COSEWIC
Assessment and Status Report

on the

Meadow Thistle
Cirsium scariosum

Rocky Mountain population
Mingan population

in Canada

ENDANGERED
2022

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

COSEWIC. 2022. COSEWIC assessment and status report on the Meadow Thistle *Cirsium scariosum*, Rocky Mountain population and Mingan population in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xv + 81 pp. (https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html).

Production note:
COSEWIC would like to acknowledge Nancy Dénommée, Peter L. Achuff and Patrick Nantel for writing the status report on Meadow Thistle (*Cirsium scariosum*), in Canada, prepared under contract with Environment and Climate Change Canada. This report was overseen and edited by Del Meidinger, Co-chair of the COSEWIC Vascular Plants Specialist Subcommittee.

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur le Chardon écailleux (*Cirsium scariosum*), population des Rocheuses et population de Mingan au Canada.

Cover illustration/photo:
Meadow Thistle — Meadow Thistle (*Cirsium scariosum*). Photograph by Nancy Dénommée.

Catalogue No. CW69-14/817-2022E-PDF
ISBN 978-0-660-44376-8

COSEWIC Assessment Summary

Assessment Summary – May 2022

Common name
Meadow Thistle - Rocky Mountain population

Scientific name
Cirsium scariosum

Status
Endangered

Reason for designation
This perennial herb occurs in grassy montane to subalpine meadows and forest openings in the mountains of southeastern British Columbia and southwestern Alberta. Plants flower and produce seed only once, after 2 to 9 years, and then die. Most plants do not survive to the flowering stage due to herbivory from small mammals and drought. Those plants that do flower are threatened by the non-native Thistle Head Weevil, resulting in little, if any, seed production and a precipitous continuing decline in thistle numbers since 2002. Other threats include mortality related to an increase in wildfire due to climate change, grazing by domestic livestock, and herbicide control programs that target exotic invasive thistle species.

Occurrence
British Columbia, Alberta

Status history
Designated Endangered in May 2022.

Assessment Summary – May 2022

Common name
Meadow Thistle - Mingan population

Scientific name
Cirsium scariosum

Status
Endangered

Reason for designation
This perennial herb is restricted to upper portions of beaches on four islands of the Mingan archipelago in the Gulf of St. Lawrence. The population has a very limited distribution and few individuals – in 2018 it consisted of only 367 mature plants. The population is expected to continue to decline as a result of continuing threats, primarily an increase in storms due to climate change, which cause beach erosion as well as the deposition of sediment and woody debris. Given the small, coastal areas over which the population is found, a single storm can severely impact entire sites. Other threats related to climate change include rising sea level, reduced winter sea ice and snow cover, drought, and tree encroachment.

Occurrence
Quebec

Status history
Designated Endangered in May 2022.

COSEWIC
Executive Summary

Meadow Thistle
Cirsium scariosum

Rocky Mountain population
Mingan population

Wildlife Species Description and Significance

Meadow Thistle (*Cirsium scariosum* var. *scariosum*) is a herbaceous perennial plant with an erect flowering stem arising from a leafy rosette. It is 10-100 cm tall and has pink to purple flowers.

Meadow Thistle has two populations in Canada separated by about 3500 km: a Rocky Mountain population and another on the Mingan Archipelago in the Gulf of St. Lawrence. The two populations have been isolated from each other for thousands of years, have diverged genetically, and are considered separate designatable units. The Mingan population is of scientific and educational significance pertaining to plant survival as affected by both glacial history over thousands of years and current climate change impacts.

Distribution

The Rocky Mountain population occurs in southeastern British Columbia and southwestern Alberta, extends over an estimated range of 3181 km², and is contiguous with populations that extend south to California, Utah, and Colorado. The Mingan population occurs in eastern Quebec in the Gulf of St Lawrence on four islands of the Mingan Archipelago, has a range of about 32 km², and is completely isolated from other North American populations. The total Canadian range represents about 0.5% of the global (North American) range.

Habitat

The western (Rocky Mountain) population occurs predominantly in grassy montane to subalpine meadows and forest openings. These open areas include undisturbed sites and sites affected by both natural (e.g., avalanche, animal activity, fire) and human disturbance (e.g., roads, well sites, gravel pits, cut blocks). The plant appears to be shade-intolerant and often occurs in moist sites.

The eastern (Mingan Archipelago) population consists of scattered individuals confined to a marginal strip of the upper beach between the seashore and inland coniferous forest in well drained soil over limestone bedrock. The plants are exposed to sea water spray as well as storms that erode the site and deposit sediment and plant debris. Meadow Thistle is often scattered between pieces of driftwood and some individuals grow on the edge of the forest where light is sufficient.

Biology

Meadow Thistle flowers and produces seed only once in its life and does not reproduce vegetatively. The flowering stem is produced from a leafy rosette and then the plant dies in that growing season. Flowering plants are produced in the Rocky Mountain population usually after 2-9 years and after 5-22 years in the Mingan population. About 70% of rosettes in the Rocky Mountain population and 97% in the Mingan population do not survive to the flowering stage. The main causes of rosette deaths in the Rocky Mountain population are small mammal herbivory and drought, and in the Mingan population are erosion from storms, competition from other plants, insufficient snow cover, and drought.

Population Sizes and Trends

The Rocky Mountain population in 2019 was estimated to have about 4.4 million individuals of all ages, including about 2.5 million mature plants (capable of reproduction). Based on two transects in Waterton Lakes National Park there was a decline of 96% over three generations (12 years) as well as a similar decline from 2002 to 2019. Repeated counts at 24 spot observations in other parts of the Rocky Mountain population also showed declines (median of -88%), suggesting that the entire population is declining.

The Mingan population in 2018 was composed of 1349 individuals of all ages, including 367 mature plants. The population is estimated to have declined by 26% over the past two generations and is expected to be reduced further by 8% over three generations (2017-2047). The numbers have fluctuated over the years, with some increased recruitment due to seeds being sown by hand. Population models indicate a continuing decline to very low numbers or extirpation, despite recovery interventions implemented since 2001.

Threats and Limiting Factors

The main threat to the Rocky Mountain population is from Thistle Head Weevil, an introduced Eurasian insect. Other lower impact threats include mortality related to an increase in fire frequency, size, and intensity, domestic livestock grazing, and herbicide control programs.

The main threats to the Mingan population are storm events which cause beach erosion as well as the deposition of sediment and woody debris. Storms are likely increasing due to climate change, which is also having effects through rising sea level and reduced winter sea ice. Other threats include reduced habitat area because of tree encroachment, reduced snow cover, and drought.

Protection, Status and Ranks

The Rocky Mountain population occurs primarily on public land (national and provincial parks, provincial crown lands). The Mingan population occurs within Mingan Archipelago National Park Reserve. Meadow Thistle is currently ranked globally as Secure; this rank was last reviewed in 2009 and needs reconsideration. In Canada, it is Vulnerable and, in the USA, ranked as Secure. It is ranked as Critically Imperiled in Quebec, Imperiled in Alberta, and Vulnerable in British Columbia. It is ranked as apparently Secure to Secure in Montana and Imperiled in Wyoming. However, there is no indication that the threat posed by the Thistle Head Weevil throughout western North America has been considered. Meadow Thistle is legally designated as Threatened in Quebec.

TECHNICAL SUMMARY – Rocky Mountain population

Cirsium scariosum

Meadow Thistle
(Rocky Mountain population)

Chardon écailleux
(Population des Rocheuses)

Range of occurrence in Canada: British Columbia, Alberta,

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines (2011) is being used)	3.8 yrs, mean age at flowering
Is there an observed, estimated, inferred, or projected continuing decline in number of mature individuals?	Yes, observed, estimated & projected
Estimated percent of continuing decline in total number of mature individuals within last 2 generations. (2 x 3.8 yrs/gen = 7.6 yrs, rounded to 8 yrs.	-78%, estimated
[Observed, estimated, inferred, or suspected] percent reduction in total number of mature individuals over the last 3 generations. (3 x 3.8 yrs/gen = 11.4 yrs, rounded to 12 yrs)	-96%, observed & estimated
[Projected or suspected] percent reduction in total number of mature individuals over the next 3 generations.	-87%, projected
[Observed, estimated, inferred, or suspected] percent reduction in total number of mature individuals over any 3 generations period, over a time period including both the past and the future.	-87%, estimated and projected
Are the causes of the decline: a. clearly reversible and b. understood and c. ceased?	a. no, b. yes, c. no
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	3181 km²
Index of area of occupancy (IAO) (Always report 2x2 grid value).	340 km² (85 grid squares)
Is the population "severely fragmented" i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. no b. no

Number of "locations"* (use plausible range to reflect uncertainty if appropriate)	2-4 locations – Thistle Head Weevil
Is there an [observed, inferred, or projected] decline in extent of occurrence?	Yes, projected
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Yes, projected
Is there an observed, inferred, or projected decline in number of local subpopulations?	Yes, projected
Is there an [observed, inferred, or projected] decline in number of "locations"*?	No.
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Possible inferred decline in habitat area and quality from grazing, Thistle Head Weevil, or weed management. Effect of fire on habitat is mixed & varies over time. See **Habitat Trends** section.
Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of "locations"*?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals

Subpopulations (give plausible ranges)	**N Mature Individuals**
Rocky Mountain population (subpopulations not delineated over the full range; 35 subpopulations recently delineated in British Columbia)	Estimated 2.5 million (range 457,000 to 4.9M) – large uncertainty
Total	Estimated 2.5 million

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations, or 10% within 100 years]?	Analysis not done

* See Definitions and Abbreviations on COSEWIC website and IUCN for more information on this term.

Threats (direct, from highest impact to least, as per IUCN Threats Calculator)

Was a threats calculator completed for this species? Yes, Very High threat impact. 8.1 non-native insect – Thistle Head Weevil (*Rhinocyllus conicus*) [Very High impact] 7.1 fire [Medium – Low impact] 7.3 herbicides [Medium – Low impact] 2.3 grazing [Medium – Low impact] What additional limiting factors are relevant? Monocarpy (plants die after flowering and setting seed) and early phenology

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	Unknown but populations in USA also affected by Thistle Head Weevil
Is immigration known or possible?	Yes
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Are conditions deteriorating in Canada?	Yes
Are conditions for the source (i.e., outside) population deteriorating?	Yes
Is the Canadian population considered to be a sink?	Yes
Is rescue from outside populations likely?	Possible, but unlikely as US population also impacted by Thistle Head Weevil, reducing the possibility of immigrants and survival an issue once established in Canada.

Data Sensitive Species

Is this a data sensitive species?	No

Status History

COSEWIC: Designated Endangered in May 2022.

Status and Reasons for Designation:

Status: Endangered	**Alpha-numeric codes:** A2bce+3bce+4bce; B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v)
Reasons for designation: This perennial herb occurs in grassy montane to subalpine meadows and forest openings in the mountains of southeastern British Columbia and southwestern Alberta. Plants flower and produce seed only once, after 2 to 9 years, and then die. Most plants do not survive to the flowering stage due to herbivory from small mammals and drought. Those plants that do flower are threatened by the non-native Thistle Head Weevil, resulting in little, if any, seed production and a precipitous continuing decline in thistle numbers since 2002. Other threats include mortality related to an increase in wildfire due to climate change, grazing by domestic livestock, and herbicide control programs that target exotic invasive thistle species.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Endangered, A2bce, as there was an estimated 96% decline in number of mature individuals over the past three generations (12 years), based on combination of direct observation and extrapolation, a decline in habitat quality, and the impact of the introduced Thistle Head Weevil. Meets Endangered, A3bce, as there was a projected 87% decline in number of mature individuals over the next three generations, and meets Endangered, A4bce, as there was an estimated and projected 87% decline in number of mature individuals over three generations spanning past and future.
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Endangered, B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v). Both EOO (3181 km²) and IAO (340 km²) are below the threshold, the population is known to exist at 2-4 locations, and is experiencing a continuing decline in (v) number of mature individuals, and an inferred or projected decline in (i) EOO, (ii) IAO, (iii) area and quality of habitat, and (iv) number of subpopulations.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Number of mature individuals is approximately 2.5 million, exceeding threshold for Threatened.
Criterion D (Very Small or Restricted Population): Not applicable. Estimate of approximately 2.5 million mature individuals exceeds thresholds for D1, and although the population is vulnerable to a rapid and substantial decline due to the impact of Thistle Head Weevil, the population is large (>1000) and has a broad distribution (>20 km²).
Criterion E (Quantitative Analysis): Not applicable. Analysis not conducted.

TECHNICAL SUMMARY – Mingan population

Cirsium scariosum

Meadow Thistle
(Mingan population)

Chardon écailleux
(Population de Mingan)

Range of occurrence in Canada: Quebec

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines (2011) is being used)	10.1 yrs, mean age at flowering
Is there an observed, estimated, inferred, or projected continuing decline in number of mature individuals?	Yes, observed, estimated and projected
Estimated percent of continuing decline in total number of mature individuals within last 2 generations. (2 x 10.1 yrs/gen = 20.2 yrs, rounded to 20 yrs.	-26%, estimated for 1995-2015; -28% observed 1995-2017.
[Observed, estimated, inferred, or suspected] percent reduction in total number of mature individuals over the last 3 generations. (3 x 10.1yrs/gen = 30.3 yrs, rounded to 30 yrs)	Unknown, as available data do not go back 30 years.
[Projected or suspected] percent reduction in total number of mature individuals over the next 3 generations. (3 x 10.1yrs/gen = 30.3 yrs, rounded to 30 yrs)	-8%, projected using a multi-site model. Same model gave a 0.21 probability of 50% decline over the next 3 generations
[Observed, estimated, inferred, or suspected] percent reduction in total number of mature individuals over any 3 generations (3 x 10.1yrs/gen = 30.3 yrs) period, over a time period including both the past and the future.	-19%, estimated for 1995-2025
Are the causes of the decline: a. clearly reversible and b. understood and c. ceased?	a. no, b. yes, partially, c. no
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	32 km²
Index of area of occupancy (IAO) (Always report 2x2 grid value). A slight shift in grid could result in an IAO of 6 grid squares or 24 km^2	32 km² (8 grid squares 2 km x 2 km)

Is the population "severely fragmented" i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. no, as all sites in one subpopulation b. no, as all sites are in one subpopulation.
Number of "locations"* (use plausible range to reflect uncertainty if appropriate)	2 to 6 locations, based on interpretation of impact of storms
Is there an [observed, inferred, or projected] decline in extent of occurrence?	Yes, observed, projected
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Yes, observed, projected
Is there an observed, inferred, or projected decline in number of local subpopulations?	No, only one subpopulation.
Is there an [observed, inferred, or projected] decline in number of "locations"*?	Yes, observed and projected
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes, observed decline in habitat area and quality
Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of "locations"∗?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals

Subpopulations (give plausible ranges)	**N Mature Individuals**
Mingan Archipelago (All occurrences are part of one subpopulation)	Occurrences no. 1: 31 no. 2: 138 no. 3: 0 no. 4: 18 no. 5: 110 no. 6: 20 no. 7: 19 no. 10: 1 no.11: 30
Total	367

* See Definitions and Abbreviations on COSEWIC website and IUCN for more information on this term.

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations, or 10% within 100 years]?	Yes, a multi-site population projection model yielded a 14% probability of quasi-extinction over 5 generations (50 yrs) and 30% probability of quasi-extinction over 100 years.

Threats (direct, from highest impact to least, as per IUCN Threats Calculator)

Was a threats calculator completed for this species? Yes, Very High-High threat impact.

11.4 storms [Very High – High impact]
11.1 loss of habitat by sea level rise and forest encroachment [High impact]
11.3 climate change induced warming [Medium impact]
11.2 droughts [Medium – Low impact]
6.1 recreational activities [Low impact]

What additional limiting factors are relevant? Low reproduction, reduced competitiveness and restricted habitat, impact of wildlife and limited seed dispersal ability.

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	n/a as DU is endemic to Canada
Is immigration known or possible?	No
Would immigrants be adapted to survive in Canada?	n/a
Is there sufficient habitat for immigrants in Canada?	n/a
Are conditions deteriorating in Canada?	Yes
Are conditions for the source (i.e., outside) population deteriorating?	n/a
Is the Canadian population considered to be a sink?	n/a
Is rescue from outside populations likely?	n/a

Data Sensitive Species

Is this a data sensitive species?	No

Status History

COSEWIC: Designated Endangered in May 2022.

Status and Reasons for Designation:

Status:	**Alpha-numeric codes:**
Endangered	B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v); C1+2a(ii)

Reasons for designation:
This perennial herb is restricted to upper portions of beaches on four islands of the Mingan archipelago in the Gulf of St. Lawrence. The population has a very limited distribution and few individuals – in 2018 it consisted of only 367 mature plants. The population is expected to continue to decline as a result of continuing threats, primarily an increase in storms due to climate change, which cause beach erosion as well as the deposition of sediment and woody debris. Given the small, coastal areas over which the population is found, a single storm can severely impact entire sites. Other threats related to climate change include rising sea level, reduced winter sea ice and snow cover, drought, and tree encroachment.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. Rate of reduction in number of mature individuals over the past three generations (30 years) and projected trend over the next three generations (19%) are below the threshold for Threatened.
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Endangered B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v). The EOO and IAO are below thresholds (both 32 km²), is known to exist at 2 to 6 locations, and is experiencing a continuing decline in (i) EOO, (ii) IAO, (iii) area and quality of habitat, (iv) number of locations, and (v) number of mature individuals.
Criterion C (Small and Declining Number of Mature Individuals): Meets Endangered, C1, as the total number of mature individuals is 367 and there has been an estimated continuing decline of 26% in the past two generations (20 years) and that decline is expected to continue. Meets Endangered, C2a(ii), as there is an observed and projected continuing decline and all mature individuals are in one subpopulation.
Criterion D (Very Small or Restricted Population): Meets Threatened, D1. Total number of mature individuals is 367. May meet Threatened, D2, with IAO close to 20 km² (32 km²) and as few as 2 locations, and population is prone to substantial decline from effects of human activities or stochastic events within 1–2 generations.
Criterion E (Quantitative Analysis): Meets Threatened, E. A multi-site population projection model yielded a 30% probability of quasi-extinction over 100 years.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2022)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

Environment and Climate Change Canada
Canadian Wildlife Service

Environnement et Changement climatique Canada
Service canadien de la faune

Canada

The Canadian Wildlife Service, Environment and Climate Change Canada, provides full administrative and financial support to the COSEWIC Secretariat.

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Scientific Name: *Cirsium scariosum* Nuttall var. *scariosum*

Synonyms: *Cirsium butleri* (Rydberg) Petrak, *Cirsium foliosum* var. *minganense* (Victorin) B. Boivin, *Cirsium hookerianum* Nuttall var. s*cariosum* (Nuttall) B. Boivin, *Cirsium lacerum* (Rydberg) Petrak, *Cirsium magnificum* (A. Nelson) Petrak, *Cirsium minganense* Victorin

Cirsium scariosum occurs in both Canada and the USA, and contains eight taxonomic varieties (Keil 2006) only one of which, *C. scariosum* var. *scariosum,* occurs in Canada with both a western (Rocky Mountain) population and an eastern (Mingan) population. The Mingan population has been described as a separate species (*C. minganense* Victorin) but the most recent review (Keil 2006) indicates it is best regarded as *C. scariosum*.

The names *Cirsium foliosum* (Hooker) DC, *C. drummondii* Torrey & Gray, and *C. hookerianum* Nuttall (as C. *kelseyi* Rydberg) have been mistakenly applied to *C. scariosum* var. *scariosum* by various authors.

English Common Name: Meadow Thistle, Elk Thistle

French Common Name: chardon écailleux, chardon de Minganie, chardon multifeuille variété de la Minganie, chardon de Mingan

Family: Asteraceae

Major Plant Group: Angiosperms (flowering plants)

Morphological Description

Meadow Thistle morphology varies widely and complexly over its range, particularly in the western USA where var. *scariosum* is in contact with other *Cirsium scariosum* varieties. The following description is based on Keil (2006), Marie-Victorin (1925), and plants observed in both eastern and western Canada.

Meadow Thistle is an herbaceous, tap-rooted, perennial that flowers only once in its life. Basal rosettes are 3 to >100 cm in diameter. The flowering stem is erect, 10-100 cm tall, leafy, and usually unbranched (Figure 1). The leaves are typically without hairs on top and hairy beneath, the uppermost enveloping the flower heads, and with short, marginal spines and a longer terminal spine. Flower heads, 1-25 per plant, have only disc flowers, are terminal on the stem and crowded at the bases of the uppermost stem leaves. The flowers have both male and female parts, are pink to red-purple, occasionally white, and are 20-25 mm long. The pappus is white to tan and composed of plumose bristles, 17-25 mm long and 3-5 mm shorter than the flowers. The seeds are 5-6.5 mm long, tan to dark brown, sometimes with a yellow apical stripe.

Figure 1. Flowering Meadow Thistles from Rocky Mountain (left) and Mingan (right) populations. Photo credit: Peter L. Achuff (left) and © Parks Canada / Pierrot Vaillancourt (right).

The morphological characters observed in the plants from the Mingan population apparently fall within the range of variation in the characters of the plants in the Rocky Mountain population. The morphological variations between individuals in the Mingan Archipelago are less pronounced (Nantel and Cantin 1998a).

Other native thistle species with morphological similarities occur within the range of the Rocky Mountain population. These species and their distinguishing characteristics are:

Hooker's Thistle (*Cirsium hookerianum*) involucres (whorl of bracts subtending the inflorescence) are narrower than Meadow Thistle, being linear-lanceolate, often 1-2 mm at the base, and are densely tomentose giving the involucre a densely hairy, often tangled look in contrast to the mostly glabrous involucres of Meadow Thistle. Hooker's Thistle occurs in moist, mesic habitats similar to those of Meadow Thistle. Occurrences of these two species can abut in the landscape, generally with a non-overlapping boundary, although in some areas (e.g., Adanac area, Alberta; Flathead Valley, British Columbia; Iceberg Lake, Glacier National Park, Montana) plants of intermediate morphology, perhaps hybrids, have been observed (Achuff 2002-2019). Some of these plants with intermediate morphology are being investigated genetically to determine their origin.

Wavy-leaved Thistle *(Cirsium undulatum*) is most easily distinguished from Meadow Thistle by a prominent glutinous ridge on the back of the involucral bracts. Wavy-leaved Thistle occurs in grasslands that are drier and lower elevation than where Meadow Thistle occurs and no overlapping occurrences are known in Canada. Outside Canada, Wavy-leaved Thistle is reported to hybridize with other varieties of *C. scariosum* as well as with Hooker's Thistle (Keil 2006) but no indication of hybridization between Wavy-leaved Thistle and Meadow Thistle has been noted in western Canada.

Flodman's Thistle (*Cirsium flodmanii*) is also morphologically similar to Meadow Thistle and has been reported from southwestern Alberta (Kuijt 1982; Packer 1983) but its current status in this area is not clear. It also has a prominent glutinous ridge on the back of the involucral bracts which Meadow Thistle lacks.

In western Canada at the rosette stage, Meadow Thistle can be difficult to distinguish morphologically from several other native and non-native thistle species. Because more than one native thistle species was not found in the same occurrence, the identity of the rosettes was inferred from the flowering plants. Rosettes of two non-native species, Canada Thistle (*Cirsium arvense*) and Bull Thistle (*C. vulgare*), sometimes occur with native thistles but can be distinguished by careful examination.

In the Mingan population, the other species of *Cirsium* are sufficiently distinct to avoid identification errors.

Population Spatial Structure and Variability

In Canada, Meadow Thistle is divided into two disjunct populations separated by about 3500 km: the Rocky Mountain population and the Mingan population (see **Distribution**). In western North America, Meadow Thistle exhibits a large range of morphological variation both within occurrences and across its wide geographic range from southern Canada to New Mexico. It is currently treated as a highly variable, broadly defined species (Keil 2006) with eight geographic varieties, which often exhibit overlapping variation (Cronquist 1994). In eastern Canada, the population is restricted to the Mingan Archipelago, on the north shore of the Gulf of St. Lawrence in Quebec.

Various hypotheses have been proposed for this geographic disjunction including migration at the end of the Pleistocene from a western refugium (Marie-Victorin 1925), a split in a continuous pre-Pleistocene range caused by various glacial events, resulting in Rocky Mountain and Mingan populations (Marie-Victorin 1938), and an early 20th century unintentional introduction to Quebec from western North America (Moore and Frankton 1967). There is no evidence to refute the hypothesis that *C. scariosum* is native to the Mingan Archipelago, which remains the most parsimonious hypothesis supported by phylogenetic analyses of molecular markers. There is no evidence to support or even suggest that Mingan population resulted from a recent introduction.

Molecular analysis indicates divergence between the two populations and that the disjunction was a Pleistocene event, i.e., thousands of years ago (Golden *et al.* 2008). The plants from the Mingan population included in the molecular analysis had the highest percentage of loci with unique alleles (23% versus 11% for plants from the Rocky Mountain population) and the lowest percentage of polymorphic loci (17% versus 51%) even though the sample size for the Mingan population was twice as large as for the Rocky Mountain population (Golden *et al.* 2008). Cluster analysis of the haplotypes present in each individual shows a clear separation of the Mingan plants from the rest of the samples. This divergence may be due to hybridization of the Rocky Mountain population with Hooker's Thistle subsequent to the east-west split or to the Mingan population arising from a population genetically different from that sampled in this analysis (Golden *et al.* 2008).

A study of phylogenetic patterns in *Cirsium* spp., including both Mingan and Rocky Mountain populations of Meadow Thistle, is currently underway at the University of Ottawa (Piché-Mongeon pers. comm. 2019), based on a broad sampling of both Meadow Thistle populations (n=165 for the Mingan population and n=57 for the Rocky Mountain population), and using genotyping by sequencing, which makes it possible to compare the whole genome. Preliminary analyses indicate significant genetic differentiation between the two populations (Piché-Mongeon pers. comm. 2021).

It has been argued that differences in breeding system and habitat warrant recognition of the Mingan population as a separate species (Morisset 1971). However, at this time, published taxonomic treatments (e.g., Keil 2006) considers that both Mingan and Rocky Mountain populations are *C. scariosum* var. *scariosum*.

Manipulated Populations

The Mingan population is "manipulated" according to the COSEWIC definition (COSEWIC 2018a). Between 2001 and 2018, thousands of seeds were sown on the same site where the seeds had been collected (Table 1) (Dénommée 1998-2019). Over 100 plants cultivated *ex situ* were reintroduced in 2018 and 2019. Also, between 2010 and 2016, hundreds of plants were rescued after winter storms by removing the sediment and debris that had completely covered them. Several plants were also rescued by cutting overshadowing trees.

Table 1. Number of seeds sown in each occurrence of the Mingan population (2001-2018).

Year	Occurrence									
	1	2	3	4	5	6	7	10	11	Total
2001	0	0	0	0	65	0	47	18	0	130
2002	40	0	0	0	0	0	0	0	0	40
2003	98	208	0	2	145	0	0	0	0	453
2004	33	409	0	677	0	0	147	0	0	1266
2005	0	0	0	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	467	0	125	592

Year	Occurrence									
2007	0	0	0	0	451	65	102	0	590	1208
2008	12	0	0	0	670	293	0	0	785	1760
2009	0	0	0	0	0	943	0	0	994	1937
2010	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	223	56	0	0	279
2012	0	0	0	0	0	118	0	0	41	159
2013	0	0	0	0	0	0	0	0	0	0
2014	127	0	0	0	0	0	0	0	0	127
2015	0	0	0	0	0	0	0	0	0	0
2016	2	0	0	0	190	0	0	0	0	192
2017	0	1581	100	215	96	0	0	0	0	1992
2018	46	2024	0	0	79	0	0	0	252	2401
Total	358	4222	100	894	1696	1642	819	18	2787	12,536

Plants that survived or originated due to the manipulations described above are all included in the population size because they originated from seeds of the Mingan population. Census data from 2018 and 2019 are excluded from the trends and viability analyses because of the significant population manipulations.

Designatable Units

The two populations, Rocky Mountain and Mingan, meet the requirements for recognizing DUs for both discreteness and significance (COSEWIC 2019). The two proposed DUs are based on the large, natural disjunction (about 3500 km) that separates populations in Quebec and British Columbia-Alberta such that movement of individuals between populations is not likely. The Rocky Mountain population occurs in the Southern Mountain National Ecological Area and the Mingan population in the Boreal National Ecological Area. Furthermore, the distinctions in habitat between the two populations (see **Habitat Requirements**) indicate large differences in natural selective regimes that likely have resulted in local adaptations. Individuals found in these two populations present evidence of some genetic distinction (see **Population Spatial Structure and Variability**). Genetic evidence indicates that this disjunction has existed for an extended period of time (Golden *et al.* 2008) and there are no likely foreseeable events that would change the disjunction. Differences in habitat and potential hybridization favour the evolution of local adaptations. The extinction of the Mingan population, in addition to causing the loss of the species in eastern North America, would represent a genetic loss for the species (see **Population Spatial Structure and Variability**).

Special Significance

Rocky Mountain population:

There may be some adverse public opinion toward this species because it is a "thistle", which to some people suggests an undesirable weed. In Canada, this reputation is based largely on introduced non-native species that can be an economic or ecological problem.

Thistles of many species can often be recognized by the public but distinguishing Meadow Thistle from other species can be difficult. At the rosette stage, it can be difficult to distinguish Meadow Thistle from other *Cirsium* species including non-native species. This confusion has led to damage of Meadow Thistle by weed control activities.

Mingan population:

This population, like the other late glacial relics of the Gulf of St. Lawrence, is of exceptional biogeographical interest. From a scientific standpoint, it constitutes a model for studying the effect of climate change on the persistence of rare plant species, as well as the effect of geographic isolation and autogamy. From an educational and heritage standpoint, Meadow Thistle is a species emblematic of Mingan flora. Interpretation panels, activities in schools, plants accessible to the public, and public lectures have introduced the species to visitors. Coastal residents are generally familiar with this species and feel a certain sense of pride in being able to claim it as part of the flora of their region[1]. Finally, the discovery of Meadow Thistle in the Mingan Archipelago represented an important event in the life of Brother Marie-Victorin, a botanist who was to become a key figure in the history of the sciences in Canada. Indeed, Marie-Victorin wrote: "But perhaps, the greatest thrill I have ever experienced in the field was the discovery of the Mingan thistle" (Marie-Victorin 1938).

DISTRIBUTION

Global Range

Cirsium scariosum, including its eight currently recognized varieties, occurs in western North America from southwestern Alberta and southeastern British Columbia south to California, northern Mexico, northern Arizona and New Mexico, Colorado, Wyoming, and Montana (Keil 2006). *Cirsium scariosum* var. *scariosum,* the variety that occurs in Canada, has a smaller range in western North America with a disjunct population in the Mingan Archipelago of Quebec (Figure 2). The western North American range extends south of Alberta and British Columbia to include western Montana, northern and central Idaho, eastern Washington, eastern Oregon, northcentral California, northeastern Utah, northwestern Colorado, and western Wyoming.

[1] A collection of poems published in 1983 by a writer from Havre-Saint-Pierre includes a text calling for the protection of Meadow Thistle.

Occurrences of Meadow Thistle in southeastern Waterton Lakes National Park (WLNP), Alberta and the lower Flathead River valley, British Columbia are contiguous with occurrences in the USA that extend south of the international border for tens of kilometres along both the east and west sides of the Continental Divide. The Mingan population is completely isolated from other North American populations of this taxon.

Figure 2. Global range of Meadow Thistle (*Cirsium scariosum* var. *scariosum*). Map produced by COSEWIC Secretariat.

Canadian Range

The Canadian population (Figure 2) is estimated to comprise about 0.5% of the global (North American) range.

<u>Rocky Mountain population:</u>

This population extends from east of the southeast corner of WLNP, Alberta, northwest along the eastern edge of the Rocky Mountains to Crowsnest Pass, Alberta-British Columbia, west into British Columbia and south along the western boundary of the Flathead River watershed to the Canada-USA border, and east to the southeast corner of

WLNP (Figure 3). It occurs in the Subalpine, Montane, and Foothills Parkland Natural Subregions in Alberta (Downing and Pettapiece 2006) and in the similar Engelmann Spruce – Subalpine Fir and Montane Spruce biogeoclimatic zones in British Columbia (Meidinger and Pojar 1991). All known occurrences of Meadow Thistle, including a few dating back nearly 100 years, are within the currently known range and no change in the extent of the distribution is apparent.

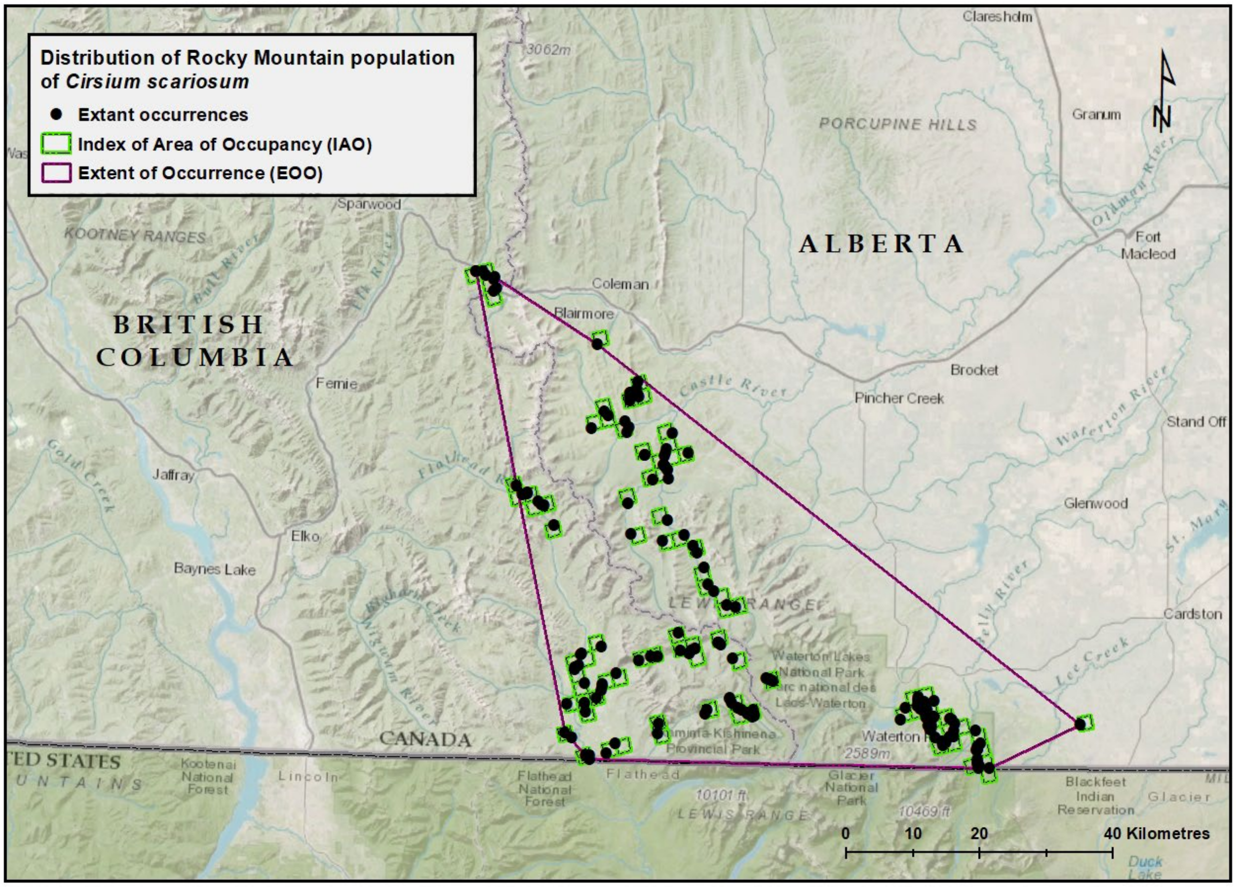


Figure 3. Extent of occurrence and index of area of occupancy for Meadow Thistle – Rocky Mountain population. Map produced by COSEWIC Secretariat.

Mingan population:

This population is located entirely in the Mingan Archipelago, in the bioclimatic domain of the Balsam Fir (*Abies balsamea*) forest with Paper Birch (*Betula papyrifera*) (Grondin *et al*. 2007). The population is subdivided into nine extant occurrences distributed on four islands (Figure 4). These are concentrations or patches[2] of 1-850 plants each extending over 1-300 m^2. One occurrence (11) is isolated whereas six occurrences (1, 2, 4, 5, 6, and 7) are in pairs separated from each other by 115-800 m. Two occurrences (3, 10) are very

[2] Also referred to as “colonies” in most of the documents in French.

small outlier patches of one plant. Three occurrences (8, 9, 14) disappeared between 1970 and 1986 on three islands, and two occurrences located on the mainland at Grande Pointe (12, 13), disappeared between 2004 and 2017 (Figure 4).

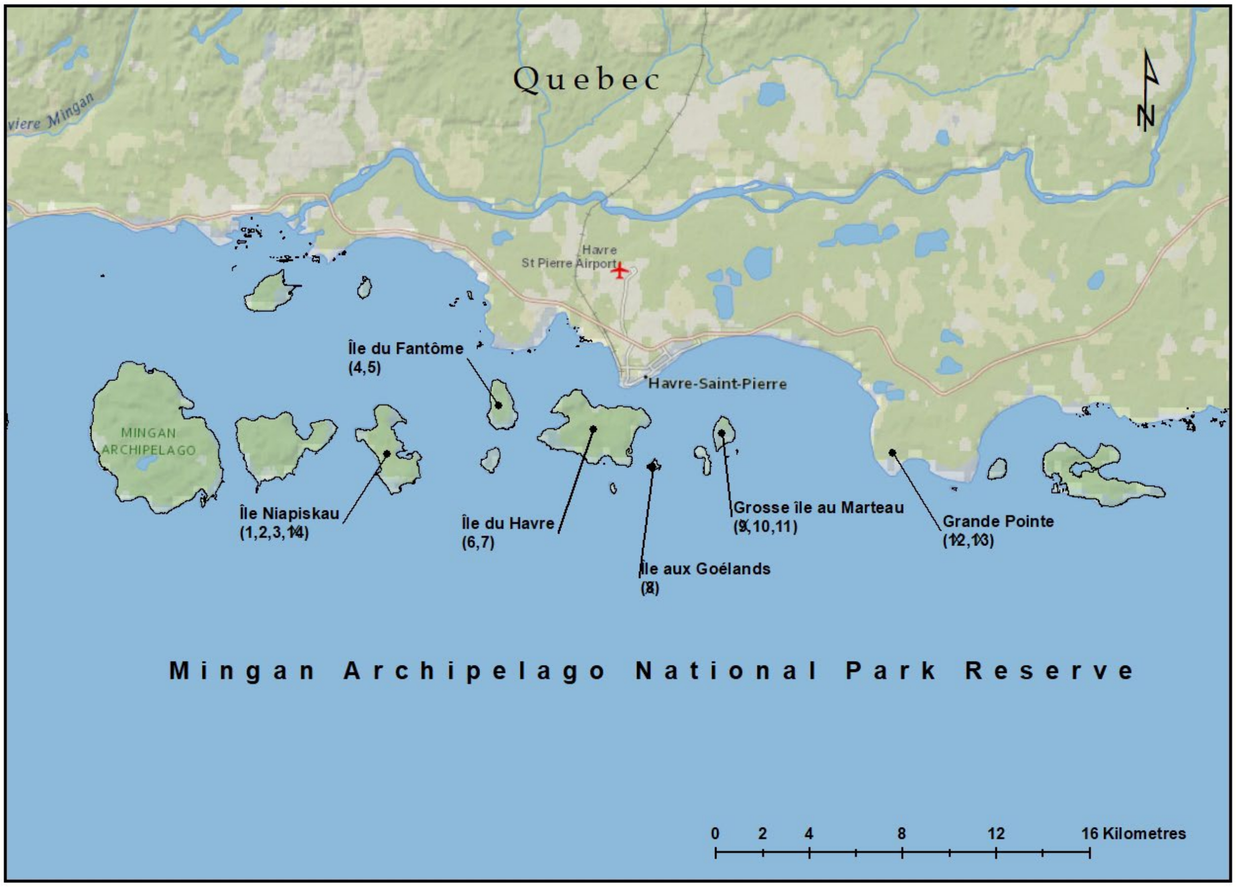


Figure 4. Extant and extirpated occurrences of Meadow Thistle of the Mingan population. Map produced by COSEWIC Secretariat.

Extent of Occurrence and Area of Occupancy

In Canada, the extent of occurrence (EOO) of Meadow Thistle is about 200,000 km². The index of area of occupancy (IAO) is 372 km².

<u>Rocky Mountain population:</u>

The extent of occurrence is 3181 km². The index of area of occupancy is 340 km² based on eighty-five 2 km x 2 km grid cells (Figure 3).

Mingan population:

The EOO is 27 km^2, 17.6 km^2 of which are open sea, and the IAO is 32 km^2 with the 2 km x 2 km grid (Figure 5). Because the EOO is less than the IAO, it is adjusted to 32 km^2. The biological area of occupancy is much lower at 0.0008 km^2. The disappearance of the two occurrences on the mainland resulted in a significant reduction in both the EOO and IAO.

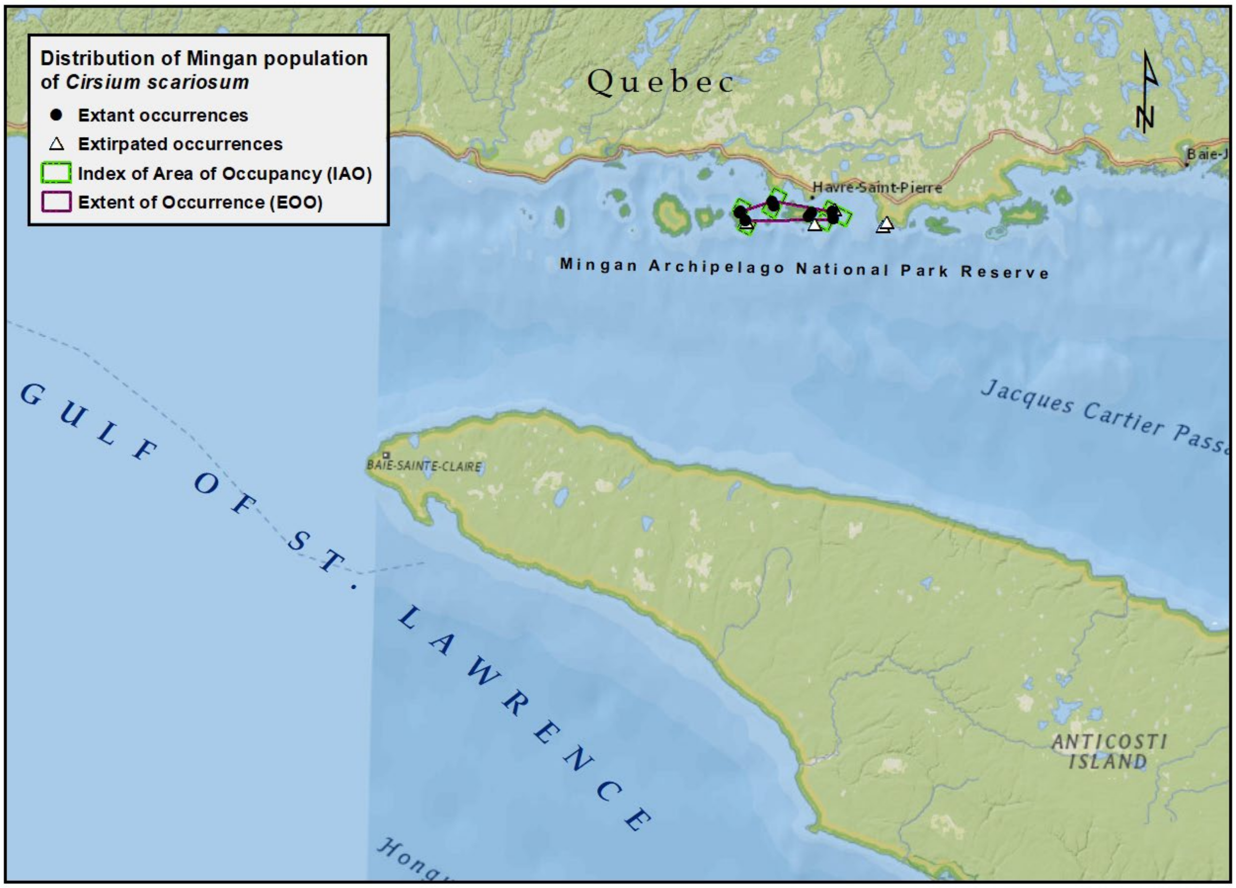


Figure 5. Extent of occurrence and index of area of occupancy for Meadow Thistle – Mingan population based on 2 km x 2 km grid. Map produced by COSEWIC Secretariat.

Search Effort

<u>Rocky Mountain population:</u>

Targeted field surveys to locate occurrences of Meadow Thistle and delineate its geographic extent in southwestern Alberta and southeastern British Columbia were conducted in 2002-2019 by P. Achuff and J. Golden (Achuff 2002-2019). Other occurrences or absences were recorded during fieldwork in the area for other purposes over the same period. Surveys were directed primarily toward areas of potentially suitable habitat. Because flowering Meadow Thistle plants stand out in the landscape (often visible at a distance with binoculars), it was possible to detect their presence or absence in areas of potentially suitable habitat.

Field surveys were extended east, north, and west of known occurrences to ensure that the extent of the range had been detected. To the east and northeast, the range abuts climatically unsuitable, dry grasslands. Areas to the north and west contain mesic habitats that appear suitable, but no Meadow Thistle plants were found there.

While field surveys determined the limits of the Rocky Mountain population, not all of the 3181 km^2 was searched for occurrences. The occurrence of Meadow Thistle within its range is not continuous. For example, in WLNP where surveys have been most thorough, only two occurrences are currently known: Sofa Mountain-Chief Mountain Highway and Lone Creek, which are separated by about 20 km, the intervening area being occupied by Wavy-leaved Thistle and Hooker's Thistle.

Voucher specimens from the surveys have been deposited in the following herbaria: University of Alberta (ALTA), Canadian Museum of Nature (CAN), and University of Lethbridge (LEA).

Regional and national herbaria were searched for specimens of Meadow Thistle (see **Collections Examined**). Specimen folders for *Cirsium scariosum* as well as common synonyms and related species (e.g., *C. kelseyi, C. foliosum, C. minganense*, *C. hookerianum, C. drummondii*) were examined.

Information for the Canadian range was obtained from the following electronic databases: E-Flora BC (2019), Consortium of Pacific Northwest Herbaria (2019), BC-Conservation Data Centre (2019), and Alberta Conservation Information System (2019). Distribution maps in the *Flora of Alberta* (Packer 1983) and *Illustrated Flora of British Columbia* (Douglas *et al.* 2002) were also consulted.

The 215 occurrences from herbarium collections, field surveys, and electronic databases are recorded in a database deposited with the COSEWIC Secretariat. Total search effort in 2002-2019, including field surveys, herbarium searches, and electronic database searches was about 67 person-days and included about 640 observation points.

Mingan population:

Many botanists have inventoried the flora of the Mingan Archipelago, especially the islands' coastline, where Meadow Thistle occurs (Marie-Victorin and Rolland-Germain 1969; Le Groupe Dryade 1986). Since 1993, Parks Canada has regularly monitored rare plants along the coastline of the Mingan Archipelago. Recent surveys of the five presumably extirpated occurrences confirmed the absence of the species on those sites. Taking into account the search effort and the low dispersal capacity of this species, all extant occurrences of the species in the Mingan Archipelago are considered well documented. No original field surveys were conducted for this status report.

HABITAT

Habitat Requirements

Rocky Mountain population:

This population occurs predominantly in grassy meadows and forest openings (Figure 6) in the Subalpine, Montane, and Foothills Parkland Natural Subregions of Alberta (Downing and Pettapiece 2006) and the Engelmann Spruce – Subalpine Fir and Montane Spruce biogeoclimatic zones in British Columbia (Meidinger and Pojar 1991). It ranges in elevation from about 1215 m in the Flathead Valley, British Columbia, to 1975 m along the Alberta-British Columbia border, to 1350 m in the southeast portion of its range in Alberta (Achuff 2002-2019).

Figure 6. Habitat of Meadow Thistle in Lone Creek transect, Waterton Lakes National Park, Alberta. Photo credit: Peter L. Achuff.

These open areas include undisturbed as well as disturbed sites resulting from both natural (e.g., avalanche, animal activity, fire) and human disturbance (e.g., roads, well sites, gravel pits, cut blocks). Within these areas, Meadow Thistle often occurs on recently disturbed microsites. The plant appears to be shade-intolerant and likely dependent on disturbance to provide bare soil for seed germination and establishment. Also, it often occurs in moist sites in lower slope positions, streamsides, or sheltered sites. Meadow Thistle occurs over a wide range of landforms, bedrock types, and soils with no apparent pattern of preferences.

Within the currently known range of the Rocky Mountain population, Meadow Thistle does not occupy all the areas of seemingly suitable habitat but occurs essentially in four areas: eastern WLNP and areas adjacent to the eastern range limit, Castle River, western Crowsnest Pass in British Columbia, and the Flathead Valley, British Columbia into upper Lone Creek in western WLNP. Between these four areas, portions of seemingly suitable habitat are occupied by Hooker's Thistle, a closely related species. It is not clear if this reflects ecological/physiological differences between the species, subtle habitat differences, competitive relationships, or perhaps disturbance history. Similarly, areas of seemingly suitable habitat occurring north and west of the Meadow Thistle boundary contain Hooker's Thistle.

Mingan population:

This population is confined to a narrow strip of the upper littoral between dense communities of seaside beach plants and coniferous forest (Figure 7). The plants typically take root in a mixture of humus, sand and gravel, on a very well drained substrate over limestone bedrock; soil samples taken from six occurrences indicate a pH ranging from 6.9 to 8.3 (average of 7.5). The surrounding vegetation is usually sparse and strongly influenced by the sea. In addition to sea water spray, storms erode the substrate and bring sediment and various plant debris. Meadow Thistle is often scattered between pieces of driftwood and some grow on the edge of the forest where there seems to be sufficient light.

Figure 7. Habitat of Meadow Thistle in the Mingan population: a narrow area between dense coastal vegetation and forest. Photo credit: © Parks Canada / Nancy Dénommée.

Meadow Thistle occupies only a small portion of the shoreline of the Mingan Archipelago. Occurrences are generally found on the eastern side of the islands, sheltered from the prevailing westerly winds but exposed to storm-force winds. Many are bordered by rocky points that limit sediment loss (Lasalle NHC 2019). Only one occurrence has been found on a cove oriented to the west. The occurrences most exposed to waves are located at a higher elevation on the beach, supporting the hypothesis of the need for a balance between the impacts of storms and the ability of the species to reproduce. However, Meadow Thistle is not able to survive lower on the beach where the impacts of storms are too severe. The absence of disturbance could cause its long-term decline, while too intense or too frequent disturbances threaten its survival (Lasalle NHC 2019).

Occurrence 2 (Figure 4), which has produced the largest number of flowering plants noted, is located in a gently sloping herbaceous meadow with approximately 20 cm of organic soil. It is characterized by a relatively high and dense vegetation and is seemingly beyond the influence of the sea.

Habitat Trends

Rocky Mountain population:

Fire exclusion activities likely reduced the amount of suitable habitat in part of the past century, but this probably has been outweighed by more recent human and natural disturbances. Over about the last 50 years, the amount of suitable habitat has possibly increased due to human disturbance, including roads and industrial development, as well as from wildfires, including the 1997 Sofa fire (15.2 km^2) in eastern WLNP, the 2003 Lost Creek fire (210 km^2) south of Crowsnest Pass, and the 2017 Kenow fire (350 km^2) in southeastern British Columbia and western WLNP. These disturbances likely increased both habitat quantity and quality.

The Kenow fire in 2017 started in southeastern British Columbia in the Flathead Valley near the western range boundary of Meadow Thistle and burned east into Alberta burning much of the central range, an estimated 15% of the area of the Rocky Mountain population. The fire had a severe effect over much of its area, consuming essentially all organic matter down to mineral soil and raising soil temperatures to lethal levels. This killed living Meadow Thistle plants and likely most seeds banked in the surficial litter and upper soil. However, much of the burn area could be considered as potential habitat that might be occupied by Meadow Thistle over future decades. Because typical seed dispersal distances are likely on the scale of tens of metres (Skarpaas and Shea 2007), it may take a decade before seed reaches some previously occupied areas. This process will be severely hampered by the reduced seed production due to Thistle Head Weevil (*Rhinocyllus conicus*). Dispersal rates of Thistle Head Weevil (Zwolfer and Harris 1984) are about an order of magnitude greater than the thistle (Skarpaas and Shea 2007) and are expected to keep up with Meadow Thistle movement; recolonizing plants are unlikely to be free of weevil attack and will produce only limited seed.

If post-fire successional change is uninterrupted by disturbance, these formerly forested burned areas may remain suitable for Meadow Thistle for 30-50 years. The possibility of additional fire, increased avalanche activity, increased slope instability, and changing climate create uncertainty about future habitat trends in the area.

Mingan population:

Storms have reduced the extent and quality of the habitat at most occurrences, either through erosion or the accumulation of sand, rock, gravel, and plant debris. This trend, affecting most of the Mingan Archipelago coastline, is expected to continue (see **Threats and Limiting Factors**).

Forest encroachment has also reduced the extent and quality of habitat. The habitat Meadow Thistle occupied in 1997 at occurrences 4 and 5 and about 30% of habitat extent at occurrence 2 have become forested (Figure 4). Tree cutting made recently by Parks Canada in those three occurrences have temporarily restored a portion of the habitat lost.

Human destruction and modification of the habitat has led to the disappearance of the only two occurrences on the mainland (Figure 4). Storms have also caused erosion and deposition, and only a small portion of the original habitat remains.

Change in vegetation due to an increase in the number of breeding seabirds has likely caused the extirpation of occurrence 8 on l'île aux Goélands (Figure 4). Compared to the conditions noted when that occurrence was discovered, the vegetation is now higher and denser and consists mainly of species favoured by nutrient enrichment from bird droppings (Morisset pers. comm. 2003).

BIOLOGY

Information on the biology of the Rocky Mountain population is derived largely from survey and monitoring studies done by Achuff (Achuff 2002-2019, 2019) (see **Population Sizes and Trends**).

Information on the biology of the Mingan population is mainly based on intensive fieldwork carried out from 1995 to 2019 by Nantel and Cantin (1998a,b) and Parks Canada staff (Dénommée 1998-2019) (see **Sampling Effort and Methods**). Observations on plants under cultivation by the Biodôme de Montréal have also provided information (Dumas pers. comm. 2018-2019; Nault pers. comm. 2018-2019).

Life Cycle and Reproduction

Meadow Thistle is a monocarpic perennial plant, meaning that it flowers and produces seed only once and does not propagate vegetatively. Following flowering, the plant dies in that same growing season. Seeds mature in 2-5 weeks. While it is apparent that seeds remain in a soil seed bank through the fall and winter, nothing is known of the germination biology or seed bank dynamics for the Rocky Mountain population. Seed dormancy has been observed in the Mingan population (see **Generation time**). Following seed germination, Meadow Thistle produces a rosette before developing a flowering stalk.

The above-ground portion dies back to the root crown at the soil surface late in the growing season, typically by early to mid-September in the Rocky Mountain population and from mid-October to early November in the Mingan population. Regrowth in the next growing season is from the root crown. Some plants in WLNP showed prolonged dormancy that lasted more than a year. Thirty plants were dormant for one growing season and five were dormant through two growing seasons before resuming growth (Achuff 2019). Prolonged dormancy has been observed in many other plants (Lesica and Steele 1994; Tuomi *et al.* 2013) and while it seems to be beneficial to maintaining fitness in a stochastic environment (Shefferson 2009; Gremer and Sala 2013), its role in the life history of Meadow Thistle is not known. Dormant plants were rarely observed in the Mingan population: four plants went dormant in the summer following a storm that caused nearby erosion and plant displacement.

Meadow Thistle may hybridize with Hooker's Thistle in some places in Alberta (Achuff 2002-2019). Several *C. scariosum* varieties in the USA apparently hybridize with other *Cirsium* species including Wavy-leaved Thistle, Northern Mountain Thistle (*C. eatonii* var. *murdockii*), and Long-style Thistle (*C. longistylum*) (Keil 2006). Wavy-leaved Thistle occurs in areas adjacent to Meadow Thistle in WLNP but each species occupies a distinct habitat; they are not sympatric and no indication of hybridization has been observed (Achuff 2002-2019). In the area of the Mingan population, the only other native species of thistle is Swamp Thistle (*C. muticum*), which occupies a completely different habitat, making hybridization unlikely. Hybridization between native *Cirsium* and those introduced from Eurasia, such as Canada Thistle and Bull Thistle, has not been reported (Keil 2006).

<u>Rocky Mountain population:</u>

Monitoring of two occurrences in WLNP showed a mean age to flowering of 3.8 years (n=129 plants) with a range of 2 to >8 years (Achuff 2019). Some rosettes were tracked to an age of at least 9 years (Achuff 2019). Missing tags and other logistical difficulties prevented continuous tracking of these plants, but they likely survived longer. Some authors have described Canadian plants as biennial, e.g., Packer (1983) in Alberta and Douglas *et al.* (1998) in British Columbia. However, while some plants do flower in their second year, many others are older when they reproduce and the species is best considered as a short-lived perennial in western Canada.

Mingan population:

The majority of wild plants flower after 5 to 16 years (Dénommée 1998-2019). One plant flowered after at least 22 years. Based on 45 plants monitored from seeds to flowering, the mean age to flowering is 10.1 years. In an outdoor garden in Montréal (Quebec), most plants grown from Mingan seeds bloomed in their second summer (Nault pers. comm. 2018-2019). Flowering usually extends from mid-July to mid-August.

The number of mature seeds per Mingan plant ranged from 0 to 1080, with an average of 193 and the proportion of mature seeds per plant ranged from 0 to 84.2%, with an average of 41.5% (Dénommée 1998-2019). Mature seeds hand-dispersed in suitable habitat germinated at a rate of 9.8% (n = 957). The germination rate of seeds naturally dispersed is presumably lower considering that many seeds do not reach suitable germination sites or are eaten before falling to the ground.

In this species, most plants die before they are able to flower. Of about 1035 plants monitored at two sites in WLNP, 27% of mortalities occurred in the first year, 32% in the second, 21% in the third, and 22% in the fourth and subsequent years (Achuff 2019). Overall, about 70% of the plants died before they were able to flower. The main causes of known death were: small mammals (eating roots and leaves or uprooting plants) (37%), drought (2%), and Grizzly Bear (*Ursus arctos*) digging (1%). Roughly 60% of deaths were due to unknown causes, although small mammal activity and drought likely were the main factors.

In the Mingan population, 97.1% of plants died without producing flowers (data from 1995 to 2017, n = 4122) (Dénommée 1998-2019). The mortality rate was 25.3% for seedlings, 29.6% for small rosettes (diameter <11.3 cm), and 15% for large rosettes (diameter ≥11.3 cm) (data from 1995 to 2017, n = 12,930). The specific cause of death of most plants is not known. Known causes of mortality include erosion during storms, competition from plants (trees and others), insufficient snow cover, drought, and ant hills. Grazing by Snowshoe Hare (*Lepus americanus*) may be significant in some years (Dénommée 1998-2019).

In 2017, the size class structure of the Mingan population showed poor regeneration with only 23.7% seedlings and small rosettes (Dénommée 1998-2019). The sowing of 1992 seeds in 2017 increased the proportion of seedlings and small rosettes to 71.4% of the total population in 2018.

Mature Individuals

The concept of "mature" individuals (IUCN Standards and Petitions Committee 2019) is difficult to apply to monocarpic species such as Meadow Thistle. For both annual and iteroparous perennial plants, maturity is considered to occur in the first year in which flowers/seeds are first produced. This approach applied strictly to Meadow Thistle, in which only flowering plants were considered mature, would result in a misleading picture of population trends because the number of flowering plants varies greatly over time while the total number of individuals (flowering and rosettes) is more stable. The number of multi-year rosettes better reflects population status and trends. However, not all rosettes persist to become flowering plants. The approach taken here is to consider the size of a rosette the year before it becomes a flowering plant as indicative of maturity, i.e., as being “known, estimated or inferred to be capable of reproduction” (IUCN Standards and Petitions Committee 2019). This approach is analogous to the Red List Guidelines (IUCN Standards and Petitions Committee 2019, sec. 4.3), which states “in many taxa there is a pool of non-reproductive (e.g., suppressed) individuals that will quickly become reproductive if a mature individual dies. These individuals can be considered to be capable of reproduction.” While Meadow Thistle rosettes are not suppressed individuals waiting for a flowering plant to die, once they reach the diameter threshold, they are capable of quickly becoming reproductive.

Rocky Mountain population:

Rosette diameter in the year before flowering varies from 30 cm to >70 cm (n = 122) (Achuff 2019). Diameter values are well distributed between 30 cm and >70 cm; the 30 cm value is not an isolated outlier. Thus, rosettes ≥30 cm in diameter are considered mature individuals in addition to the flowering plants.

Mingan population:

Rosette diameter the year before flowering ranged from 11.3 to 113.3 cm (mean 43.7 cm) (data from 1995 to 2003, n = 43) (Dénommée 1998-2019). Rosettes having a diameter at least equivalent to the smallest rosette having flowered the following year (11.3 cm) were considered mature individuals as were flowering plants. This approach estimates the maximum number of rosettes likely to flower in the next year, which are considered to be capable of reproduction. In this case, because the size of the population is so small, the precise definition of mature individuals does not affect its assessment.

Generation Time

The most appropriate definition for generation time in Meadow Thistle is the mean plant age at flowering. The IUCN guidelines (IUCN Standards and Petitions Committee 2019) also specify that “for plants with seed banks, use the juvenile period and either the half-life of seeds in the seed bank or the median time to germination.”

Rocky Mountain population:

The mean plant age at flowering is 3.8 years (Achuff 2019). Meadow Thistle presumably has a seed bank but no data are known of its dynamics in the Rocky Mountain population. The appearance of seedlings in sites close to where plants flowered the previous year suggests that some seeds germinate in the first year. But the maximum residence time in the seed bank or median time to germination are unknown.

Mingan population:

The mean plant age at flowering is 10.1 years (Dénommée 1998-2019). In the Mingan population, data from 2002 to 2010 indicate that 91% of all the seeds that germinated sprouted in the spring following their production (Dénommée 2011). The dormancy period was one year for 62% of dormant seeds (n = 66). A dormancy period of up to eight years was observed when sown seeds germinated after a storm disturbance. Although such dormancy could be important for long-term persistence, its frequency remains unknown. Soil samples yielded only two seeds in a hundred soil samples and no seedlings appeared in areas covered to exclude seeds from reaching soil (Nantel and Cantin 1998a,b).

Physiology and Adaptability

No specific information on the physiology of this species is known. Meadow Thistle is a hemicryptophyte, which survives in winter with its bud near the soil surface, making it particularly sensitive to cold winters without adequate snow cover. It appears to be shade-intolerant.

Rocky Mountain population:

This population appears to be adapted to recently disturbed sites where bare soil provides suitable microsites for seed germination and establishment. It grows typically in moist, unshaded areas.

Mingan population:

This population seems adapted to occasional disturbances by storms of low to medium intensity that limit competition at the edge of the forest. It seems to be tolerant to seawater flooding during storms and spring freshwater flooding to some extent.

Since 2001, various measures have been implemented to increase the production of plants. From 2001 to 2018, more than 12,500 seeds (Table 1) were sown with a germination rate of 40.6% the first year (n = 6314, 2001-2017 data).

Since 2017, the Biodôme de Montréal has participated in a recovery project by growing plants from seeds collected on the Mingan Archipelago, with the objective of producing seeds in large quantities for population augmentation. A first trial with seeds kept dry for five years at 4˚C, then transferred to moist, cold conditions for eight weeks yielded a germination rate of 60% (Dumas pers. comm. 2018-2019; Nault pers. comm. 2018-2019). Seeds that were placed in cold, wet stratification for about six months, and then placed outdoors under a cloth for the winter had a germination rate of 70%. Seeds sown in February 2019 with cold and wet stratification of 13-14 weeks had a germination rate of 35%. Without cold and wet stratification, a germination rate of 14.3% was obtained (Saxena pers. comm. 2018; Dumas pers. comm. 2018-2019; Nault pers. comm. 2018-2019).

The Gosling Research Institute for Plant Preservation (GRIPP) also developed a tissue culture method to clonally propagate (micro-propagation) Meadow Thistle. GRIPP succeeded in producing plants and growing them in a greenhouse.

In 2018, 25 plants of about 30 cm diameter, grown *ex situ* at the Biodôme de Montréal for five months, were transplanted to the Mingan Archipelago. Growth was good in the first year, with 23 of the plants surviving and 12 flowering the following year (Dénommée 1998-2019). Such early flowering had never been seen in the wild. In 2019, 119 plants grown *ex situ* (Biodôme de Montréal and GRIPP) were transplanted to the Mingan Archipelago. All but two were alive by mid-September.

The plants grown *ex situ* (at the Biodôme de Montréal) and rooted in a mixture of sand and gravel similar in texture to the soil in the Mingan Archipelago had much faster growth, reaching 65 cm of diameter during the first summer (Nault pers. comm. 2018-2019) compared to about 5 cm when grown in field conditions in the Mingan Archipelago. Although they came from seeds of the same occurrence, these plants have a different morphology, with leaves more deeply cut and with more robust spines.

Dispersal and Migration

Meadow Thistle seeds disperse soon after the seeds mature late in the growing season. No specific information is known about the dispersal distances of Meadow Thistle seeds. However, information on species with similar seed characteristics suggests that the dispersal pattern is likely leptokurtic with the vast majority of seeds dispersing <30 m and perhaps only 10% going further (Skarpaas and Shea 2007). Although most Meadow Thistle seeds land near the parent plant, the plumose pappus bristles act as a sail or parachute to facilitate wind-aided movement, enabling low frequency dispersal beyond 30 m.

In the Mingan Archipelago most seeds of Meadow Thistle disperse near the parent plants because the pappus detaches easily and quickly during dispersal (Nantel and Cantin 1998a).

Interspecific Interactions

<u>Insects</u>

Although the species is autogamous, the pollen from one flower must reach the stigma of another flower, on the same capitulum or on a neighbouring capitulum, in order for fertilization to occur (Nantel and Cantin 1998a). It is thus highly likely that the fertility of the plants depends largely on the activity of pollinators. Little is known specifically about the pollination biology of Meadow Thistle but pollinators of other *Cirsium* spp., which have similar characteristics, likely include a wide variety of bees, flies, and butterflies (Eckberg *et al*. 2017). Bumble bees (High Country Bumble Bee [*Bombus kirbiellus*] and California Bumble Bee [*B. californicus*]), and Unarmed Leaf-cutter Bees (*Megachile inermis*) have been documented to use one or more varieties of Meadow Thistle. Other insects, including tephritid flies, likely feed on foliage and sap.

Rocky Mountain population:

Meadow Thistle is a host plant for the non-native Thistle Head Weevil (see **Threats**). At the start of the growing season, Meadow Thistle is typically the first thistle to produce flower buds (Achuff 2002-2019). Thus, Meadow Thistle is the first to be attacked by the weevil, which typically results in nearly all Meadow Thistle flowers being attacked. The other later flowering thistle species typically are not as thoroughly attacked by the weevil and generally have a better chance of producing viable seeds. The timing (phenology) of development in the weevil and its plant hosts can vary year-to-year, with some years in which weevil development seems out of synchrony with plant development, resulting in unattacked or lightly attacked plants and greater seed production. In other years, perhaps higher weevil numbers or favourable phenological development result in heavy attack on virtually all flowers on host plants and few if any seeds are produced. The weevil has been observed to reduce seed production in Meadow Thistle every year, often to very low levels as attacked heads produce few if any seeds (Achuff 2002-2019). Flower heads produced later in the growing season may escape weevil attack but usually mature too late to complete seed development before the end of the growing season.

The precise role played by Meadow Thistle in providing food resources (nectar, pollen, sap, leaf, stem, and root tissue) for insects is unknown. However, reduced amounts of Meadow Thistle nectar and pollen likely directly reduce the size of pollinator populations both for itself and plant species.

Mingan population:

Various insects have been observed on Mingan Meadow Thistle but their impact is unknown. Spittlebug larvae (Aphrophoridae) have regularly been observed on the plants (Dénommée 1998-2019). Following observation of seed predation, some insects present in flowering heads were identified in 2019. Larvae of the tortricid moth Hoary Bell (*Eucosma cana*), the noctuid moth Rustic Shoulder-Knot (*Apamea sordens*), and a species of gall midge (Cecidomyiidae) have been found in these flower heads. Larvae of Artichoke Plume moth (*Platyptilia carduidactyla,* Pterophoridae) were found on recently transplanted rosettes. They were grazing on the small leaves in the centre of the rosette. In some areas, ant hills have caused the loss of a few individuals, and at occurrence 1 (Figure 4), ant hills are abundant enough to significantly limit habitat.

The presence of Thistle Head Weevil has been reported in Quebec (Canadian Endangered Species Conservation Council 2016), but it has not been detected yet in the Mingan subpopulation.

In 2020, Canada Thistle Bud Weevil (*Larinus carlinae*) was harvested from the flower heads of Meadow Thistle present at the Biodôme de Montréal. It significantly reduced the production of mature seeds. The species was introduced to Canada as a biocontrol agent of invasive thistles. It is reported in Alberta, British Columbia, Ontario, Quebec, and Nova Scotia (Canadian Endangered Species Conservation Council 2016). It has not yet been detected in the Mingan population.

<u>Rodents</u>

Rocky Mountain population:

Throughout the range of the Rocky Mountain population, evidence (tunnels and surficial soil deposits) of Northern Pocket Gopher (*Thomomys talpoides*) has been observed within Meadow Thistle occurrences (Achuff 2002-2019). The underground parts and root crown of Meadow Thistle plants at the Belly River monitoring site in WLNP are frequently consumed by pocket gophers, usually when the plants are seasonally dormant (Achuff 2019). Some browsing of stems and leaves may occur early in the growing season. Pocket gophers caused 42% of the deaths where the cause was identifiable and likely caused a significant proportion of the 55% of deaths for which the cause was unknown. As the rosette stage of Meadow Thistle grows through multiple years before flowering, the root increases in size and food value. Pocket gophers frequently consume these large roots just prior to when the plant could be expected to flower, based on its size.

Pocket gophers deposit elongated mounds of excavated soil on the soil surface, often under the snow, as they tunnel. These areas of bare soil are favourable sites for Meadow Thistle seeds to germinate and new plant establishment has been observed on these sites (Achuff 2019). This interaction of the two species provides some mutual benefits, but the comparative magnitudes and dynamics of these benefits are unknown. It may be that over the recent past, pocket gopher herbivory has continued at “normal” rates while reduced seed production due to the Thistle Head Weevil has resulted in fewer plants establishing, with a consequent negative effect on Meadow Thistle population numbers.

Similarly, Columbian Ground Squirrel (*Urocitellus columbianus*) burrows have been observed at many occurrences of the Rocky Mountain population (Achuff 2002-2019). Columbian Ground Squirrels are nearly entirely herbivorous (Montana Natural Heritage Program 2019) and appear to consume both roots and above-ground parts of Meadow Thistle. At the Lone Creek monitoring site in WLNP, ground squirrels caused 31% of the deaths where the cause was identifiable and likely caused a significant proportion of the 65% of deaths where the cause was unknown.

Bare soil around ground squirrel burrows may provide favourable sites for Meadow Thistle seeds to germinate and establish new plants. However, ground squirrel activity is more continuous in these sites than in bare soil areas created by pocket gophers and it is not clear how important or effective these ground squirrel-disturbed areas are for plant establishment.

Secondarily, Grizzly Bears excavate ground squirrel burrows, especially in the fall after the ground squirrels have entered dormancy. Such digging at the Lone Creek site both directly killed some Meadow Thistle plants and created bare soil patches which were later colonized by Meadow Thistle (Achuff 2019). Bear digging accounted for 2% of the non-flowering mortality of Meadow Thistle at this site (Achuff 2019). Although Grizzly Bears are largely herbivorous, no evidence is known of them using Meadow Thistle.

Mingan population:

Meadow Thistle leaves are among the first to come out of the ground and can therefore be particularly attractive to Snowshoe Hare. Grazing on Meadow Thistle is usually of low intensity, but from 1995 to 1997 it was one of the main causes of plant mortality and plant size reduction (Nantel and Cantin 1998b). In 2013, roughly 70% of plants at one occurrence site had been damaged by Snowshoe Hare (Dénommée 1998-2019).

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

<u>Rocky Mountain population:</u>

Information on population sizes and trends is from two sources: two transects in WLNP, and observations of occurrences made throughout the population range.

The two transects in WLNP were established in 2002: one in the Foothills Aspen Parkland Ecoregion at an elevation of 1380 m (Belly River), and one in the Lower Subalpine Ecoregion at an elevation of 1715 m (Lone Creek) (Figure 6). They were established in natural meadows containing a sizable number of Meadow Thistle rosettes. These meadows appear to be successionally stable over long periods of time. No successional changes of major vegetation type were apparent during the period of observation. The Kenow fire of 2017 burned the Lone Creek meadow, which will remain a meadow post-fire. Each transect was 10 m wide and the length was determined by the distance needed to contain about 300 plants (Belly River: 90 m long, Lone Creek: 25 m long). The beginning and end of each transect were marked with a permanently installed metal post and plants were marked with metal tags on nails at the base of each plant to enable individual plants to be measured and followed over time. The transects were observed annually in late summer in 2002-2008. The number of flowering plants as well as the number and diameter of rosettes were recorded (Appendix 1). The diameter of the rosettes was later used to determine which rosettes would be considered as “mature.” Over time as tags were lost and destroyed by animal activity, it was no longer possible to follow individual plants. However, counts were continued within the transect area. There was a gap in observations from 2009-2016, followed by observations in 2017-2019. Belly River data in 2007 were inconsistent and so were not used, and the Lone Creek site was not accessible in 2018 due to a post-Kenow fire closure. Overall, each transect was sampled nine times over 17 years.

“Spot observations” were made at various times from 2002 to 2019. Some were made during targeted surveys to determine occurrences and range boundaries, while others were opportunistic during fieldwork for other species. Twenty-four occurrences were selected as “spot observations” for analysis from a pool of 215 observed occurrences, based on having initial observations in 2002, 2003, or 2005 and being well delimited spatially to allow reliable recounting in 2019. Some occurrences were surveyed more than twice but only 2002, 2003, or 2005 versus 2019 observations are used here to provide a standard basis for comparison. While not a random sample of the larger pool of occurrences, the twenty-four spot observations occurred over a wide environmental range, in all portions of the geographical range of the Rocky Mountain population, with roughly similar numbers of observations in the eastern and western portions.

Spot observation areas were delimited by topographic features (e.g., meadow/road/clearing edge, creek), GPS points, and rough distances (paced or determined via GPS unit) from features and points. Both flowering plants and rosettes were counted, area size was roughly estimated, and the presence of Thistle Head Weevil and other disturbances (e.g., grazing, herbicide application) was noted. Rosette diameters were not recorded so data are the number of individuals, not “mature” individuals. Spot observations are repeatable but not as precisely as the transects. The main value of the spot observations is to put the transect data (n = 2 in WLNP) in a wider geographic context (n = 24 from throughout the Rocky Mountain population). The changes in spot observation numbers over time are mostly quite large and nearly all the changes are negative, portraying a similar picture of decline as in the two transects.

Subpopulations have not been delineated over the entire range of this population; however, British Columbia recently determined that there are 35 subpopulations in British Columbia (Penny pers. comm. 2021).

<u>Mingan population:</u>

Information on population sizes and trends for the Mingan population is from two sources: a detailed demographic study from 1995 to 1997 by Nantel and Cantin (1998a,b) and yearly surveys by Parks Canada staff, from 1998 to 2019. The information in this section only relates to occurrences still extant in 2018. This may underestimate decline, but data are not available to include the extirpated occurrences in the analyses. All plants at all occurrences were censused from 1995 to 2019, annually or every three years depending on the occurrence, with each occurrence being censused 8 to 20 times (Appendix 2). Individual monitoring of all plants was carried out at eight of the nine occurrences in the Mingan Archipelago, with each plant tagged and mapped. The size class of each plant was noted as seedling, small rosette, large rosette (diameter ≥ 11.3 cm), flowering plant, or dead plant. In occurrence 2 (Figure 4), plants were counted by stage class without being tagged and mapped, because the tall and dense vegetation at this site made the plants and tags difficult to find from one year to the other. From 1995 to 2004, the number of leaves and the diameter of the rosettes were noted for each plant, which allowed stage classes to be defined for later monitoring. As all sites are on islands in close proximity, there is only one subpopulation.

Abundance

Rocky Mountain population:

The abundance (total number of individuals) of Meadow Thistle is difficult to estimate. Few surveys have measured the plant densities of occurrences and the area occupied is not known reliably. Using counts in 2019 from the two transects and three occurrences gives an average of ca. 13,000 plants/km² (range 2400 – 25,700/km²). Using the index of area of occupancy (IAO) of 340 km² gives an estimate of ca. 4.4 million plants (range 816,000 to 8.7 million). It is not known how well the IAO represents the actual area occupied. Occurrences of Meadow Thistle are not likely continuous over a 4 km^2 grid cell as used to compute IAO. Conversely, there are likely more occurrences than are currently known but the additional area is difficult to estimate. Much of the area of seemingly suitable habitat is not occupied by Meadow Thistle. Some of this seemingly suitable habitat is occupied by Hooker's Thistle; other areas contain neither species. The inaccuracy of these two opposing factors (overestimation from IAO grid cell versus underestimation from unknown occurrences) is unknown and thus the estimate has a large uncertainty.

The number of mature individuals (flowering plants + rosettes ≥30 cm) can be estimated using data on the ratio of mature to all individuals from the Belly River and Lone Creek transects. A total of 3279 individual plants were counted on the two transects between 2002 and 2019 with 56% being mature. Applying 56% to the abundance estimate of 4.4 million gives an estimated 2.5 million mature individuals in the Rocky Mountain population (range about 457,000 to 4.9 million). This estimate has a large uncertainty due to the uncertainty in estimating the total abundance, discussed above, and from the ratio of mature to all individuals being based on only two occurrences (transects) comprising 3279 plants.

Mingan population:

There were 444 individuals remaining in 2017, including 339 mature plants (Appendices 3 and 4). A few small individuals may have been missed, but this error is thought to be minimal. A census at all occurrences conducted in 2018 counted a total of 1349 plants (Appendix 3). The number of mature individuals in 2018 was 367 (Appendix 4), which included 349 large rosettes and 18 flowering plants. These numbers included all individuals from recovery interventions implemented since 2001 (see **Manipulated Populations**). Excluding these individuals, we obtain a total of 185 plants, including 148 mature.

Fluctuations and Trends

Rocky Mountain population:

Both transects showed a rise in the number of mature individuals from initial measurements in 2002, with Belly River peaking in 2003 and Lone Creek peaking in 2005 (Figure 8). The number of all individuals (mature and immature) at Belly River declined from 2002 to 2019, while the number of individuals at Lone Creek increased from 2002 to 2004 and then declined to 2019. The overall pattern is one of decline and there is no indication that the early changes were a fluctuation. The Lone Creek data include the effects of the intense fire of 2017, which occurred after sampling was completed that year.

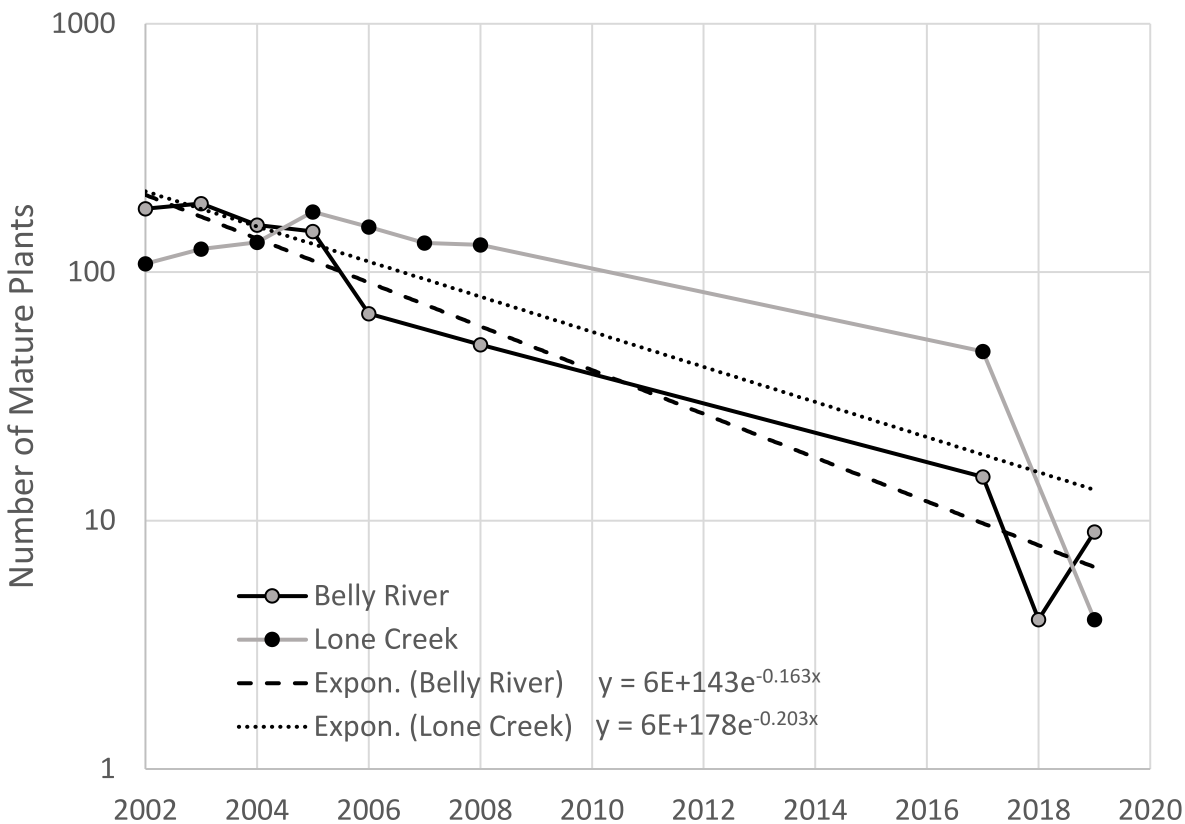


Figure 8. Number of mature plants of Meadow Thistle counted in Belly River and Lone Creek transects. Mature plants are flowering plants plus rosettes ≥30 cm. The Lone Creek transect was impacted by wildfire after the 2017 inventory.

With a generation time of 3.8 years for the Rocky Mountain population of Meadow Thistle, the three-generation period (of the A criterion for assessment) is 12 years (3.8 x 3 = 11.4, rounded to 12 years). Due to differing gaps in observation, Belly River three-generation data are for 2006-2018 and for Lone Creek 2007-2019. Over the three-generation period, the number of mature individuals declined by 94% in the Belly River transect, by 97% in the Lone Creek transect, and by 96% for the two transects combined (Table 2a). The number of all plants declined by 96% at Belly River, by 98% at Lone Creek, and by 96% when combined. Over the full 17-year period of observation (2002-2019), the number of mature individuals declined by 95% in the Belly River transect, by 96% at Lone Creek, and by 95% when combined. Similarly, the number of all plants over the 17-year period declined by 97% at Belly River, by 99% at Lone Creek, and by 98% when combined.

To estimate percent change in number of mature individuals over two and three generations, the growth rates from the 17-year period were applied to 2002 numbers (Table 2b).

Table 2. Meadow Thistle observations and population projections for the two transects of the Rocky Mountain population.

a) Transect observations. *Mature individuals* is flowering plants plus rosettes >30 cm. Generation time = 3.8 years; 3 generations = 12 years. Three-generation period for Belly River is 2006-2018, for Lone Creek 2007-2019. Note: a wildfire occurred at Lone Creek in 2017, after the survey.

Belly River	**20 02**	**20 03**	**20 04**	**20 05**	**20 06**	**20 07**	**20 08**	**09-16**	**20 17**	**20 18**	**20 19**	**12y %**	**17y %**
flowering	20	26	4	39	18	nd	33	nd	4	0	4		
ros>30cm	160	163	151	107	50	nd	18	nd	11	4	5		
mature	180	189	155	146	68	nd	51	nd	15	4	9	-94	-95
ros<30cm	131	79	67	47	30	nd	5	nd	0	0	0		
all plants	311	268	222	193	98	nd	56	nd	15	4	9	-96	-97
Lone Creek	**20 02**	**20 03**	**20 04**	**20 05**	**20 06**	**20 07**	**20 08**	**09-16**	**20 17**	**20 18**	**20 19**	**12y %**	**17y %**
flowering	4	3	1	8	9	4	4	nd	11	nd	1		
ros>30cm	104	121	131	167	143	127	125	nd	37	nd	3		
mature	108	124	132	175	152	131	129	nd	48	nd	4	-97	-96
ros<30cm	196	221	239	177	112	83	53	nd	19	nd	0		
all plants	304	345	371	352	264	214	182	nd	67	nd	4	-98	-99
Both transects	**20 02**	**20 03**	**20 04**	**20 05**	**20 06**	**20 07**	**20 08**	**09-16**	**20 17**	**20 18**	**20 19**	**12y %**	**17y %**
Total mature												-96	-95
Total all												-96	-98

b) Growth rates (r) and number of mature plants (N) forecast for the sampled Rocky Mountain transect populations of Meadow Thistle. The growth rates were applied to numbers at first census $N_{(2002)}$ to forecast to 2010 (2 generations) and 2013 (3 generations) respectively, as $N_{(2002)}\ e^{8r}$ and $N_{(2002)}\ e^{11r}$. Projection to 3 generations in the future (2024) applied the growth rates to numbers at last census (2019) as $N_{(2019)}\ e^{1}$.

Census transect	r (2002-2019)	N (2002)	N (2010)	% change	N (2013)	% change	N (2024)	% change
Belly River	-0.203	180	35	-80%	19	-89%	1	-89%
Lone Creek	-0.163	108	29	-73%	18	-83%	1	-83%
Total		288	64	-78%	37	-87%	2	-87%

Both transects followed similar trajectories in size/age structure with a decreasing ratio of immature to mature plants over the 17-year period (Figure 9). A ratio of <1 indicates that the transect population is not producing enough young plants to replace the loss of older plants. This drop below the replacement threshold is most likely due to reduced seed production caused by Thistle Head Weevil.

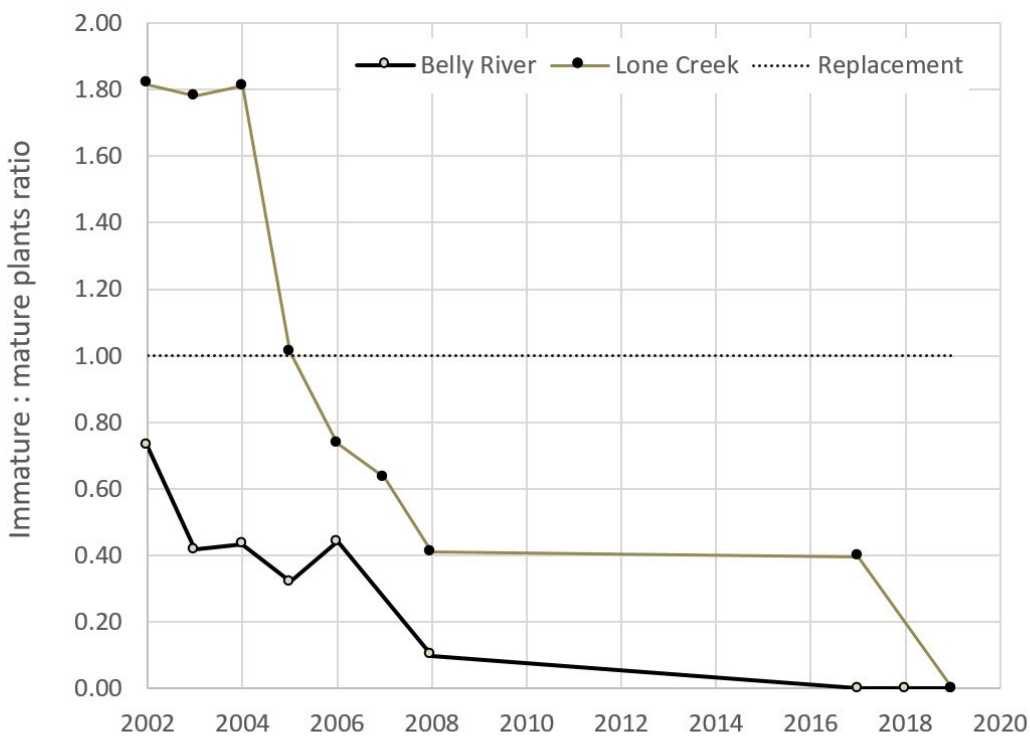


Figure 9. Immature: mature plants ratio for Meadow Thistle counted in Belly River and Lone Creek transects. A ratio of <1 indicates that the transect population is not producing enough young plants to replace the loss of older plants. The Lone Creek transect was impacted by wildfire after the 2017 inventory.

In the Belly River transect, the size/age ratio in 2002 was already 0.73 and continued to decline in the following years. No immature plants were observed in 2017, 2018, or 2019. In the Lone Creek transect, the 2002 ratio was 1.81. In 2005, the ratio dropped essentially to 1, following which the number of immature plants and the ratio declined through 2019. No immature plants were found in 2019. The Kenow fire, which occurred in September 2017 after the 2017 count of 67 rosettes (48 mature, 19 immature), likely was the primary cause of reducing the population to the three mature rosettes observed in 2019.

The results for the 24 spot observations show a similar pattern of decline across a wider geographic extent than the two transects (Table 3). The period of record for the spot observations included 17 years (n = 13), 16 years (n = 5), and 14 years (n = 6), all ending in 2019. Only three of the 24 spot observations showed an increase with the other 21 declining. The median percent change of the 24 sites is -88. Of the three spot observations with an increase, Seed Head Weevil was present at LNX1 in 2005 but absent in 2019, present at F24 in 2003 but absent in 2019, and absent at F25 in both 2003 and 2019.

Table 3. Spot observation data for Rocky Mountain population. N = number of individuals (mature and immature).

Spot	t1	t2	yrs	N(t1)	N(t2)	change	%change
B3	2005	2019	14	88	19	-69	-78
B7	2005	2019	14	300	38	-262	-87
CRB-CF	2005	2019	14	2500	75	-2425	-97
JG16a	2005	2019	14	220	199	-21	-10
LNX1	2005	2019	14	8	9	1	13
LNX2	2005	2019	14	1000	136	-864	-86
F24	2003	2019	16	61	131	70	115
F25	2003	2019	16	58	211	153	264
F27	2003	2019	16	212	138	-74	-35
PA09	2002	2019	16	12	7	-5	-42
PA46	2003	2019	16	248	12	-236	-95
JG12	2002	2019	17	60	52	-8	-13
PA06	2002	2019	17	83	11	-72	-87
PA07	2002	2019	17	23	3	-20	-87
PA20	2002	2019	17	131	1	-130	-99
PA21	2002	2019	17	160	0	-160	-100
PA22	2002	2019	17	120	2	-118	-98
PA32b	2002	2019	17	362	2	-360	-99
PA34	2002	2019	17	85	6	-79	-93
PA40	2002	2019	17	87	9	-78	-90
PA41	2002	2019	17	492	2	-490	-100
PA49	2002	2019	17	763	23	-740	-97
PA50	2002	2019	17	476	38	-438	-92
PA65	2002	2019	17	324	34	-290	-90
14y (n=6)				4116	476	-3640	-88
16y (n=5)				591	499	-92	-16
17y (n=13)				3116	183	-2983	-94

Taken together, transect and occurrence data indicate a precipitous decline in the Rocky Mountain population of Meadow Thistle since 2002.

Mingan population:

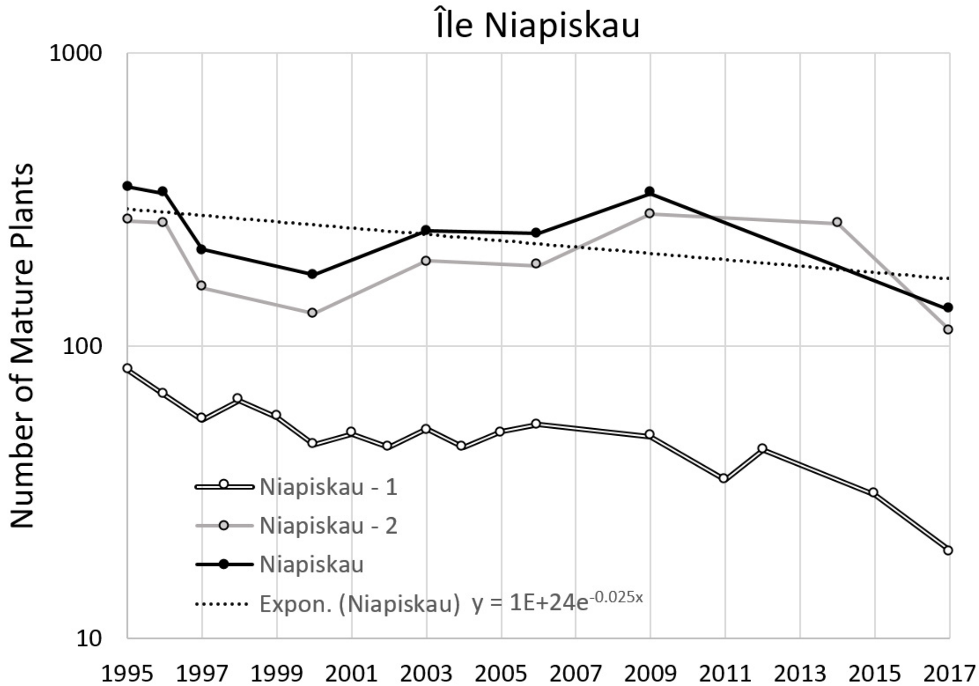
The trends analyses include plants that were established or survived because of recovery interventions implemented from 2001 to 2017 (see **Manipulated Populations**), and therefore trend values assume those recovery interventions would continue over time, which may not be the case.

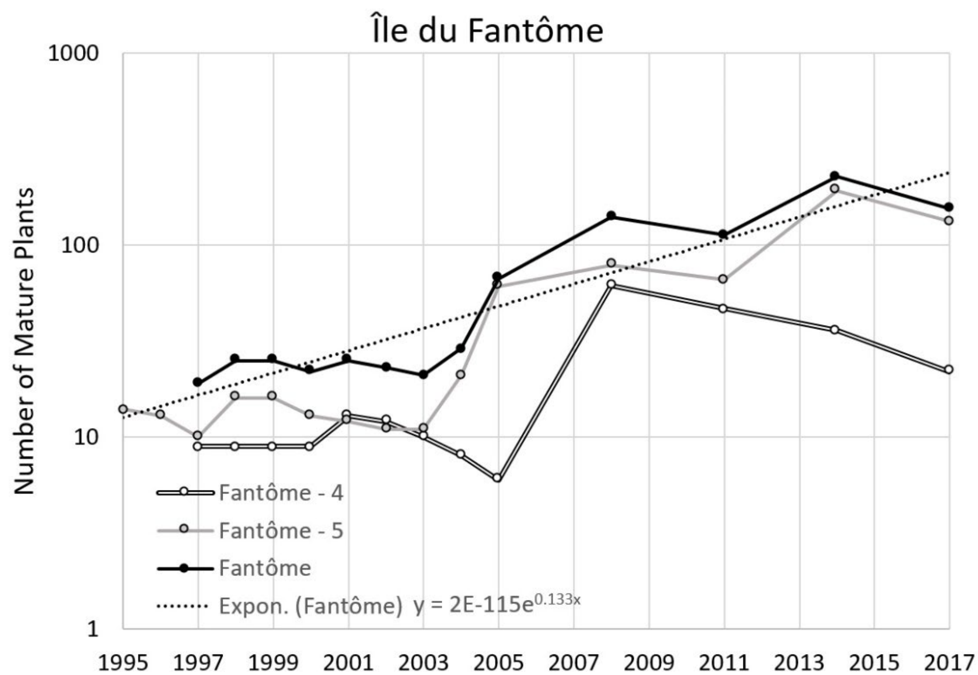
Trends were analyzed for each of the four occupied islands (Île Niapiskau, Île du Fantôme, Île du Havre, and Grosse île au Marteau) and for the Mingan Archipelago as a whole (Figure 4). Number of mature plants, as indicated by the time series of mature plants by island and occurrence, show relatively large variations in space and time from 1995 to 2017 (Figure 10). Number of mature plants on Île Niapiskau declined almost continuously while on Grosse île au Marteau it increased until 2012 and then declined thereafter but overall was almost stationary. On Île du Fantôme and Île du Havre it increased overall, but with recent steep declines. Short and longer periods of population growth are mainly due to increased recruitment resulting from population augmentation efforts. Steep declines are partly due to direct and indirect mortality from winter storm events.

On three islands, time series of two distinct (yet very close) occurrences were combined for further analyses so that growth rates and variance could be based on larger numbers and therefore increase robustness.

The observed change in number of mature plants from 1995-2017 varied among occurrences from a decline of 64% to an increase of 716%, with an overall decline of 27% (Table 4a). Population growth rates were estimated as (r) the slope of a linear regression of number of mature plants (on a natural logarithmic scale) across time and as the average slope between each pair of consecutive censuses (μ) (see **Population Viability Analysis**). To estimate percent change in number of mature individuals over two and three generations, assuming a generation time of 10 years, the growth rates were applied to numbers at first census (1995) to forecast to 2015 and 2025 respectively (Table 4b). Another assumption was that the abundance at Île du Fantôme and Île Havre cannot exceed 250 mature plants, because of very limited habitat. Overall, actual number of mature plants in 2017 is better predicted using mean growth rate μ rather than using r, so percent changes computed from applying μ appear more reliable for assessing the status of the population (Table 4c). In this case, the estimated reduction in number of mature plants is 26% over the past two generations, and 19% over three generations from past to future.

The immature:mature ratio varied from 0.4 to 3.2 among years and from 0.1 to 2.8 among occurrences (mean = 1.5) (Appendix 5). This variation is mainly due to the seeding carried out the previous year and does not show any trend or pattern.


Île Niapiskau
1000
100
10
Number of Mature Plants
Niapiskau - 1
Niapiskau - 2
Niapiskau
Expon. (Niapiskau) y = 1E+24e^-0.025x
1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015 2017


Île du Fantôme
1000
100
10
1
Number of Mature Plants
Fantôme - 4
Fantôme - 5
Fantôme
Expon. (Fantôme) y = 2E-115e^0.133x
1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015 2017

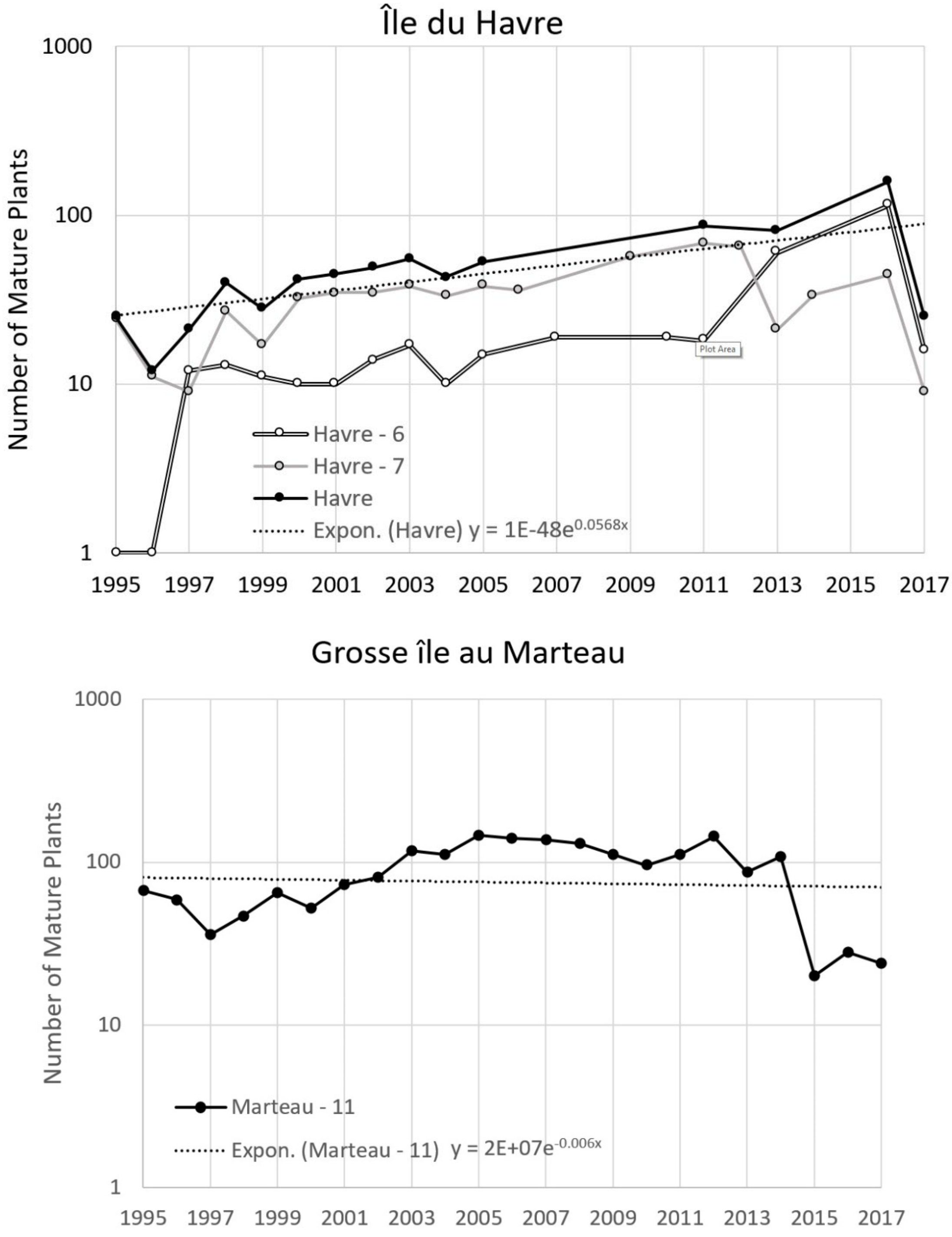


Figure 10. Number of mature plants of Meadow Thistle on the four islands of the Mingan Archipelago where the species occurs, from 1995 to 2017. Mature plants are flowering plants plus rosettes ≥ 11.3 cm in diameter. Counts in distinct patches within occurrence are plotted as well as their combined, total mature plants on each island; regression lines and equations are for counts of all mature plants on each island.

Table 4. Percent change observed and forecasted in number of mature plants over two and three generations in the Mingan population.

a) Change in number of mature plants as observed from 1995-2017.

Island	$N_{(1995)}$	$N_{(2017)}$	% change 1995-2017
Île Niapiskau	351	133	-62%
Île du Fantôme	19	155	716%
Île du Havre	25	25	0%
Grosse île au Marteau	67	24	-64%
Total	462	337	-27%

b) Change in number of mature plants as forecasted using estimated growth rates r applied to numbers at first census (1995) to forecast to 2015 (2 generations) and 2025 (3 generations) respectively, as $N_{(1995)}\ e^{20r}$ and $N_{(1995)}\ e^{30r}$.

Island	r (1995-2017)	$N_{(1995)}$	$N_{(2015)}$	% change 1995-2015	$N_{(2025)}$	% change 1995-2025
Île Niapiskau	-0.025	351	213	-39%	166	-53%
Île du Fantôme	0.133	19	250	1216%	250	1216%
Île du Havre	0.057	25	78	211%	137	450%
Grosse île au Marteau	-0.006	67	59	-11%	56	-16%
Total		462	600	30%	609	32%

c) Change in number of mature plants as forecasted using mean growth rate (μ), the average slope between each pair of consecutive censuses, applied to numbers at first census (1995) to forecast to 2015 (2 generations) and 2025 (3 generations) respectively, $N_{(1995)}\ e^{20\mu}$ and $N_{(1995)}\ e^{30\mu}$.

Island	μ (1995-2017)	$N_{(1995)}$	$N_{(2015)}$	% change 1995-2015	$N_{(2025)}$	% change 1995-2025
Île Niapiskau	-0.047	351	138	-61%	86	-75%
Île du Fantôme	0.105	19	155	716%	250	1216%
Île du Havre	0.000	25	25	0%	25	0%
Grosse île au Marteau	-0.047	67	26	-61%	17	-75%
Total		462	343	-26%	378	-18%

Population Viability Analysis (Mingan population)

Stochastic exponential growth models with year-to-year variability in the growth rates and no density-dependence were run to estimate probabilities of decline and extinction (Appendix 6), as was done for a similar species, Pitcher's Thistle (*Cirsium pitcheri)* (Nantel *et al.* 2018).

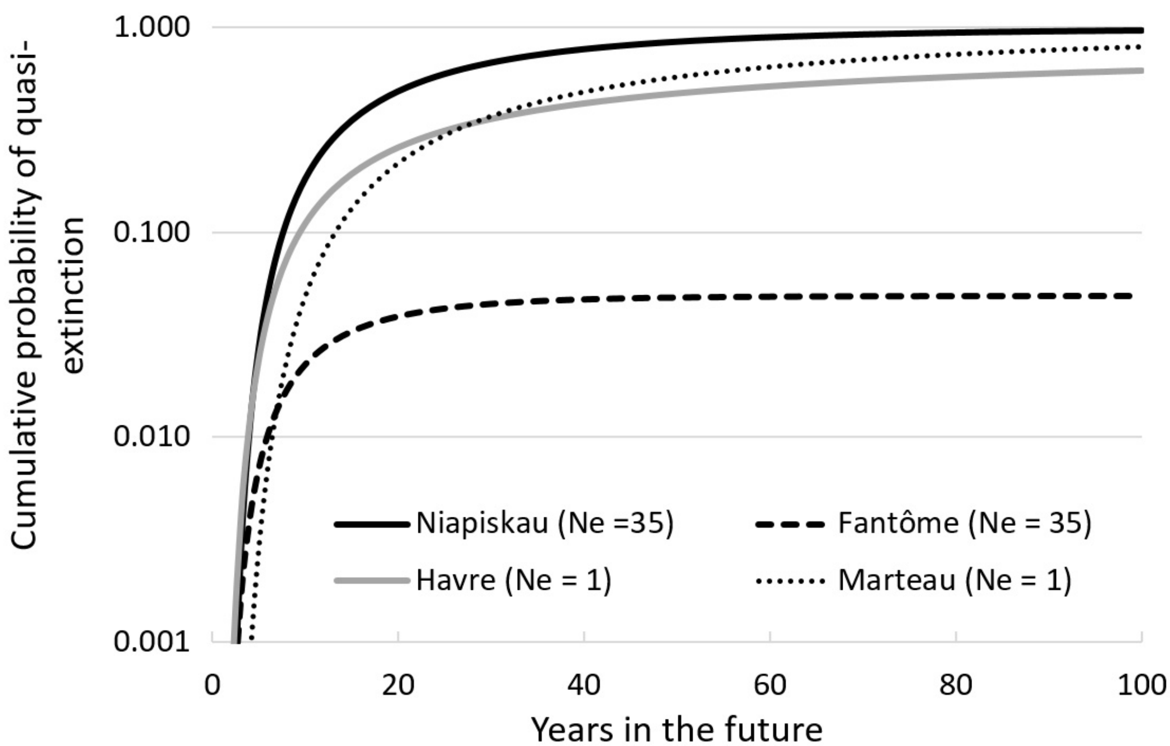
On all islands, the probability of reaching in the next 100 years a quasi-extinction threshold[3] or 50% of the number of mature plants counted in 2017, ranges from 0.05 to 1.0 (Table 5). Extinction was expected given that the occurrences contained small numbers of mature plants and were either declining, experiencing large fluctuations, or both. If trends and fluctuations continue as measured, the species is predicted to disappear from all islands, except perhaps one (Île du Fantôme), which has the lowest probability of extinction. Based on the cumulative distribution functions for probability of quasi-extinction, overall, extinction happens early in the time series, typically in the first 20 years (Figure 11).

Table 5. Viability statistics for Meadow Thistle in the Mingan Archipelago, based on 23-yr time series of counts of mature individuals (large rosettes and flowering plants), 1995-2017.

Island	Trends in log N	Mean growth (μ)	Variance (σ^2)	Number of transitions	Population size (2017)	P decline 50% over 100 yrs	P quasi-extinction over 100 yrs[a]
Île Niapiskau	-0.022	-0.047	0.052	7	133	0.992	0.975
Île du Fantôme	0.133	0.105	0.103	11	155	0.243	0.050
Île du Havre	0.057	0.000	0.406	13	25	0.913	1.000
Grosse île au Marteau	-0.006	-0.047	0.200	21	24	0.972	1.000

a- For a quasi-extinction threshold of 35 mature individuals.

[3] Quasi-extinction is defined as 35 mature plants because it is the estimated number of plants required for a population to recover from a decline, given that 0.5-5% of large rosettes transitioned annually to a flowering plant.



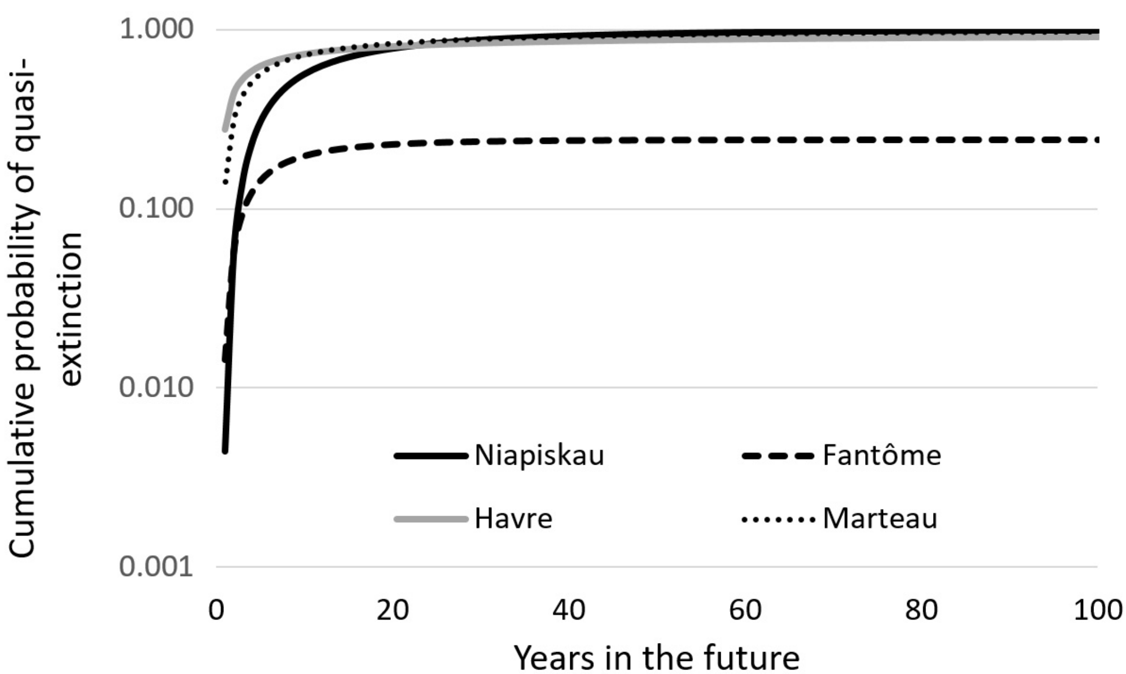


Figure 11. Cumulative probability through time in the future, that the populations will reach A) the quasi-extinction threshold (Ne) indicated on the graph, and B) a quasi-extinction threshold that is 50% the size at last census (2017), for Meadow Thistle of the Mingan population.

The occurrences on Île du Havre and Grosse île au Marteau were both below the threshold in 2017, so they are already “quasi-extinct”. At a threshold of one mature plant, the probability of extinction for those two occurrences is also very high, respectively 0.613 and 0.805 (Figure 11).

For the whole Mingan Archipelago, the multi-site population projection model yielded a 0.14 and 0.30 probability of quasi-extinction over 50 and 100 years, respectively, and a 0.21 probability of 50% decline over the next three generations (Figure 12). The stochastic population growth rate computed from the same model (r = -0.003) predicts a slow continuing decline, which would lead to an 8% reduction in number of mature individuals over the next three generations (2017-2047).

Taken together, island by island and multi-site PVAs indicate that the Mingan population is likely to disappear over the next 50 years on all but one island, and that even if the species persists on that island, the number of mature individuals will likely be low. Also, extinction predicted on three islands will entail a decline in extent of occurrence and index of area of occupancy. Finally, although the PVA indicates that the population may meet one criterion for severely fragmented, as most (>50%) of its population is in habitat patches that are not viable, the IUCN standards also imply that the patches are subpopulations (IUCN Standards and Petitions Committee 2019) and with all habitat patches in one subpopulation, this criterion is not met. The population could also meet the second criterion for severely fragmented – “[habitat patches] are separated from other habitat patches by a large distance”, if we consider the poor dispersal capacity of the species’ seeds together with the fact that habitat patches occur on different islands, but again, the habitat patches are intended to be subpopulations. As such, the population is not severely fragmented.

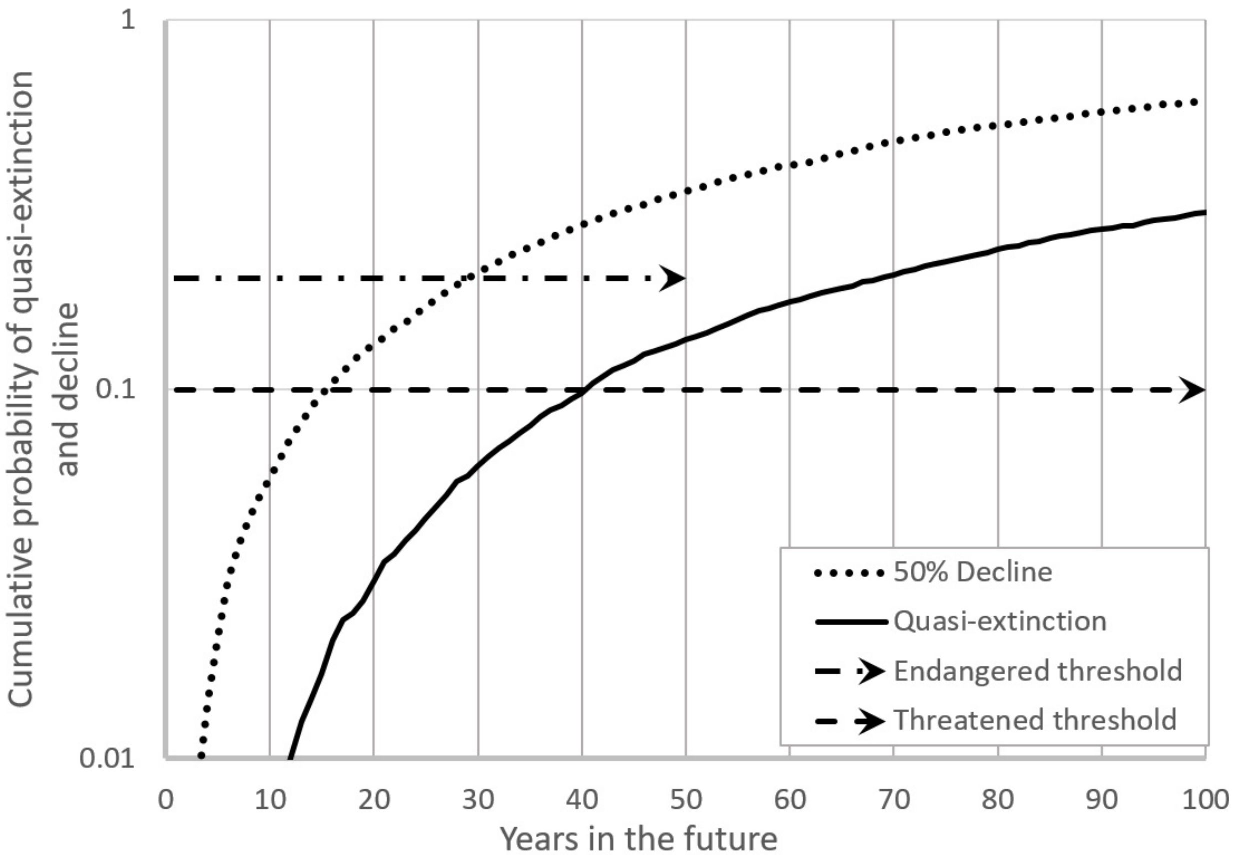


Figure 12. Cumulative distribution function (CDF) for the probability of 50% decline and of quasi-extinction for the whole Mingan population of Meadow Thistle. Each CDF is based on 5000 simulated multi-site trajectories.

Rescue Effect

<u>Rocky Mountain population:</u>

No rescue effect for the Rocky Mountain population from the USA can be foreseen at this time. There are occurrences of Meadow Thistle in the USA that are essentially contiguous with Canadian occurrences in both Alberta and British Columbia. Seed dispersal from the USA occurrences is possible, seed from the USA likely would be adapted for the western Canadian range, and suitable habitat for seed germination and establishment is likely available in Canada. However, Thistle Head Weevil is established in these US occurrences (Achuff 2002-2019) and likely is reducing seed production there as it is in Canada. Populations of other *Cirsium* spp. in the USA provide an alternative host for the weevil and it is unlikely that any US occurrences of Meadow Thistle will escape the effects of the weevil. These effects, coupled with the short seed dispersal distances of Meadow Thistle, make the probability of successful mitigation from the USA of an extirpation or population decline extremely low.

Mingan population:

The Mingan population is disjunct from the species in both Canada (about 3500 km) and the western USA. The likelihood of dispersal between these populations is essentially impossible.

THREATS AND LIMITING FACTORS

Direct threats facing Meadow Thistle assessed in this report were organized and evaluated based on the IUCN-CMP (World Conservation Union-Conservation Measures Partnership) unified threats classification system (Salafsky *et al*. 2008; Master *et al*. 2012). The overall threat impact estimated using the threats calculator is Very High for the Rocky Mountain population (Appendix 7) and from High to Very High for the Mingan population (Appendix 8).

Threats – Rocky Mountain Population

Threat 8 (IUCN). Invasive and Other Problematic Species and Genes

8.1 Invasive Non-Native / Alien Species [Very High threat impact]

Thistle Head Weevil (Coleoptera: Curculionidae) is native to southern and central Europe, North Africa, and western Asia (Kok 2019). Weevils from Alsace, France, and the Rhine Valley, Germany, were introduced in 1968 to Canada near Regina, Saskatchewan by Agriculture Canada (Harris 1981; Gassmann and Louda 2001) as a biological control agent for Nodding Thistle (*Carduus nutans*). The weevil has been introduced to Alberta, Saskatchewan, Manitoba, Quebec, Ontario, and British Columbia (Harris 1981; Desrochers *et al.* 1988; BC FLNRORD 2019) and widely in the USA, including in 1969 to Montana (CABI 2019), which borders the range of Meadow Thistle in western Canada. The weevil observed on Meadow Thistle in the Rocky Mountain population has been identified as Thistle Head Weevil by Agriculture and Agri-Food Canada staff in Lethbridge who have been involved with biological control research, including the initial introduction of the weevil to Canada.

It is not clear when the weevil first arrived within the range of the Rocky Mountain population nor where those weevils may have originated. They appear to have been in southern Alberta by the early 1990s (Bourchier pers. comm. 2019). The weevils have naturalized in western Canada (i.e., reproduce successfully and increase their population numbers without human assistance) and were found throughout the Alberta portion of Meadow Thistle range in 2002 and in the British Columbia portion in 2003; 2019 observations confirm their continued presence (Achuff 2002-2019). It is unlikely that the weevils had just spread to these areas in 2002-2003, rather these are first documented occurrences. Currently, the weevil appears to be dispersing naturally although some dispersal by humans is known to be occurring within the range of Meadow Thistle in Canada (BC FLNRORD 2019).

Adult beetles are brown, 10-15 mm long (Kok 2019) and overwinter in litter near host plants. In late spring to early summer, females seek out developing flower heads of host thistles, lay 100-200 eggs on the base of the bracts surrounding the developing flower and cover the eggs with chewed plant tissue (CABI 2019). The eggs hatch within 6 days and the larvae burrow into the base of the flower, into the receptacle tissue immediately below the developing seeds. The white larvae develop through four stages over 4-6 weeks. The larvae typically consume seeds during development (Sheppard *et al*. 1994) as well as receptacle tissue. The larvae then deposit frass and chewed plant material to form a rigid pupation chamber. Pupation takes 7-10 days. Newly emerged adults move into the ground litter where they remain during the rest of the growing season and following winter, to emerge at the start of the next growing season. Typically, one generation occurs each year (Zwolfer and Harris 1984).

Adult weevils feed on host plant leaves but the effect on the host is minimal compared to the damage done to the flower head. Adult weevils can disperse up to 20 km in the spring (Zwolfer and Harris 1984). Many parasitoids attack the weevil but laying excess eggs appears to compensate for such losses (CABI 2019).

The weevil has been introduced elsewhere in North America to successfully control other non-native thistles besides Musk Thistle: Bull Thistle, Plumed Thistle (*Cirsium acanthoides*), and Milk Thistle (*Silybum marianum*) (Harris and Zwolfer 1971). Effective control of these species usually has occurred within 5-6 years of introduction but has occurred within 2-3 years under favourable conditions (Texas A&M 2019).

This weevil is not limited to non-native host plants in North America but has successfully attacked and suppressed at least 22 species of native, large-headed thistles, including Meadow Thistle and other species of conservation concern (Harris 1981; Arnett and Louda 2000; Pemberton 2000). In western Canada within the range of Meadow Thistle, the weevil has been observed to damage the seed heads of two other native thistles: Wavy-leaved Thistle and Hooker's Thistle (Achuff 2002-2019).

Platte Thistle (*Cirsium canescens*) is a native thistle endemic to western Nebraska and eastern Wyoming that has a life history very similar to that of Meadow Thistle – monocarpic, flowers within 2-5 years, first native thistle to flower in the spring (Arnett and Louda 2000). The effect of Thistle Head Weevil on Platte Thistle has been studied in detail and the findings are relevant to Meadow Thistle. The impact of the weevil on native thistles depends on synchrony between adult weevil emergence and flower head development of the host plant (Goeden and Richer 1985). Species that flower earliest in the growing season are affected most (Arnett and Louda 2000). Within the range of Meadow Thistle in western Canada, Meadow Thistle has been observed to be the earliest flowering host species (Achuff 2002-2019). Meadow Thistle flowers develop from the top of the stem downward through the growing season and the earlier flowers are most attacked by the weevil. Flowers lower on the stem may not be attacked as heavily or at all in some years, as the number of egg-laying female weevils declines through the growing season. However, these later flowers seldom have enough time to complete seed development before the plant senesces and dies (Achuff 2002-2019). Thus, the weevil attack on the upper, earlier flowers is usually sufficient to prevent or severely reduce viable seed production. Seed production in Platte Thistle was reduced five-fold (Arnett and Louda 2000). Given its monocarpic life cycle, a single year of weevil infestation can severely reduce seed production and have a lasting impact on population size.

Population modelling of Platte Thistle indicated that, before the introduction of Thistle Head Weevil, thistle population density was limited by seed production, which was in turn limited by native insect predation (Arnett and Louda 2000; Rose *et al.* 2005). The introduction of Thistle Head Weevil has augmented seed predation and driven population densities lower. This appears to have happened in Meadow Thistle as well.

Biological control agents are subject to screening to determine possible effects on non-target species, both native and non-native. Thistle Head Weevil was screened and "the potential impact of *R. conicus* was considered to be "acceptable" (Harris and Zwolfer 1971). Subsequent evaluation of the decision to release Thistle Head Weevil in North America (Gassmann and Louda 2001) concluded that with the information available, the effects on native thistles could have been predicted but the analysis was not done.

In recognition of the threat posed to native species by Thistle Head Weevil in the USA, further release of the weevil is prohibited in many areas and interstate movement has been banned (Rose *et al.* 2005). However, human-assisted distribution of the weevil currently continues in both Canada (BC FLNRORD 2019) and within states in the USA (Gassmann and Louda 2001; Texas A&M 2019).

Eight arthropod species have been introduced as biocontrol agents to control thistles in western Canada (De Clerck-Floate and Carcamo 2011) and of these only one introduction was unsuccessful. The Seed Head Weevil has been the most successful introduction for thistle control.

<u>Threat 7 (IUCN). Natural System Modifications</u>

7.1 Fire and Fire Suppression [Medium – Low impact]

Fire affects Meadow Thistle in two ways: direct mortality, which is treated as a threat, and through fire's effect on habitat (see **Habitat Trends**). Fire is considered here to be a threat according to the guidance definitions (COSEWIC 2018b), which state that threats "are defined as activities or processes that directly negatively affect the Canadian population… natural phenomena can be regarded as direct threats in some situations, particularly when a species or habitat is damaged from other threats and has lost its resilience, and is thus vulnerable to the disturbance to the degree where a population decline is observed, projected, or suspected."

Because Meadow Thistle has been damaged by Thistle Head Weevil (reduced seed production causing declining population size), it has lost its resilience (reduced seed production reduces ability to replace plants killed by fire) and is thus disproportionately vulnerable to fire mortality compared to the historical situation (reduced seed production reduces the ability to recolonize burned areas, the weevil has much greater dispersal capacity and can keep up with thistle dispersal). With continued climatic change, fires in western Canada are expected to increase in frequency, size and intensity (Flannigan *et al.* 2005; Bush and Lemmen 2019; Hanes *et al.* 2019), a situation to which Meadow Thistle will be increasingly unable to respond due to reduced seed production. The negative effects of direct mortality from fire likely will outweigh the increase in potentially suitable habitat from a changed fire regime.

7.3 Other Ecosystem Modifications (herbicide application) [Medium – Low impact]

Herbicide spraying of Meadow Thistle by weed control programs has been observed in Alberta on public lands, including protected areas, and in British Columbia where spraying has been observed on public lands adjacent to current occurrences (Achuff 2002-2019). Control programs have not targeted Meadow Thistle *per se*, but confusion of Meadow Thistle with target species, such as Bull Thistle, and poor spray techniques have led to Meadow Thistle being sprayed over many years. In both provinces, spraying likely contributes to population declines and perhaps to local extirpations.

<u>Threat 2 (IUCN). Agriculture and Aquaculture</u>

2.3 Livestock Farming and Ranching [Medium – Low impact]

Damage to Meadow Thistle plants by domestic livestock has been observed on both private and public lands in Alberta (Achuff 2002-2019). The damage includes grazing of rosettes as well as trampling/breakage of flowering plants. Rosette grazing reduces annual growth and, as root:shoot ratio adjustment occurs after grazing, slows the accumulation of resources that ultimately allow the monocarpic flowering event to occur. Grazed rosettes likely take longer before flowering and are likely to suffer greater mortality. Breakage of flowering stalks usually results in death of the plant before seeds can be produced. These effects are especially notable in areas that have been heavily grazed; in more lightly grazed areas much less damage has been observed.

Threats – Mingan Population

<u>Threat 11 (IUCN). Climate Change and Severe Weather</u>

Using a standard approach (Foden *et al.* 2013), Meadow Thistles of the Mingan population could be considered “highly vulnerable to climate change” because of the scarcity of its restricted and specialized habitat, its weak capacity of adaptation, poor evolvability, and especially its exposure to storms amplified by sea level rise and loss of sea ice cover due to warmer winter temperature. The NatureServe climate change vulnerability index for the Meadow Thistle of the Mingan population is Extremely High, mainly because of sea-level rise and temperature change (Gendreau *et al.* 2016).

In the following sections, to assess climate change as a threat to the Mingan population of Meadow Thistle, scenario RCP8.5 was used, which assumes greenhouse gas emissions will continue to rise throughout the 21st century (Ouranos 2015)[4].

11.4 Storms and Flooding [Very High – High impact]

The balance between storm disturbance-mediated habitat maintenance and the ability of the species to survive seems to have been broken over the last ten years. Storms have affected occurrences by covering plants with sediments (gravel, sand, rocks) and plant debris (herbaceous plants and wood) and by eroding the substrate (Figure 13). Occurrences were also covered with sea water but the residual impact is not known. Loss of habitat following storms occurs through erosion, but also through changes in substrate (gravel, rocks) making recruitment unlikely before the soil recovers after many years without a storm.

Figure 13. Impact of storms in the Meadow Thistle occurrences of the Mingan Archipelago (left: erosion, right: accumulation of plant debris). Photo credit: © Parks Canada / Nancy Dénommée.

The impacts of storms were observed previously on Grosse île au Marteau in 1968 (Morisset 1971), and on Île du Havre and Île Niapiskau during the winter of 1995-1996 (Nantel and Cantin 1998b). Occurrence 14 (Figure 4) disappeared shortly after a major storm in 1983. Minor storm impacts were observed during the 2002-2003, 2003-2004, and 2007-2008 fall-winters. The plants were more seriously affected in 2010, during the fall-winter of 2015-2016, and in 2016.

[4] Representative Concentration Pathway RCP8.5 is one of the four greenhouse gas concentration trajectories adopted by the IPCC for its Fifth Assessment Report in 2014. RCP 8.5 is named after a radiative forcing value of +8.5 W/m^2 in the year 2100 relative to pre-industrial conditions.

During the storm tide of December 6, 2010, there was no ice cover on the sea to reduce the impact of the waves. The resulting wave height corresponded to a storm with a return period of 35 years (Lasalle NHC 2019). Five of the nine occurrences were very seriously affected: 53-95% of the plants were covered by sand, rocks, wood and dead vegetation ranging from 1 to 50 cm thick (Table 6) (Dénommée 2012).

Table 6. Proportion of Meadow Thistle plants affected by storms from 2010 to 2016 in each of the occurrences of the Mingan population.

Island - Occurrence	2010	Sediment accumulation 2010	2015-2016	Sediment accumulation 2015-2016	2016	Sediment accumulation and other effects 2016
Île Niapiskau - 1	95%	Yes	0%	No	0%	No
Île Niapiskau - 2	<2%	Yes	0%	No	0%	No
Île Niapiskau - 3	?	No plant observed in 2010	0%	No	0%	Yes, beside the plant
Île du Fantôme - 4	91%	Yes	0%	No	100%	Yes
Île du Fantôme - 5	58%	Yes	0%	No	80%	Yes
Île du Havre - 6	53%	Yes	59%	Yes	100%	Erosion and soil washed out. 87.6% plant mortality
Île du Havre - 7	64%	Yes	80%	Yes	100%	Erosion and soil washed out. A little accumulation. 85.9% plant mortality
Grosse île au Marteau - 10	0 %	No	0%	No	100%	Yes, 1 plant present
Grosse île au Marteau - 11	5%	Yes	15%	Yes	79%	Yes

No major storms occurred during the fall-winter of 2015-2016. Despite this, three occurrences were partially buried (Table 6). The cumulative effect of a few storm events with a return period of only two years can have a significant impact on occurrences that are particularly exposed to easterly storms (Lasalle NHC 2019).

The storm of December 30, 2016, which also occurred while there was no sea ice cover, had a return period estimated at 50 years (Lasalle NHC 2019). It seriously affected six of the nine occurrences (Table 6) and caused irreversible damage in occurrences 6 and 7 (Figure 4), where erosion resulted in the loss of more than 80% of the plants. In the other four affected occurrences, the majority of plants were buried under 1 to 35 cm of sand, gravel, rocks, or plant debris. The plants were not physically affected in occurrences 1 and 3 (Figure 4), although they were likely flooded by sea water.

Two storms of the intensity of those of 2010 and 2016 were very unlikely to occur in such a short period and could have made some occurrences disappear quickly had the plants not been uncovered by Parks Canada staff.

Hydrodynamic models in which large storms with a return period of 50 years are simulated show that only two occurrences (2 and 3) would persist in the current climate, with occurrence 11 (Figure 4) having the potential to persist under certain conditions (Lasalle NHC 2019). When the models were adjusted to reflect the hydrodynamic conditions that would occur in 50 years, including a later ice setting (in February rather than January) and sea level rise (57.4 cm), the results indicate that no occurrence meets all of the persistence criteria after major storms (with a return of 50 years). The results of the models consider occurrences at their current location, without restoration intervention after each storm.

Temperature rise due to climate change (see **Temperature Extremes**) can reduce winter ice cover in the marine environment, amplifying the impact of storms. In the Gulf of St. Lawrence, the ice season is shorter than in the past (Ouranos 2015). For the 2041-2070 horizon, the models project a later freeze delayed by 10 to 20 days and a shortening of the ice season by 20 to 30 days compared to the 1982-2011 period. The maximum annual ice concentration could decrease by 67% in this region (Ouranos 2015). Ice cover protects beaches by reducing the available fetch area and allowing the waves to break before arriving at the beach (Lasalle NHC 2019).

Given the limited size and extent of each occurrence, a storm can easily affect all plants at a site. As the occurrences are isolated from each other and often from different islands, natural recolonization is highly unlikely. In addition, low abundance and low reproductive capacity (see **Limiting Factors**) limit each occurrence's ability to survive storms.

11.1 Habitat Shifting and Alteration [High impact]

The area of coastal ecosystems of the Mingan Archipelago is likely to be reduced by coastal erosion and rising sea levels. A study of the Gulf and the St. Lawrence Estuary estimates that by 2060 loss of coastal habitat through erosion and submersion could reach, respectively, 25% and 23% (Bernatchez *et al*. 2016). Sea level rise will also increase the impact of storms. The median projection of the Intergovernmental Panel on Climate Change (IPCC) estimates a relative sea level rise of 30 to 75 cm for the Gulf of St. Lawrence for the period of 2081-2100 compared to the period of 1986-2005 (Ouranos 2015). These rises will be slightly lower on the North Shore because of the slow isostatic rebound from now to 2100.

Following the last glaciation, the isostatic rise allowed the Mingan Archipelago to gradually emerge from the sea. Thistle habitat evolved under relative sea level decline for thousands of years, allowing beaches to expand towards the sea (Lasalle NHC, 2019). Due to climate change, the archipelago is transitioning into a system of continued rise in relative sea level which makes this habitat vulnerable and could make it disappear (Lasalle NHC 2019). These rapid changes do not allow time for the local populations to adapt to their new environment because of, among other things, a small number of individuals and the low capacity for reproduction and dispersal (see **Limiting Factors**).

Rising temperatures and a longer growing season (Ouranos 2015) may result in faster tree growth and acceleration of forest encroachment. Without intervention, habitat will be lost (see **Habitat Trends**) and plants will die before reproduction due to low light.

11.3 Temperature Extremes [Medium impact]

Winters with little snow, combined with cold temperatures, can have a significant negative impact on Meadow Thistle. The bud that ensures its survival is near the surface of the ground and needs snow cover to be well protected. Rain in winter followed by a cold period has been observed a few times in recent years. Data from a weather station at Rivière-au-Tonnerre (Environment and Climate Change Canada 2019) show that there was significant rain in the three winters with the lowest recorded survival rates. In addition, average ground snow levels for the months of December to February of those years ranged from 2.7 to 26.2 cm while the average from 1980 to 2019 was 36.0 cm.

An increase in annual temperatures of 2.0 to 4.3°C is projected for the Gulf of St. Lawrence region for the period 2041-2070 (Ouranos 2015). This projected increase will be more pronounced in winter (December to February: 2.3 to 4.8°C). Higher winter temperatures will increase the incidence of winter rain events, reducing the snow cover on the ground. Significant changes in snow cover are expected in the Gulf of St. Lawrence region, mainly on the North Shore, with a predicted reduction in the duration of snow cover from 45 to 75 days for the period 2041-2070 compared to that of 1970 to 1999 (Ouranos 2015).

11.2 Droughts [Medium – Low impact]

From 1995 to 1997, drought was an important cause of plant mortality and reduction in size of plants (Nantel and Cantin 1998b). The sand and gravel substrate at most occurrences and exposure of the shoreline to the sun and wind could increase the effect of a drought. During the summer of 2013 drought, dried and withered Meadow Thistle plants were observed at occurrence 11 (Figure 4), but the effect of drought on plant survival was not assessed.

Although climate models predict an increase of 5 to 13 mm of annual precipitation between 2041 and 2070 for the Gulf of St. Lawrence region, the projections of precipitation in summer and autumn are not consistent (Ouranos 2015): some models predict a slight decrease, while others an increase (summer: -3 to 16 mm, autumn: -1 to + 11mm). With respect to drought periods, studies of past trends lack consensus (Ouranos 2015), but long-term projections (2081 to 2100) tend towards drier conditions in summer throughout Quebec.

Threat 6 (IUCN). Human intrusions & disturbance

6.1 Recreational activities [Low impact]

The Mingan population is found in the Mingan Archipelago National Park Reserve, where 20,000 to 30,000 visits are recorded annually. Visitors can hike and camp on the islands. Only occurrence 6 (Figure 4) is near a campsite that can accommodate a maximum of six tents. Although trails are not found near Meadow Thistle occurrences, hiking along the coastline is permitted, but discouraged where Meadow Thistle is found. In addition, visitors are asked to stay in the unvegetated littoral zone. Visitors can disembark their boat at any point. Three occurrences (4, 5, 6) (Figure 4) are found in places where people usually stop by boat, although those visitors usually stay on the sandy beach where Meadow Thistle does not occur. Occasionally, local residents pick berries near the Meadow Thistle plants. Fences and awareness panels have been installed to prevent trampling. Incidents related to recreational activities rarely occur and affect very few plants. The measures put in place have minimized impacts.

Limiting Factors

Rocky Mountain population:

The primary factor limiting its response to recovery/conservation efforts is its monocarpic life history. Having only one year in which an individual plant can reproduce makes it more susceptible to disturbance events than species that reproduce in more than one year. Disturbances, such as, herbivory, drought, mechanical damage, and Thistle Head Weevil attack can cause reduced reproduction, which can limit occurrence size and the ability to colonize unoccupied suitable habitat.

Being the earliest thistle species to flower in the growing season increases the likelihood of being attacked by Thistle Head Weevil, which in turn reduces seed production. Reduced seed production, coupled with a limited seed dispersal distance compared to Thistle Head Weevil, likely limits its ability to recolonize after disturbances.

Mingan Population:

Four factors are considered as limiting. The first one is low reproduction. From 1995 to 2018, the number of flowering plants in the Mingan population ranged from 2 to 23 per year (mean 9.1). The proportion of mature seeds is highly variable (see **Life Cycle and Reproduction**). Insect pollination (see **Interspecific Interactions**) and the number of plants in flower per occurrence could influence fertility rates; flower fertilization rate was about 90% in the occurrence where the number of flowering plants was highest (Nantel and Cantin 1998a). The average number of flowering plants across occurrences varies from 0.05 to 5.2 per year. Frequently, no plants flowered for many years at some occurrences. A period of no flowering of up to 20 years has been recorded at occurrence 10 (Figure 4). For the entire Mingan population, the number of flowering plants, the proportion of large rosettes flowering the next year, and the number of flower heads per plant have all declined since 1995 (Daigle 2017).

The second limiting factor is low competitiveness and restricted habitat. In the Mingan Archipelago, a number of species grow in the immediate environment of Meadow Thistle and most are native. The species' habitat specialization contributes to its rarity in the Mingan Archipelago (see **Habitat Requirements**). In this restricted habitat, the growth of shrubs such as Soapberry (*Shepherdia canadensis*), Red-Osier Dogwood (*Cornus sericea*), Common Bearberry (*Arctostaphylos uva-ursi*), herbaceous plants such as Hair-like Sedge (*Carex capillaris*) and some mosses and lichens can limit the growth of Meadow Thistle and lead to the loss of individuals. This occurs by limiting the amount of light available, but also by stifling plants that no longer seem able to grow. Plants can survive a few years under low light by remaining at the rosette stage, but most die without flowering in such condition. Almost all plants growing in lichens or Hair-like Sedge remained small and died before blooming (Dénommée 1998-2019).

Although the number of replicates is low (n=4), none of the 84 seeds dispersed in moss-covered areas germinated the following year. Mosses have increased in abundance in occurrence 2 (Figure 4) located in an herbaceous plant community protected from storms. There is very little natural recruitment at that occurrence although plants are flowering every year. The presence of dense, tall vegetation could also have contributed to the decline in recruitment.

The impact of wildlife is another limiting factor. Some species feeding on Meadow Thistle seeds have been identified (see **Interspecific Interactions**). From 2017 to 2019, the proportion of mature seeds eaten or damaged by insects ranged from 1.1 to 3.3%[5]. When harvesting seeds for sowing, Parks Canada staff observed that seed predation is more important towards the end of seed maturation.

[5] This is an underestimate of the effect of predation because all seeds are harvested for seeding once a week, limiting predation opportunities. In addition, it is difficult to quantify the actual proportion of predated seeds as some are eaten before the seeds ripen.

Grazing by Snowshoe Hare may be important in some years (see **Interspecific Interactions**). The impact on survival, growth, and flowering has not been evaluated, but is likely significant when all leaves are browsed.

The presence of many ant hills in some occurrences is of growing concern. Ants kill Meadow Thistle rosettes by digging to develop ant hills which reduce available habitat.

Finally, in the Mingan Archipelago, the seeds of Meadow Thistle disperse mainly near the parent plants (see **Dispersal and Migration**). Colonization of new sites is therefore very limited.

Number of Locations

Rocky Mountain population:

Thistle Head Weevil is the most serious threat and is most suitable for determining the number of locations. The area of the Rocky Mountain population constitutes 2-4 locations, presuming that it will take more than one generation (3.8 years) to see a severe decline (> 50%) in the population. Documented declines (Tables 2 and 3) over 14-17 years are mostly > 80%, but the distribution of the decline in unknown. Field surveys (Achuff 2002-2019) have found Thistle Head Weevil to be present in all parts of the Rocky Mountain population. The spread is estimated to have occurred within a period of no more than 25 years and likely less. The weevils pose a serious, ongoing threat that is unlikely to decrease even with a greatly reduced Meadow Thistle population because of the occurrence of other thistle hosts that are better able to tolerate the weevil.

Mingan population:

Storms are the most serious threat, with impacts amplified by sea level rise caused by global warming, which also reduces sea ice cover. Different options are considered here to determine the number of locations. Depending on the option used, two to six locations could be identified under that threat (Table 7). The approach, in line with IUCN's “definition of location under climate change” (IUCN Standards and Petitions Committee 2019), considers that one storm event does not affect all occurrences the same way because of variation in their elevation and exposure to waves. In the first option, occurrences are grouped in six locations based on the similarity of impacts observed during storm events between 2010 and 2016 (Table 6). Similarity of impacts observed was determined by the nature of the disturbance, the proportion of plants affected, and if an occurrence was affected by one or more storms. The other options are based on four hydrodynamic conditions deemed necessary for Meadow Thistle to persist (Lasalle NHC 2019): low wave agitation, no breaking waves, an absence of floating debris, but sufficiently covered by seawater. Whether or not occurrences have this combination of conditions during storm modelling (Lasalle NHC 2019) could give either three locations in current climatic conditions (option 2) or two in future climatic conditions (option 3).

Table 7. Distribution of the Mingan population occurrences into locations under three options.

	Option 1 (6 locations)	Option 2 (3 locations)	Option 3 (2 locations)
Occurrences	1	1, 4, 5, 10, 11	1, 4, 5, 6, 7, 10, 11
	2, 3	2, 3	2, 3
	4, 5	6, 7	
	6, 7		
	10		
	11		

Note: Option 1: Based on the impacts observed during storm events between 2010 and 2016, Option 2: based on models of hydrodynamic conditions during storms under current climate, Option 3: based on models of hydrodynamic conditions during storms under future climate.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

Meadow Thistle is currently designated as a threatened species (espèce menacée) under Quebec's *Loi sur les espèces menacées ou vulnérables, 1989* (Threatened or Vulnerable Species Act). There is no legal protection in any other jurisdiction.

Non-Legal Status and Ranks

Meadow Thistle (as *Cirsium scariosum* var. *scariosum*) is currently ranked by NatureServe (NatureServe 2021) as G5T5? (Globally Secure as a species, variety considered Secure but with uncertainty apparently about taxonomic status). The global rank was last reviewed in 2009. It is noted that it needs review. Nationally, it is ranked in the USA as N5 (Secure) and in Canada as N3 (Vulnerable). Within Canada, it is ranked in Quebec as S1 (Critically Imperilled), in Alberta as S2 (Imperilled), and in British Columbia as S3 (Vulnerable). Within the USA, it is ranked in Montana as S4S5 (Apparently Secure to Secure) and in Wyoming as S2 (Imperilled). Note that for Alberta and Montana the ranks are for *C. scariosum* because they are not available for the variety.

Habitat Protection and Ownership

<u>Rocky Mountain population:</u>

This population occurs primarily on public lands (Waterton Lakes National Park, Alberta; Akamina-Kishenina Provincial Park, British Columbia; as well as Alberta and British Columbia provincial crown lands), with a small amount occurring on private lands, including some managed private conservation organizations. Meadow Thistle also occurs on the Blood Indian Reserve (Timber Limit 148a) adjacent to WLNP.

Approximately 1000 km² of the 3181 km² extent of occurrence, roughly one-third, is managed for conservation purposes by both public and private agencies. While current management practices are likely to maintain suitable habitat in much of Meadow Thistle range over the long term, some occurrences are being adversely affected by livestock grazing and weed control activities. However, the most critical threat to Meadow Thistle is not habitat but the effects of Thistle Head Weevil.

Mingan population:

This population is restricted to four islands of the Mingan Archipelago which are part of the Mingan Archipelago National Park Reserve.

ACKNOWLEDGEMENTS

Rocky Mountain population:

Much of the work has been supported by Parks Canada, both Waterton Lakes National Park and National Office, Species at Risk program. Observations of Meadow Thistle were often piggybacked on field surveys for other species at risk. The broad shoulders of Whitebark Pine (*Pinus albicaulis*), Limber Pine (*P. flexilis*), and Bolander's Quillwort (*Isoetes bolanderi*), in particular, are much appreciated. The work was enabled by a series of Parks Canada research and collection permits, the latest being WL-2019-32079.

Thanks for assistance and information from John Bain, Cheryl Bradley, Richard Caners, Varina Crisfield, the late Bill Cody, Adam Collingwood, Bill Dolan, Marta Donovan, Dorothy Fabijan, Lorne Fitch, Joanne Golden, Shane Hansen, Barb Johnston, Matt Lavin, Peter Lesica, Adrian Leslie, Tony McCue, Jenifer Penny, Simon Piché-Mongeon, Celina Praymak, Wilf Schofield, Rob Sissons, Iain Smith, Cyndi Smith, Jana Vamosi, and Drjas Vujnovic. Assistance with field monitoring of the Rocky Mountain population by Joanne Golden and Cyndi Smith was especially helpful.

Mingan population:

Most of the work has also been supported by Parks Canada. Thanks to all those who contributed to improve this report with their comments and suggestions: Jacques Labrecque, Andrée Nault, Stephanie Pellerin, Aurore Perot, and Marie-Claude Roy. Thanks to Sydney Allen for preparing the maps.

The assistance of reviewers from the COSEWIC Vascular Plants Subcommittee and the various federal and provincial agencies is appreciated.

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INFORMATION SOURCES

Achuff, P.L. 2002-2019. Field notes *in* author's possession, Canmore, Alberta.

Achuff, P.L. 2019. *Cirsium scariosum* (meadow thistle): monitoring and status in Waterton Lakes National Park. Report to Parks Canada, Waterton Park, Alberta. 36 pp.

Alberta Conservation Information System. 2019. *Cirsium scariosum*. Website: https://albertaparks.ca/albertaparksca/management-land-use/alberta-conservation-information-management-system-acims/ [accessed April 2019].

Arnett, A., and S.M. Louda. 2000. Predicting non-target ecological effects of biological control agents: Evidence from *Rhinocyllus conicus*. Pp. 551-567 *in* N.R. Spencer (ed.), Proceedings of the X International Symposium on Biological Control of Weeds, Montana State University, Bozeman, Montana, USA.

BC-Conservation Data Centre. 2019. *Cirsium scariosum*. Website: https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/conservation-data-centre [accessed February 2019].

BC FLNRORD. 2019. Biological control. BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development. Priorities for testing biocontrol agents for BC.

Bernatchez, P., S. Jolicoeur, C. Quintin, J.-P.Savard, M. Corriveau, S. O'Carroll, D. Bérubé, M. Garneau, G.L. Chmura, T. Nguyen-Quang, C.K. Lieou, D. Torio, L. Van Ardenne, H. Sammari, and M. St-Pierre. 2016. Impacts des changements climatiques et des contraintes physiques sur le réajustement des écosystèmes côtiers (coastal squeeze) du golfe et de l'estuaire du Saint-Laurent (GESL) et évaluation des mesures d'atténuation de ces impacts. Research report submitted to Ouranos and Natural Resources Canada. 204 pp.

Bourchier, R., pers. comm. 2019. *Email correspondence to P.L. Achuff.* May 2019. Research Scientist, Agriculture and AgriFood Canada, Lethbridge, Alberta.

Bush, E., and D.S. Lemmen (eds.). 2019. Canada's changing climate report. chap 8 – Changes in Canada's regions in a national and global context. Website: https://changingclimate.ca/site/assets/uploads/sites/2/2019/01/CCCR-Chapter8-ChangesInCanadasRegionInANationalGlobalContext.pdf [accessed September 2019].

CABI (Commonwealth Agricultural Bureaux International). 2019. *Rhinocylllus conicus* (thistle-head weevil), Invasive species compendium. Website: http://www.cabi.org/ISC/datasheet/47083#C67DDA6-6EAC-462A-9B82-5A413B92CDC5 [accessed March 2019].

Canadian Endangered Species Conservation Council. 2016. Wild Species 2015: The General Status of Species in Canada. National General Status Working Group. Database of the report. Website: https://www.wildspecies.ca/reports [accessed August 2020].

Consortium of Pacific Northwest Herbaria. 2019. *Cirsium scariosum*. Website: http://www.pnwherbaria.org/ [accessed April 2019].

COSEWIC. 2018a. COSEWIC Guidelines on Manipulated Wildlife Species. Approved by COSEWIC November 2018. Website: http://cosewic.ca/index.php/en-ca/reports/preparing-status-reports/guidelines-manipulated-wildlife-species. [accessed November 2019].

COSEWIC. 2018b. Instructions for the Preparation of COSEWIC Status Reports. Approved by COSEWIC November 2018. Website: http://cosewic.ca/index.php/en-ca/reports/preparing-status-reports/instructions-preparing-status-reports [accessed September 2019].

COSEWIC. 2019. Guidelines for recognizing designatable units. Website: http://cosewic.ca/index.php/en-ca/reports/preparing-status-reports/guidelines-recognizing-designatable-units [accessed April 2019].

Cronquist, A. 1994. *Cirsium scariosum, in* Intermountain Flora: Vascular Plants of the Intermountain West, USA (A. Cronquist, A.H. Holmgren, N.H. Holmgren, J.L. Reveal and P.K. Holmgren), vol. 5, Asterales, pp. 406-408. New York Botanical Garden, Bronx, New York.

C.V. Starr Virtual Herbarium. 2019. New York Botanical Garden, Bronx, New York. Website: http://sweetgum.nybg.org/science/vh/ [accessed May 2019].

Daigle, G. 2017. Results from the analysis of the Meadow Thistle population data of the Mingan Archipelago National Park Reserve. Université Laval, Service de Consultation Statistique, Québec, Quebec.

De Clerck-Floate, R., and H. Cárcamo. 2011. Biocontrol Arthropods: New Denizens of Canada's Grassland Agroecosystems. *In* Arthropods of Canadian Grasslands (Volume 2): Inhabitants of a Changing Landscape. Edited by K. D. Floate. Biological Survey of Canada. pp. 291-321.

Dennis B., P.L. Munholland, and J.M. Scott. 1991. Estimation of growth and extinction parameters for endangered species. Ecological Monographs 61:115–143.

Dénommée, N. 1998-2019. Field notes and databases from Parks Canada, Mingan Field Unit, Havre-St-Pierre, Quebec.

Dénommée, N. 2011. Activités de rétablissement, de suivi et d'éducation pour le chardon de Mingan (*Cirsium scariosum* var. *scariosum*) – Compte-rendu 1995-2010. Parks Canada, Mingan Field Unit, Havre-Saint-Pierre, Quebec. 44 pp.

Dénommée, N. 2012. Restauration des colonies de chardon de Mingan (*Cirsium scariosum*) suite aux grandes marées de décembre 2010. Parks Canada, Mingan Field Unit, Havre-Saint-Pierre, Quebec. 12 pp.

Desrochers, A.M, J.F. Bain, and S.I. Warwick. 1988. The biology of Canadian weeds. 89. *Carduus nutans* L. and *Carduus acanthoides* L. Canadian Journal of Plant Science 68:1053-1068.

Douglas, G.W., G.B. Straley, D. Meidinger, and J. Pojar (eds.). 1998. Illustrated flora of British Columbia, volume 1: Gymnosperms and Dicotyledonae (Aceraceae through Asteraceae). British Columbia Ministry of Sustainable Resource Management and Ministry of Forests, Victoria, British Columbia. 346 pp.

Douglas, G.W., D. Meidinger, and J. Pojar (eds.). 2002. Illustrated flora of British Columbia, volume 8: General summary, maps and keys. British Columbia Ministry of Sustainable Resource Management and Ministry of Forests, Victoria, British Columbia. 457 pp.

Downing, D.J., and W.W. Pettapiece (comps.). 2006. Natural regions and subregions of Alberta. Natural Regions Committee, Alberta Government Publication T/852: 254 pp.

Dumas, S., pers. comm. 2018-2019. *Email correspondence and phone calls to N. Dénommée*. Between January 2018 and June 2019. Horticulturist, Biodôme / Espace pour la vie, Montréal, Quebec.

Eckberg, J., E. Lee-Mader, J. Hopwood, S.F. Jordan, and B. Borders. 2017. Native thistles: a conservation practitioner's guide. Xerces Society for Invertebrate Conservation, Portland, Oregon, USA. 92 pp.

E-Flora BC. 2019. *Cirsium scariosum*. Website: https://linnet.geog.ubc.ca/Atlas/Atlas.aspx?sciname=Cirsium%20scariosum [accessed April 2019].

Environment and Climate Change Canada. 2019. Past weather and climate historical data - Rivière-au-Tonnerre Station. Website: https://climat.meteo.gc.ca/climate_data/daily_data_e.html?hlyRange=%7C&dlyRange=1965-11-01%7C2022-01-31&mlyRange=1965-01-01%7C2018-02-01&StationID=5650&Prov=QC&urlExtension=_e.html&searchType=stnName&optLimit=yearRange&StartYear=1840&EndYear=2022&selRowPerPage=25&Line=0&searchMethod=contains&txtStationName=Riviere-au-Tonnerre+&timeframe=2&Day=5&Year=2019&Month=2# [accessed February 2019].

Flannigan, M.D., K.A. Logan, B.D. Amiro, W.P. Skinner, and B.J. Stocks. 2005. Future area burned in Canada. Climatic Change 72:1-16.

Foden, W.B., S.H.M. Butchart, S.N. Stuart, J.-C. Vié, H.R. Akçakaya, A. Angulo, L.M. DeVantier, A. Gutsche, E. Turak, L. Cao, S.D. Donner, V. Katariya, R. Bernard, R.A. Holland, A.F. Hughes, S.E. O'Hanlon, S.T. Garnett, Ç.H. Şekercioğlu, and G.M. Mace. 2013. Identifying the world's most climate change vulnerable species: A systematic trait-based assessment of all birds, amphibians and corals. PLoS ONE 8(6): e65427. https://doi.org/10.1371/journal.pone.0065427

Gassmann, A., and S.M. Louda. 2001. *Rhinocyllus conicus*: Initial evaluation and subsequent ecological impacts in North America. pp. 147-183 *in* E. Waijberg, J.K. Scott, and P.C. Quimby (eds.), Evaluating indirect ecological effects of biological control. CAB International.

Gendreau, Y., A. Lachance, H. Gilbert, N. Casajus, and D. Berteaux. 2016. Analyse des effets des changements climatiques sur les plantes vasculaires menacées ou vulnérables du Québec. Bureau d'écologie appliquée, Saint-Étienne-de-Lauzon, Quebec. 59 pp.

Goeden, R.D., and D.W. Richer. 1985. Seasonal asynchrony of Italian Thistle (*Cirsium pycnocephalum)* and the weevil *Rhinocyllus conicus* (Coleoptera: Curculionidae) introduced for biological control in southern California. Entomology 14:433-436.

Golden, J.L., P. Achuff, and J.F. Bain. 2008. Genetic divergence of *Cirsium scariosum* in eastern and western Canada. Ecoscience 15:293-297.

Gremer, J.R., and A. Sala. 2013. It is risky out there: the costs of emergence and the benefits of prolonged dormancy. Oecologia 172:937-947.

Grondin, P., J.-P. Berger, Y. Landry, and P. Leboeuf. 2007. Guide de reconnaissance des types écologiques des régions écologiques 5j – île d'Anticosti et îles de Mingan de même que 5k – Îles de la Madeleine, Québec, ministère des Ressources naturelles et de la Faune, Forêt Québec, Direction des inventaires forestiers, Division de l'analyse et de la diffusion des informations forestières et écologiques, Québec, Quebec. 135 pp.

Hanes, C.C., X. Wang, P. Jain, M-A. Parisien, J.M. Little, and M.D. Flannigan. 2019. Fire-regime changes in Canada over the last half century. Canadian Journal of Forest Research 49:256-269.

Harris, P. 1981. *Carduus nutans* L., nodding thistle and *C. acanthoides* L., plumeless thistle (Compositae). pp. 115-126 *in* J.S. Keldeher and M.A. Hulme (eds.), Biological control programmes against insects and weeds in Canada 1959-1968. CIBC, Technical Communication 4, Commonwealth Agricultural Bureaux, Slough, United Kingdom.

Harris, P., and H. Zwolfer. 1971. Biological control of weeds in Canada, 1955-1968. 29. *Carduus acanthoides* L., welted thistle and *Carduus nutans* L., nodding thistle (Compositae). Technical Committee, Commonwealth Institute of Biological Control 4:76-79.

Holmes E.E. 2004. Beyond theory to application and evaluation: diffusion approximations for population viability analysis. Ecological Applications 14:1272–1293.

IUCN Standards and Petitions Committee. 2019. Guidelines for Using the IUCN Red List Categories and Criteria. Version 14. Prepared by the Standards and Petitions Committee. Website: https://www.iucnredlist.org/resources/redlistguidelines [accessed December 2019].

Keil, D.J. 2006. *Cirsium scariosum*. pp. 154-159 *in* Flora of North America Editorial Committee, Flora of North America, volume 19: Magnoliophyta: Asteridae, part 6: Asterales, part 1, Asteraceae, part 1, Oxford University Press, New York, USA.

Kok, L.T. 2019. *Rhinocyllus conicus* (Coleoptera: Curculionidae). Biological control: a guide to natural enemies in North America, Cornell University. Website: http://www.nysaes.cornell.edu/biocontrol/weedfeeders/rhinocyllus_c.html [accessed March 2019].

Kuijt, J. 1982. A flora of Waterton Lakes National Park. University of Alberta Press, Edmonton, Alberta. 684 pp.

Lasalle NHC. 2019. Analyse des conditions hydrodynamiques des colonies de chardons de Mingan. Report submitted to Parks Canada, Mingan Field Unit. Montréal, Quebec, 100 pp.

Le Groupe Dryade. 1986. Flore vasculaire de l'archipel de Mingan. Tome 1: Description et analyse. Report submitted to Parks Canada, Québec, Quebec. 221 pp.

Lesica, P., and B.W. Steele. 1994. Prolonged dormancy in vascular plants and implications for monitoring studies. Natural Areas Journal 14:209-214.

Marie-Victorin, Fr. 1925. Sur quelques composées nouvelles, rares ou critiques du Québec oriental. Contributions du Laboratoire de botanique de l'Université de Montréal 5:79-96.

Marie-Victorin, Fr. 1938. Phytogeographical problems of eastern Canada. American Midland Naturalist 19:489-558.

Marie-Victorin, Fr., and Fr. Rolland-Germain. 1969. Flore de l'Anticosti-Minganie. Presses de l'Université de Montréal. Montréal, Quebec. 527 pp.

Master, L. L., D. Faber-Langendoen, R. Bittman, G. A. Hammerson, B. Heidel, L. Ramsay, K. Snow, A. Teucher, and A. Tomaino. 2012. NatureServe Conservation Status Assessments: Factors for Evaluating Species and Ecosystem Risk. NatureServe, Arlington, Virginia. 64 pp.

Meidinger, D., and J. Pojar (eds.). 1991. Ecosystems of British Columbia. British Columbia Ministry of Forests, Victoria, British Columbia, Special Report Series 6. 330 pp.

Montana Natural Heritage Program. 2019. Columbian Ground Squirrel – *Urocitellus columbianus*. Montana Natural Heritage Program and Montana Fish, Wildlife and Parks, Helena, Montana. Website: http://fieldguide.mt.gov/speciesDetail.aspx?elcode=AMAFB05070 [accessed May 2019].

Moore, R. J., and C. Frankton. 1967. Cytotaxonomy of foliose thistles (*Cirsium* spp. aff. *C. foliosum*) of western North America. Canadian Journal of Botany 47:1733-1749.

Morris, W. F., and D. F. Doak. 2002. Quantitative conservation biology: theory and practice of population viability analysis. Sinauer Press, Sunderland, Massachusetts, USA.

Morisset, P. 1971. Endemism in the vascular plants of the Gulf of St. Lawrence region. Naturaliste canadien 98:167-177.

Morisset, P., pers. comm. 2003. *Discussion with N. Dénommée*. July 2003. Botanist, Retired Professor, Université Laval, Québec, Quebec.

Nantel, P., and D. Cantin. 1998a. La situation du chardon écailleux (*Cirsium scariosum*) au Québec. Report submitted to the Ministère de l'Environnement et de la Faune, Direction de la conservation et du patrimoine écologique, Québec, Quebec. 37 pp.

Nantel, P., and D. Cantin. 1998b. Viabilité des populations de *Cirsium scariosum* et de *Cypripedium passerinum* à la réserve de parc national de l'Archipel-de-Mingan. Report submitted to Parks Canada, Québec, Quebec. 76 pp.

Nantel, P.L., J. Jones, and C. Drake. 2018. Viability of multiple populations across the range of a species at risk: The case of Pitcher's Thistle, *Cirsium pitcheri*, in Canada. Global Ecology and Conservation 16:e00445. 16 pp.

NatureServe. 2021. *Cirsium scariosum*. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.0. NatureServe Arlington, Virginia. Website: http://explorer.natureserve.org [accessed February 2021].

Nault, A., pers. comm. 2018-2019. *Email correspondence and phone calls to N. Dénommée*. Between January 2018 and June 2019. Horticulturist, Biodôme / Espace pour la vie, Montréal, Quebec.

Ouranos. 2015. Vers l'adaptation. Synthèse des connaissances sur les changements climatiques au Québec. Edition 2015. Montréal, Quebec. 415 pp.

Packer, J.G. 1983. Flora of Alberta, Second Edition. University of Toronto Press, Toronto, Ontario. 687 pp.

Pemberton, R.W. 2000. Predictable risk to native plants in weed biological control. Oecologia 125:489-494.

Penny, J., pers. comm. 2021. *Email correspondence to D. Meidinger.* November 24, 2021. Botanist, British Columbia Conservation Data Centre. Victoria, British Columbia.

Piché-Mongeon, S., pers. comm. 2019. *Email to P. Achuff.* May 2019. Graduate student, Department of Biology, University of Ottawa, Ottawa, Ontario.

Piché-Mongeon, S., pers. comm. 2021. *Email correspondence and phone call to N. Dénommée.* February 2021. Graduate student, Department of Biology, University of Ottawa, Ottawa, Ontario.

Rose, K.E., S.M. Louda, and M. Rees. 2005. Demographic and evolutionary impacts of native and invasive insect herbivores: a case study with Platte thistle, *Cirsium canescens*. Ecology 86:453-465.

Salafsky, N., D. Salzer, A.J. Stattersfield, C. Hilton-Taylor, R. Neugarten, S.H.M. Butchart, B. Collen, N. Cox, L.L. Master, S. O'Connor, and D. Wilkie. 2008. A Standard Lexicon for Biodiversity Conservation: Unified Classifications of Threats and Actions. Conservation Biology 22:897-911.

Saxena, P.K., pers. comm. 2018. *Email correspondence to N. Dénommée.* November 2008. Professor and director, Gosling Research Institute for Plant Preservation, Department of Plant Agriculture, University of Guelph, Guelph, Ontario.

Shefferson, R.P. 2009. The evolutionary ecology of vegetative dormancy in mature herbaceous plants. Journal of Ecology 97:1000-1009.

Sheppard, A.W., J.M. Cullen, and J.P Aeschlimann. 1994. Predispersal seed predation on *Carduus nutans* (Asteraceae) in southern Europe. Acta Oecologica 15:529-541.

Skarpaas, O., and K. Shea. 2007. Dispersal patterns, dispersal mechanisms and invasive wave speeds for invasive thistles. American Naturalist 170:421-430.

Stubben, C., and B. Milligan 2007. Estimating and Analyzing Demographic Models using the popbio Package in R. Journal of Statistical Software 22(11). www.jstatsoft.org/v22/i11

Texas A&M. 2019. Thistle head weevil, Biological control of weeds in Texas, Department of Entomology, Texas A&M University. Website: https://bc4weeds.tamu.edu/agents/thistleheadweevil/ [accessed March 2019].

Tuomi, J., E.E. Crone, J.R. Gremer, A. Jakalanienii, P. Lesica, B. Pedersen, S. Ramula, and R.P. Shefferson. 2013. Prolonged dormancy interacts with senescence for two perennial herbs. Journal of Ecology 101:566-576.

University of Colorado. 2019. Museum of Natural History Herbarium. Website: https://www.gbif.org/dataset/7ed55b51-4336-4f74-a05a-274afffe771f [accessed September 2019].

University of Wyoming. 2019. Rocky Mountain Herbarium. Website: http://uwyo.edu/botany/rocky-mountain-herbarium [accessed September 2019].

Zwolfer, H., and P. Harris. 1984. Biology and host specificity of *Rhinocyllus conicus* (Froel.) (Col., Curculionidae), a successful agent for biocontrol of the thistle, *Carduus nutans* L. Journal of Applied Entomology 97:36-62.

BIOGRAPHICAL SUMMARY OF REPORT WRITER(S)

Nancy Dénommée obtained a bachelor's degree in biology (ecology) from the Université du Québec à Montréal and a graduate diploma specializing in wildlife management from the Université du Québec à Rimouski. She has worked for Parks Canada at the Mingan Archipelago National Park Reserve (RPNAM) since 1996, and has been in charge of monitoring rare plants, including the Meadow Thistle, since 1998. She has coordinated recovery actions for this species since 2001, and developed the monitoring protocol for rare plants of the RPNAM. She has written numerous reports as the resource person for the flora of the Mingan Archipelago.

Peter L. Achuff is a Scientist Emeritus with Parks Canada and a former member of COSEWIC. He has previously written or co-written five status reports and has degrees in Botany (systematics and plant ecology) from the University of Montana, New York Botanical Garden-Columbia University, and the University of Alberta. He has worked mainly in western and northern North America over the past 45 years on a variety of projects involving natural resource inventory and monitoring, protected areas management, rare species and plant conservation.

Patrick Nantel has a Ph.D. in Environmental Science from Université du Québec à Montréal and has been a science advisor at Parks Canada's National Office since 2002, where he works with the Conservation and Restoration Program. He has published many plant population viability analyses in peer-reviewed journals. In 1995, he initiated a demographic study of the population of Meadow Thistle of the Mingan Archipelago, which continues today. Patrick was the Parks Canada member on COSEWIC from 2007 to 2017, during which time he developed a standard for the presentation of population viability analyses in status reports. Patrick currently chairs the Comité aviseur sur la flore menacée du Québec (Advisory Committee on Threatened Flora of Quebec), for which he has been a member since 1999.

COLLECTIONS EXAMINED

- Agriculture Canada – Ottawa (DAO)
- Canadian Museum of Nature (CAN)
- Montana State University (MONT)
- Provincial Museum of Alberta (RAM) including Alberta Biodiversity Monitoring Institute
- Royal BC Museum (V)
- University of Alberta (ALTA)
- University of British Columbia (UBC)
- University of Calgary (UAC)
- University of Lethbridge (LEA)
- University of Montana (MONTU)
- Waterton Lakes National Park

On-line databases provided virtual examination of many other herbaria. These include: E-Flora BC (2019), Consortium of Pacific Northwest Herbaria (2019), BC-Conservation Data Centre (2019), Alberta Conservation Information System (2019), C.V. Starr Virtual Herbarium - New York Botanical Garden (2019), University of Colorado (2019), and University of Wyoming (2019).

Appendix 1. Meadow Thistle plant observations for Belly River and Lone Creek transects. *Mature individuals* are flowering plants plus rosettes >30 cm. Generation time = 3.8 years; 3 generations = 12 years. "immat: mat" is ratio of immature to mature rosettes.

Belly River	2002	2003	2004	2005	2006	2007	2008	09-16	2017	2018	2019	11y %	17y %
flowering	20	26	4	39	18	nd	33	nd	4	0	4		
ros>30cm	160	163	151	107	50	nd	18	nd	11	4	5		
mature	180	189	155	146	68	nd	51	nd	15	4	9	-82	-95
ros<30cm	131	79	67	47	30	nd	5	nd	0	0	0		
all plants	311	268	222	193	98	nd	56	nd	15	4	9	-84	-97
immat: mat	0.73	0.42	0.43	0.32	0.44	nd	0.10	nd	0	0	0		

Lone Creek	2002	2003	2004	2005	2006	2007	2008	09-16	2017	2018	2019	11y %	17y %
flowering	4	3	1	8	9	4	4	nd	11	nd	1		
ros>30cm	104	121	131	167	143	127	125	nd	37	nd	3		
mature	108	124	132	175	152	131	129	nd	48	nd	4	-97	-96
ros<30cm	196	221	239	177	112	83	53	nd	19	nd	0		
all plants	304	345	371	352	264	214	182	nd	67	nd	4	-98	-99
immat: mat	1.81	1.78	1.81	1.01	0.74	0.63	0.41	nd	0.40	nd	0		

Both transects	2002	2003	2004	2005	2006	2007	2008	09-16	2017	2018	2019	11y %	17y %
Total mature	288	313	287	321	220	nd	180	nd	63	nd	13	-93	-95
Total all	615	613	593	545	362	nd	238	nd	82	nd	13	-95	-98

Appendix 2. Surveys and monitoring conducted at each of the nine occurrences of the Mingan population from 1995 to 2019.

Years	Survey method and frequency
1995-1998	In eight of the nine occurrences: annual census and individual monitoring. In occurrence 2: annual individual follow-up in two permanent transects (2m x 20m).
1998-2005	In eight of the nine occurrences: annual census and individual monitoring. In occurrence 2: monitoring in two permanent transects (2m x 20m) every 3 years, with complete census in 2003.
2006-2010	In eight of the nine occurrences: census of large rosettes every 3 years and annual count of number of flowering plants. In occurrence 11: annual census of large rosettes and flowering plants.
2011-2016	In eight of the nine occurrences: census and individual monitoring every 3 years, annual count of the number of flowering plants. In occurrence 11: annual census and individual monitoring.
2017-2018	In eight of the nine occurrences: annual census and individual monitoring. In occurrence 2: annual census and individual monitoring in seeding quadrats.
2019	In eight of the nine occurrences: annual census and individual monitoring. In occurrence 2: individual monitoring in seeding quadrats.

Appendix 3. Total number of individuals of Meadow Thistle in each occurrence of the Mingan population (1995-2019).

Occurrence Year	1	2	3	4	5	6	7	10	11	Total
1995	132	493	nd	nd	25	1	65	3	90	nd
1996	133	573	nd	nd	24	1	92	4	69	nd
1997	100	409	2	9	19	14	68	4	45	670
1998	106	nd	nd	9	19	14	64	5	106	nd
1999	79	nd	nd	9	18	14	42	4	96	nd
2000	99	270	1	9	15	19	44	5	167	629
2001	95	nd	2	13	13	27	43	12	244	nd
2002	133	nd	2	12	164	50	86	11	310	nd
2003	115	470	2	10	143	42	94	11	261	1148
2004	149	nd	2	10	203	26	97	9	236	nd
2005	154	nd	1	104	165	23	128	6	185	nd
2006	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2007	nd	nd	0	nd	nd	nd	nd	nd	nd	nd
2008	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2009	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2010	nd	nd	0	nd	nd	nd	nd	nd	nd	nd
2011	68	nd	nd	66	273	251	173	1	522	nd
2012	64	nd	nd	nd	nd	nd	193	nd	443	nd
2013	nd	nd	1	nd	nd	287	152	1	349	nd
2014	nd	291	nd	39	221	nd	127	nd	320	nd
2015	79	nd	1	nd	nd	nd	nd	nd	84	nd
2016	nd	nd	nd	nd	nd	186	85	1	50	nd
2017	51	135	1	24	152	30	16	1	34	444
2018	53	846	57	128	187	24	21	1	32	1349
2019	60	nd	8	142	163	27	21	1	154	nd

Appendix 4. Number of mature individuals (large rosette and flowering plant) of Meadow Thistle in each occurrence of the Mingan population (1995-2019).

Occurrence Year	1	2	3	4	5	6	7	10	11	Total
1995	83	268	nd	nd	14	1	24	3	67	nd
1996	68	264	nd	nd	13	1	11	4	59	nd
1997	56	158	1	9	10	12	9	4	36	295
1998	65	nd	nd	9	16	13	27	5	47	nd
1999	57	nd	nd	9	16	11	17	4	65	nd
2000	46	129	1	9	13	10	32	5	52	297
2001	50	nd	2	13	12	10	35	8	73	nd
2002	45	nd	2	12	11	14	35	11	81	nd
2003	52	195	2	10	11	17	38	10	118	453
2004	45	nd	2	8	21	10	33	8	112	nd
2005	51	nd	1	6	61	15	38	2	146	nd
2006	54	188	nd	nd	nd	nd	36	nd	141	nd
2007	nd	nd	0	nd	nd	19	nd	3	138	nd
2008	nd	nd	nd	62	79	nd	nd	nd	131	nd
2009	49	283	nd	nd	nd	nd	57	nd	112	nd
2010	nd	nd	0	nd	nd	19	nd	1	96	nd
2011	35	nd	nd	47	66	18	68	1	112	nd
2012	44	193	nd	nd	nd	nd	65	nd	144	nd
2013	nd	nd	1	nd	nd	60	21	1	87	nd
2014	nd	261	nd	36	193	nd	34	nd	108	nd
2015	31	nd	1	nd	nd	nd	nd	nd	20	nd
2016	nd	nd	nd	nd	nd	114	44	1	28	nd
2017	20	113	1	22	133	16	9	1	24	339
2018	31	138	0	18	110	20	19	1	30	367
2019	32	nd	0	45	94	23	21	1	33	nd

Appendix 5. Immature:mature plants ratio for Meadow Thistle for the Mingan population. A ratio of <1 indicates that the population is not producing enough young plants to replace the loss of older plants.

Occurrence Year	1	2	3	4	5	6	7	10	11	Total
1995	0.6	0.8	nd	nd	0.8	0	1.7	0	0.3	0.6
1996	1.0	1.2	nd	nd	0.8	0	7.4	0	0.2	1.5
1997	0.8	1.6	1	0	0.9	0.2	6.6	0	0.3	1.2
1998	0.6	nd	nd	0	0.2	0.1	1.4	0	1.3	0.5
1999	0.4	nd	nd	0	0.1	0.3	1.5	0	0.5	0.4
2000	1.2	1.1	0	0	0.2	0.9	0.4	0	2.2	0.7
2001	0.9	nd	0	0	0.1	1.7	0.2	0.5	2.3	0.7
2002	2	nd	0	0	14	2.6	1.5	0	2.8	2.8
2003	1.2	1.4	0	0	12	1.5	1.5	0.1	1.2	2.1
2004	2.3	nd	0	0.3	8.7	1.6	1.9	0.1	1.1	2
2005	2	nd	0	16	1.7	0.5	2.4	2	0.3	3.2
2006	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2007	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2008	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2009	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2010	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2011	0.9	nd	nd	0.4	3.1	13	1.5	0	3.7	3.2
2012	0.5	nd	nd	nd	nd	nd	2	nd	2.1	1.5
2013	nd	nd	0	nd	nd	3.8	6.2	0	3	2.6
2014	nd	0.1	nd	0.1	0.1	nd	2.7	nd	2	1
2015	1.5	nd	0	nd	nd	nd	nd	nd	3.2	1.6
2016	nd	nd	nd	nd	nd	0.6	0.9	0	0.8	0.6
2017	1.6	0.2	0	0.1	0.1	0.9	0.8	0	0.4	0.4
2018	0.7	5.1	nd	6.1	0.7	0.2	0.1	0	0.1	1.6
2019	0.9	nd	nd	2.2	0.7	0.2	0	0	3.7	1.1
Mean	1.1	1.4	0.1	1.8	2.8	1.6	2.1	0.2	1.6	

Appendix 6. Methods for Population Viability Analysis (Mingan population).

The simplest class of viability analysis (PVA) was used—a basic stochastic exponential growth model with year-to-year variability in the growth rate and no density-dependence, as was done for a similar species, Pitcher's Thistle (Nantel *et al*. 2018). This type of PVA only requires data on both current population size and variation in population size over time. One property of this basic model is that it can be approximated by a diffusion equation that provides analytical estimates of the probability of crossing a particular threshold within a given time frame (Dennis *et al.* 1991; Holmes 2004).

The regression method was used for estimating the parameters of the diffusion approximation model, because it is reasonable to assume that most of the observed year-to-year variability in the population growth rates is due to environmental variation, rather than observation error (Holmes 2004). The regression method consists in running a linear regression of the y_i's against the x_i's, forcing the intercept to be zero, where the x_i's are each time interval transformed as:

$$x_i = \sqrt{t_{i+1} - t_i}\ ;$$

and the y_i's are population change from the counts of mature individuals N, transformed as:

$$y_i = \log\left(\frac{N_{t+1}}{N_t}\right)/x_i$$

The slope of the regression and the regression's error mean square are respectively estimates of the mean (μ) and variance (σ^2) of the annual growth rates (Morris & Doak 2002). We then input μ and σ^2 into the diffusion approximation function in the popbio R package, which yields the cumulative distribution function for time to quasi-extinction (Stubben and Milligan 2007). Quasi-extinction means that a population falls below a size (threshold) that would have been large enough to allow for recovery, which is not only precautionary but an assumption of all extinction models.

To estimate the viability of the Mingan population of Meadow Thistle, we used the estimated means and variance of annual population growth rates for every island, and Kendall rank correlations of annual population growth rates among them, to run multi-site stochastic simulations. The multi-site stochastic model is (Morris and Doak 2002):

$$\mathbf{N}_i(t+1) = \mathbf{M}_t\mathbf{N}_i(t)$$

where $\mathbf{N}_i$ is a vector of number of rosettes in each island i, $\mathbf{M}_t$ is a time-variable matrix in which diagonal elements are the annual growth rates of each occurrence in year t; non-diagonal elements are migration rates among islands, assumed here to be all null. To simulate a population trajectory over 100 years, annual growth rates were generated randomly each year of the simulation, taking into account their mean and variance in each island, and their rank correlations among islands. Cumulative distribution functions for probability of quasi-extinction were each estimated based on 5000 simulated multi-site trajectories.

Appendix 7. Threat assessment for Meadow Thistle - Rocky Mountain population.

THREATS ASSESSMENT WORKSHEET					
Species or Ecosystem Scientific Name	*Cirsium scariosum var. scariosum*				
Element ID			**Elcode**		
Date:	2020-03-26				
Assessor(s):	Nancy Dénommée (report writer), Jenny Heron (facililtator), Del Meidinger (Vascular Plant SSC Co-chair), Greg Wilson (BC COSEWIC Representative), Patrick Nantel (report writer), Sarah Lee (Vascular Plant SSC member), Brenda Costanzo (BC representative), Bruce Bennett (Vascular Plant SSC member), Jacques Labreque (QC COSEWIC Representative), Peter Achuff (report writer), Jenifer Penny (BC Conservation Data Centre), Syd Cannings (Canadian Wildlife Service) and Angèle Cyr (COSEWIC Secretariat).				
References:					
Overall Threat Impact Calculation Help:			**Level 1 Threat Impact Counts**		
	Threat Impact		**high range**	**low range**	
	A	Very High	1	1	
	B	High	0	0	
	C	Medium	2	0	
	D	Low	0	2	
Calculated Overall Threat Impact:			Very High	Very High	
Assigned Overall Threat Impact:			**A = Very High**		
Impact Adjustment Reasons:			No adjustment; 87% decline observed over past three generations so 50-100% is reasonable in next three.		
Overall Threat Comments			Generation time of 3.8 years; three generations = 11.4 years. Occurs in meadows and forest openings at mid to high elevations. Monitoring over about 15 years. Microhabitat needs are exposed soils, including those periodically disturbed. E.g., those found in avalanche tracks, flood plains, Pocket Gopher excavations, roadsides, etc.		

Threat		**Impact (calculated)**		**Scope (next 10 Yrs)**	**Severity (10 Yrs or 3 Gen.)**	**Timing**	**Comments**
1	Residential & commercial development						
1.1	Housing & urban areas						Not applicable. Places where Meadow Thistle occurs are not near potential housing or urban developments.
1.2	Commercial & industrial areas						Not applicable. Places where Meadow Thistle occurs are not near potential industrial development.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1.3	Tourism & recreation areas						Not applicable. Places where Meadow Thistle occur are not within areas where ski hills, golf courses or recreational trail expansions are proposed.
2	Agriculture & aquaculture	CD	Medium - Low	Restricted - Small (1-30%)	Serious (31-70%)	High (Continuing)	
2.1	Annual & perennial non-timber crops						Not applicable.
2.2	Wood & pulp plantations						Not applicable.
2.3	Livestock farming & ranching	CD	Medium - Low	Restricted - Small (1-30%)	Serious (31-70%)	High (Continuing)	Damage to plants by domestic livestock noted on private and public lands in Alberta. Damage includes grazing and trampling. Grazing intensity variable. When rosettes are small, the prickles are soft, so plants are eaten. Grazing of rosette may not kill the plant, but likely to delay time to flowering (as flowering appears related to storage of sufficient food resources over time). Grazing also occurs on Nature Conservancy Canada lands. Cattle urination and defecation also potential issues but of unknown impact. Grazing not thought to be an issue in BC.
2.4	Marine & freshwater aquaculture						Not applicable.
3	Energy production & mining						
3.1	Oil & gas drilling						Not applicable. Oil pad installation and/or expansion, particularly in AB areas, is not considered a threat.
3.2	Mining & quarrying						There are mining leases in area but no active mines.
3.3	Renewable energy						Not applicable.
4	Transportation & service corridors						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
4.1	Roads & railroads						Right-of-way spraying observed in BC but not known if area included Meadow Thistle. Some roadways could experience period soil disturbance, which may enable some subpopulations to remain at a site.
4.2	Utility & service lines						Not applicable.
4.3	Shipping lanes						Not applicable.
4.4	Flight paths						Not applicable.
5	Biological resource use		Unknown	Restricted (11-30%)	Unknown	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						Not applicable.
5.2	Gathering terrestrial plants						Not applicable. This species is not of cultural or economic importance.
5.3	Logging & wood harvesting		Unknown	Restricted (11-30%)	Unknown	High (Continuing)	Salvage logging occurs after wildfires. Logging activity can cause some mortality but also some increase in potential thistle sites in medium term through logging related disturbance.
5.4	Fishing & harvesting aquatic resources						Not applicable.
6	Human intrusions & disturbance		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	
6.1	Recreational activities		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	Observed a lot of hikers whacking flowering stems off the plant, as they walk along trails in Waterton Lakes National Park but not a huge number of plants relative to subpopulation. Plant only flowers once and loss of floret eliminates seed production.
6.2	War, civil unrest & military exercises						Not applicable. No subpopulations are on military properties or on properties used for military training.
6.3	Work & other activities						Not applicable.
7	Natural system modifications	CD	Medium - Low	Large - Restricted (11-70%)	Moderate (11-30%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
7.1	Fire & fire suppression	CD	Medium - Low	Large - Restricted (11-70%)	Moderate (11-30%)	High (Continuing)	Direct mortality due to fires and reduced ability to re-seed after fire is nature of threat. Due to reduced seed production from impact of Thistle Head Weevil, thistle has less ability to colonize post-fire. Fire frequency, size, and intensity expected to increase over time due to on-going climate change. Portions of range have had large fires in recent years; fire frequency and severity has increased. One flipside -- later in season weevils down in duff and late season, severe fires can kill weevils. Weevil can disperse 10x the distance of the seeds of thistle, so can keep up to any migration into areas post fire. Rough successional models show that post fire habitat suitable for thistle for up to 30 years, but then canopies close and not enough light for thistle to reproduce. In the past 20 years, about 25% area burned; as anticipating greater fire frequency, severity, and size in future, scope could be in the "restricted" category.
7.2	Dams & water management/use						Not applicable.
7.3	Other ecosystem modifications	CD	Medium - Low	Restricted - Small (1-30%)	Extreme (71-100%)	High (Continuing)	Herbicide spraying related to control programs for introduced thistles in protected areas impacts on Meadow Thistle. Spray crews spray Meadow Thistle thinking it might be Bull Thistle. Hand-pulling does occur as well -- pulling every thistle -- which can also reduce the Meadow Thistle population; however, this does not occur frequently.
8	Invasive & other problematic species & genes	A	Very High	Pervasive (71-100%)	Extreme (71-100%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.1	Invasive non-native/alien species/diseases	A	Very High	Pervasive (71-100%)	Extreme (71-100%)	High (Continuing)	Thistle Head Weevil introduced to control weedy thistles but is impacting on native thistles. First appeared in southern Alberta in early 1990s and found throughout range by 2002-2003. The weevil can prevent or severely reduce seed production. Larva eat tissue below where seeds are being produced. As Meadow Thistle is flowering early in the season, it gets attacked first. Also, because monocarpic, the impact is severe as compared to perennial thistles.
8.2	Problematic native species/diseases						Not applicable. Native deer, native insects and other potential consumers are not at levels that would otherwise be a threat. Predation by Pocket Gopher is discussed. They have always been there and their spoils seem to also offer good sites for seed germination. Cause of lack of reproduction is the weevil--not the Pocket Gopher as attack rates by weevil high. Although we don't have population data, Pocket Gopher population is not considered to be higher than 'normal'.
8.3	Introduced genetic material						Considered hybridization between thistles as a potential problem. Although Hooker's Thistle and Meadow Thistle occur together in a few areas and morphological intermediates have been observed, hybridization is not considered a significant issue. It is unknown if these intermediates are hybrids; and the two species occur in different habitats. Doesn't seem that Meadow Thistle will be 'hybridized out'.
8.4	Problematic species/diseases of unknown origin						
8.5	Viral/prion-induced diseases						Not applicable.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.6	Diseases of unknown cause						Not applicable.
9	Pollution						
9.1	Domestic & urban waste water						Not applicable.
9.2	Industrial & military effluents						Not applicable.
9.3	Agricultural & forestry effluents						Not applicable.
9.4	Garbage & solid waste						Not applicable.
9.5	Air-borne pollutants						Not applicable.
9.6	Excess energy						Not applicable.
10	Geological events						
10.1	Volcanoes						Not applicable.
10.2	Earthquakes/tsunamis						Not applicable.
10.3	Avalanches/landslides						Natural factor; creates habitat. Not a threat.
11	Climate change & severe weather		Not Calculated (outside assessment timeframe)	Pervasive (71-100%)	Unknown	Low (Possibly in the long term, >10 yrs/3 gen)	
11.1	Habitat shifting & alteration		Not Calculated (outside assessment timeframe)	Pervasive (71-100%)	Unknown	Low (Possibly in the long term, >10 yrs/3 gen)	Plants occur in "mesic" areas and these sites could reduce in extent under climate change; potential shift in habitat
11.2	Droughts						Drought may lead to increased fire frequency and severity, but increasing wildfire frequency and severity treated in 7.1.
11.3	Temperature extremes						Increased temperatures may lead to increased fire frequency and severity, but increasing wildfire frequency and severity treated in 7.1.
11.4	Storms & flooding						Not applicable. The habitat is not within areas that would be impacted from storms or flooding.
11.5	Other impacts						Not applicable.

Classification of Threats adopted from IUCN-CMP, Salafsky *et al.* (2008).

Appendix 8. Threats assessment worksheet for Meadow Thistle - Mingan population.

THREATS ASSESSMENT WORKSHEET				
Species or Ecosystem Scientific Name	*Cirsium scariosum var. scariosum*			
Element ID			Elcode	
Date (Ctrl + ";" for today's date):	2020-03-26			
Assessor(s):	Nancy Dénommée (report writer), Jenny Heron (facililtator), Del Meidinger (Vascular Plant SSC Co-chair), Greg Wilson (BC COSEWIC Representative), Patrick Nantel (report writer), Sarah Lee (Vascular Plant SSC member), Brenda Costanzo (BC representative), Bruce Bennett (Vascular Plant SSC member), Jacques Labreque (QC COSEWIC Representative), Jenifer Penny (BC Conservation Data Centre), Peter Achuff (report writer) and Angèle Cyr (COSEWIC Secretariat)			
References:				

Overall Threat Impact Calculation Help:		Level 1 Threat Impact Counts	
Threat Impact		high range	low range
A	Very High	1	0
B	High	0	1
C	Medium	0	0
D	Low	1	1
Calculated Overall Threat Impact:		Very High	High

Assigned Overall Threat Impact:	**AB = Very High - High**
Impact Adjustment Reasons:	No change, consistent with population decline modelling.
Overall Threat Comments	Generation time - 10.1 years; three generations 30 years. Average 10 years to produce seed; seeds only once; no vegetative reproduction; in the littoral zone between forest and sea; storms; habitat narrow and very exposed. Severe impact from storm surge. Good data on trends.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & commercial development						
1.1	Housing & urban areas						Not applicable.
1.2	Commercial & industrial areas						Not applicable.
1.3	Tourism & recreation areas						Not applicable. Unlikely to be campground expansion and/or trail construction.
2	Agriculture & aquaculture						
2.1	Annual & perennial non-timber crops						Not applicable.
2.2	Wood & pulp plantations						Not applicable.
2.3	Livestock farming & ranching						Not applicable.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
2.4	Marine & freshwater aquaculture						Not applicable.
3	Energy production & mining						
3.1	Oil & gas drilling						Not applicable.
3.2	Mining & quarrying						Not applicable.
3.3	Renewable energy						Not applicable.
4	Transportation & service corridors						
4.1	Roads & railroads						Not applicable.
4.2	Utility & service lines						Not applicable.
4.3	Shipping lanes						Not applicable.
4.4	Flight paths						Not applicable.
5	Biological resource use						
5.1	Hunting & collecting terrestrial animals						Not applicable.
5.2	Gathering terrestrial plants						Not applicable. Berry picking is scored under 6.1 Recreational activities.
5.3	Logging & wood harvesting						Not applicable.
5.4	Fishing & harvesting aquatic resources						Not applicable.
6	Human intrusions & disturbance	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	
6.1	Recreational activities	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	There are people in the park; activities include hiking and camping, but not a big problem. There are established campsites near some sites. Nearest campsite to a site is for 5-6 tents. Only known site outside the park was extirpated by recreation activities. Strawberry pickers also frequent park and might also inadvertently trample plants.
6.2	War, civil unrest & military exercises						Not applicable. There are no subpopulations in properties owned/managed by the Department of National Defence.
6.3	Work & other activities						Last year, at one site all transplants were removed by someone, but this was a rare event.
7	Natural system modifications						
7.1	Fire & fire suppression						Not applicable.
7.2	Dams & water management/use						Not applicable.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
7.3	Other ecosystem modifications						Forest encroachment scored under 11.1 as considered to increase partly due to climate change.
8	Invasive & other problematic species & genes						
8.1	Invasive non-native/alien species/diseases						Not applicable.
8.2	Problematic native species/diseases						Not applicable.
8.3	Introduced genetic material						Not applicable.
8.4	Problematic species/diseases of unknown origin						Not applicable.
8.5	Viral/prion-induced diseases						Not applicable.
8.6	Diseases of unknown cause						Not applicable.
9	Pollution						
9.1	Domestic & urban waste water						Not applicable.
9.2	Industrial & military effluents						Not applicable.
9.3	Agricultural & forestry effluents						Not applicable.
9.4	Garbage & solid waste						Not applicable.
9.5	Air-borne pollutants						Not applicable.
9.6	Excess energy						Not applicable.
10	Geological events						
10.1	Volcanoes						Not applicable.
10.2	Earthquakes/tsunamis						Not applicable.
10.3	Avalanches/landslides						Not applicable.
11	Climate change & severe weather	AB	Very High - High	Pervasive (71-100%)	Extreme - Serious (31-100%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11.1	Habitat shifting & alteration	B	High	Large (31-70%)	Extreme - Serious (31-100%)	High (Continuing)	Two processes will potentially impact Meadow Thistle -- rising temperatures and a longer growing season could result in acceleration of forest encroachment. About 33% have this potential problem. Forest encroachment considered for Threat 7.3 but treated here due to relationship to climate change and 7.3 is for threats that "convert of degrade habitat in service of 'managing' natural systems to improve human welfare."
11.2	Droughts	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Droughts have been shown to cause mortality and reduce plant growth. Climate models predict an increase in annual precipitation, summer precipitation projections vary from a slight decrease to an increase. Long term projections indicate drier conditions in summer in Quebec.
11.3	Temperature extremes	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Low survival has been demonstrated in winters with low snow, and then rain followed by cold temperatures. Projected increases in temperature will impact on snow cover and, presumably, the survival of Meadow Thistle. Snow cover important for species. Mortality higher in years with less snow.
11.4	Storms & flooding	AB	Very High - High	Pervasive (71-100%)	Extreme - Serious (31-100%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Storms are increasingly impacting plants and habitat. Recent storms have covered plants with sediments and plant debris, and sea water. Storms have also eroded habitat. With ice cover coming later, due to a warming climate, winter storms have a greater impact than in the past. Climate models predict a shorter ice season going forward. As sites are small, a single storm can severely impact an entire site. Only one site has a lower potential impact from storms as it further away from water edge. Three significant storms in the past 10 years. If there was not some intervention by Parks, plants would have died.
11.5	Other impacts						
Classification of Threats adopted from IUCN-CMP, Salafsky *et al.* (2008).							