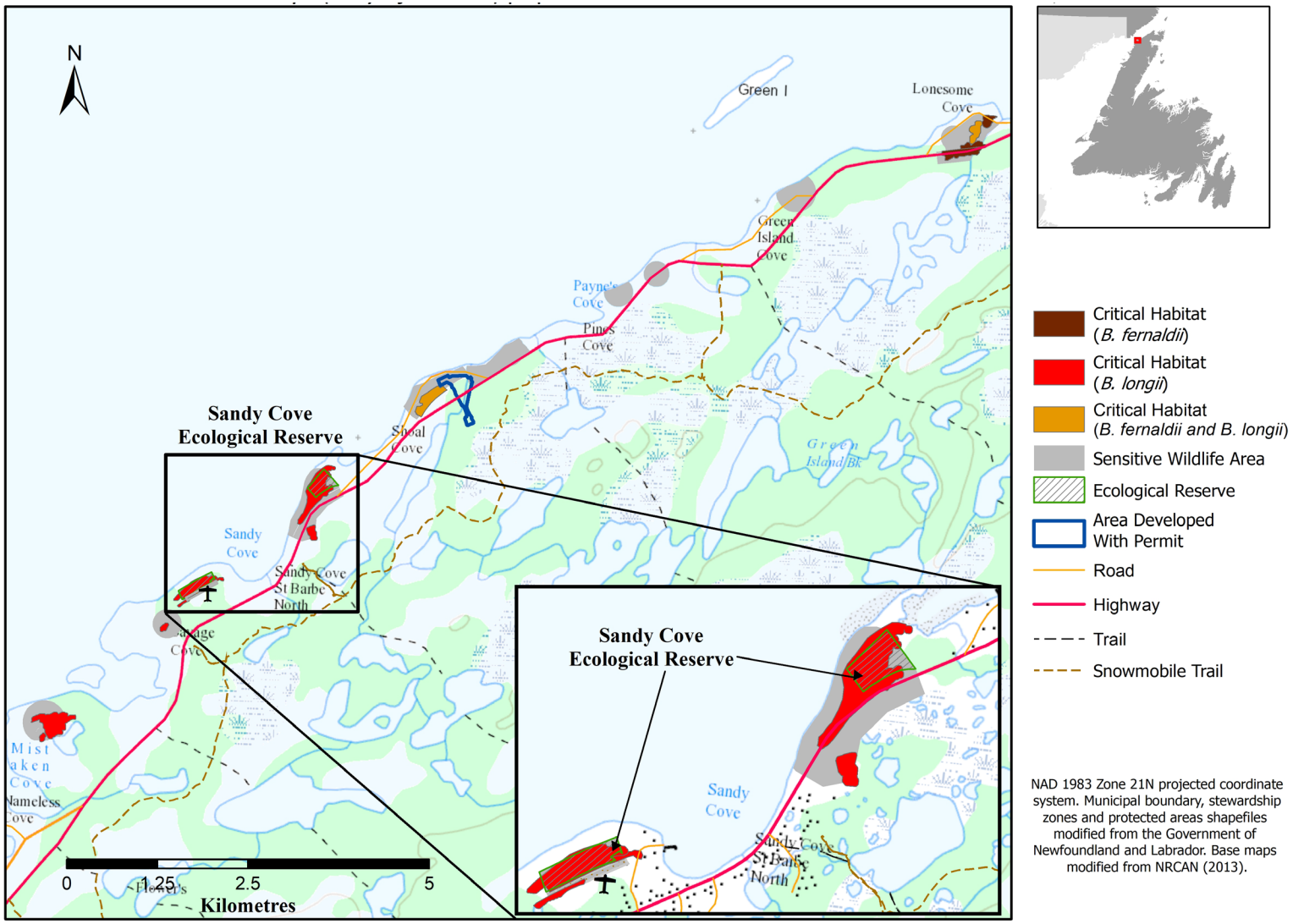

Figure B2. Long's Braya (*Braya longii*) and Fernald's Braya (*Braya fernaldii*) Critical Habitat between Flower's Cove and Green Island Brook. Sensitive Wildlife Areas are for multiple plant species.

Figure B3. Fernald's Braya (*Braya fernaldii*). (Photo: D. Pelley 2010)

Fernald's Braya (*Braya fernaldii*) is a small herbaceous perennial in the Brassicaceae. It is very similar in appearance to Long's Braya, only smaller and with pubescent (hairy) leaves and fruit pods (Meades 1997b) (Figure B3). Its flower stalks reach heights of 1-7 cm (Meades 1997b), with smaller flowers (Parsons and Hermanutz 2006). In contrast to Long's Braya, the flowers are also sometimes tinged pinkish or purplish.

<table>
<tr><td colspan="2">Common name: Fernald's Braya</td><td colspan="2">Scientific name: Braya fernaldii Abbe</td></tr>
<tr><td colspan="2">Provincial Listing (ESA): Endangered</td><td colspan="2">Federal listing (SARA): Endangered</td></tr>
<tr><td>Global:
G1 Critically Imperilled (NatureServe)</td><td>National:
S1 Critically Imperilled (Canadian Endangered Species Conservation Council 2016)</td><td colspan="2">Provincial:
S1 Critically Imperilled (Canadian Endangered Species Conservation Council 2016)</td></tr>
<tr><td colspan="2">SSAC assessment history: NA (only assessed by COSEWIC)</td><td colspan="2">COSEWIC assessment history: Threatened (1997), Threatened (2000), Endangered (2012)</td></tr>
<tr><td colspan="4">Reason for designation: An endemic of the limestone barrens that occurs at low numbers and is in decline as a result of natural and human threats.</td></tr>
<tr><td colspan="4">Newfoundland and Labrador occurrence: Fernald's Braya is restricted to the coastal limestone barrens of the Great Northern Peninsula of Newfoundland between just north of Bellburns and Burnt Cape Ecological Reserve, a distance of about 180 km. Fernald's Braya has never been relocated at two historical sites - Ice Point and inland of Savage Cove.</td></tr>
<tr><td colspan="4">Canadian & Global occurrence: Other than on the Island of Newfoundland, Fernald's Braya is not found anywhere else in Canada or the world.</td></tr>
<tr><td colspan="4">Legal protection: Endangered Species Act (NL), Species at Risk Act (Federal)</td></tr>
<tr><td colspan="4">Distribution: An occurrence discovered in 2015 north of Bellburns extended the known range approximately 33 km to the south, and extensive surveys have also better defined the occupied area at the northern end of the species range. During surveys where the number of barrens searched was recorded, approximately 29% of the searched potential habitat patches were occupied and the species has been found up to 5 km inland (Greene 2002, Copp 2014, Mazerolle and Belliveau 2016, 2017, Chapman and Mazerolle 2020, Wildlife Division, unpublished data). A large number of potential habitat patches remain unsearched.</td></tr>
</table>

Best Population Estimate: Approximately 5000 flowering individuals, assuming that a) the 3,300 plants at 16 sites counted in 2008 have not further declined, and b) the populations discovered since 2008 harbour at least several hundred flowering individuals (Wildlife Division, unpublished data). Based on an average ratio of vegetative plants to flowering plants of 15:1 observed in permanent plots, the total number of individuals, including vegetative plants and seedlings, is estimated to be between 40,000 and 45,000 (Wildlife Division, unpublished data).

Trends: Overall, declining. The number of flowering plants at 15 occurrences decreased 64% from 3450 to 1250 between initial counts in 1998 to 2000 and 2008 (Hermanutz *et al.* 2002, Hermanutz *et al.* 2009). Since 2008, seven monitored occurrences experienced a near population collapse, many of them in relatively undisturbed habitat. At the largest known occurrence which is in degraded habitat, large plot-specific fluctuations without a clear overall trend have been observed but one plot of six had been destroyed and two very clearly re-disturbed. No trend information is available for the vast majority of the occupied habitat patches found since 2008 (Wildlife Division, unpublished data).

Relevant Biological Information: Primarily autogamous (self-fertilizing) with a low potential for outcrossing (Parsons 2002). Plants take at 3-5 years to flower, and mature plants do not necessarily flower every year; species can transition between flowering and non-flowering in subsequent years. The species has a long-lived seed bank, with seed living for more than 10 years (Hermanutz, unpublished data).

Natural Stressors and Limiting Factors: Fernald's Braya is shade intolerant. Competition by taller plants, as well as frost heave, are the main stressors, with soil erosion by rain splash and local periodic inundation less common. (Wildlife Division, unpublished data). Restricted distribution and potential hybridization with Long's Braya occurring where the ranges of the two species overlap.

Threats to Species:

Land use: Off-road use of road vehicles, ATV use, utility maintenance, unauthorized quarrying, tourist traffic, illegal garbage dumping.

Pests: Diamondback Moth (*Plutella xylostella*) herbivory has caused increased plant mortality and reduced reproductive output but attack severity fluctuates highly from year to year (Hillier 2020, unpublished data, Squires 2010, Squires et al. 2009, Wildlife Division, unpublished data).

Pathogens: Over 30 species of fungi have been detected on Braya plants, not all of them pathogens, with the vast majority of them encountered only once or twice, or in single years. More common species detected regularly over the summer include: *Alternaria* spp., *Boeremia*/*Phoma* group, *Colletotrichum* sp., *Fusarium* sp., *Stemphyllium vesicum*. The following are known plant pathogens or parasites: *Boeremia exigua*, *Botrytis cinerea*, *Sclerotinia sclerotiorum* and *Colletotrichum* sp. In addition, several others such as *Alternaria* sp., *Cladosprorium herbarum*, *Fusarium* sp., and *Phoma* sp. are pathogens or saprobes (De La Bastide and Finston 2021, unpublished data). Climate change is likely to alter the rates of infection by pathogens and infestation of pests.

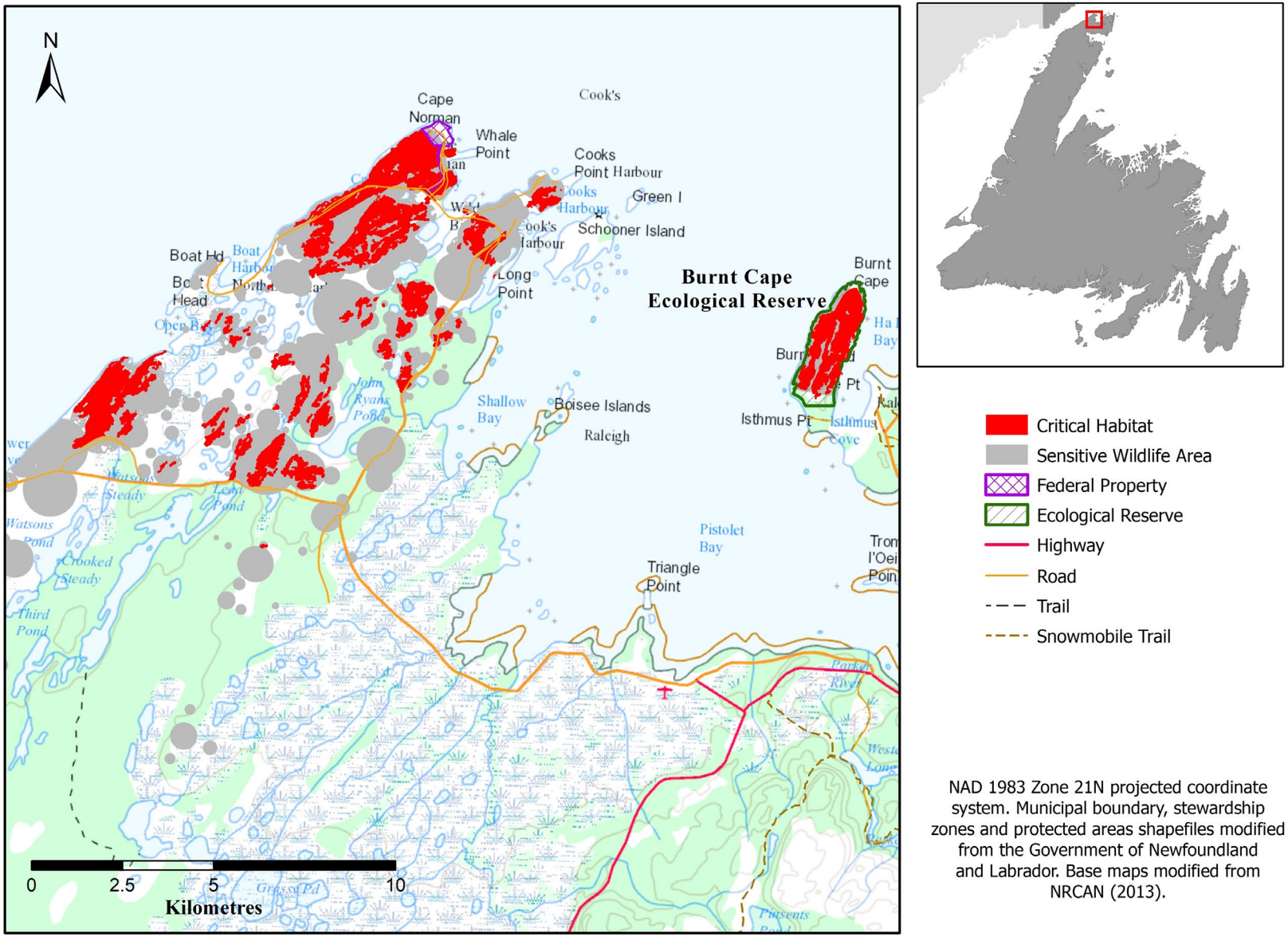

Figure B4. Fernald's Braya (*Braya fernaldii*) Critical Habitat in the Cape Norman area and Burnt Cape Ecological Reserve. Sensitive Wildlife Areas are for multiple plant species.

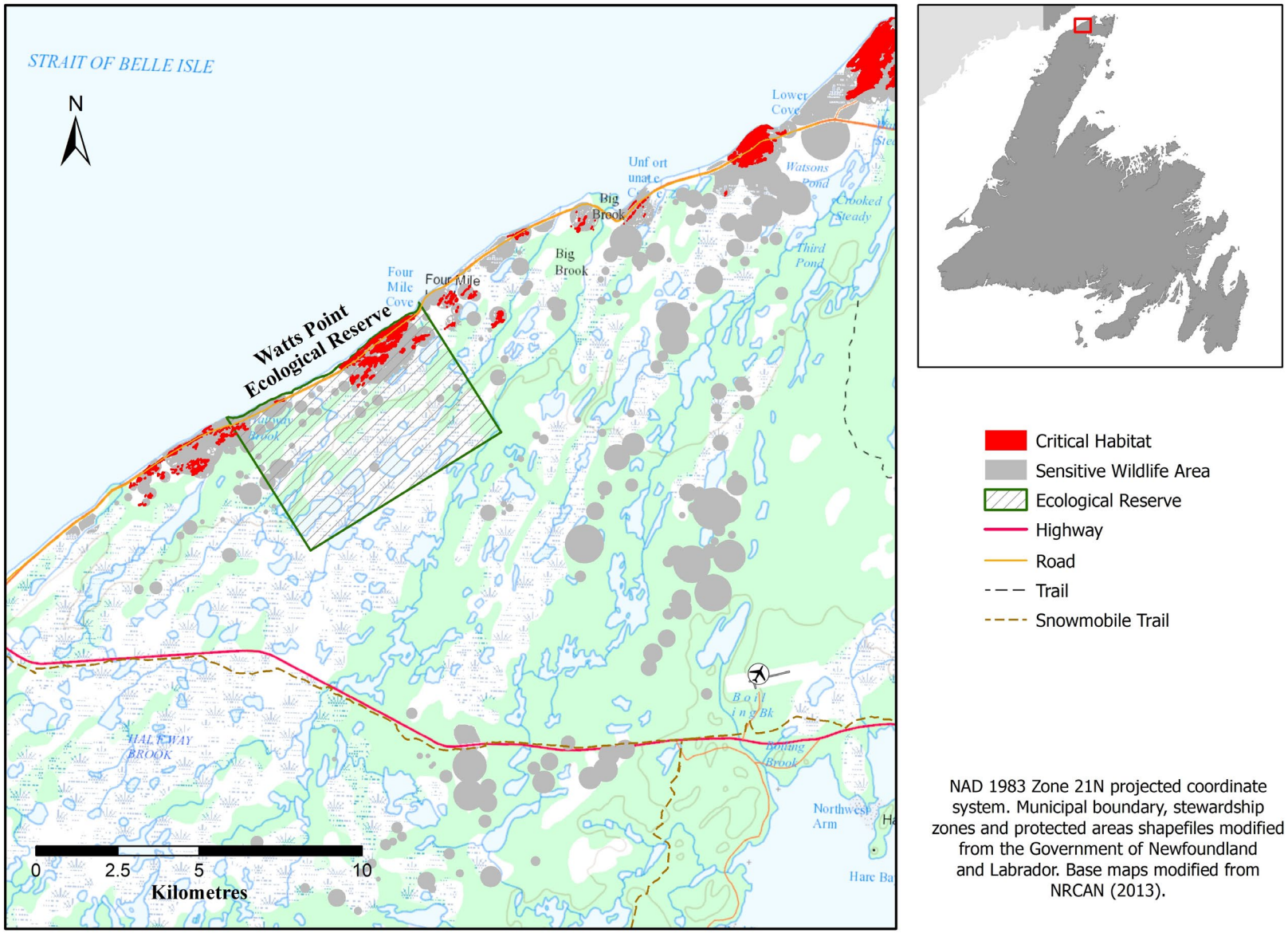

Figure B5. Fernald's Braya (*Braya fernaldii*) Critical Habitat in the area of Watts Point Ecological Reserve. Sensitive Wildlife Areas are for multiple plant species.

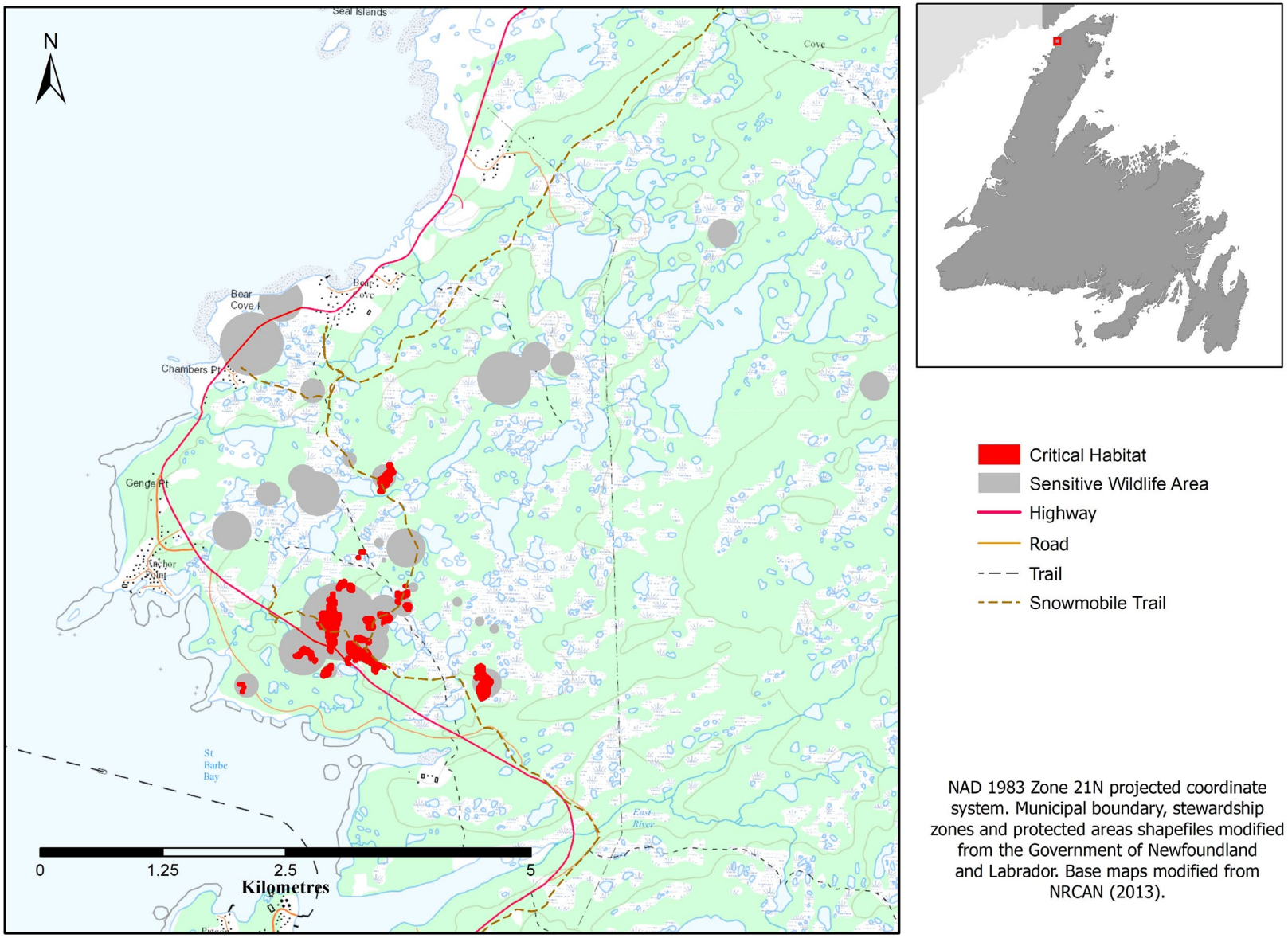

Figure B6. Fernald's Braya (*Braya fernaldii*) Critical Habitat near Anchor Point. Sensitive Wildlife Areas are for multiple plant species.

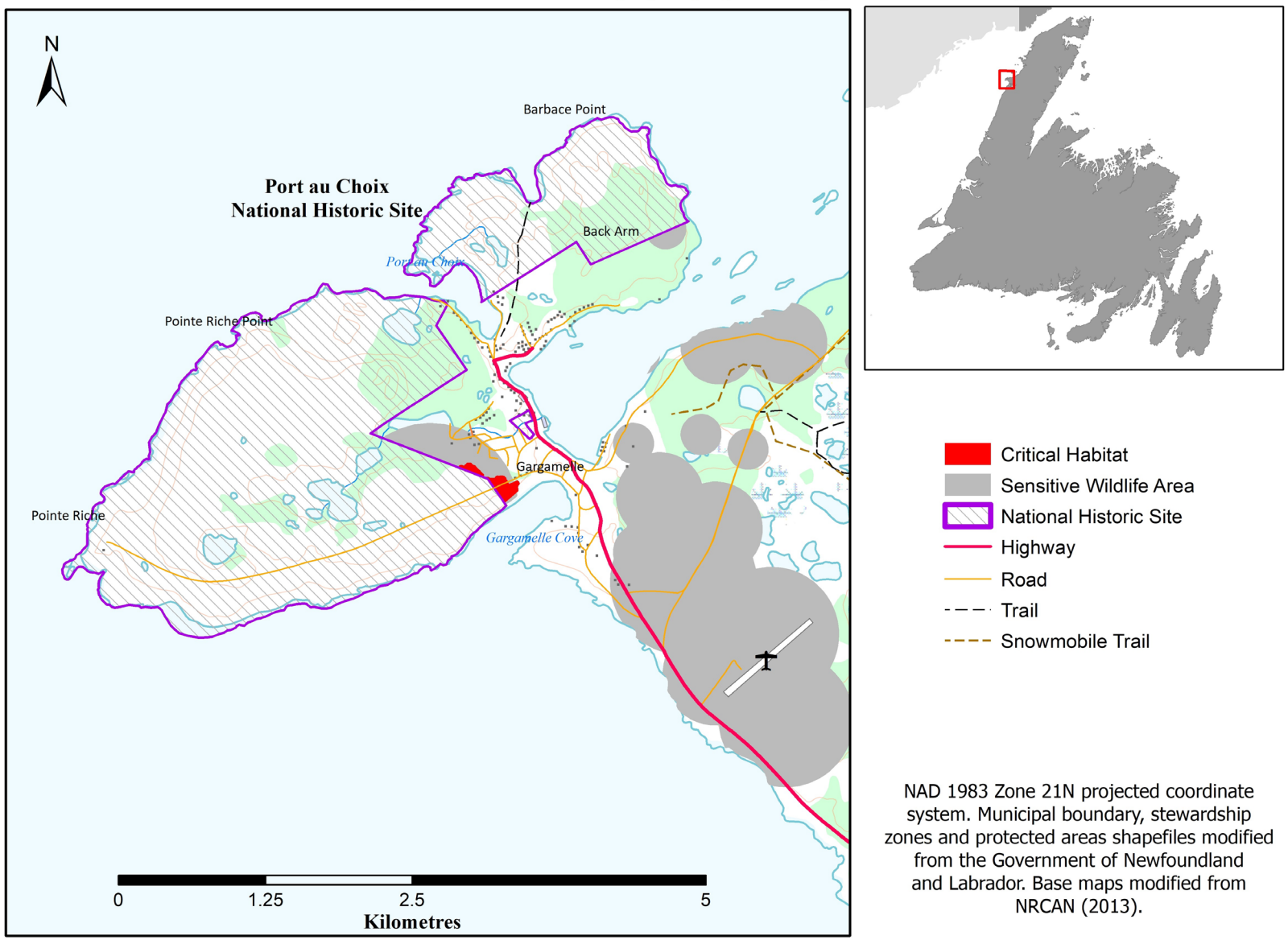

Figure B7. Fernald's Braya (*Braya fernaldii*) Critical Habitat near Port au Choix National Historic Site. Sensitive Wildlife Areas are for multiple plant species.

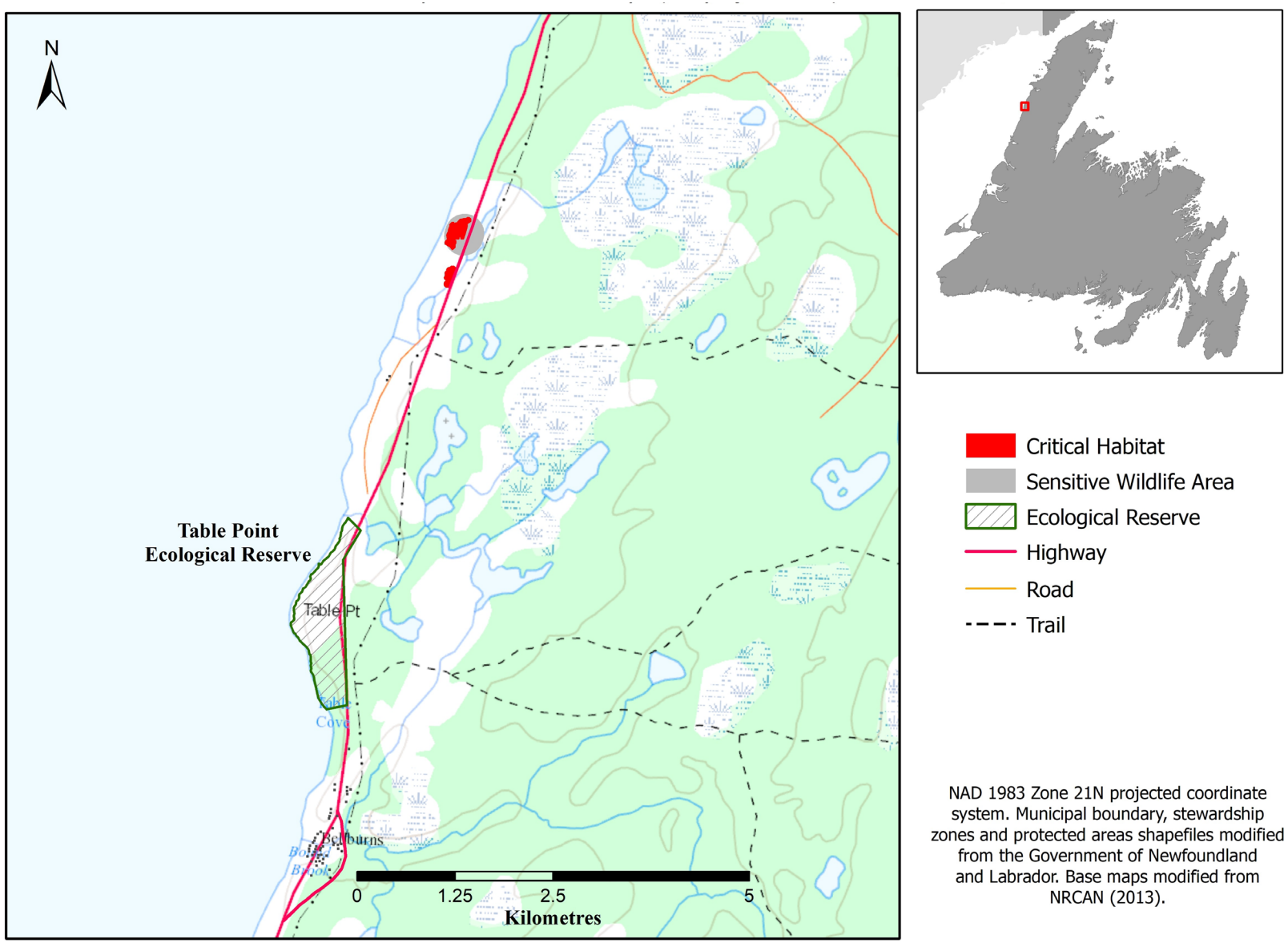

Figure B8. Fernald's Braya (*Braya fernaldii*) Critical Habitat near Table Point Ecological Reserve. Sensitive Wildlife Areas are for multiple plant species.

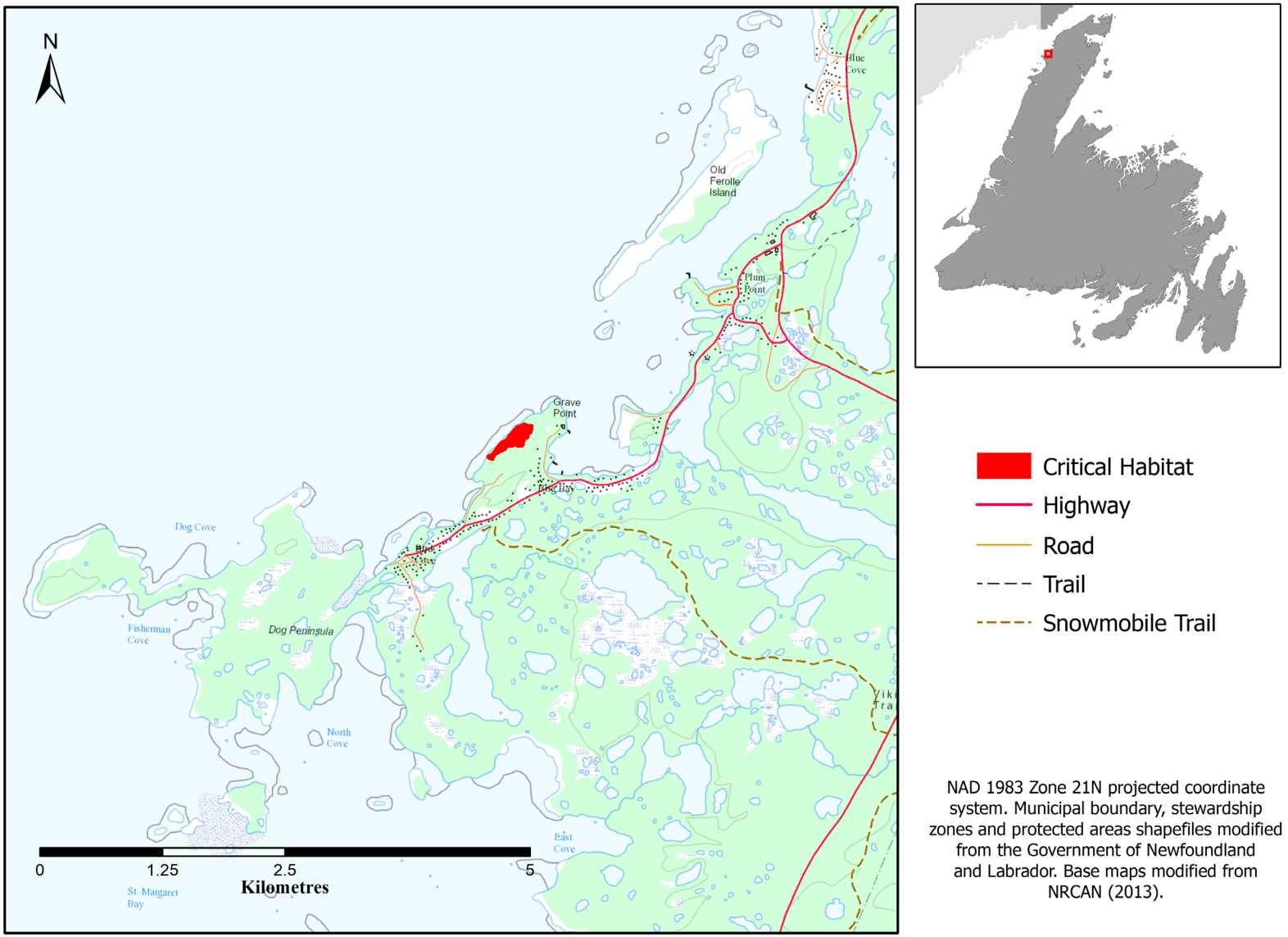

Figure B9. Fernald's Braya (*Braya fernaldii*) Critical Habitat in the Brig Bay area, NL. Sensitive Wildlife Areas are for multiple plant species.

Figure B10. Barrens Willow (*Salix jejuna*). (Photo: J. Maunder 2001)

Barrens Willow (*Salix jejuna*) is an endemic dwarf, prostrate, mat-forming shrub in the Salicaceae (Figure B10). Leaves are small (8-25 mm long, 4-22 mm wide), short-stalked, round, glabrous (hairless), and have in-rolled margins (Anions 2000). The bark of the stems is red-brown and smooth. It is a calciphile.

Barrens Willow is dioecious, developing staminate (male) and pistillate (female) catkins on separate plants. Catkins are 8-20 mm long and borne laterally on the branches (Anions 2000). Female catkins are hairless and usually dark purple. Seeds are short lived and wind dispersed (Robinson and Hermanutz 2015).

<table>
<tr><td colspan="2">Common name: Barrens Willow</td><td colspan="2">Scientific name: Salix jejuna Fernald</td></tr>
<tr><td colspan="2">Provincial Listing (ESA):
Endangered</td><td colspan="2">Federal listing (SARA): Endangered</td></tr>
<tr><td>Global:
G1G2 Critically Imperilled - Imperilled (NatureServe)</td><td colspan="2">National:
N1N2 Critically Imperilled to Imperilled (Canadian Endangered Species Conservation Council 2016)</td><td>Provincial:
S1S2 Critically Imperilled to Imperilled (Canadian Endangered Species Conservation Council 2016)</td></tr>
<tr><td colspan="2">SSAC assessment history: NA (only assessed by COSEWIC)</td><td colspan="2">COSEWIC assessment history: Endangered (2001)</td></tr>
<tr><td colspan="4">Reason for designation: Highly localized limestone barrens endemic occurring at only a few sites and subject to habitat loss and degradation from land-use activities.</td></tr>
<tr><td colspan="4">Newfoundland and Labrador occurrence: Barrens Willow is restricted to the coastal limestone barrens of the Great Northern Peninsula of Newfoundland, a 20 km span between the Watts Point Ecological Reserve and Cape Norman (Anions 2000, Djan-Chékar et al. 2003). Locations contain both natural and human-degraded substrate (Robinson 2010).</td></tr>
<tr><td colspan="4">Canadian & Global occurrence: Other than on the Island of Newfoundland, Barrens Willow is not found anywhere else in Canada or the world.</td></tr>
<tr><td colspan="4">Legal protection: Endangered Species Act (NL), Species At Risk Act (Federal).</td></tr>
<tr><td colspan="4">Distribution: Since 2000, many surveys have contributed to a better range definition for the species and discovery of additional occupied limestone barrens (Greene 2002, Copp 2014, Mazerolle and Belliveau 2016, 2017, Chapman and Mazerolle 2020, Wildlife Division, unpublished data). However, many patches of potential habitat within this range have not yet been searched.</td></tr>
</table>

Best population estimate: Not available
Trends: Not available
Relevant biological information: Barrens Willow does not have a long-lived seedbank as seeds are viable for only a year. Primary spread is by vegetative reproduction, branches rooting where they contact the ground. This vegetative growth makes numbers of genetically distinct individuals difficult to determine (Robinson 2010; Pelley 2011). It is closest in appearance, as well as genetically, to Bearberry Willow (*Salix uva-ursi*), but both are also very closely related to, and probably hybridizing with, Beautiful Willow (*Salix glauca*). The populations are genetically similar to each other, and there may be high levels of inbreeding at each site (Martinez and Good 2011).
Natural stressors and limiting factors: The species has a very restricted range and the rate of reproduction by seed is low. There is a high likelihood of hybridization with at least three, and possibly more, other Willow species (Martinez and Good 2011).
Threats to the species: Off-road vehicle use, quarrying, road and utility maintenance, and tourist traffic threaten individual plants and potentially facilitate hybridization.

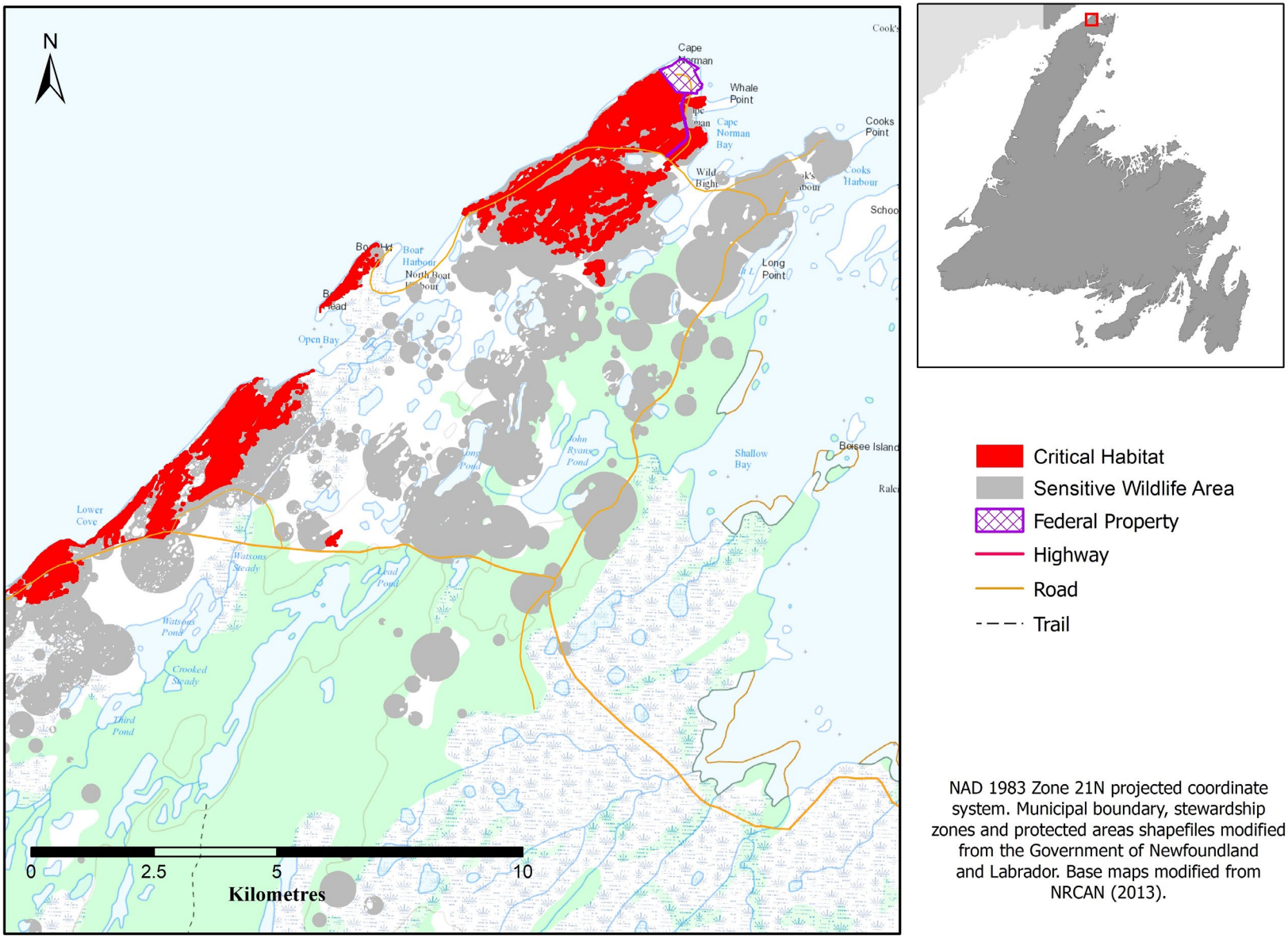

Figure B11. Barrens Willow (*Salix jejuna*) Critical Habitat in the Cape Norman area. Sensitive Wildlife Areas are for multiple plant species.

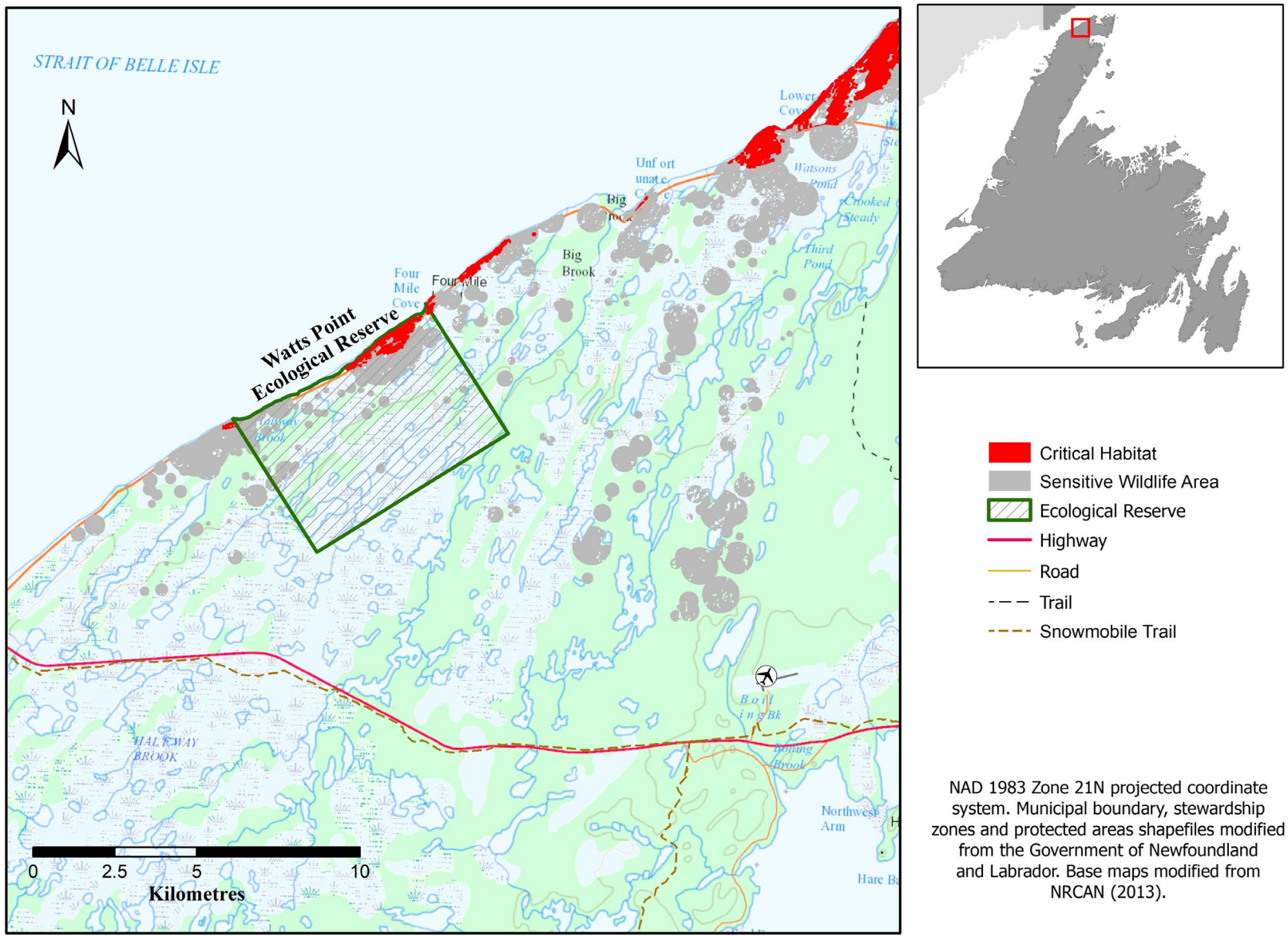

Figure B12. Barrens Willow (*Salix jejuna*) Critical Habitat in the area of Watts Point Ecological Reserve. Sensitive Wildlife Areas are for multiple plant species.

Figure B13. Wooly Arnica (*Arnica angustifolia subsp. tomentosa*) (Photo: M. Burzynski 2002).

Wooly Arnica *(Arnica angustifolia subsp. tomentosa*) is a low-growing, daisy-like perennial in the Asteraceae (Figure B13). It has a single, relatively large, bell-shaped, yellow flower head on each flowering stem about 15-20 cm above the ground. Dense woolly white hairs cover both surfaces of the narrow lance-shaped leaves, flower stalks, and bases of the flower heads. The basal leaves grow at about a 45-degree angle to the ground (Species Status Advisory Committee 2012b).

It is a calciphile, typically found as a single plant or in small clusters. Clusters usually have only one or two flowering stems and may be connected to nearby plants by underground stems (rhizomes) (Species Status Advisory Committee 2012b).

<table>
<tr><td colspan="2">Common name: Wooly arnica, Woolly Arnica</td><td colspan="2">Scientific name: Arnica angustifolia subsp. tomentosa</td></tr>
<tr><td colspan="2">Provincial listing (ESA): Endangered</td><td colspan="2">Federal listing (SARA): None</td></tr>
<tr><td>Global:
G5T5 Secure, Subspecies Secure (NatureServe)</td><td>National:
Not ranked separately from parent taxon</td><td colspan="2">Provincial:
Not ranked separately from parent taxon</td></tr>
<tr><td colspan="2">SSAC assessment history: Endangered (2012)</td><td colspan="2">COSEWIC assessment history: N/A</td></tr>
<tr><td colspan="4">Reason for designation: This species has a limited distribution. It is known to exist at 5 or fewer locations and the habitat quality is continuing to decline due to climate change and anthropogenic activity, such as ATV use and quarry development (Species Status Advisory Committee 2012b).</td></tr>
<tr><td colspan="4">Newfoundland and Labrador occurrence: Wooly Arnica is found on the west coast of the island and five occurrences have been verified as extant in the last 25 years; one on the Port au Port Peninsula and the others on the Great Northern Peninsula. The largest population is in the Port au Choix National Historic Site, which includes approximately two-thirds of the known habitat for the species as well (Species Status Advisory Committee 2012b).</td></tr>
<tr><td colspan="4">Canadian and Global occurrence: In Canada, Wooly Arnica is found in AB, BC, Northwest Territories, Yukon Territory and is disjunct on the island of Newfoundland. It is also found in the western United States in Montana, Wyoming, Idaho, and Colorado. It is not found outside North America (Species Advisory Committee 2012b).</td></tr>
<tr><td colspan="4">Legal protection: Endangered Species Act (NL)</td></tr>
</table>

Distribution: Since 2000, no new occurrences have been found, but the area of occupancy in the Port au Choix area has been further refined (Wentzell 2016). Not all potential habitat has been surveyed.
Best population estimate: Approximately 1,500 plants, with 320 of them flowering, based in part on a 2016 count of 1416 individuals (263 of them flowering) at Port au Choix, as well as a 2018 count and a 1999 estimate for two smaller occupied barrens in the Port au Choix area (Wentzell, 2016, Wildlife Division, unpublished data). No population estimates are available for St. Paul's Inlet and the Port au Port Peninsula, but there are no indications that these populations are large (Species Advisory Committee 2012b).
Trends: Not available.
Relevant biological information: Wooly Arnica is a slow-growing, long-lived perennial that does not tolerate competition for sunlight. It is apomictic (produces seeds without fertilization), and its fruit are wind dispersed (Species Advisory Committee 2012b). Its asexual seed production and rhizomes connecting tufts underground make the determination of an individual very difficult.
Natural stressors and limiting factors: The species grows in small, isolated populations, has limited seed production and does not tolerate competition for sunlight (Species Advisory Committee 2012b).
Threats to the species: Wood piling, trampling (by ungulates and tourist traffic), ATV use, vehicle traffic on roadside, including landings, oil exploration, indirect effects of climate change, which may favour faster growing plants (Species Advisory Committee 2012b).

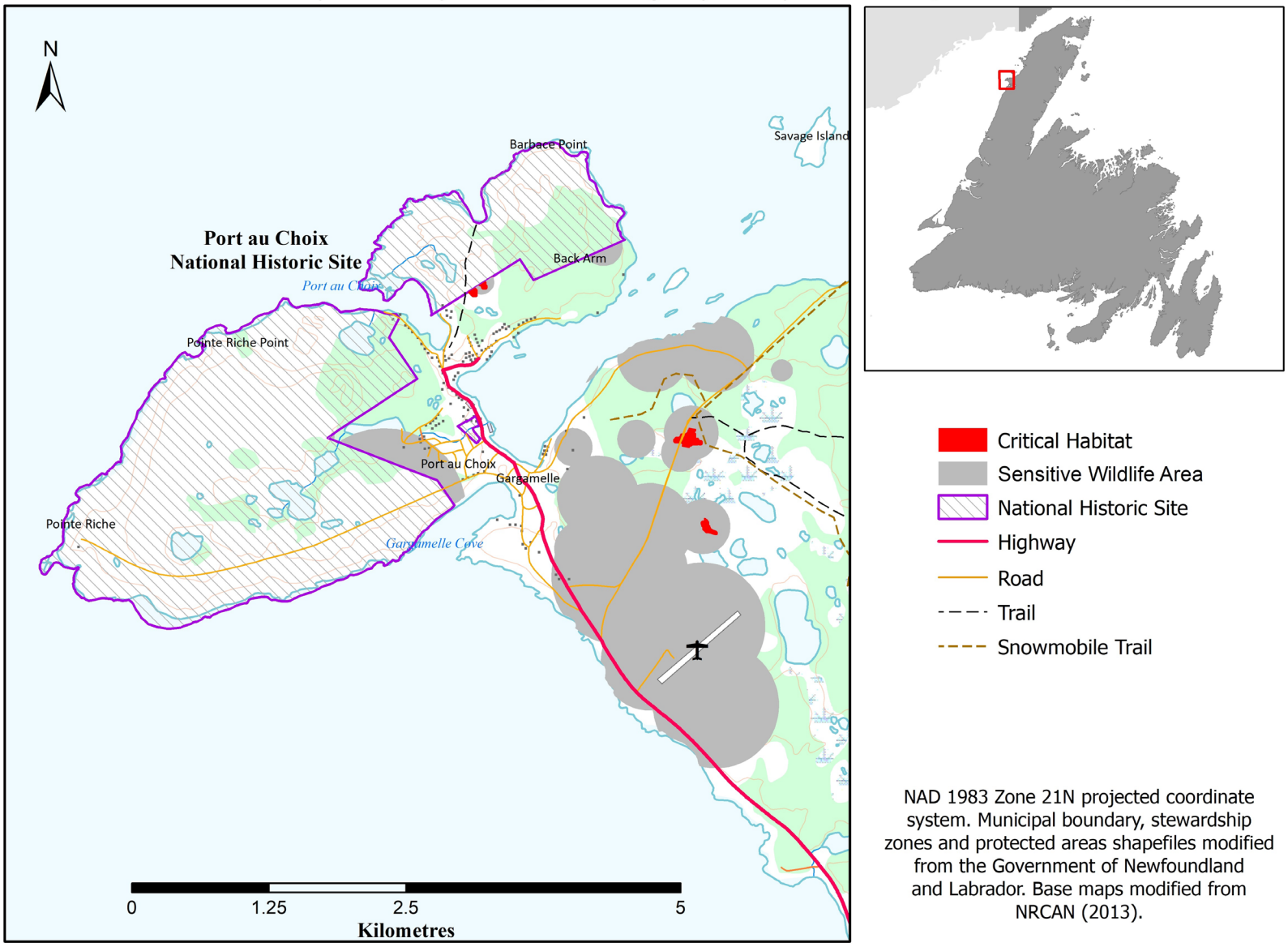

Figure B14. Wooly Arnica (*Arnica angustifolia subsp. tomentosa*) Critical Habitat near Port au Choix National Historic Site. Sensitive Wildlife Areas are for multiple plant species.

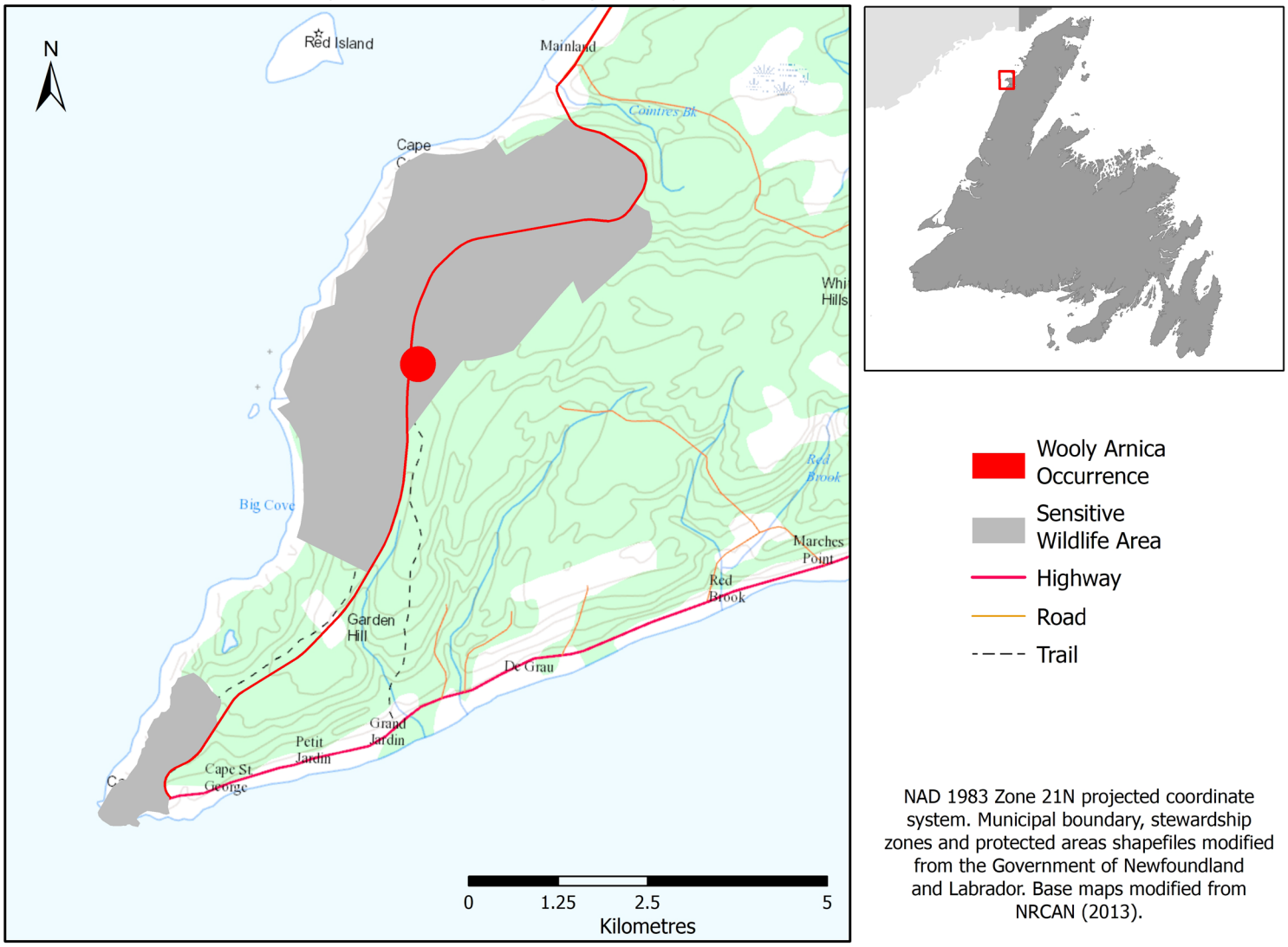

Figure B15. Wooly Arnica (*Arnica angustifolia subsp. tomentosa*) occurrence on the Port au Port Peninsula. Critical Habitat will be identified at a later date. Sensitive Wildlife Areas are for multiple plant species.

Figure B16. Griscom's Arnica (*Arnica griscomii* subsp. *griscomii*) (Photo: M. Burzynski 2012).

Griscom's Arnica (*Arnica griscomii subsp. griscomii*) is a low-growing, showy, perennial in the Asteraceae that produces a rosette of basal leaves with typically one (but up to three) yellow, daisy-like flower heads (Figure B16). It is a calciphile. The hairless, slightly fleshy, yellow-green leaves tend to lie flat to the ground (COSEWIC 2014).

Each leaf has three or four pairs of small, shallow teeth along the margin and three main veins. Occasionally, a reddish coloration may be seen along the veins and edges. The two lower lateral veins of each leaf curve inward towards the middle vein (Species Status Advisory Committee 2012a).

<table>
<tr><td colspan="2">Common name: Griscom's Arnica</td><td colspan="2">Scientific name: Arnica griscomii subsp. griscomii</td></tr>
<tr><td colspan="2">Provincial listing (ESA): Endangered</td><td colspan="2">Federal listing (SARA): Threatened</td></tr>
<tr><td>Global:
G5T1 Secure, Subspecies Critically Imperilled
(NatureServe)</td><td>National:
Not ranked separately from parent taxon</td><td colspan="2">Provincial:
S1S2 Critically Imperilled to Imperilled (Canadian Endangered Species Conservation Council 2016)</td></tr>
<tr><td colspan="2">SSAC assessment history: Endangered (2012)</td><td colspan="2">COSEWIC assessment history: Threatened (2014)</td></tr>
<tr><td colspan="4">Reason for designation: Griscom's Arnica has a limited distribution with only four extant populations in NL. Quality of habitat in limestone barrens faces continued decline due to climate change, anthropogenic activity and ungulate activity (Species Status Advisory Committee 2012a).</td></tr>
<tr><td colspan="4">Newfoundland and Labrador occurrence: Within NL, Griscom's Arnica only four extant or former occurrences are known: St. John Island, Highlands of St. John, Port au Choix and Killdevil Mountain. The Highlands of St. John population is historical (Species Status Advisory Committee 2012a). All sites are within 2 km of the coast.</td></tr>
<tr><td colspan="4">Canadian and Global occurrence: Griscom's Arnica is only found in Newfoundland and Labrador (island portion) and Quebec. These occurrences represent the plant's entire global range (Species Status Advisory Committee 2012a; COSEWIC 2014).</td></tr>
<tr><td colspan="4">Legal protection: Endangered Species Act (NL), Species at Risk Act (Federal)</td></tr>
</table>

Distribution: Since 2000, no new occurrences have been found, but the area of occupancy in the Port au Choix area has been further refined (Wentzell 2016). Not all potential habitat has been surveyed.
Best population estimate: Approximately 50,000 shoots, of which 8,000 are flowering. This estimate is based on 40,000 shoots (including 6,400 flowering) counted from 2012 to 2017 and the high likelihood of occurrence of this species in patches of potential habitat that have not yet been searched (M. Burzynski, pers. comm., Wentzell 2016, Whitaker and Robineau-Charette 2017). In 2012, the Newfoundland population represented approximately 84% of the global total (COSEWIC 2014). It is not known how many of these shoots are connected belowground or genetically distinct.
Trends: Long term trends are not known. During a recount at Port au Choix, the total number of plants declined from an estimated 63,800 in 2012 to 35,000 in 2016. The number of flowering stems decreased by >70%. (M. Burzynski, pers. comm., Wentzell 2016). The Killdevil Mountain population declined from 338 flowering plants in 2004 to 145 in 2017, which includes the complete loss of an isolated patch of 45 flowering plants (Whitaker and Robineau-Charette 2017).
Relevant biological information: The species is apomictic (able to produce seeds without fertilization) (COSEWIC 2014). Because pollen viability is low, cross fertilization among different plants is probably rare and sub-populations are probably genetically unique. It is easily grown from stratified (cold treated) seeds, which are dispersed by wind. The species also reproduces vegetatively by rhizomes (underground stems). Clumps in full-sun have a higher percentage of flowering stems than clumps growing in partial shade. (Species Status Advisory Committee 2012a). Its asexual seed production and rhizomes connecting tufts underground make the determination of an individual very difficult.
Natural stressors and limiting factors: It does not colonize new sites easily, has not colonized degraded barrens, and is not very competitive with faster growing plant species (Species Status Advisory Committee 2012a, COSEWIC 2014). It likely has a higher requirement for moisture than the other three Arnica species in Newfoundland (Species Status Advisory Committee 2012a). Substrate instability may also be a stressor for plants growing on cliffs and other sites subject to erosion.
Threats to the species: Trampling (by ungulates and tourist traffic), ATV use, indirect effects of climate change which may favour faster growing plants (Species Status Advisory Committee 2012a, COSEWIC 2014).

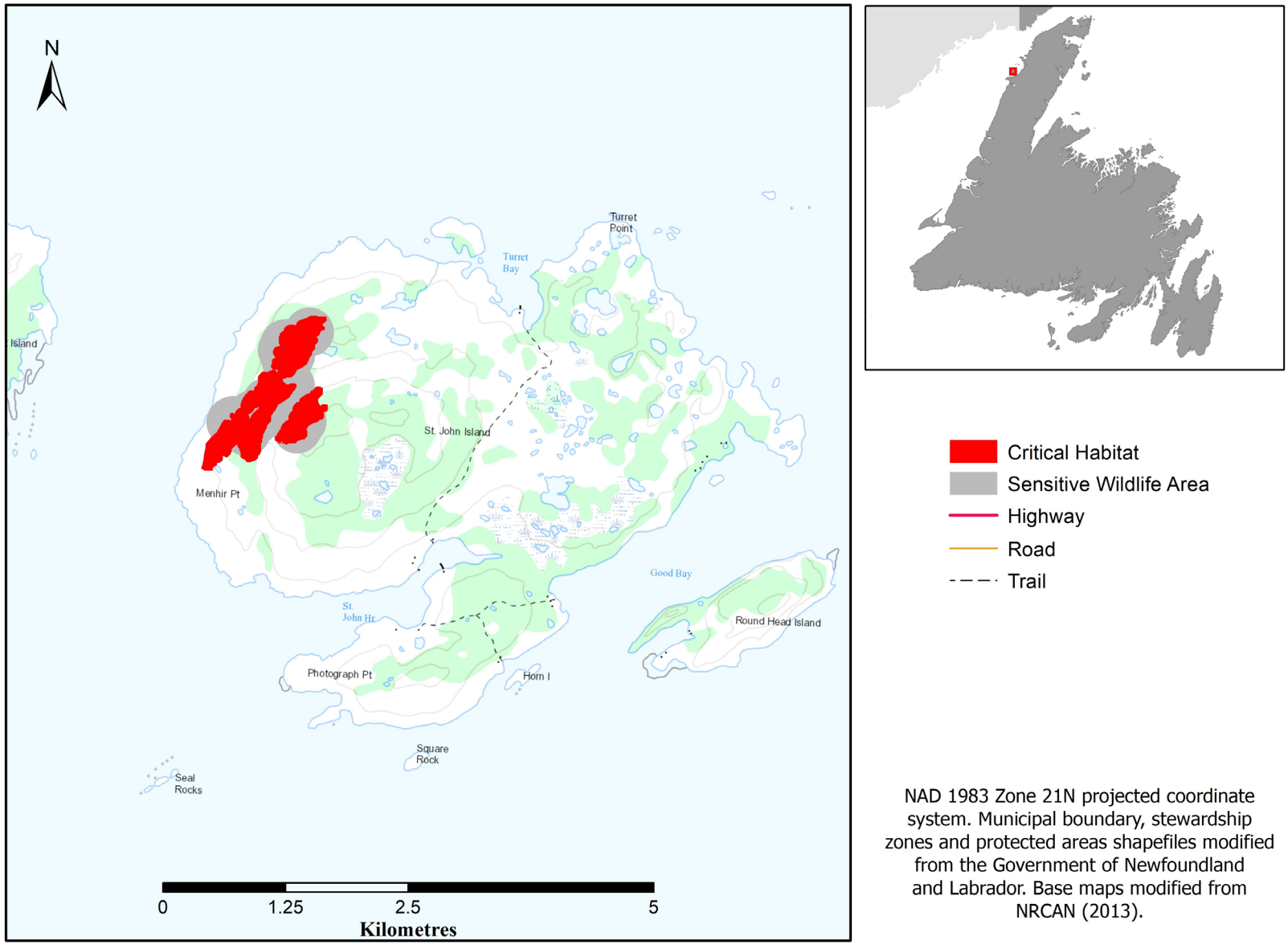

Figure B17. Griscom's Arnica (*Arnica griscomii subsp. griscomii*) Critical Habitat on St. John Island. Sensitive Wildlife Areas are for multiple plant species.

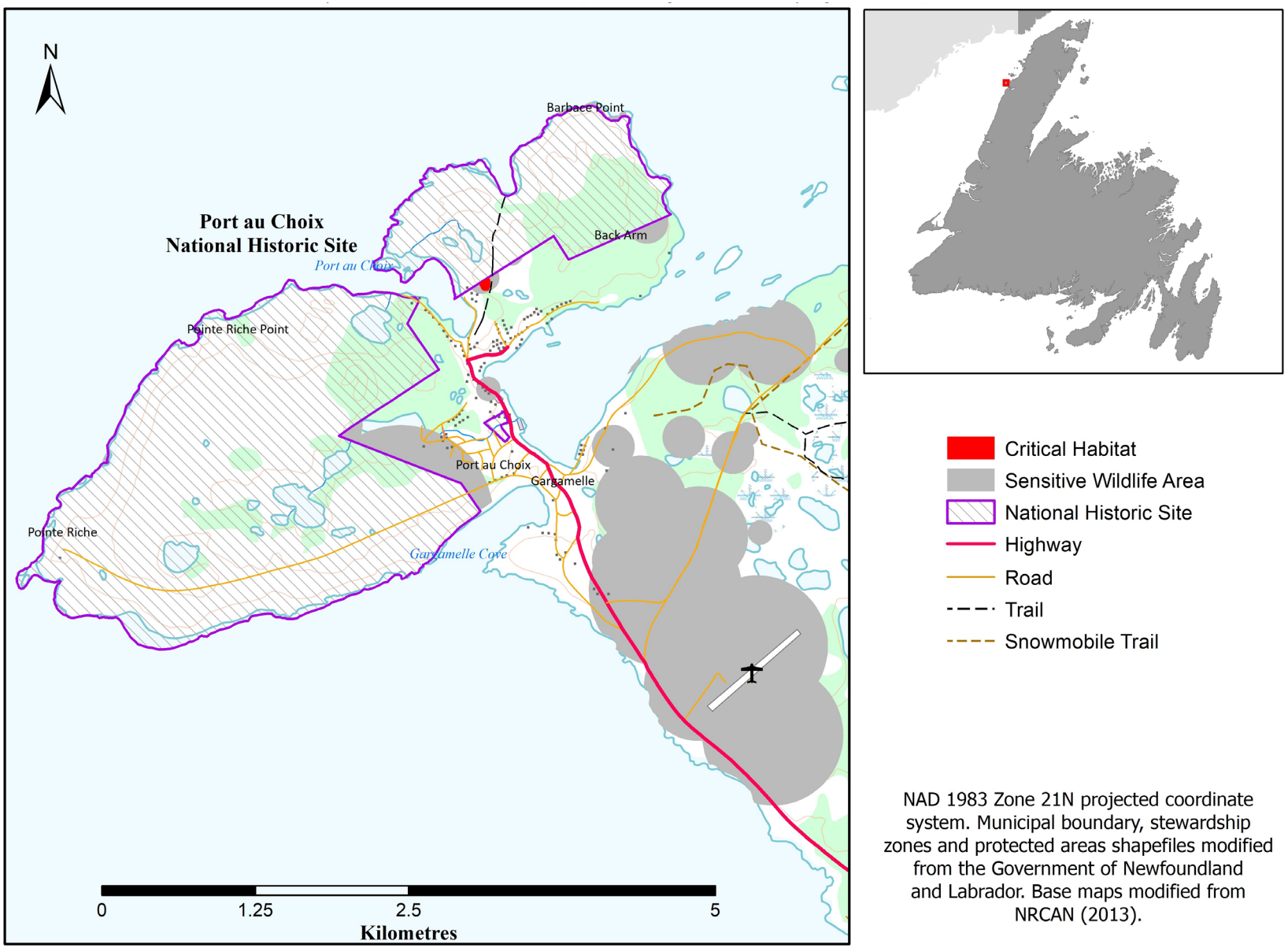

Figure B18. Griscom's Arnica (*Arnica griscomii subsp. griscomii*) Critical Habitat near Port au Choix National Historic Site. Sensitive Wildlife Areas are for multiple plant species.

Figure B19. Bodin's Milkvetch (*Astralagalus bodinii*). (Photo: J. Maunder 2008).

Bodin's Milkvetch (*Astragalus bodinii*) is a calciphilic perennial in the Fabaceae (Figure B19). Growing from a taproot, its radial branches are carpet forming. Stems are usually many, slender, and typically reddish tinged (Species Status Advisory Committee 2008a).

Pinnately-divided, leaves are divergent, with 8-19 elliptic, blueish-green leaflets 0.2-1 cm long. Flowers are solitary or in small clusters of 2-10, pea-like, pinkish-blue (magenta), and typically 8-11 mm in diameter or length. Legumes (fruit) are 6-8 mm long, 2.5-4 mm thick, and 5-8 seeded (Species Status Advisory Committee 2008a).

<table>
<tr><td colspan="2">Common name: Bodin's Milkvetch</td><td colspan="2">Scientific name: Astragalus bodinii</td></tr>
<tr><td colspan="2">Provincial listing (ESA): Threatened</td><td colspan="2">Federal listing (SARA): None</td></tr>
<tr><td>Global:
G4 Apparently Secure
(NatureServe)</td><td colspan="2">National:
N4N5 – Apparently Secure to Secure (Canadian Endangered Species Conservation Council 2016)</td><td>Provincial:
S1 – Critically Imperilled (Canadian Endangered Species Conservation Council 2016)</td></tr>
<tr><td colspan="2">SSAC assessment history:
Threatened (2008), Threatened (2019)</td><td colspan="2">COSEWIC assessment history: N/A</td></tr>
<tr><td colspan="4">Reason for designation: This calciphillic perennial is highly restricted to a 1.6 km stretch of coastal limestone barren, in an ecosystem that has suffered habitat loss and degradation (Species Status Advisory Committee 2008a).</td></tr>
<tr><td colspan="4">Newfoundland and Labrador occurrence: Bodin's Milkvetch is known from only one location near Cook's Point Peninsula of NF (Species Status Advisory Committee 2008a).</td></tr>
<tr><td colspan="4">Canadian & Global occurrence: Bodin's Milkvetch is a North American species found mainly in the western USA and in western Canada in MB, SK, AB, the Northwest Territories, and Yukon Territory. It is disjunct in Newfoundland and Labrador (Species Status Advisory Committee 2008a).</td></tr>
<tr><td colspan="4">Legal protection: Endangered Species Act (NL)</td></tr>
<tr><td colspan="4">Distribution: No new information or changes since 2008 (Species Status Advisory Committee 2019).</td></tr>
<tr><td colspan="4">Best population estimate: Not available due to its mat-forming growth habit.</td></tr>
<tr><td colspan="4">Trends: Not available</td></tr>
</table>

Relevant biological information: The species fixes nitrogen (Allen et al. 1964). Tolerant of, but probably not requiring, close proximity to the coast, including salt spray.
Natural stressors and limiting factors: Believed to be a poor competitor with taller plants due to its low stature.
Threats to the species: ATV use, turf cutting, sea level rise due to climate change.

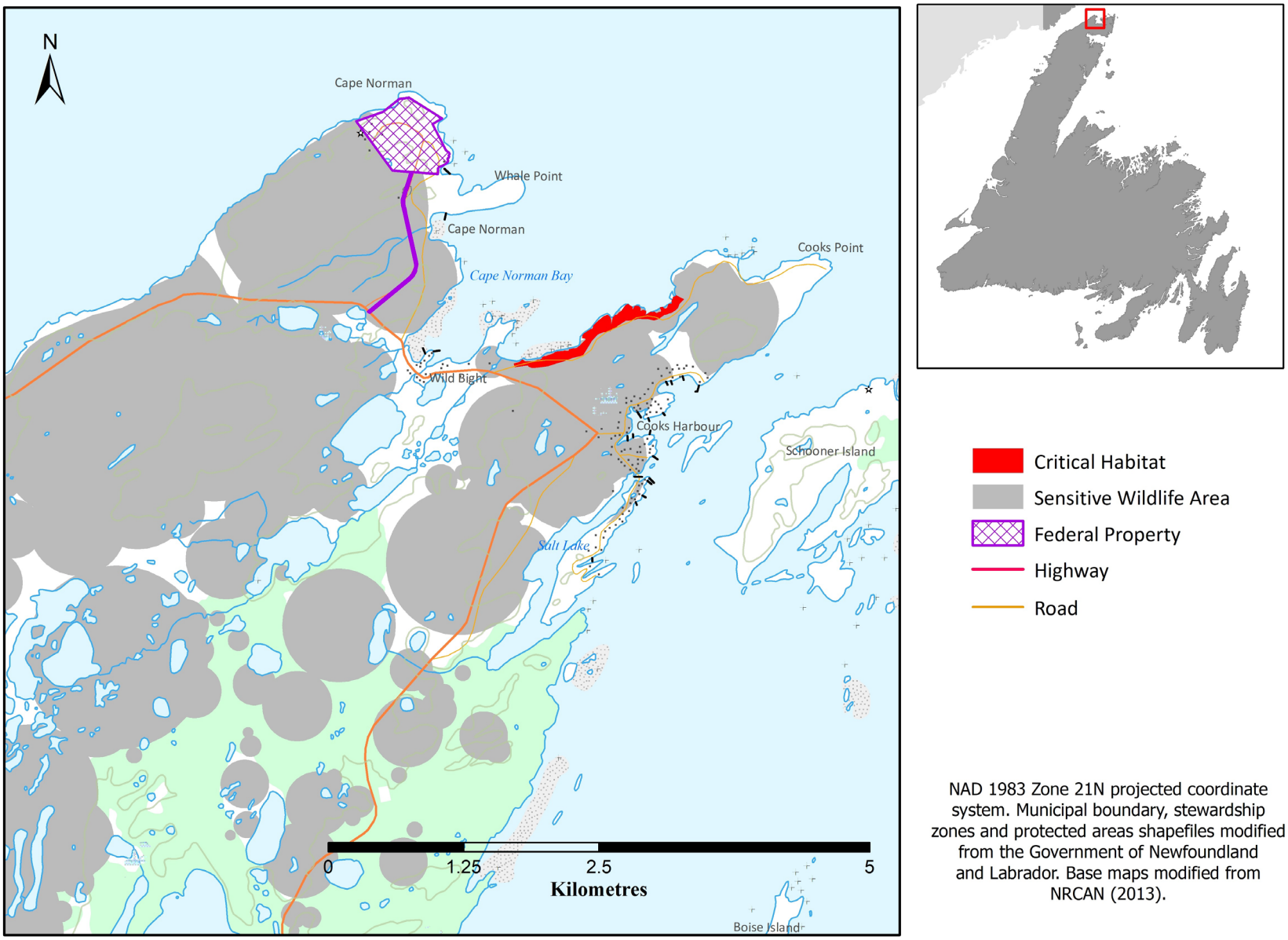

Figure B20. Bodin's Milkvetch (*Astragalus bodinii*) Critical Habitat in the Cook's Harbour area. Sensitive Wildlife Areas are for multiple plant species.

Figure B21. Oval-leaved Creeping Spearwort (*Ranunculus flammula* var. *ovalis*) (Photo: J. Maunder 2008).

Oval-leaved Creeping Spearwort (*Ranunculus flammula* var. *ovalis*) is an amphibious, trailing perennial rooting at the nodes, in the Ranunculaceae (Figure B21) (Species Status Advisory Committee 2008b).

Leaves are short, spoon-shaped, broad and thick, with a narrow base and pointed tip

Small, yellow flowers are produced throughout the summer starting in June (Species Status Advisory Committee 2008b).

<table>
<tr><td colspan="2">Common name: Oval-leaved Creeping Spearwort</td><td colspan="2">Scientific name: Ranunculus flammula var. ovalis</td></tr>
<tr><td colspan="2">Provincial listing (ESA): Endangered</td><td colspan="2">Federal listing (SARA): None</td></tr>
<tr><td>Global:
G5T5 Secure, Secure Variety (NatureServe)</td><td>National:
Not ranked separately from parent taxon</td><td colspan="2">Provincial:
Not ranked separately from parent taxon</td></tr>
<tr><td colspan="2">SSAC assessment history: Endangered (2008)</td><td colspan="2">COSEWIC assessment history: N/A</td></tr>
<tr><td colspan="4">Reason for designation: Historical gravel quarrying and scraping heavily affected this species, resulting in loss of suitable limestone barrens habitat, and probable extirpation from one area (Species Status Advisory Committee 2008b).</td></tr>
<tr><td colspan="4">Newfoundland and Labrador occurrence: Only four occurrences of Oval-leaved Creeping Spearwort are known, all on the island of Newfoundland: Port au Choix, Point Riche, St. John Island, and Sandy Cove; the latter two are historical (Species Status Advisory Committee 2008b).</td></tr>
<tr><td colspan="4">Canadian & Global occurrence: Oval-leaved Creeping Spearwort is found across Canada in all provinces and the Northwest Territories, in several northeastern, northern, and western states of the USA, and in Iceland (Species Status Advisory Committee 2008b).</td></tr>
<tr><td colspan="4">Legal protection: Endangered Species Act (NL)</td></tr>
<tr><td colspan="4">Distribution: No new occurrences have been added since 2008 but the known occurrence at Port au Choix has been expanded to a much larger area. Much unexamined habitat that is transitional between limestone barrens and wetland exists in the northern barrens.</td></tr>
<tr><td colspan="4">Best population estimate: Intensive searches in the Port au Choix area revealed that the species is much more widespread and abundant in this area than the 500 individuals</td></tr>
</table>

estimated to exist in 2008 (Species Status Advisory Committee 2008b). The species population possibly exceeds 2000 individuals, but is impossible to count due to the intermixed trailing stems.
Trends: Not available. Patches exhibit a large amount of annual fluctuation in area and density depending on precipitation patterns.
Relevant biological information: Birds and vehicles suspected to be dispersal vectors, has a prolonged flowering season (Wildlife Division, unpublished data).
Natural stressors and limiting factors: The species dependence on high amount of soil moisture, which varies greatly among years. It could potentially be confused, and is suspected to hybridize, with Creeping Spearwort (*Ranunculus flammula* var. *reptans*) (Wildlife Division, unpublished data).
Threats to the species: Off-road use of road vehicles, ATV use, wood piling, unauthorized quarrying.

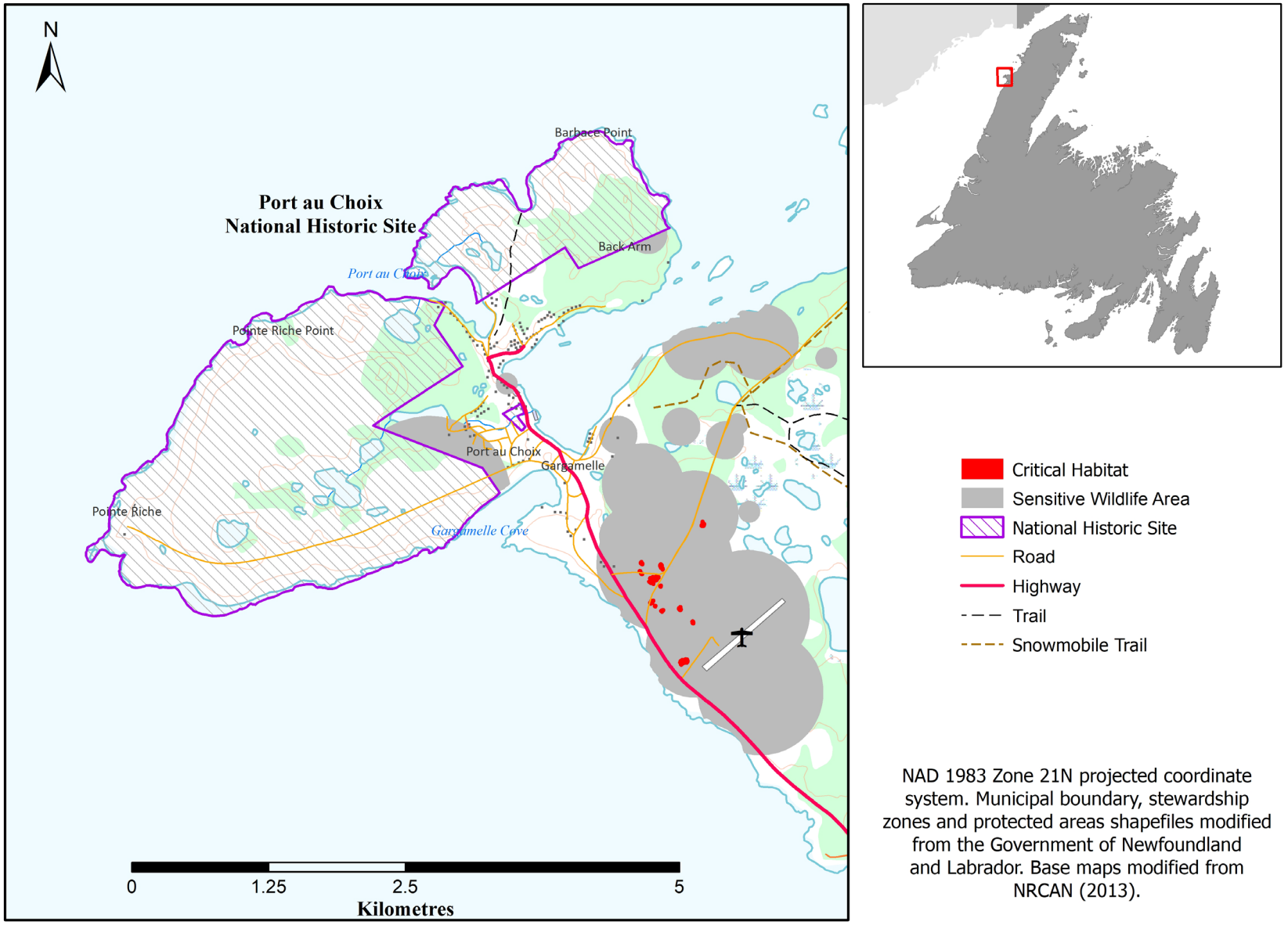

Figure B22. Oval-leaved Creeping Spearwort (*Ranunculus flammula var. ovalis*) Critical Habitat near Port au Choix National Historic Site. Sensitive Wildlife Areas are for multiple plant species.

Figure B23. Lindley's Aster (*Symphyotrichum ciliolatum*) (Photo: C. Hanel 2007).

Lindley's Aster (*Symphyotrichum ciliolatum*) is a medium-sized perennial in the Asteraceae, which can form small clumps and spread by rhizomes (underground runners) (Figure B23). It is a calciphile. The basal leaves have broad, shallowly cordate (heart-shaped) blades, which often appear uneven, and are usually withering by the time the plant flowers (Species Status Advisory Committee 2009).

A small cluster of flower heads is borne on leafy stems sometimes tinged with purple. The showy ray flowers are purple-blue and surround a cluster of yellow disk flowers in the centre. The fruit are dry with a pappus (hair or parachute) for dispersal (Species Status Advisory Committee 2009).

<table>
<tr><td colspan="2">Common name: Lindley's Aster</td><td colspan="2">Scientific name: Symphyotrichum ciliolatum</td></tr>
<tr><td colspan="2">Provincial listing (ESA): Endangered</td><td colspan="2">Federal listing (SARA): None</td></tr>
<tr><td>Global:
G5 Secure
(NatureServe)</td><td colspan="2">National:
N5 Secure (Canadian Endangered Species Conservation Council 2016)</td><td>Provincial:
S2 Imperilled (Canadian Endangered Species Conservation Council 2016)</td></tr>
<tr><td colspan="2">SSAC assessment history:
Endangered (2012)</td><td colspan="2">COSEWIC assessment history: N/A</td></tr>
<tr><td colspan="4">Reason for designation: The area of occupancy is less than 50 km² with only 5 known localities (two of them being historical). Within the occupied area, the extent and quality of the habitat have declined, and are predicted to continue declining, due to anthropogenic activities (Species Status Advisory Committee 2009).</td></tr>
<tr><td colspan="4">Newfoundland and Labrador occurrence: Lindley's Aster is known from five occurrences surrounding St. Georges Bay, with two of these being historical. The most significant occurrences are the central Port au Port Peninsula and Table Mountain (Species Status Advisory Committee 2009, Wildlife Division, unpublished data).</td></tr>
<tr><td colspan="4">Canadian and Global occurrence: Lindley's Aster is widely distributed throughout Canada, found in all provinces and territories, excluding Nunavut. Throughout North America it is also found in Maine, Vermont, New Hampshire, Massachusetts, New York, Michigan, Indiana, Wisconsin, Illinois, Minnesota, North Dakota, South Dakota, Montana and Wyoming (Species Status Advisory Committee 2009).</td></tr>
<tr><td colspan="4">Legal protection: Endangered Species Act (NL)</td></tr>
</table>

Distribution: The full area of occupancy within its NL distribution is not yet completely known. No new occurrences have been found since 2007, but the known occupied area has been expanded (Wildlife Division, unpublished data).
Best population estimate: The number of reproductive individuals was estimated at 600,000 based on extrapolation from transect surveys conducted in 2007 in the central Port au Port Peninsula (Species Status Advisory Committee 2009). During a short survey on Table Mountain in 2015, many patches were recorded in a relatively small area, suggesting that there are at least several hundred, possibly up to tens of thousands, of additional individuals in this area (S. Bennett, unpublished data).
Trends: Not available
Relevant biological information: The species is rhizomatous, insect pollinated, less moisture-requiring than the related New York Aster (Species Status Advisory Committee 2009).
Natural stressors and limiting factors: The species is known to hybridize with New York Aster (*Symphyotrichum novi-belgii*), but the full extent of the hybridization is not known. It has not known to which extent the hybridization is naturally occurring is believed to be facilitated by clearing of woody vegetation
Threats to the species: Quarrying, road and utility maintenance, oil and mineral exploration, acceleration of hybridization due to anthropogenic alteration of surrounding habitat, which facilitates contact with New York Aster (Species Status Advisory Committee 2009, C. Hanel, pers. comm). Moose are also believed to be a threat by inhibiting reforestation of clearings and transporting seeds, both of which increase the area of contact between the two Aster species (Species Status Advisory Committee 2009).

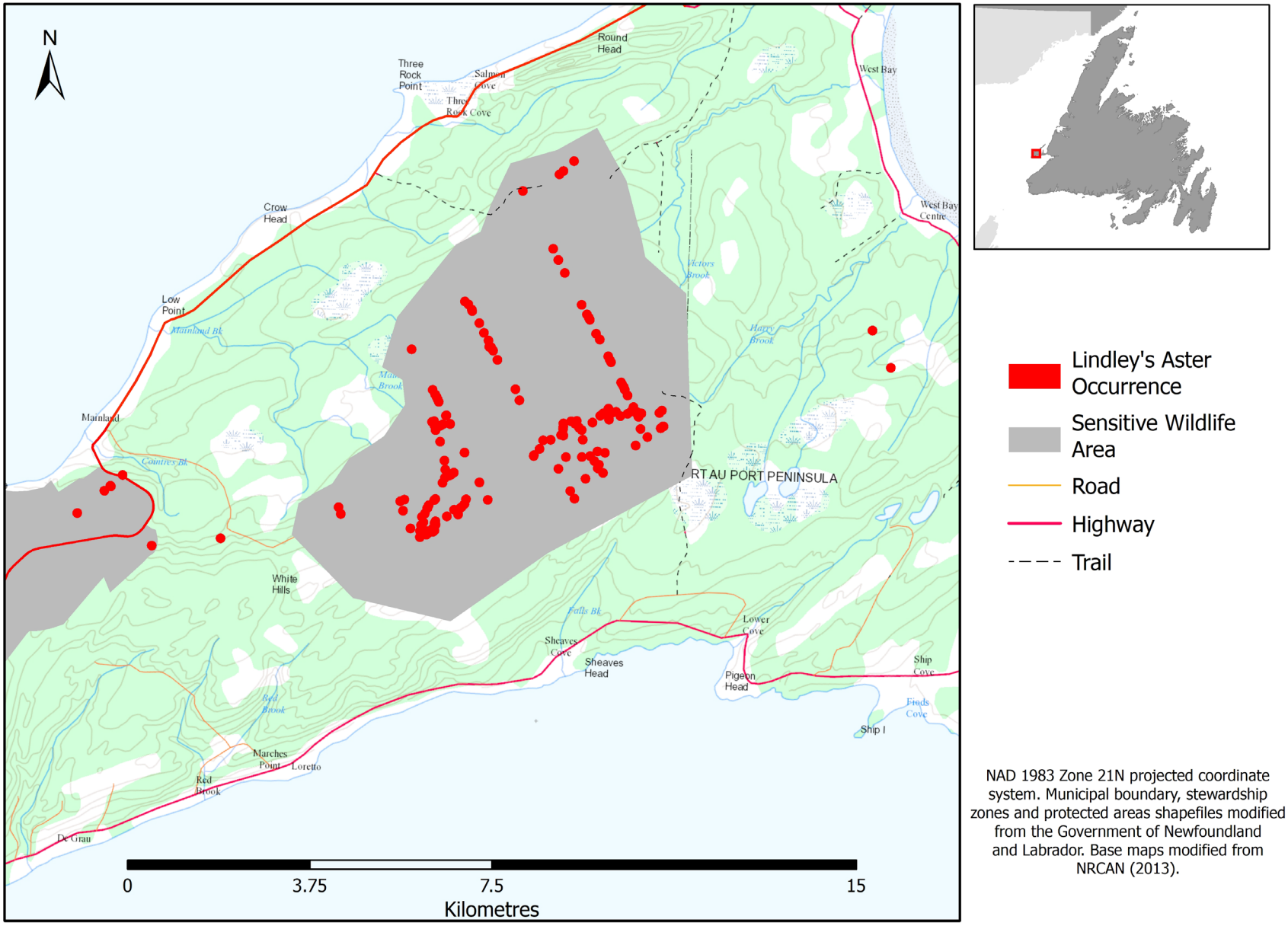

Figure B24. Lindley's Aster (*Symphyotrichum ciliolatum*) occurrences on the Port au Port Peninsula. Sensitive Wildlife Areas are for multiple plant species.

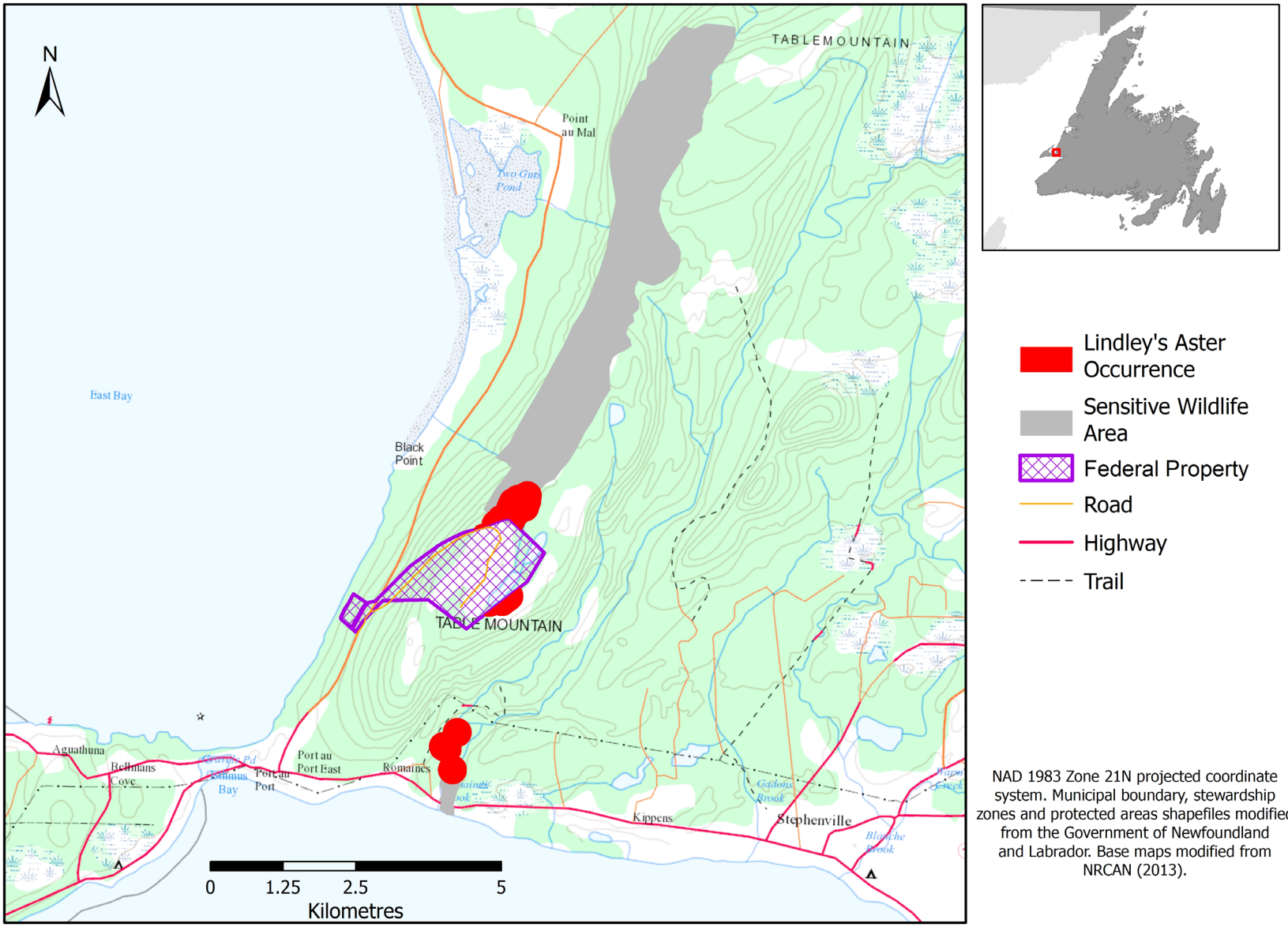

Figure B25. Lindley's Aster (*Symphyotrichum ciliolatum*) occurrences at Table Mountain and Romaines Brook. Sensitive Wildlife Areas are for multiple plant species.

Figure B26. Mackenzie's Sweetvetch (*Hedysarum boreale* subsp. *mackenzii*). (Photo: J. Maunder 2007).

Mackenzie's Sweetvetch (*Hedysarum boreale* subsp*. mackenzii*) is a low-growing perennial in the Fabaceae (Figure B26). Its stems spread radially from a thick and fibrous taproot, forming a circular clump (Species Status Advisory Committee 2006).

Pinnately compound, hairy leaves are distributed along the stem in an alternate pattern. Leaflets are typically 5-13 mm wide and 5-15 mm long. Each clustered inflorescence contains 5-15 flowers, which are pea-like, magenta, scented, and typically 15 mm in diameter or length (Species Status Advisory Committee 2006).

<table>
<tr><td colspan="2">Common name: Mackenzie's Sweetvetch</td><td colspan="2">Scientific name: Hedysarum boreale subsp. mackenzii</td></tr>
<tr><td colspan="2">Provincial listing (ESA): Endangered</td><td colspan="2">Federal listing (SARA): None</td></tr>
<tr><td>Global:
G5T5 Secure, Subspecies Secure (NatureServe)</td><td colspan="2">National:
N5 Secure (Canadian Endangered Species Conservation Council 2016)</td><td>Provincial:
S1 Critically Imperilled (Canadian Endangered Species Conservation Council 2016)</td></tr>
<tr><td colspan="2">SSAC assessment history: Endangered (2006), Threatened (2019)</td><td colspan="2">COSEWIC assessment history: N/A</td></tr>
<tr><td colspan="4">Reason for designation: A boreal-arctic disjunct that is restricted to two occurrences on the limestone barrens in an ecosystem that has suffered habitat loss and degradation. No rescue effect possible due to disjunction.</td></tr>
<tr><td colspan="4">Newfoundland and Labrador occurrence: Mackenzie's Sweetvetch is only known from Cape St. George and a nearby area south of Mainland (Grand Terre), both on the Port au Port Peninsula of NF (Species Status Advisory Committee 2006).</td></tr>
<tr><td colspan="4">Canadian & Global occurrence: Mackenzie's Sweetvetch is found in all provinces and territories except the NS, NB, and PE (Species Status Advisory Committee 2006).</td></tr>
<tr><td colspan="4">Legal protection: Endangered Species Act (NL)</td></tr>
<tr><td colspan="4">Distribution: Between 2014 and 2018, the previously known area of occupancy south of Mainland (Grand Terre) has expanded to the north, south and west, with thousands of additional plants counted. The known area of occupancy at Cape St. George has been expanded to the north. An estimated 60-80% of the suitable habitat has been searched (Species Status Advisory Committee 2019).</td></tr>
</table>

Best population estimate: Between 2011 and 2018, 3860 plants were counted or extrapolated from subsamples, covering most of the known area of occupancy. These were casual counts, which included only large plants visible while walking. During detailed counts in permanent plots, 2.5 vegetative plants were detected for each flowering plant. This ratio was used estimate the total population estimate, which includes unsurveyed potential habitat, of between 9,500 and 15,000 individuals, including 2700 to 4300 flowering plants (Wildlife Division, unpublished data).
Trends: Not available.
Relevant biological information: The species fixes nitrogen, lives up to 20 years, and needs to be pollinated by insects (Species Status Advisory Committee 2006). No seed bank was found and if one is present it is probably insignificant to the species. Seedlings do not make up a large proportion of the population (Zheng 2011, Wildlife Division, unpublished data). Mackenzie's Sweetvetch dislikes root disturbance, and is not easily transplanted, but use of a cultivar for range improvement demonstrated that it is easily grown from seed (Species Status Advisory Committee 2006).
Natural stressors and limiting factors: Low rates of fruit set and seed production were observed in 2016. Leaf spots were also observed, potentially indicating pathogens (Species Status Advisory Committee 2019). The species is intolerant of competition (Species Status Advisory Committee 2006).
Threats to the species: ATV use, maintenance work in parks and on hiking trails, tourist traffic.

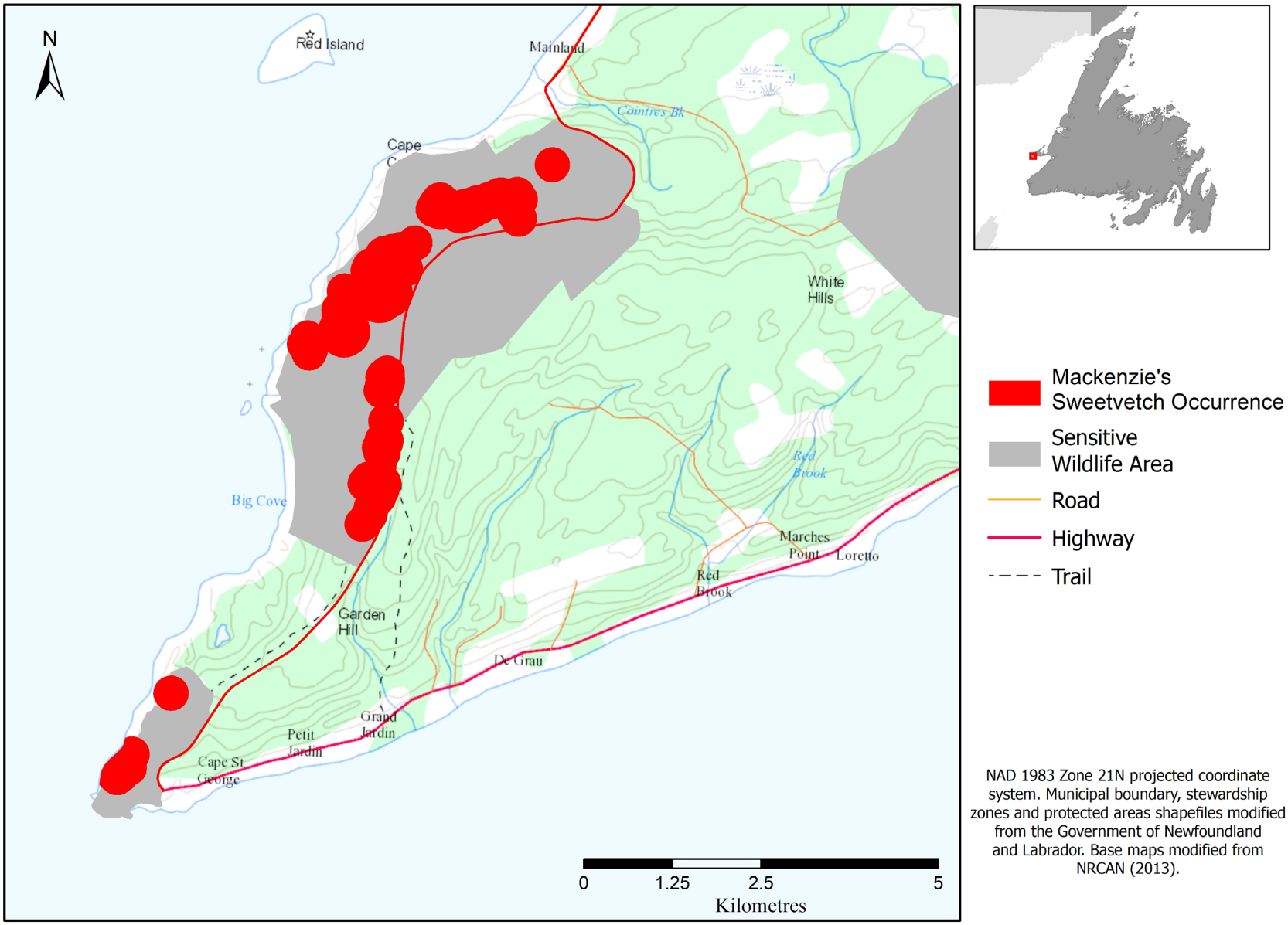

Figure B27. Mackenzie's Sweetvetch (*Hedysarum boreale* subsp. *mackenzii*) occurrences on the Port au Port Peninsula. Sensitive Wildlife Areas are for multiple plant species.

Figure B28. Low Northern Rockcress (*Braya humilis*). (Photo: M. Burzynski 2011)

Low Northern Rockcress (*Braya humilis*) is a small herbaceous perennial in the Brassicaceae (Figure B28). It is a calciphile with a contractile taproot. It has fleshy, dark-green to purplish, basal leaves (2-6 mm long) which are narrow, but widened near the tip to spoon-shaped. Plants can reach heights up to 10 cm (Species Status Advisory Committee 2004).

Unlike Long's Braya and Fernald's Braya, the basal leaves can be toothed, and stem leaves are present but scattered. The inflorescence is a dense raceme of small four-petalled white flowers, which elongates in fruit (Species Status Advisory Committee 2004).

<table>
<tr><td colspan="2">Common name: Low Northern Rockcress</td><td colspan="2">Scientific name: Braya humilis = Neotorularia humilis</td></tr>
<tr><td colspan="2">Provincial Listing (ESA): Endangered</td><td colspan="2">Federal listing (SARA): None</td></tr>
<tr><td>Global:
G5 Secure
(NatureServe)</td><td colspan="2">National:
S1 Critically Imperilled (Canadian Endangered Species Conservation Council 2016)</td><td>Provincial:
S1 Critically Imperilled (Canadian Endangered Species Conservation Council 2016)</td></tr>
<tr><td colspan="2">SSAC assessment history: Endangered (2004)</td><td colspan="2">COSEWIC assessment history: N/A</td></tr>
<tr><td colspan="4">Reason for designation: An arctic-alpine disjunct of the southern limestone barrens, occurring at only one small site on the island of Newfoundland that has suffered habitat loss and degradation.</td></tr>
<tr><td colspan="4">Newfoundland and Labrador occurrence: Low Northern Rockcress is only known to occur on Table Mountain, near the Port au Port Peninsula (Species Status Advisory Committee 2004).</td></tr>
<tr><td colspan="4">Canadian & Global occurrence: Low Northern Rockcress occurs in BC, AB, MB, Yukon Territory, Northwest Territories, NU, ON, QC, and NL, in addition to Greenland, USA, Siberia and Asia (Species Status Advisory Committee 2004).</td></tr>
<tr><td colspan="4">Legal protection: Endangered Species Act (NL)</td></tr>
<tr><td colspan="4">Distribution: Found only on Table Mountain; NL range defined by surveys in 2005, 2006 and 2009 (Wildlife Division, unpublished data). Not found on the nearby Port au Port Peninsula despite extensive surveys.</td></tr>
<tr><td colspan="4">Best population estimate: a few hundred to a few thousand individuals</td></tr>
<tr><td colspan="4">Trends: In permanent plots, large fluctuations in numbers of individuals, up to one order of magnitude, were observed within a 16 year monitoring period, but no single trend predominated. The number of individuals increased from 2004 to high in 2006. This was followed by decline to a low in</td></tr>
</table>

2015, with the number of individuals falling to 1/10 of the maximum and later by a partial recovery to 3x the minimum in 2020. Within the span of one year (2005 to 2006) the number of individuals (both flowering and vegetative) doubled.

Relevant biological information: Based on information about other species of the genus *Braya*, flowers can be self- or cross-pollinated (Parsons 2002; Parsons and Hermanutz 2006). Plants take at least 3-5 years to flower, and mature plants do not necessarily flower every year. Specifics on a seedbank and seed viability are not known but are probably similar to the other Braya species, which have a long-lived seed bank.

Natural stressors and limiting factors: Extremely restricted distribution.

Threats to the species:

Land use: ATV use, utility maintenance, tourist traffic

Pests: Diamondback Moth eggs were observed but in most survey years very little or no damage was recorded (Tilley et al. 2005, Wildlife Division, unpublished data, Species Status Advisory Committee 2016).

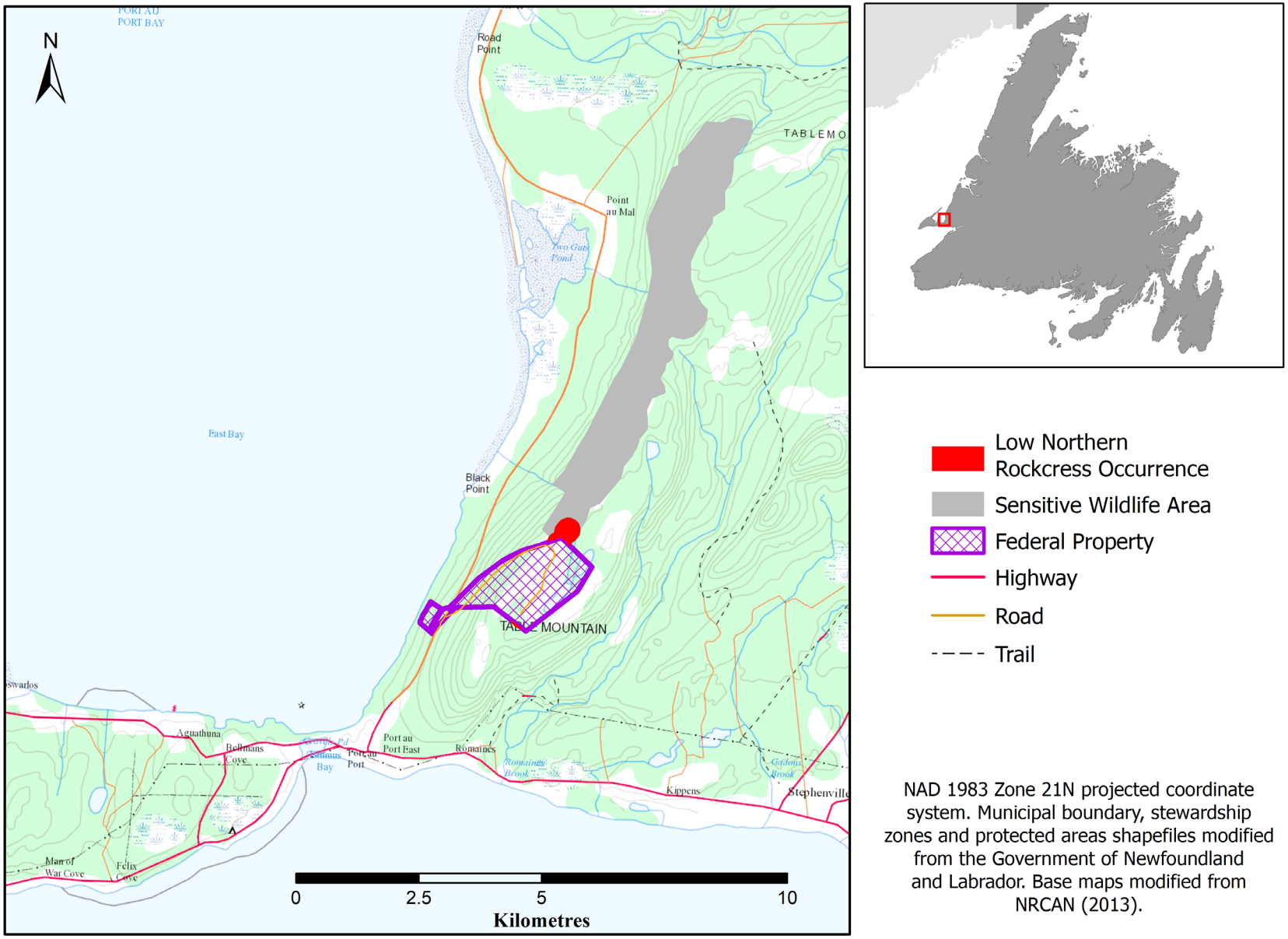

Figure B29. Low Northern Rockcress (*Braya humilis*) occurrences at Table Mountain. Sensitive Wildlife Areas are for multiple plant species.