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Management Plan for the Pitcher's Thistle (*Cirsium pitcheri*) in Canada

Pitcher's Thistle

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[1] www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html

Preface

The federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996)[2] agreed to establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada. Under the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the federal competent ministers are responsible for the preparation of management plans for listed species of special concern and are required to report on progress five years after the publication of the final document on the SAR public registry.

The Minister of Environment and Climate Change, also the Minister responsible for the Parks Canada Agency, is the competent minister under SARA for the Pitcher's Thistle and has prepared this management plan as per section 65 of SARA. To the extent possible it has been prepared in cooperation with the Province of Ontario, as per section 66(1) of SARA.

Success in the conservation of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this plan and will not be achieved by Environment and Climate Change Canada and the Parks Canada Agency, or any other jurisdiction alone. All Canadians are invited to join in supporting and implementing this plan for the benefit of the Pitcher's Thistle and Canadian society as a whole.

Implementation of this management plan is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

[2] www.canada.ca/en/environment-climate-change/services/species-risk-act-accord-funding.html#2

Acknowledgments

This management plan was prepared by Karolyne Pickett (Environment and Climate Change Canada, Canadian Wildlife Service – Ontario Region (CWS-ON). The management plan was informed by the *Recovery Strategy for Pitcher’s Thistle* (Cirsium pitcheri)) *in Canada* (2011) prepared by the Parks Canada Agency, and the 2010 *COSEWIC Assessment and Status Report on the Pitcher’s Thistle* (Cirsium pitcheri) *in Canada*, prepared by Judith Jones. The management plan benefited from input, review, and suggestions from the following individuals and organizations: Krista Holmes (CWS-ON), Angela Barakat (CWS–National Capital Region), Lucy Patterson (Parks Canada Agency), and the Ontario Ministry of the Environment, Conservation and Parks.

The conservation measures outlined in this management plan were developed based on an assessment of threats to the species. This threats assessment was conducted by a multi-jurisdictional group of individuals that included: David Fraser and Judith Jones (consultants); Lucy Patterson (Parks Canada Agency); Jenni Kaija, Alistair Mackenzie and Edward Morris (Ontario Parks); Eric Snyder (Ontario Ministry of the Environment, Conservation and Parks); Bob Barnett (Escarpment Biosphere Conservancy); Esme Batten and Kaitlin Richardson (Nature Conservancy of Canada); Brent St. Denis (Township of Cockburn Island); Ellen Weatherbee (University of Michigan); and Karolyne Pickett (ECCC-CWS). Acknowledgement and thanks are given to the individuals and respective organizations that participated in the threats assessment.

Executive Summary

Pitcher's Thistle (*Cirsium pitcheri*) is a perennial herb of the aster family that only occurs on the shores of Lake Huron, Lake Michigan and Lake Superior in North America. The plant spends several years in the juvenile life-stage as a ring of narrow, whitish-green leaves growing low to the ground (a "rosette"). At maturity, the rosette forms an upright flowering stalk topped with thistle heads consisting of numerous pale, pinkish-white flowers. After flowering and setting seed, the plant dies.

In Canada, Pitcher's Thistle is only found in Ontario, on sand dunes and beaches located on the southern shores of Lake Huron, on the southern shore of Manitoulin Island and smaller neighbouring islands, and on the shores of Lake Superior in Pukaskwa National Park. Optimal habitat consists of dry, loose sand with little other vegetation. The habitat is dynamic in nature, meaning that suitable habitat patches shift locations over time as vegetation cover naturally increases in some areas rendering them unsuitable for the species, while in others the action of wind, longshore currents, lake level fluctuations and ice scour maintains or creates areas of loose, sparsely vegetated sand dunes.

Pitcher's Thistle was listed as Endangered on Schedule 1 of the federal *Species at Risk Act* (SARA) in 2003 and a recovery strategy for the species was published on the Species at Risk public registry in 2011. During subsequent surveys, some subpopulations were found to have increased in size and several additional subpopulations were discovered: as of 2022, there are 37 known extant subpopulations in Canada. As a result, COSEWIC re-assessed the species as Special Concern in November 2010, and the species status under SARA was changed accordingly in 2017. The species is listed as Threatened on the Species at Risk in Ontario List under the provincial *Endangered Species Act, 2007* (ESA).

Due to the specific habitat requirements of Pitcher’s Thistle, the greatest threats to its recovery are those that impact the availability and quality of habitat. These include destruction of dune habitat from residential development and associated shoreline alteration, off-trail ATV use and pedestrian traffic, vegetation encroachment, and competition from non-native plants. Pitcher’s Thistle is also significantly impacted at some sites by browsing by herbivores.

The management objective for Pitcher’s Thistle in Canada is to prevent the population from becoming Threatened or Endangered by maintaining the population’s extent of occurrence, maintaining or increasing the population’s index of area of occupancy, and maintaining or increasing the number of subpopulations of Pitcher’s Thistle.

Broad strategies to achieve this management objective include management of vegetation cover, invasive plant species, herbivory and recreational activities, public outreach, information sharing with land-use planning authorities, population monitoring, and research related to potential threats from non-native insects and climate change.

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1. COSEWIC* Species Assessment Information

Date of Assessment: November 2010

Common name
Pitcher's Thistle

Scientific name
Cirsium pitcheri

COSEWIC Status
Special Concern

Reason for designation
This globally vulnerable endemic thistle of the Great Lakes occupies a small area including a series of sandy shoreline habitats from southeastern Lake Huron to Pukaskwa National Park on the north shore of Lake Superior. The species' core range in Canada occurs along the southern margin of Manitoulin Island and nearby islands. Increases in population size and number have occurred over the past decade due to increased surveys. This species is at continued but reduced risk because of its specialized life history of flowering and reproducing only once at age 3-11 years before dying, its mainly small populations that undergo fluctuation, and ongoing habitat impacts from a variety of causes. Such threats as recreational ATV use in the species' habitat, presence of exotic grass (Common Reed) and spread of woody plants into its habitat affect various populations.

Canadian Occurrence
Ontario

COSEWIC status history
Designated Threatened in April 1988. Status re-examined and designated Endangered in April 1999. Status re-examined and confirmed in May 2000. Status re-examined and designated Special Concern in November 2010.

* COSEWIC – Committee on the Status of Endangered Wildlife in Canada

2. Species Status Information

Pitcher's Thistle (*Cirsium pitcheri*) is endemic to the Great Lakes basin of North America and is only found in the province of Ontario, Canada, and in four states in the U.S. (Wisconsin, Illinois, Indiana and Michigan). It has been estimated that the Canadian population comprises 15% of global abundance of the species (COSEWIC 2010). The species status at the global scale was ranked as Vulnerable[3] (G3) (last assessed in 2020, NatureServe (2022)). At the national scale, it is ranked as Imperiled (N2) in Canada and 'Vulnerable' (N3) in the U.S. At the sub-national level, it is ranked as 'Imperiled' (S2) in Ontario, and its status at the state level varies from 'Critically Imperiled' to 'Vulnerable' (listed in Appendix B, Table B-1).

[3] See Appendix B for definitions of rank categories.

Pitcher's Thistle was listed as Endangered on Schedule 1 of the federal *Species at Risk Act* (SARA) in 2003. Subsequent survey efforts found that some subpopulations were larger than previously reported, and several additional subpopulations were discovered. As a result, COSEWIC re-assessed the species as Special Concern in November 2010, and the species status under SARA was changed accordingly to Special Concern in 2017. The species is currently listed as Threatened on the Species at Risk in Ontario List under the Province of Ontario’s *Endangered Species Act, 2007* (ESA).

3. Species Information

3.1. Species Description

Pitcher's Thistle is a perennial herb of the aster family (NatureServe 2022). The leaves are whitish-green, narrow and deeply divided (summarized from COSEWIC 2010). After its first year as a seedling, the plant grows basal leaves low to the ground, in the form of a 15 to 30 cm wide ring (a "rosette") (see COSEWIC 2010, Fig. 1). After remaining in this growth form for 2 to 11 years, the plant produces an upright flowering stalk topped by several clusters (capitula) of multiple pale, pinkish-white flowers. After pollination, flowers produce seed-like fruit; after setting seed, the plant dies.

Pitcher’s Thistle can be distinguished from other thistles by the colour of its leaves and flowers, together with the presence of spikes on the flower head and at the tip of the leaves (see key to *Cirsium* genus in Voss & Reznicek 2012).

3.2. Species Population and Distribution

Globally, Pitcher's Thistle occurs on the shores of Lake Superior, Lake Michigan and Lake Huron. In Canada, the species is found on the southeastern shore of Lake Huron, the southern shore of Manitoulin Island and neighbouring islands, and the north shore of Lake Superior in Pukaskwa National Park (Figure 1).

Number of subpopulations

There are currently 234 known extant subpopulations of Pitcher’s Thistle in the world, 197 of which occur in the U.S.: 170 in Michigan (MNFI 2022), 16 in Indiana and eight in Wisconsin (NatureServe 2022), as well as three in Illinois (Illinois Department of Natural Resources 2022). The number of known extant subpopulations has increased compared to what was reported in COSEWIC (2010) in all jurisdictions except Wisconsin (Table 1).

Table 1. Number of known extant subpopulations reported in 2010 and 2022.

Jurisdiction	Subpopulations reported in COSEWIC (2010)	Subpopulations reported in 2022 (see text for sources)
Michigan	156	170
Indiana	8	16
Wisconsin	9	8
Illinois	0	3
Ontario	30	37
Total	203	234

As of 2022, there are 37 extant subpopulations[4] in Ontario (listed in Appendix C, Table C-1). As reported in the federal recovery strategy (PCA 2011) (hereafter, the "recovery strategy"), two subpopulations are located on the shores of Lake Superior in Pukaskwa National Park, and another three occur on the southeastern shore of Lake Huron (Figure 1). The remaining 32 subpopulations, which include those newly recorded since the publication of the recovery strategy, are found on the southern shore of Manitoulin Island and smaller neighbouring islands (see inset, Figure 1). No new subpopulation extirpations have been recorded since the publication of the recovery strategy (extirpated subpopulations are listed in Appendix C, Table C-2).

Abundance

The highest abundance estimate for the Canadian population of Pitcher's Thistle reported since the publication of the recovery strategy was for the year 2017, when a total of 90,000 plants (16,500 mature individuals) were recorded across 32 surveyed subpopulations (data source: Jones 2020). In comparison, the abundance of the Canadian population in 2008 was estimated at 55,000 plants (15,000 mature individuals) (PCA 2011). However, some subpopulations experience wide fluctuations in annual growth rates (Nantel et al. 2018), and overall population abundance can vary drastically from one year to the next. For instance, total abundance for the subset of subpopulations surveyed in both 2017 and 2018 fell from 86,000 plants in 2017 to 39,000 plants in 2018 (data source: Jones 2020). The year-to-year variability in abundance at the population-level reflects the high degree of yearly fluctuations in abundance of Pitcher's Thistle at the subpopulation level, which is characteristic of a species occurring in a dynamic type of habitat (see section 3.3.1 below); for instance, the abundance of several subpopulations on Manitoulin Island dropped by half from 2017 to 2018, yet others remained stable.

It is therefore particularly relevant for the conservation of Pitcher's Thistle in Canada to consider the viability of each of its subpopulations. The general rule-of-thumb since the 1980s has been that a subpopulation should consist of at least 500 interbreeding

[4] Subpopulations, as defined by COSEWIC, are "geographically or otherwise distinct groups in the population between which there is little demographic or genetic exchange (typically one successful migrant individual or gamete per year or less)." (COSEWIC 2021b). Consistent with NatureServe guidelines, in this management plan a subpopulation of Pitcher's Thistle consists of all of the individuals of the species located within 1 km of each other (NatureServe 2020).

individuals in order to retain evolutionary potential[5] (e.g., Given 1994; see review of the rule's origin in Steeves et al. 2017). Demographic models developed for a Pitcher's Thistle subpopulation in Illinois showed that subpopulation abundance should consist of at least 500 individuals for its risk of extirpation to be less than 5% over 100 years (Bell et al. 2002). On the other hand, the authors of a later study found that generally, an effective population size[6] of at least 1,000 individuals of a given species would be required to maintain a population's evolutionary potential, which would translate to a minimum viable population size (MVP) of several thousand individuals to achieve a risk of extirpation of 1% over 40 generations (Frankham et al. 2014). In 2017, 72% (n=23) of the 32 Canadian subpopulations surveyed that year were below the MVP proposed by Frankham et al. (2014). (data source: Jones 2020).

Under an alternative estimation of the probability of extinction, based on rosette abundance rather than the total number of plants at all life stages, Nantel et al. (2018) found that 14 subpopulations out of 25 subpopulations[7] for which there were sufficient data to conduct analyses, had a greater than 5% probability of extirpation over the next 100 years. Most of these vulnerable subpopulations had a declining or stable annual population growth rate and consisted of fewer than 100 rosettes, whereas fluctuations in annual subpopulation growth rate had a weak effect on probability of extirpation (Nantel et al. 2018).

[5] A subpopulation that has retained its evolutionary potential is sufficiently genetically diverse to be viable in the long-term (Steeves et al. 2017).
[6] Effective population size: the number of individuals that breed in the span of one generation.
[7] As per the NHIC guidelines used to delineate subpopulations in this management plan, the subpopulation counts reported in Nantel et al. (2018) correspond to 13 subpopulations having a greater than 5% probability of extirpation over the next 100 years, out of a total 24 subpopulations for which estimates were calculated.

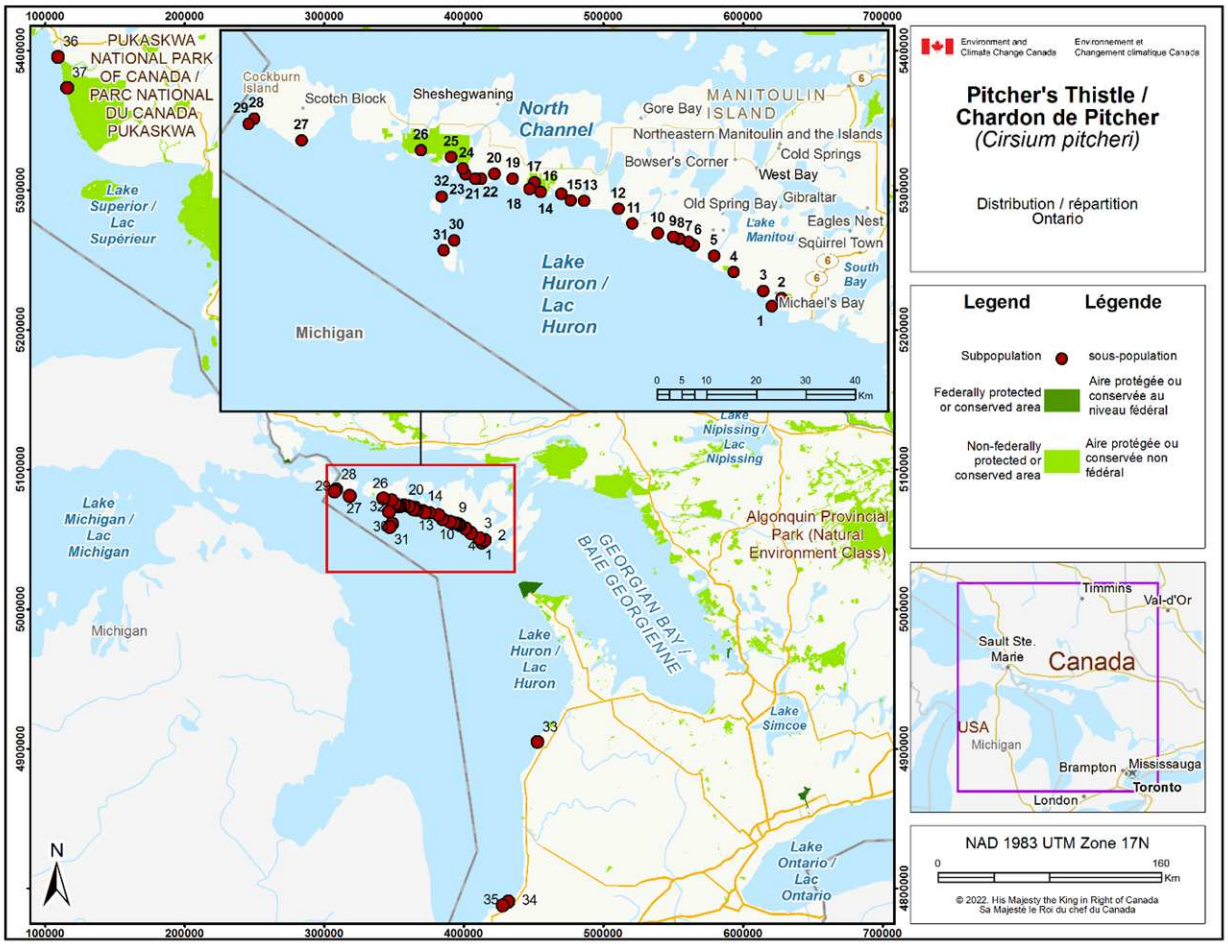

Figure 1. Distribution of Pitcher's Thistle subpopulations in Ontario. Data source: Jones (2020, 2022), NHIC (2022).

3.3. Biological Needs

3.3.1 Habitat

In Ontario, Pitcher's Thistle occurs on sand beaches and sand dunes within the disturbance-prone zone located between open lake water and the landward forest edge. This zone is usually between 25 m to 500 m wide and occurs discontinuously along the shores of Lake Huron and Lake Superior, in stretches ranging from 25 m to more than 1 km in length (COSEWIC 2010). Within this zone, the species will be found in patches of dry, loose sand with sparse vegetation cover (less than 30% in some sites, Havens et al. 2012) comprising grasses such as Marram Grass (*Ammophila breviligulata*) (Keddy & Keddy 1984). The species does not appear to be present in several large areas of seemingly suitable habitat (Maun 1997, COSEWIC 2010, PCA 2011).

In a study conducted on the Lake Michigan shoreline, seedling emergence and survivorship has been found to be higher on perched dunes (200-300 m above lake

level) than on lakeshore linear dunes (1-20 m above lake level), which have a lower surface soil moisture (Rand et al. 2015). However dune type did not affect survivorship to the flowering stage, suggesting that once plants have developed a taproot that can access groundwater (which is closer to the surface in lakeshore dunes compared to perched dunes), the initial negative effect of lower surface soil water availability on the species disappears (Rand et al. 2015).

The location, size and configuration of suitable habitat patches for Pitcher's Thistle shifts over time: as vegetation cover naturally increases in some areas, they become unsuitable for the species; conversely, suitable habitat is maintained or develops in other areas when disturbance from wind, waves, lake level fluctuations and ice scour remove vegetation and create patches of loose, open sand. This pattern of Pitcher's Thistle disappearing from one area and appearing in a new area is characteristic of a species exhibiting metapopulation[8] dynamics (McEachren et al. 1994; Halsey et al. 2015). Metapopulations cannot persist unless the rate of colonization (establishment of new subpopulations) is equal to or greater than the rate of subpopulation extirpation, which requires a dune system that is large enough to allow dune erosion and dune building events to occur independently (McEachren et al. 1994; Halsey et al. 2015).

3.3.2 Pollination and Dispersal

Pitcher's Thistle only reproduces sexually. Although the species is capable of self-pollination (Loveless 1984), fewer seeds are produced when cross-pollination by insects is prevented (Keddy & Keddy 1984). A variety of insects belonging to seventeen different families across six different orders have been recorded visiting Pitcher's Thistle flowers, including bees, ants, flies, butterflies, beetles and true bugs; more than half of the visits being from bumble bees (Jolls et al. 2019). At Oiseau Bay in Pukaskwa National Park, the most frequent visitor of Pitcher's Thistle flowers was the Half-black Bumblebee (*Bombus vagans*), followed by the leaf-cutter bee *Megachile melanophaea* (Keddy & Keddy 1984). Across the plant' entire range, pollination occurs between late May to mid-September (see review in McEachren et al. 1994); the peak flowering period is in early July in Wisconsin (Vitt et al. 2020), and in the last week of July further north in Pukaskwa National Park (Keddy & Keddy 1984).

Seeds are dispersed by wind between July and October (McEachren et al. 1994), and most land within 4 m of the parent plant (Keddy & Keddy 1984, Loveless 1984). The clustering of plants at a scale of about 1 m reported by Girdler & Radtke (2006) is consistent with the observed short seed dispersal distances. Although Pitcher's Thistle rosettes occur in a clustered spatial pattern (Girdler & Radtke 2006), the species grows at very low densities (e.g., 0.02 plants/m^2 (Maun 1997), 0.92 plants/m^2 (Girdler & Radtke 2006). The frequency and mechanism by which long-distance seed/capitula dispersal occurs remains a knowledge gap in the species life history.

[8] Metapopulation: a regional group of populations ('subpopulations' under COSEWIC terminology) of a species that occurs in spatially and temporally variable habitat, and on which environmental events that cause a decline in abundance act independently (McEachren et al. 1994).

The species is monocarpic, meaning that an individual plant produces seed only once, after which it dies; the risk of a plant dying prior to reproduction is inherently increased under this reproductive strategy (Maun 1997). For instance, Rand et al. (2015) have reported an extremely low probability of seeds and seedlings reaching the adult flowering stage (0.3% and 1.7%, respectively). Seed have remained viable for 1-2 years in laboratory (Hamzé & Jolls 2000), and up to 2 or 3 years in the field (Rowland & Maun 2001; Nantel et al. 2018).

4. Threats

4.1. Threat assessment

Threats to the Canadian population of Pitcher's Thistle were described and assessed by a group of species experts during the development of this management plan (ECCC 2019), in order to provide an update to the information published in the species' status report (COSEWIC 2010). Threats were assessed according to the methodology described in "Guidance for completing the Threats Classification and Assessment Calculator and Determining the number of 'Locations'" (COSEWIC 2012), which is based on the IUCN-CMP (International Union for Conservation of Nature and Natural Resources-Conservation Measures Partnership) unified threats classification system, version 1.1.

For the purposes of the above assessment, threats are defined as the proximate activities or processes that are causing or may cause in the future the destruction, degradation, and/or impairment of the entity being assessed (population, species, community, or ecosystem) in the area of interest (global, national, or subnational). Limiting factors (e.g., intrinsic biological characteristics of a species) are not considered during this assessment process. Historical threats, indirect or cumulative effects of the threats, or any other relevant information that would help understand the nature of current or future threats are presented in the Description of Threats section.

The main threats to the Canadian population of Pitcher's Thistle are residential development and associated shoreline alteration, off-trail ATV use and pedestrian traffic, vegetation encroachment, competition from non-native plants and browsing by herbivores. The threats assessment is summarized in Table 2.

Table 2. Threats assessment summary for Pitcher's Thistle in Canada.

Threat #	Threat category	Description	Impact[a]	Scope[b]	Severity[c]	Timing[d]
1.	Residential & commercial development		Low	Small	Extreme	High
1.1	Housing & urban areas	New housing construction & associated shoreline alteration	Low	Small (1-10%)	Extreme (71-100%)	High
4.	Transportation & service corridors		Negligible	Negligible	Moderate	Moderate
4.1	Roads & railroads	New road construction	Negligible	Negligible (<1%)	Moderate (11-30%)	Moderate
5.	Biological resource use		Negligible	Restricted-Small	Negligible	High
5.2	Gathering terrestrial plants	Plant removal/ beach clearing	Negligible	Restricted-Small (1-30%)	Negligible (<1%)	High
6.	Human intrusions & disturbance		Low	Small	Serious	High
6.1	Recreational activities	Trampling by ATVs and pedestrian traffic	Low	Small (1-10%)	Serious (31-70%)	High
7.	Natural system modifications		Medium	Restricted	Serious	High
7.3	Other ecosystem modifications	Vegetation succession	Medium	Restricted (11-30%)	Serious (31-70%)	High
8.	Invasive & other problematic species & genes		Low	Pervasive	Slight	High
8.1	Invasive non-native/alien species	Non-native plants and insects	Low	Small (1-10%)	Moderate (11-30%)	High
8.2	Problematic native species	Animal browsing	Low	Pervasive (71-100%)	Slight (1-10%)	High
11.	Climate change & severe weather		Unknown	Large	Unknown	High
11.4	Storms & flooding	Winter storms	Unknown	Large (31-70%)	Unknown	High

[a] **Impact** – The degree to which a species is observed, inferred, or suspected to be directly or indirectly threatened in the area of interest. The impact of each threat is based on Severity and Scope rating and considers only present and future threats. Threat impact reflects a reduction of a species population or decline/degradation of the area of an ecosystem. The median rate of population reduction or area decline for each combination of scope and severity corresponds to the following classes of threat impact: Very High (75% decline), High (40%), Medium (15%), and Low (3%). Unknown: used when impact cannot be determined (e.g., if values for either scope or severity are unknown); Negligible: when scope or severity is negligible.

[b] **Scope** – Proportion of the species that can reasonably be expected to be affected by the threat within 10 years. Usually measured as a proportion of the species' population in the area of interest. (Pervasive = 71–100%; Large = 31–70%; Restricted = 11–30%; Small = 1–10%; Negligible < 1%).

[c] **Severity** – Within the scope, the level of damage to the species from the threat that can reasonably be expected within a 10-year or three-generation timeframe. Usually measured as the degree of reduction of the species' population. (Extreme = 71–100%; Serious = 31–70%; Moderate = 11–30%; Slight = 1–10%; Negligible < 1%; Neutral or Potential Benefit ≥ 0%).

[d] **Timing** – High = continuing; Moderate = only in the future (could happen in the short term [< 10 years or 3 generations]) or now suspended (could come back in the short term); Low = only in the future (could happen in the long term) or now suspended (could come back in the long term); Insignificant/Negligible = only in the past and unlikely to return, or no direct effect but limiting.

4.2. Threat descriptions

Threat 1.1. Housing & urban areas - Impact: Low

- Construction of residential structures

Undertaking construction projects where Pitcher's Thistle occurs will kill individual plants and eliminate the species' habitat located within the project's direct footprint. For instance, Maun (1997) attributed the extirpation of the Kettle Point subpopulation to coastal development (and recreational activities, see threat 6.1 below). Associated shoreline alteration (e.g., installation of riprap or armour stone) can disrupt longshore currents thus altering patterns of sand transport and deposition, both on and off-site, which may prevent colonization of new areas by the species (Girdler & Radtke 2006). Reduced habitat connectivity may also lead to lower genetic diversity and higher inbreeding levels (Fant et al. 2013, 2014).

Given that most sandy bays on Manitoulin Island are currently subdivided for residential development, ongoing and planned residential construction is a threat to Pitcher's Thistle (ECCC 2019). For example Carter Bay, where 50% of the Canadian population occurs, is zoned for development, though there is no plan of subdivision at this time. The scope is nevertheless assessed as 'Small' to account for scenarios where the extent of habitat loss is reduced when structures are built landward of the beach zone rather than directly on the sand dunes. Furthermore, the overall impact of the threat may be tempered by the generally large size of lots, such that the proportion of habitat destroyed by the building footprint is small relative to the lot size (ECCC 2019).

Threat 4.1. Roads and railroads - Impact: Negligible

- New road construction

Undertaking a road construction project where Pitcher's Thistle occurs will kill individual plants and eliminate the species' habitat within the road's direct footprint. There would also be negative effects to the species from the use of associated machinery within the project's direct and indirect footprint. At this time, this threat only applies to the Port Franks subpopulation, where an application for the construction of a new road allowance has been submitted to municipal council by landowners seeking an alternative access to their properties (ECCC 2019). The impact to the species may be mitigated by the fact that a large proportion (60 – 70%) of the subpopulation occurs outside of the proposed road allowance footprint, on provincial park property. Nevertheless, the subpopulation would be impacted by sand erosion stemming from wind action generated by vehicles using the road.

Threat 5.2 Gathering terrestrial plans - Impact: Negligible

- Deliberate removal of plants

Some landowners pull individual plants from their properties for a variety of reasons, such as landscaping, a dislike of thistles, or because the species is mistaken for a noxious weed. This threat does not currently impact the Carter Bay or Great Duck Island subpopulations, which together account for 74% of the Canadian population.

Severity may be more serious than assessed in ECCC (2019) given that the species does not have a persistent seed bank (seed viability of 3 years or less, see section 3.3.2).

Threat 6.1 Recreational activities - Impact: Low

- Trampling by pedestrians and all-terrain vehicles (ATVs)

Although habitat disturbance events that are staggered in time and place within a dune system are necessary to maintain the presence of areas of suitable habitat for the species at the landscape scale, they can be detrimental at the local scale and lead to the extirpation of a subpopulation. Trampling by off-trail pedestrian activity and ATV use can accelerate subpopulation extirpation by causing plants to be killed from being crushed, uprooted or buried by sand (Girdler & Radtke 2006). Seedlings are especially vulnerable to complete burial (Maun et al. 1996). In addition, seed germination and seedling emergence decrease with increased burial depth (Chen & Maun 1999).

ATVs can also damage habitat by altering the structure and configuration of dunes and ridges directly, which may subsequently render the habitat unsuitable for Pitcher's Thistle. Damage to habitat from ATVs occurs on Manitoulin Island, especially where there are municipal road allowances within the beach zone. Subpopulations at Burnt Island Harbour, Belanger Bay West, and Doc Hewson Bay on Cockburn Island are at particular risk of extirpation due to ATV use. The threat from ATV use is more severe when lake levels are high (see Threat 11.1) as they force ATVs onto higher ground where plants beyond the flood line persist (ECCC 2019).

Blowouts (depressions in the sand dune) due to people jumping off the top of dunes result in holes that increase in size over time because loosened sand is vulnerable to wind erosion. This threat is a particular concern for the Pinery Provincial Park subpopulation (ECCC 2019).

Threat 7.3 Other ecosystem modifications – Impact: Medium

- Encroachment by woody vegetation

Vegetation succession is a natural process by which herbaceous plant communities (e.g., fields) gradually transition into forests until, or unless, an environmental disturbance (e.g. wildfire) removes or prevents the establishment of woody vegetation. On the coast of the Great Lakes where Pitcher's Thistle occurs, encroachment of shoreline habitat by woody vegetation is mainly influenced by daily, seasonal, and long-term fluctuations of lake water levels that occur in response to wind, precipitation and temperature (Fuller et al. 1995), ice scour, and wave and wind action directly.

Site-level disturbances such as wind, wave action and ice scour prevent vegetation encroachment of dunes along the lakeshore and maintain the sparsely vegetated, tree-less habitat that is suitable for Pitcher's Thistle (see section 3.3.1). (Conversely, during years of lower lake water levels, decreased proximity of Pitcher's Thistle individuals to disturbance from wave-action facilitates vegetation encroachment (PCA 2011)). Vegetation encroachment can negatively impact Pitcher's Thistle; for

example, Pitcher's Thistle experienced negative population growth and decreased seedling emergence in lower light conditions and higher plant litter depth that would result from greater vegetation cover (Jolls et al. 2015).

Although the succession cycle is a natural process, it is discussed as a threat in this management plan because Pitcher's Thistle abundance is such that the absence of disturbance in a relatively small subset of subpopulations is likely to have a more severe impact on the Canadian population than it would have had prior to the species being put at risk by human activities.

Currently, the Oiseau Bay subpopulation in Pukaskwa National Park is threatened by woody vegetation encroachment. Within that subpopulation, the species was extirpated from the Crescent Beach site over a span of 20 years largely due to vegetation succession that ensued following a change in the course of a nearby river in 1985 (Patterson pers. comm. 2019). Plants growing at a second site within the subpopulation, Creek Beach, are now at risk of extirpation due to encroachment by vegetation such as the native Silverberry shrub (*Elaeagnus commutata*). Pitcher's Thistle is no longer found in some areas within the subpopulations at Fisher's Bay , Michael's Bay and Christina's Bay as a result of vegetation encroachment (ECCC 2019), and only one plant was found at the Sand Bay site on Cockburn Island in 2019 (data source: Jones 2020).

<u>Threat 8.1. Invasive non-native/alien species – Impact: Low</u>

- Non-native plants

There is concern that non-native plants that have the capacity to rapidly spread within newly colonized areas pose a threat to Pitcher's Thistle because they might overtake the substrate and/or shade out Pitcher's Thistle. These potential scenarios are inferred from observations that the species is only found in sparsely vegetated habitat, and that Pitcher's Thistle juveniles that are further isolated from conspecifics have been found to grow to larger sizes than those closer together (Girdler & Radtke 2006). Until recently, the non-native European Reed (*Phragmites australis* subsp. *australis*) was considered a threat to some Pitcher's Thistle subpopulations, particularly those on Manitoulin Island (ECCC 2019). However, a program to eradicate European Reed from the shores of Lake Huron has significantly reduced the scope and severity of the threat, though on-going management will likely be necessary to prevent re-colonization (ECCC 2019).

The two non-native plant species discussed below are considered low impact threats given that there is some uncertainty as to how severely they may negatively affect Pitcher's Thistle.

- Baby's Breath

Baby's Breath (*Gypsophila paniculata*) is a perennial flowering plant native to Europe and Asia, likely introduced in North America in the late 1800s as an ornamental plant (Lamar & Partridge 2021). It is now found throughout the northern and western U.S. and several Canadian provinces (EDDMapS 2022), and is considered an invasive species in coastal sand dune habitat of Lake Michigan (Emery et al. 2013; Reid & Emery 2018;

Rice et al. 2020; Lamar & Partridge 2021). The first herbarium record of the species for Ontario dates from the time period 1964 to 1983 (Lamar and Partridge 2021), and the plant is currently present where Pitcher's Thistle occurs on Cockburn Island, Duck Island, and at Horseshoe Bay on Great Duck Island (ECCC 2019). The deep roots of *G. paniculata* stabilize dunes that would otherwise be subjected to natural disturbance (Emery et al. 2013). Yet although Baby's Breath can significantly reduce the amount of bare sand (Reid & Emery 2018), studies have not provided conclusive evidence that its presence is detrimental to Pitcher's Thistle. For example, removal of Baby's Breath did not increase the absolute number of pollinator visits to Pitcher's Thistle flowers (Baskett et al. 2011), or the abundance of the species (Emery et al. 2013; Reid & Emery 2018).

- Spotted Knapweed

Spotted Knapweed (*Centaurea stoebe* subsp. *micranthos*) is another plant native to central Eurasia that is considered a major invader of the Great Lakes' coastal dune habitat in the U.S. (Girdler et al. 2016). Although Spotted Knapweed has not been reported in the Early Detection & Distribution Mapping System where Pitcher's Thistle occurs in Ontario (EDDMapS 2022), it was found in Pukaskwa National Park in 2021, approximately 25 km from the Oiseau Bay subpopulation (Patterson pers. comm. 2022). The Spotted Knapweed record closest to Pitcher's Thistle subpopulations on Manitoulin Island is located 45 km to the south on the Bruce Peninsula (EDDMapS 2022). Again, there is uncertainty as to whether the plant has negative impacts on Pitcher's Thistle. For example, one study found that the proportion of Pitcher's Thistle individuals surviving to the flowering stage was lower for individuals growing near Spotted Knapweed compared to those growing in areas of open sand, and seedling emergence was lower, particularly in habitat with lower surface soil water (Rand et al. 2015). On the other hand, Girdler et al. (2016) did not find negative effects of Spotted Knapweed on Pitcher's Thistle abundance.

- Non-native insects

Four introduced, seed-eating weevil species have been found to impact Pitcher's Thistle in some U.S. subpopulations. They are discussed below as potential threats because they have not been detected in Canadian subpopulations of Pitcher's Thistle at this time. Eggs of a fifth species, *Hadroplontus lidura*, have been documented on Pitcher's Thistle leaves in the U.S. but there is no evidence yet that the plant can support the insect through to adult emergence (Katovich *et al.* 2022).

- *Larinus planus*, *L. minutus* and *L. obtusus*

The Eurasian weevils *Larinus planus*, *L. minutus* and *L. obtusus* were deliberately spread in the U.S. in the early 1990s as biocontrol agents for non-native plant species: *L. planus*, to target the thistle *Cirsium arvense* (Louda and O'Brien 2002, Dodge 2005), and the other two weevil species, to control invasive knapweeds (CALS 2022). All three weevil species can feed on Pitcher's Thistle flowers (Warneke et al. 2020). The prevalence of *L. planus* on the flowers appears to be influenced by dune elevation and by the presence of other vegetation around plants (Hakes & Meunier 2018).

L. planus also uses the flowers for reproduction: the weevil bores holes in the flower heads in which it deposits an egg, and the developing larvae feed on the thistle's ovules and developing seeds (Dodge 2005). As a result, Havens et al. (2012) found that 45% of flower heads did not disperse any seeds due to damage by the weevil, and according to the authors' model, weevil infestation could decrease the growth rate of Pitcher's Thistle by 10-12%. Infestation of flower heads by *L. planus* has also been found to reduce the number and weight of mature seeds produced (Gijsman et al. 2020). Warneke et al. (2020) further suggest that *C. arvense* may facilitate the movement of *L. planus* into Pitcher's Thistle habitat, and that extensive feeding by *L. minutus* and *L. obtusus* could reduce the reproductive success of Pitcher's Thistle. The severity of the threat from *L. planus* may be reduced by applying kaolin clay, an organic insect deterrent (Inkster 2016).

- *Rhinocyllus conicus*

Another European weevil from a different genus, *Rhinocyllus conicus*, was introduced to North America in 1969 as a biocontrol agent for the non-native thistle *Carduus nutans* (Havens et al. 2012). Since its introduction, *R. conicus* has been documented feeding on the seeds of 16 native *Cirsium* species (Dodge 2005), and was found on Pitcher's Thistle flower heads in a botanical garden in 2007 (Havens et al. 2012). Based on the rate of oviposition of *R. conicus* on *C. pitcheri* observed in an experimental setting, demographic models predict a decrease in population growth rate and a steep decrease in the time to halve a population of Pitcher's Thistle colonized by *R. conicus* (Louda et al. 2005).

<u>Threat 8.2. Problematic native species – Impact: Low</u>

- Browsing

Herbivory is another type of local-scale disturbance that can accelerate subpopulation extirpation (Girdler & Radtke 2006). For example, increasing intensity and frequency of herbivory negatively affected Pitcher's Thistle root biomass (Phillips & Maun 1996). Herbivory may therefore lower the flowering probability of affected plants, by forcing a re-allocation of resources to the regrowth of browsed shoots and leaves while simultaneously decreasing total nutrient and water uptake (Phillips & Maun 1996; Girdler & Radtke 2006). The rate of herbivory, which determines the severity of its impact on individual plants, may be influenced by the spatial distribution and size of Pitcher's Thistles individuals: for instance, Girdler & Radtke (2006) found that rosettes with only one or two other rosettes within a 1 m radius were more likely to be browsed than those with nine or more neighbours, and that generally, herbivory was more prevalent in larger individuals.

Browsing of the species by the native White-tailed Deer (*Odocoileus virginianus*) has been observed in the field (e.g., Bell et al. 2003), and is considered a threat to some Pitcher's Thistle subpopulations –as opposed to a natural component of the species ecology– due to a presumed increase in deer abundance since European settlement. For instance, Maun (1997) reported that in the mid-1990s, deer abundance in Pinery Provincial Park was four times the carrying capacity of the Park; concurrently, the

author found that 90% of flowering Pitcher's Thistle individuals were grazed and that 50% of capitula were consumed. Currently, deer browsing is a threat to the Desert Point and Duck Island subpopulations in particular. Deer abundance is low in Pukaskwa National Park and as such deer browse is not currently a threat to the subpopulations that occur within that Park (Patterson pers. comm. 2019).

The Spotted Cucumber Beetle, *Diabrotica undecimpunctata howardi*, is a leaf beetle native to North America that feeds on a wide variety of agricultural crops including gourds, squashes and corn. In one study in Indiana, Marshall (2013) documented the species feeding on Pitcher's Thistle flower heads. It is not known whether the beetle larvae feed on Pitcher's Thistle roots, or whether herbivory by *D. u. howardi* impacts the plant's reproductive success. The subspecies is present in Ontario (EPPO 2022) but the impact of this insect, if any, on the Canadian population of Pitcher's Thistle is unknown.

Threat 11. Climate change and severe weather – Impact: Unknown

In light of a projected increase of 2.85 ºC to 3.48 ºC by 2050 in mean annual temperature across the species range in Ontario, Pitcher's Thistle has been assessed as 'Highly Vulnerable'[9] to climate change under the Climate Change Vulnerability Index developed for species occurring in Ontario's Great Lakes basin (Brinker et al. 2018). This level of vulnerability is in part due to the following intrinsic characteristics of the species: its cool temperature niche (namely, cold-water coastal habitat), its highly restricted dispersal capability (see subsection 3.2.2), its low genetic variation (Loveless and Hamrick 1988; Coleman 2007; Fant et al. 2013, 2014), and its dependence on an uncommon geological feature (sand dunes) (Brinker *et al.* 2018). The predicted vulnerability is consistent with results of an experimental study that showed depressed growth of *C. pitcheri* plants under a temperature increase of 6 ºC that is projected for Illinois by 2095 (Staehlin & Fant 2015). Seed germination was also found to be lower at 25 ºC compared to 20 ºC (Gijsman & Vitt 2021), a result that warrants attention given that, under a high-emissions scenario, average summertime air temperature is projected to be above 20 ºC in both the Lake Superior and Lake Huron basins by 2066 (ECCC 2022).

Threat 11.1 Habitat shifting and alteration

- Increased water levels in the Great Lakes

The threat posed by changes to water levels in the Great Lakes as a result of climate change was not specifically addressed during the species threats assessment (ECCC 2019); however it is discussed in this management plan in light of recently published projections for future water levels in the Great Lakes. This parameter is applicable to Ontario's Pitcher's Thistle subpopulations given their occurrence within 500m of the Lake Superior and Lake Huron shorelines. Model projections show that the greater the increases in global temperatures, the wider the range of future water level values (i.e., both extreme highs and extreme lows compared to pre-2020 measured data are

[9] Highly vulnerable: Abundance and/or range extent within geographical area assessed likely to decrease significantly by 2050. (Brinker *et al.* 2018).

projected); they also show, on average, an increase in total over-lake precipitation and an increase in overall water levels for the Great Lakes (Seglenieks & Temgoua 2022). Under high lake water levels, the amount of Pitcher's Thistle habitat would likely decrease as water engulfs low elevation beaches and dunes. This was observed in 2019 when water levels were high: habitat availability was reduced and plants were restricted to higher ground at the top of the dunes (ECCC 2019). By the same token, higher lake levels would also decrease habitat connectivity, thereby further isolating extant subpopulations (Fant et al. 2014).

Threat 11.4. Storms & flooding – Impact: Unknown

- Winter storms

Winter storms create wave action and ice scour that act as natural disturbance events in dune habitat. However, violent winter storms can also result in intense sand accretion that can lead to declines in Pitcher's Thistle abundance (Sandacz et al. 2023). Although an increase in the frequency and severity of winter storms has been observed over the last few years on the Lake Huron coast (ECCC 2019), uncertainty remains as to how climate change will affect sand dune dynamics along the Great Lakes (Yurk and Hansen 2021). The threat from increased wave action and ice scour on the Canadian population of Pitcher's Thistle is temperedby the fact that the Carter Bay and Desert Point subpopulations (which together account for 73% of the Canadian population) occur on parabolic (U-shaped) dunes, which are not affected to the same degree as other dune forms by these types of disturbance (ECCC 2019).

5. Management Objective

The management objective for Pitcher's Thistle in Canada is to prevent the population from becoming Threatened or Endangered by:

- Maintaining the population's extent of occurrence (EOO)[10];
- Maintaining or increasing the population's index of area of occupancy (IAO)[11]; and
- Maintaining or increasing the current number of subpopulations of Pitcher's Thistle.

The population's EOO, currently calculated to be 43,438 km^2, is above the threshold for Threatened status (20,000 km^2) and is not known to have been significantly larger historically[12]. However the IAO, currently estimated to be 136 km^2, is below the

[10] EOO: Extent of Occurrence. The area included in a polygon without concave angles that encompasses the geographic distribution of all known populations of a wildlife species (COSEWIC 2021a).
[11] IAO: Index of Area of Occupancy. For Pitcher's Thistle, it is the area within the Extent of Occurrence that is occupied by the species in Canada based on a grid with a cell size of 2 km X 2 km (COSEWIC 2009).
[12] The Kettle Point subpopulation is the only extirpated subpopulation on record to have occurred outside the species' current range, approximately 10 km south of the extant Port Franks subpopulation.

threshold for Endangered status (500 km^2)[13], and its value does decrease when a subpopulation is lost. According to COSEWIC criteria, declines in any of the parameters used to assess a species status, such as the EOO, IAO and number of subpopulations, must be prevented in order to reduce the risk of the species becoming Threatened or Endangered in Canada (COSEWIC 2021b).

To further reduce this risk, the objectives strive to not only maintain, but increase the area of occupancy and the number of subpopulations present in Ontario. The augmentation of extant, and the (re)introduction of new subpopulations could increase the viability of Pitcher's Thistle metapopulations (Girdler & Radtke 2006, Halsey et al. 2015). Both types of interventions warrant consideration given the extremely small size[14] and/or the elevated risk of extirpation identified for several subpopulations of Pitcher's Thistle in Canada (Nantel et al. (2018), as well as the species' occurrence in dynamic habitat which renders subpopulations highly sensitive to environmental stochasticity[15] (Bell et al. 2003).

An increase in the number of subpopulations (colonization of unoccupied habitat) is likely possible given the existence of numerous areas of seemingly suitable, unoccupied habitat within the Canadian population's natural range (PCA 2011, COSEWIC 2010). Establishment of new subpopulations will likely require human-facilitated dispersal, given the short dispersal distance of Pitcher's Thistle seeds and reduced connectivity (greater distances) between extant subpopulations and unoccupied habitat (Halsey et al. 2015; Jolls et al. 2015). Facilitated dispersal has successfully led to the establishment of one introduced subpopulation (Hattie Cove) and two new sites[16] within the Oiseau Bay subpopulation in Pukaskwa National Park (PCA 2017, Patterson pers. comm. 2019), as well as the re-introduction of the species within the Christina's Bay subpopulation (ECCC 2019). New subpopulations have also been successfully established in Indiana and Illinois (Fant et al. 2013; NatureServe 2022).

6. Broad Strategies and Conservation Measures

6.1. Actions Already Completed or Currently Underway

The following conservation measures have been completed since the 2011 publication of the *Recovery Strategy for Pitcher's Thistle* (Cirsium pitcheri) *in Canada* under SARA:

[13] Estimates of the EOO and IAO from COSEWIC (2010), threshold values from COSEWIC (2021b).
[14] For the years 2015 through to 2019, annual abundance of the following subpopulations consisted of fewer than 50 individuals: Michael's Bay, Lougheed's Bay, Misery Bay West, Fisher Bay, Christina Bay, Burnt Island Harbour, Belanger Bay, Sand Bay-Doc Hewson Bay (Cockburn Island). (Data source: Jones 2020).
[15] Environmental stochasticity: the occurrence of unpredictable environmental events (e.g., floods, droughts) that can affect population distribution.
[16] Oiseau Creek and Tombolo

- Supported by funding from the federal government's Natural Areas Conservation Program (NACP) and other partners, the Nature Conservancy of Canada (NCC) acquired the following properties where Pitcher's Thistle occurs:
    - Kenewallyn, June 2011 (Kenewallyn-Murphy Harbour subpopulation)
    - Tasker Wilderness Shore, March 2012 (Taskerville subpopulation)
    - Cockburn Island properties, December 2012 and May 2017 (three subpopulations: Sand Bay - Doc Hewson Bay, Wagosh Bay, and Western Shore); see Appendix C, Table C-1.

- In 2013, Pukaskwa National Park staff initiated a long-term project to facilitate the dispersal of Pitcher's Thistle seed, which has resulted in the successful establishment of two new sites within the Oiseau Bay subpopulation. Plants at both sites were observed in flower for the first time in 2021 (Patterson pers. comm. 2022).

- In 2013, as part of their project to address the threat of coastal wetland degradation due to recreational activities and invasive species, the Lake Huron Centre for Coastal Conservation, a non-government charitable organization, developed a guide for the cottager community that provides stewardship recommendations for dune grassland habitat. This project was supported by the federal government's Habitat Stewardship Program for Species at Risk.

- Given its status as a Threatened species on the Species at Risk in Ontario List, individuals and habitat of the Pitcher's Thistle benefit from the protection provisions afforded under the ESA on non-federal lands. In 2014, a regulation prescribing the area as the habitat of the Pitcher's Thistle came into force under the ESA (see Ontario Regulation 832/21, section 26).

- In 2017, the Parks Canada Agency (PCA) published the *Multi-species Action Plan for Pukaskwa National Park of Canada* under SARA (PCA 2017). The Action Plan provides details on the measures to undertake towards achieving the population and distribution objectives for the species included in the plan, which includes Pitcher's Thistle. In 2022, PCA published the *Implementation Report: Multi-species Action Plan for Pukaskwa National Park of Canada (2017 to 2022)* (PCA 2022), which reports on the progress achieved towards implementing the measures described in the Action Plan.

- In 2019, the Lake Huron Centre for Coastal Conservation published the Coastal Action Plan for the Southeastern Shores of Lake Huron. The plan identifies management strategies to address threats to natural features and species within the Lake Huron shoreline from Sarnia to Tobermory, and specifically mentions Pitcher's Thistle.

- In 2019, the Ontario Ministry of the Environment, Conservation and Parks published a Review of Progress report for Pitcher's Thistle under the ESA. The report summarizes recent activities that have taken place in Ontario related to the

protection and recovery of the species at risk. 2019 review of progress towards the protection and recovery of Ontario's species at risk: Pitcher's Thistle | Ontario.ca

- From 2016 to 2019 and in 2021, a Manitoulin Island-wide project led by Winter Spider Eco-Consulting collected abundance data and controlled or eradicated the invasive European Reed at over two dozen sites where Pitcher's Thistle subpopulations occur, resulting in the rehabilitation of at least 106.5 ha of Pitcher's Thistle habitat. Through its outreach activities, the project has also raised public awareness of the threat from European Reed and engaged landowners in the stewardship and monitoring of Pitcher's Thistle (Jones 2020, 2021). This project was supported by the federal government's Habitat Stewardship Program for Species at Risk and by the Province of Ontario's Species at Risk Stewardship Program.

6.2. Broad Strategies

In order to achieve the management objective for Pitcher's Thistle, conservation measures are organized under the following broad strategies:

- Land management, at both the site and ecosystem scales, to maintain sparsely vegetated sand dune habitat that is appropriate for metapopulation persistence;
- Species management, to decrease herbivory and facilitate Pitcher's Thistle seed dispersal;
- Outreach and communications, to raise public awareness regarding the threat posed by off-trail ATV and pedestrian activity, and to encourage habitat stewardship;
- Municipal land-use planning and regulation development/enforcement, to decrease impacts of ATV use and mitigate threats from residential and shoreline development, construction of roads and recreational use in Pitcher's Thistle habitat;
- Research and status monitoring, to effectively address threats, and assess subpopulation abundance trends;
- Alliance and partnership development, to coordinate conservation action implementation and share knowledge with land managers.

6.3. Conservation Measures

As previously mentioned, the sand dunes where Pitcher's Thistle occurs is dynamic habitat: over time, sand erosion and deposition patterns, influenced by wind and longshore currents, lead to the creation of suitable habitat in new areas and its disappearance from others. Continued collaboration between the federal and provincial governments in supporting Indigenous communities, municipalities, industry and non-governmental organizations that undertake activities to benefit Pitcher's Thistle will facilitate a landscape approach to conserving the species.

Measures to conserve the species in Canada are listed in Table 3. They include measures aimed at lowering the risk of subpopulation extirpation, in combination with

measures that aim to increase colonization of new areas. The conservation measures intend to counter the threats to the species in order to achieve the management objective identified in Section 5 above. The conservation measures have been categorized according to the Conservation Actions Classification system developed by the Conservation Measures Partnership, version 2.0 (CMP 2016).

The first category of conservation measures pertains to direct management of land and of the species itself. The measures focus on implementation of plans to control vegetation cover and the spread of non-native plants, in order to minimize encroachment into Pitcher's Thistle habitat and maintain sparsely vegetated sand dunes; elimination of trampling due to recreational activities, in order to avoid direct mortality of individuals and sand erosion; reduction of browsing pressure, and; improvement of habitat connectivity at the landscape scale.

The second category of measures relates to human behavioural change. It includes outreach measures targeting private landowners and municipal governments in order to promote and implement beneficial habitat stewardship and management practices, as well as raising community awareness and improving and/or increasing enforcement of recreational trail use regulations.

The third category of conservation measures relates to planning and research activities that will enable the successful implementation of the management and outreach activities described above, the prevention of further negative impacts to the species, and the monitoring of emerging and potential threats. The measures include developing the site management plans described above, using municipal land-use planning processes to avoid impacts on subpopulations, conducting research on the pollination biology of the species, gaining a better understanding of potential impacts of climate change on the population, and conducting abundance surveys to evaluate the effectiveness of management action implementation.

Table 3. Conservation Measures

Category		Targeted threats	Priority[a]
A. Target Restoration/ Stress Reduction Actions			
1. Land/ Water Management			
1.1 Site/ Area Stewardship			
1.1.1 Mechanical actions	Implement site-level vegetation cover control plans (e.g., removal of shrubs) in order to maintain low vegetation density in Pitcher's Thistle habitat, while maintaining a variety of native plant species with sequential bloom periods to provide forage for Pitcher's Thistle pollinators throughout their active season.	7.3	High

Category		Targeted threats	Priority[a]
	Implement site-level invasive plant species control plans to minimize encroachment into Pitcher's Thistle habitat.	8.1	Medium
1.1.2 Chemical actions	Implement site-level invasive plant species control plans where appropriate (e.g., herbicide application in accordance with applicable federal and provincial regulations).	8.1	Medium
1.1.8 Visitor management	Implement site-level plans to eliminate damage to the species and its habitat from recreational use of dunes (e.g., designated pathways, re-routing trails, fences and signs, rotation of recreation areas).	6.1	Medium
1.2 Ecosystem & Natural Process (Re)Creation			
1.2.2 Abiotic functions & processes	Implement shoreline naturalization measures in order to restore disrupted sand transport and deposition patterns at the landscape scale, for example, by removing coastal structures (rock rip-rap revetment, metal sheet walls, groins, etc.) and replacing them with non-structural living shoreline elements.	1.1 7.3 11.1	High
2. Species Management			
2.1 Species Stewardship			
2.1.1 Population management	Manage White-tailed Deer abundance to decrease browsing pressure (e.g., via issuance of hunting tags).	8.2	Medium
B. Behavioural Change/ Threat reduction			
3. Awareness Raising			
3.1 Outreach & Communications			
3.1.4 Displays	Install signs at trail-heads (ATV and pedestrian) and beach entrances to raise awareness of the importance of staying on designated trails to prevent sand dune erosion and trampling of Pitcher's Thistle.	6.1	Low
	Install displays about the species on the Manitoulin ferry and Pinery Provincial Park Visitor Centre.	6.1	Low
3.1.7 Person-to-person engagement	Engage private landowners in habitat stewardship (e.g. shoreline naturalization) and species conservation (e.g. discouraging pulling of Pitcher's Thistle on beaches).	1.1 5.2	Low
4. Law Enforcement and Prosecution			

Category		Targeted threats	Priority[a]
4.3 Non-Criminal Legal Action			
4.3.2 Agency enforcement	Enforce rules prohibiting off-trail use of ATVs.	6.1	High
5. Livelihood, Economic & Moral Incentives			
5.2 Better Products & Management Practices			
5.2.2 Promoting better products & practices	Encourage land managers and landowners to adopt better management practices related to the maintenance of residential property, beaches and shorelines.	1.1 5.2 7.3 8.1	Medium
C. Enabling Conditions			
6. Conservation Designation & Planning			
6.1 Protected Area Designation &/or Acquisition			
6.1.1/6.1.2 Government and/or private protected area	Acquire land to establish protected areas consisting of dune systems of sufficient size to allow persistence of metapopulations.	1.1 6.1	Low
6.3 Land/Water use Zoning & Designation			
6.3.1 Land-use zoning	Include areas of Pitcher's Thistle occurrence in municipal official plans to minimize instances where species occurrence coincides with the footprint of new housing and road construction.	1.1 4.1	Medium
6.4 Conservation Planning			
6.4.1 Ecoregions or large land/ seascapes	Develop landscape-scale plan to mitigate the impact of offshore structures that affect longshore currents and sand supply.		High
6.4.2 Sites/ protected areas	Identify priority subpopulations for implementation of conservation measures based on predicted impact of climate change/ lake levels.	11.1 11.4	High
	Develop site-level vegetation management plans for subpopulations where vegetation succession is a threat.	7.3	High
	Develop site-level deer browsing control plans for subpopulations where threat is present.	8.2	High
	Develop site-level invasive plant species control plans for subpopulations where they are a threat.	8.1	Medium
	Develop site-level plans to restore connectivity between inland dunes and beaches as warranted.	1.1	Medium

Category		Targeted threats	Priority[a]
	Develop site-level plans to eliminate threat from recreational use of dunes (e.g., designated pathways, fences and signs, rotation of recreation areas), where warranted.	6.1	Low
6.4.3 Species/ taxonomic groups	If warranted (see action under 8.2), develop a (re)introduction protocol addressing: seed source provenance and make-up; candidate site identification parameters (e.g., dune elevation, surface soil water, risk of herbivory and vulnerability to climate change and other threats); seed germination methods; minimum number of transplants per size and life stage (seed/seedling/rosette); planting density and spatial pattern[b].	All threats	Medium
7. Legal & policy frameworks			
7.1 Laws, Regulations & Codes			
7.1.4 Municipal law or regulations	Include conditions in building permits and shoreline alteration proposals that require reduction and mitigation of impacts to Pitcher's Thistle and its habitat (e.g., no development between inland dunes and the beach, sufficient set-back distance from active dunes to avoid habitat and maintain natural shoreline disturbance events).	1.1	High
	Prohibit the use of ATVs on beaches and dunes where Pitcher's Thistle occurs.	6.1	High
8. Research & Monitoring			
8.1 Basic Research & Status Monitoring			
8.1.1 Biological targets	Collect data on abundance and area of occupancy for all extant subpopulations at least once every 10 years.	To measure progress	High
	Determine key aspects of Pitcher's Thistle reproduction (pollination and dispersal syndromes; seed viability).	7.3 8.1 11.1	Low
8.1.3 Threats/ biophysical factors	Continue to monitor the severity of threats (trampling, invasive plant species, herbivory) and to rapidly detect colonization by non-native weevil species where Pitcher's Thistle occurs.	6.1 8.1 8.2	High
	Determine the impact of climate change on Lake Huron and Lake Superior water levels and on the frequency and severity of droughts, floods and ice scour where the species occurs.	11.1 11.4	Medium

Category		Targeted threats	Priority[a]
8.2 Evaluation, Effectiveness Measures & Learning			
8.2.1 Specific projects	Evaluate the effectiveness of site and species stewardship actions (see section A. above) in meeting the species' management objective.	7.3 8.1 8.2	Medium
	If stewardship actions are not sufficient to meet the species' management objective, evaluate whether the species should be translocated to unoccupied habitat (e.g., via ex-situ seed germination and facilitated species dispersal) and/or whether individuals of various origins should be introduced within extant subpopulations in order to increase abundance and genetic diversity.	All threats	Medium
10. Institutional development			
10.3 Alliance & partnership development			
10.3.1 Coordinating conservation implemen-tation	Coordinate surveys, monitoring and threat mitigation activities with other conservation initiatives in shoreline/ dune habitat.	All threats	Medium
	Support initiatives by Indigenous communities to conserve Pitcher's Thistle.	All threats	Medium
10.3.2 Knowledge generation & sharing	Provide locations of subpopulations to municipal and land-use planning authorities to inform land-use decisions and minimize instances where species occurrence coincides within the footprint of new housing, roads or recreational trails	1.1 4.1 6.1	High
	Support the gathering and sharing of Traditional Ecological Knowledge	All threats	Medium
	Encourage the submission of Pitcher's Thistle observations to the Ontario Natural Heritage Information Centre.	All threats	Low

[a] "Priority" reflects the degree to which the measure contributes directly to the conservation of the species or is an essential precursor to a measure that contributes to the conservation of the species. High priority measures are considered those most likely to have an immediate and/or direct influence on attaining the management objective for the species. Medium priority measures may have a less immediate or less direct influence on reaching the management objective, but are still important for the management of the population. Low priority conservation measures will likely have an indirect or gradual influence on reaching the management objective, but are considered important contributions to the knowledge base and/or public involvement and acceptance of the species.

[b] See recommendations in McEachren et al. 1994, Stanforth et al. 1997, Bell et al. 2003, Girdler & Radtke 2006, Fant et al. 2013, Rand et al. 2015, Staehlin & Fant 2015, Godefroid et al. 2016.

7. Measuring Progress

Every ten years, progress towards achieving the management objectives and monitoring the implementation of this management plan for the Canadian population of Pitcher’s Thistle will be measured against the following performance indicators:

- EOO has been maintained (most recent estimate: 43,438 km^2);
- IAO has been maintained or increased (most recent estimate: 136 km^2);
- The number of extant subpopulations (currently 37) has been maintained or increased.

8. References

Baskett, C.A., S.M. Emery, and J.A. Rudgers. 2011. Pollinator visits to threatened species are restored following invasive plant removal. International Journal of Plant Sciences 172:411-422.

Bell, T.J., M. Bowles, J. McBride, K. Havens, P. Vitt, and K. McEachern. 2002. Reintroducing Pitcher's Thistle. Endangered Species Bulletin 27(3):14-15.

Bell, T.J., M.L. Bowles, and A.K. McEachern. 2003. Projecting the success of plant population restoration with viability analysis. Pp. 313-348. *In* C.A. Brigham and M.W. Schwartz (eds.). Population viability in plants, Springer-Verlag, Berlin Heidelberg.

Brinker, S.R., M. Garvey, and C.D. Jones. 2018. Climate change vulnerability assessment of species in the Ontario Great Lakes Basin. Ontario Ministry of Natural Resources and Forestry, Science and Research Branch, Peterborough, ON. Climate Change Research Report CCRR-48. 85 p. + append.

CALS (College of Agriculture and Life Sciences). 2022. Biological Control, College of Agriculture and Life Sciences, Cornell University, Ithaca, New York. https://biocontrol.entomology.cornell.edu/weedfeedTOC.php

Chen, H. and M.A. Maun. 1999. Effects of sand burial depth on seed germination and seedling emergence of *Cirsium pitcheri*. Plant Ecology 140:53–60.

CMP (Conservation Measures Partnership). 2016. Conservation actions classification . Webpage: https://conservationstandards.org/library-item/conservation-actions-classification-v1-0/

Coleman, M.J. 2007. The conservation genetics of two endangered plants of Ontario, Canada, *Cirsium pitcheri* and *Isoetes engelmannii*, using nuclear and chloroplast DNA. M.Sc, thesis, Trent University, Peterborough, Ontario, Canada. 82 pp.

COSEWIC. 2010. COSEWIC assessment and status report on the Pitcher's Thistle *Cirsium pitcheri* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa. x + 32 pp.

COSEWIC. 2012. Guidance for completing the threats classification and assessment calculator and determining the number of 'locations'. Version 1.2. Committee on the Status of Endangered Wildlife in Canada, Ottawa. 18 pp + append.

COSEWIC. 2021a. COSEWIC wildlife species assessment: quantitative criteria and guidelines. Committee on the Status of Endangered Wildlife in Canada. Ottawa. https://cosewic.ca/index.php/en-ca/assessment-process/wildlife-species-assessment-process-categories-guidelines/quantitative-criteria

COSEWIC. 2021b. COSEWIC wildlife species assessment: quantitative criteria definitions. Committee on the Status of Endangered Wildlife in Canada. Ottawa. https://cosewic.ca/index.php/en-ca/assessment-process/wildlife-species-assessment-process-categories-guidelines/quantitative-criteria-definitions.html

Dodge, G.J. 2005. Ecological effects of the biocontrol insects, *Larinus planus* and *Rhinocyllus conicus*, on native thistles. PhD dissertation, University of Maryland, U.S.A. 196 pp.

ECCC (Environment and Climate Change Canada). 2019. Threats classification and assessment calculator for Pitcher's Thistle in Canada. Environment and Climate Change Canada, Ottawa. Unpublished Microsoft Excel file.

ECCC (Environment and Climate Change Canada). 2022. Future hydroclimate variables and lake levels for the Great Lakes using data from the coupled model intercomparison project phase 5. Environment and Climate Change Canada, Ottawa. 83 pp.

EDDMapS. 2022. Early Detection & Distribution Mapping System. The University of Georgia - Center for Invasive Species and Ecosystem Health. Available online at http://www.eddmaps.org/ [accessed April 2022].

Emery, S.M., P.J. Doran, J.T. Legge, M. Kleitch, and S. Howard. 2013. Aboveground and belowground impacts following removal of the invasive species baby's breath (*Gypsophila paniculata*) on Lake Michigan sand dunes. Restoration Ecology 21:506-514.

EPPO (European and Mediterranean Plant Protection Organization). 2022. *Diabrotica undecimpunctata howardi*. EPPO datasheets on pests recommended for regulation. EPPO Global Database. https://gd.eppo.int

Fant, J.B., A. Kramer, E. Sirkin, and K. Havens. 2013. Genetics of reintroduced populations of the narrowly endemic thistle, *Cirsium pitcheri* (Asteraceae). Botany 91(5):301-308. https://doi.org/10.1139/cjb-2012-0232

Fant, J.B., K. Havens, J.M. Keller, A. Radosavljevic, and E.D. Yates. 2014. The influence of contemporary and historic landscape features on the genetic structure of the sand dune endemic, *Cirsium pitcheri* (Asteraceae). Heredity 112(5):519–530. https://doi.org/10.1038/hdy.2013.134

Frankham, R., C.J.A. Bradshaw, and B.W. Brook. 2014. Genetics in conservation management: revised recommendations for the 50/500 rules, Red List criteria and population viability analyses. Biological Conservation 170:56-63. https://doi.org/10.1016/j.biocon.2013.12.036

Fuller, K., H. Shear and J. Wittig (eds.). 1995. The Great Lakes- An Environmental Atlas and Resource Book. 3rd edition. United States Environmental Protection Agency and Government of Canada. 46 pp. https://nepis.epa.gov/Exe/ZyPDF.cgi/P1004ICU.PDF?Dockey=P1004ICU.PDF

Gijsman, F., K. Havens, and P. Vitt. 2020. Effect of capitulum position and weevil infestation on seed production of threatened monocarpic perennial, *Cirsium pitcheri.* Global Ecology and Conservation 22. https://doi.org/10.1016/j.gecco.2020.e00945

Gijsman, F. and P. Vitt. 2021. Seed size and capitulum position drive germination and dormancy responses to projected warming for the threatened dune endemic *Cirsium pitcheri* (Asteraceae). Ecology and Evolution 11(2):955–966. https://doi.org/10.1002/ece3.7109

Girdler, E.B. and T.A. Radtke. 2006. Conservation implications of individual scale spatial pattern in the threatened dune thistle, *Cirsium pitcheri*. The American Midland Naturalist 156(2):213-228. https://doi.org/10.1674/0003-0031(2006)156[213:CIOISS]2.0.CO;2

Girdler, E.B., M.P. Davis, and Z.M. Smith. 2016. Dynamics of an invasion: the spatial interactions of invasive *Centaurea stoebe* with native *Cirsium pitcheri* and *Tanacetum huronense* in a dune environment. The American Midland Naturalist 176(1):20-35. https://doi.org/10.1674/0003-0031-176.1.20

Given, D.R. 1994. Principles and practice of plant conservation. Timber Press, Portland, Oregon. 292 pp.

Godefroid, S., S. Le Pajolec, and F. Van Rossum. 2016. Pre-translocation considerations in rare plant reintroductions: implications for designing protocols. Plant Ecology 217:169-182. https://link.springer.com/article/10.1007/s11258-015-0526-0

Hakes, A.S. and Z.D. Meunier. 2018. Nonhost neighborhood increases biocontrol weevil damage to the nontarget, federally threatened Pitcher's thistle (*Cirsium pitcheri*). Global Ecology and Conservation 13:1-11. https://doi.org/10.1016/j.gecco.2018.e00376

Halsey, S.J., T.J. Bell, K. McEachern, and N.B. Pavlovic. 2015. Comparison of reintroduction and enhancement effects on metapopulation viability. Restoration Ecology 23:375-384. https://doi.org/10.1111/rec.12191

Hamzé, S.I. and C.L. Jolls. 2000. Germination ecology of a federally threatened endemic thistle, *Cirsium pitcheri*, of the Great Lakes. The American Midland Naturalist 143(1):141-153. https://www.jstor.org/stable/3082990

Havens, K., C.L. Jolls, J.E. Marik, P. Vitt, A.K. McEachern, and D. Kind. 2012. Effects of a non-native biocontrol weevil, *Larinus planus*, and other emerging threats on populations of the federally threatened Pitcher's Thistle, *Cirsium pitcheri*. Biological Conservation 155:202–211. https://doi.org/10.1016/j.biocon.2012.06.010

Inkster, J.N. 2016. The antagonistic and mutualistic plant-insect interactions of Pitcher's Thistle (*Cirsium pitcheri* [Torr. ex Eat.] Torr. & A. Gray, Asteraceae), a federally threatened Great Lakes dune and cobble shore endemic plant. M.Sc. Thesis, Department of Biology, East Carolina University, U.S.A. 64 pp.

Jolls, C.L., J.N. Inkster, B.G. Scholtens, P. Vitt, and K. Havens. 2019. An endemic plant and the plant-insect visitor network of a dune ecosystem. Global Ecology and Conservation 18 e00603. https://doi.org/10.1016/j.gecco.2019.e00603

Jolls, C.L., J.E. Marik, S.I. Hamzé, and K. Havens. 2015. Population viability analysis and the effects of light availability and litter on populations of *Cirsium pitcheri*, a rare, monocarpic perennial of Great Lakes shorelines. Biological Conservation 187:82-90. https://doi.org/10.1016/j.biocon.2015.04.006

Jones, J. 2020.The Manitoulin Island Phragmites project: control and reduction of Phragmites across the Manitoulin region, Habitat Stewardship Program for Species at Risk Final Report. Winter Spider Eco-Consulting, Manitowaning, Ontario.

Jones, J. 2022. The Manitoulin Phragmites project: control of invasive Phragmites in the habitats of Blanding's Turtle, Monarch butterfly and other SAR in the Manitoulin region, Habitat Stewardship Program for Species at Risk Annual Report. Winter Spider Eco-Consulting, Manitowaning, Ontario.

Katovich, E., R. Beckera, M. Chandler, and M. Marek-Spartz. 2022. Biological control of Canada thistle (*Cirsium arvense*) revisited: host range of *Hadroplontus litura* on *Cirsium* species native to the Upper Midwest, USA. Biocontrol Science and Technology 32(9):1050–1064. https://doi.org/10.1080/09583157.2022.2085245

Keddy, C.J. and P.A. Keddy. 1984. Reproductive biology and habitat of *Cirsium pitcheri*. Michigan Botanist 23(2):57-67.

Lamar, S.K. and C.G. Partridge. 2021. Combining herbarium databases and genetic methods to evaluate the invasion of a popular horticultural species, baby's breath (*Gypsophila paniculata*), in the United States. Biological Invasions 23:37–52. https://doi.org/10.1007/s10530-020-02354-x

Louda, S.M. and C.W. O'Brien. 2002. Unexpected ecological effects of distributing the exotic weevil, *Larinus planus* (F.), for the biological control of Canada Thistle. Conservation Biology 16:717–727.

Louda, S.M., T.A. Rand, A.E. Arnett, A.S. McClay, K. Shea, and A.K. McEachern. 2005. Evaluation of ecological risk to populations of a threatened plant from an invasive biocontrol insect. Ecological Applications 15:234-249.

Loveless, M. D. 1984. Population biology and genetic organization in *Cirsium pitcheri*, an endemic thistle. PhD Thesis, Department of Systematics and Ecology, Kansas University, U.S.A. 109 pp. + append.

Loveless, M.D. and J.L. Hamrick. 1988. Genetic organization and evolutionary history in two North American species of *Cirsium*. Evolution 42(2):254-265.

Marshall, J.M. 2013. Occurrence of *Diabrotica undecimpunctata howardi* Barber (Coleoptera: Chrysomelidae) feeding on *Cirsium pitcheri* flowers. The Great Lakes Entomologist 46:138-141. https://scholar.valpo.edu/tgle/vol46/iss1/11

Maun, M.A. 1997. Restoration ecology of a threatened endemic: *Cirsium pitcheri* along the Great Lakes. Coenoses 12:109-117.

Maun, M.A., H. Elberling, and A. D'Ulisse. 1996. The effects of burial by sand on survival and growth of Pitcher's Thistle along Lake Huron. Journal of Coastal Conservation 2:3-12.

McEachern, A. K., M.L. Bowles, and N.B. Pavlovic. 1994. A metapopulation approach to Pitcher's thistle (*Cirsium pitcheri*) recovery in southern Lake Michigan dunes *in* M. Bowles, C. Whelen (Eds.), Restoration of Endangered Species, Cambridge University Press, Cambridge, Massachusetts, pp. 194-218. https://digitalcommons.unl.edu/usgsstaffpub/239

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 16:1-16 https://doi.org/10.1016/j.gecco.2018.e00445

NatureServe. 2020. Habitat-based plant element occurrence delimitation guidance. NatureServe, Arlington, Virginia. Available: https://www.natureserve.org/sites/default/files/eo_specs-habitat-based_plant_delimitation_guidance_may2020.pdf [accessed May 2022].

NatureServe. 2022. Explorer: An online encyclopedia of life [web application] Arlington, Virginia, USA: NatureServe. Available: http://www.natureserve.org/explorer [accessed June 2022).

NHIC (Natural Heritage Information Centre). 2022. Element occurrence data for Pitcher's Thistle. Natural Heritage Information Centre, Ministry of Natural Resources and Forestry, Peterborough, Ontario

PCA (Parks Canada Agency). 2011. Recovery Strategy for Pitcher's Thistle (*Cirsium pitcheri*) in Canada. Species at Risk Act Recovery Strategy Series. Parks Canada Agency, Ottawa. x + 31 pp. https://wildlife-species.canada.ca/species-risk-registry/virtual_sara/files/plans/rs_pitchers_thistle_0311_e.pdf

PCA (Parks Canada Agency). 2017. Multi-species Action Plan for Pukaskwa National Park of Canada. Species at Risk Act Action Plan Series. Parks Canada Agency, Ottawa. iv + 16 pp. https://wildlife-species.canada.ca/species-risk-registry/virtual_sara/files/plans/Ap-PukaskwaFinale-v00-Apr2017_Eng.pdf

PCA (Parks Canada Agency). 2022. Implementation Report: Multi-species Action Plan for Pukaskwa National Park of Canada (2017 –2022). Species at Risk Act Action Plan Series. Parks Canada Agency, Ottawa. vi+ 16 pp. https://species-registry.canada.ca/index-en.html#/documents/1620

Patterson, L., pers. comm. 2019. Email correspondence to K. Pickett. Ecologist Team Leader, Pukaskwa National Park, Parks Canada Agency, Heron Bay, Ontario.

Phillips, T. and M. A. Maun. 1996. Population ecology of *Cirsium pitcheri* on Lake Huron sand dunes I. Impact of White-tailed Deer. Canadian Journal of Botany 74(9):1439-1444. https://doi.org/10.1139/b96-173

Rand, T.A., S.M. Louda, K.M. Bradley, and K.K. Crider. 2015. Effects of invasive knapweed (*Centaurea stoebe* subsp. *micranthos*) on a threatened native thistle (*Cirsium pitcheri*) vary with environment and life stage. Botany 93:543-558. https://doi.org/10.1139/cjb-2015-0032

Reid, M.L. and S.M. Emery. 2018. Scale-dependent effects of *Gypsophila paniculata* invasion and management on plant and soil nematode community diversity and heterogeneity. Biological Conservation. 224:153-161. https://doi.org/10.1016/j.biocon.2018.05.026

Rice, E.K., H. Leimbach-Maus, C. Partridge, and J.N. McNair. 2020. Assessment of invasive *Gypsophila paniculata* control methods in the northwest Michigan dunes. Invasive Plant Science and Management 13(2):94-101. https://doi.org/10.1017/inp.2020.10

Rowland, J.M. and M.A. Maun. 2001. Restoration ecology of an endangered plant species: establishment of new populations of *Cirsium pitcheri.* Restoration Ecology 9(1):1-11.

Sandacz, D., P. Vitt, T.M. Knight, P. CaraDonna, and K. Havens. 2023. The effects of the decline of a keystone plant species on a dune community plant-pollinator network. Frontiers in Conservation Science 4:1183976. https://doi.org/10.3389/fcosc.2023.1183976

Seglenieks, F. and A. Temgoua. 2022. Future water levels of the Great Lakes under 1.5°C to 3°C warmer climates. Journal of Great Lakes Research 48(4):865-875. https://doi.org/10.1016/j.jglr.2022.05.012

Staehlin, B.M. and J.B. Fant. 2015. Climate change impacts on seedling establishment for a threatened endemic thistle, *Cirsium pitcheri*. The American Midland Naturalist 173(1):47-60. https://doi.org/10.1674/0003-0031-173.1.47

Stanforth, L.M., S.M. Louda, and R.L. Bevill. 1997. Insect herbivory on juveniles of a threatened plant, *Cirsium pitcheri,* in relation to plant size, density and distribution. Ecoscience 4(1):57-66.

Steeves, T.E., J.A. Johnson, and M.L. Hale. 2017. Maximising evolutionary potential in functional proxies for extinct species: a conservation genetic perspective on de-extinction. Functional Ecology 31(5):1032-1040. https://doi.org/10.1111/1365-2435.12843

Vitt, P., K. Havens, C.L. Jolls, and T.M. Knight. 2020. Temporal variation in the roles of exotic and native plant species in plant–pollinator networks. Ecosphere 11(2) e02981. https://doi.org/10.1002/ecs2.2981

Voss, E.G. and A.A. Reznicek. 2012. Field Manual of Michigan Flora. University of Michigan Press, Ann Arbour, Michigan. 990 pp.

Warneke, C.R., P. Vitt, and K. Havens. 2020. Laboratory feeding preferences of three *Larinus* weevil species on a threatened thistle and a co-occurring invasive knapweed: implications for host choice and conservation. The American Midland Naturalist 183(2):164-179. https://doi.org/10.1637/0003-0031-183.2.164

Yurk, B. and E. Hansen. 2021. Effects of wind patterns and changing wind velocities on aeolian drift potential along the Lake Michigan shore. Journal of Great Lakes Research 47(6):1504-1517. https://doi.org/10.1016/j.jglr.2021.09.006

Appendix A: Effects on the Environment and Other Species

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*[17]. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision-making and to evaluate whether the outcomes of a recovery planning document could affect any component of the environment or achievement of any of the Federal Sustainable Development Strategy's[18] (FSDS) goals and targets.

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

Pitcher's Thistle is associated with the most open parts of dune habitats, both on the foredunes and in natural blowouts in backdunes. At least 46 rare or at-risk species are known from dunes on Lake Huron or Lake Superior in Ontario (Jalava *et al.* 2003), and some of these species share beach ridge, foredune, interdunal meadow, and blowout habitat with Pitcher's Thistle and are likely to benefit from similar management activities. However, managing solely for early-successional dune stages could reduce the habitat for some species that require more stabilized backdunes, dune savannahs, or woodlands. The backdune shrubland and savannah communities associated with Great Lakes Dune Grasslands are also globally and provincially rare and support a high number of imperiled species.

The results of ecological modeling and site conservation planning suggest that maintaining a mosaic of dune stages is best for ensuring the long-term survival of the ecosystem (McEachern *et al*.1994). Management and land use planning for dune sites should therefore allow the dynamic dune-building and breakdown processes to occur, yet also incorporate enough landscape to allow natural succession in the inland parts of the dunes, thus maintaining the mosaic of microhabitats.

This management plan seeks to maintain a balance of microhabitats by simply allowing natural processes to occur unimpeded by threats to habitat, such as inappropriate ATV use and trampling from foot traffic. Reducing threats to habitat should benefit all dune species.

[17] www.canada.ca/en/environmental-assessment-agency/programs/strategic-environmental-assessment/cabinet-directive-environmental-assessment-policy-plan-program-proposals.html
[18] www.fsds-sfdd.ca/index.html#/en/goals/

Managing deer and geese populations to limit browse will benefit dune vegetation, but depending on the approach taken, may have direct negative effects on the herbivore population. Currently, deer and geese have high population numbers, so presumably negative impacts from a slight reduction in numbers would be minimal. Discussion with wildlife management staff about how to mitigate the threat of browsing is a recommended approach.

Removal of invasive species, such as European Reed, will benefit surrounding native vegetation and associated native animal and insect species. However, methods to curtail the spread of European Reed have included the use of herbicide and mechanical cutting with machinery, both of which could have potential impacts to dune vegetation. Therefore, assessment will be needed prior to implementing removal to ensure the expected positive outcomes of the removal outweigh the expected negative impacts of not undertaking removal.

Other actions to mitigate threats involve the use of policy or public education and outreach, which are not expected to have any negative impacts to the natural environment or other species. Some examples of species at risk that will benefit from these conservation measures are listed below in Table A-1.

Table A-1. Species at risk that may benefit from conservation measures directed at the Pitcher's Thistle in Ontario.

Common Name	**Scientific Name**	**SARA Status**	**COSEWIC Status**
Aweme Borer	*Papaipema aweme*	Endangered	Data Deficient
Dwarf Hackberry	*Celtis tenuifolia*	Threatened	Threatened
Eastern Hog-nosed Snake	*Heterodon platirhinos*	Threatened	Threatened
Hill's Thistle	*Cirsium hillii*	Threatened	Threatened
Houghton's Goldenrod	*Solidago houghtonii*	Special Concern	Special Concern
Lake Huron Grasshopper	*Trimerotropis huroniana*	Threatened	Threatened
Mottled Duskywing (Great Lakes Plains Population)	*Erynnis martialis*	Not on Schedule 1	Endangered
Northern Barrens Tiger Beetle	*Cicindela patruela*	Endangered	Endangered
Piping Plover *circumcinctus* subspecies	*Charadrius melodus circumcinctus*	Endangered	Endangered

Appendix B: NatureServe Subnational Conservation Ranks for *Cirsium pitcheri* in Canada and the United States

Table B-1. Subnational Conservation Ranks (S-ranks) for *Cirsium pitcheri* in Canada and the United States (source: NatureServe 2022)

Country	Jurisdiction	Subnational Rank
Canada	Ontario	S2
United States	Illinois Indiana Michigan Wisconsin	S1 S1 S3 S2

Rank Definitions

S1: Critically Imperiled - At very high risk of extirpation in the jurisdiction due to very restricted range, very few populations or occurrences, very steep declines, severe threats, or other factors.

S2: Imperiled - At high risk of extirpation in the jurisdiction due to restricted range, few populations or occurrences, steep declines, severe threats, or other factors.

S3: Vulnerable - At moderate risk of extirpation in the jurisdiction due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats or other factors.

Appendix C: Pitcher's Thistle Subpopulations in Canada

Table C-1. List of extant Pitcher's Thistle subpopulations in Canada. Data sources: Jones (2020, 2022), NHIC (2022).

1	Michael's Peninsula*	20	Carroll Wood Bay*
2	Michael's Bay**	21	Fisher Bay**
3	Carter Bay**	22	East of Black Point*
4	Timber Bay	23	Ivan Point*
5	Providence Bay	24	Christina Bay**
6	Dean's Bay*	25	Burnt Island Harbour**
7	Lonely Bay	26	West Belanger Bay**
8	Lougheed's Bay	27	Sand Bay-Doc Hewson Bay, Cockburn Island**
9	Square Bay*	28	Wagosh Bay, Cockburn Island
10	Dominion Bay*	29	Western Shore, Cockburn Island
11	Shrigley Bay*	30	Desert Point, Great Duck Island
12	Portage Bay-Gallagher Beach*	31	Horseshoe Bay, Great Duck Island
13	Taskerville West**	32	Western Duck Island
14	Kenewallyn-Murphy Harbour	33	Inverhuron Provincial Park**
15	Burpee Beach	34	Pinery Provincial Park*
16	Misery Bay East**	35	Port Franks**
17	Misery Bay Centre	36	Hattie Cove, Pukaskwa National Park**
18	Misery Bay West	37	Oiseau Bay, Pukaskwa National Park**
19	Sand Bay*		

*Subpopulations for which there were sufficient data to estimate extinction probabilities by Nantel et al. (2018). Of these, subpopulations assessed has having a greater than 5% probability of extirpation over the next 100 years are identified by double stars (**).

Table C-2. List of historical and extirpated Pitcher's Thistle subpopulations in Canada. Data source: NHIC (2022).

Subpopulation	**Status**
Walkhouse Point, Manitoulin Island	Historical (last observed 1994)
Sauble Beach	Extirpated
South of Grand Bend	Extirpated
Kettle Point	Extirpated