COSEWIC
Assessment and Status Report

on the

Deerberry
Vaccinium stamineum

in Canada

THREATENED
2020

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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White, D.J., and M.J. Oldham. 2000. Update COSEWIC status report on the deerberry *Vaccinium stamineum* in Canada, *in* COSEWIC assessment and update status report on the deerberry *Vaccinium stamineum* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 1-10 pp.

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COSEWIC would like to acknowledge Holly Bickerton for writing the status report on Deerberry, *Vaccinium stamineum*, in Canada, prepared under contract with Environment and Climate Change Canada. This report was overseen and edited by Jana Vamosi, Co-chair of the COSEWIC Vascular Plants Specialist Subcommittee.

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Deerberry — Photo credit: H. Bickerton.

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COSEWIC
Assessment Summary

Assessment Summary – November 2020

Common name
Deerberry

Scientific name
Vaccinium stamineum

Status
Threatened

Reason for designation
This long-lived shrub is found in Canada only in the Niagara and Thousand Islands regions of Ontario, at the northern edge of its range. Restoration and management efforts have resulted in a new subpopulation at Thousand Islands National Park. Other remaining subpopulations are currently threatened by shading (caused by fire suppression) and browsing by White-tailed Deer. One subpopulation is currently very small and not expected to persist. While meeting criteria for Endangered, this species was designated Threatened because four of the five extant subpopulations are protected through conservation ownership and management actions in recent years that have benefited the species. The long-term persistence of this species depends on continued conservation efforts.

Occurrence
Ontario

Status history
Designated Threatened in April 1994. Status re-examined and confirmed in November 2000 and November 2020.

COSEWIC
Executive Summary

Deerberry
Vaccinium stamineum

Wildlife Species Description and Significance

Deerberry (*Vaccinium stamineum*) is a perennial shrub in the Ericaceae family. In Ontario, it flowers in late May and June, with clusters of bell-shaped, white flowers. Both the leaves and fleshy fruits provide food for wildlife. Despite considerable variation in stem and leaf morphology range-wide, there are no infraspecific taxa recognized for Deerberry.

Distribution

Deerberry reaches its northern range edge in Canada, where it is found only in the moderate climates of the Niagara and Thousand Islands regions. The species' distribution ranges from Texas, Louisiana and Florida in the south to New York, Vermont and Ontario in the north. In the core of its American range, Deerberry is a common understory species of dry woodland associations.

Habitat

Across its range, Deerberry is most frequently found in dry to mesic open forests and woodlands. It is often found in association with oak and pine. In Ontario, Deerberry occurs in dry woods and on shorelines, on both limestone and granitic substrates. Habitat at some extant sites was previously open woodland but is now less favourable closed forest, with canopy cover exceeding 70%.

Biology

Deerberry reproduces clonally and by seed. The average lifespan of a genetic individual is not known and is difficult to estimate. Individuals of other clonal *Vaccinium* can reach hundreds of years in age. Generation time is estimated at 52 years for COSEWIC purposes using the IUCN guidelines. Flowers are buzz-pollinated by bees and are self-incompatible. The fruits are dispersed by birds and mammals. Often found in association with seral species, Deerberry tolerates and even benefits from fire. It is thought to have a mutualistic association with soil mycorrhizae.

Population Sizes and Trends

There are five extant subpopulations in Canada. Four of these are naturally occurring and one is the result of a successful intralimital introduction that has persisted for nine years and is now flowering and spreading clonally. Six or seven subpopulations, all in the Niagara Region, are extirpated. In total, 3743 stems were present at five extant sites in 2018. The Niagara subpopulation is most precarious, with only 6 stems. Trends at other subpopulations are uncertain because of changes in survey methods, but overall abundance is probably stable to increasing. Habitat quality may be declining at two sites due to shading. The most significant change since the previous assessment is the successful addition of a new subpopulation due to recovery efforts at Thousand Islands National Park (TINP). Four other introduction sites persist but are not yet self-sustaining. Overall, the Canadian population is probably stable to increasing slightly, mostly due to restoration and management efforts.

Threats and Limiting Factors

The suppression of natural wildfire is a threat to Deerberry in Canada. At least two Deerberry subpopulations are threatened by the increased shading resulting from past fire suppression. Browsing by White-tailed Deer and competition from invasive non-native species could further threaten Deerberry. The associations that Deerberry has with soil mycorrhizae and pollinators capable of buzz-pollination are considered limiting factors.

Protection, Status and Ranks

Deerberry has a Global NatureServe conservation rank of G5 (Secure). It is ranked N5 (Secure) in the United States, N1 (Critically Imperilled) in Canada, and S1 in Ontario. Of the 20 American states where it occurs, Deerberry is legally protected in Illinois and Vermont. It is listed as Threatened under the Ontario *Endangered Species Act* and the Canadian *Species at Risk Act*. Three Canadian subpopulations are managed by Parks Canada, one is managed by the Niagara Parks Commission, and a fifth is on private land.

TECHNICAL SUMMARY

Vaccinium stamineum

Deerberry

Airelle à longues étamines

Range of occurrence in Canada: Ontario

Demographic Information

Generation time (usually average age of parents in the population; see IUCN guidelines (2017, p. 27, Method 3)	~50 years Based on IUCN methods (see **Biology – Life Cycle and Reproduction**).
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Yes 6-7 subpopulations of unknown size have been extirpated, and one subpopulation has been introduced. The small Niagara subpopulation is likely declining, but the TINP subpopulations appear currently stable, despite ongoing threats.
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown Five subpopulations have been lost but the estimated percent of continuing decline is not known.
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Yes, inferred Six or seven subpopulations have been lost in 3 generations (~150 years). A reduction of an unknown amount can be inferred.
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	a. Yes, partially b. Yes, partially c. No
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	231 km²
Index of area of occupancy (IAO)	24 km²
Is the population “severely fragmented” i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No (but see **Population Spatial Structure and Variability**) b. No

Number of “locations”* (use plausible range to reflect uncertainty if appropriate)	5
Is there an [observed, inferred, or projected] decline in extent of occurrence?	Yes The EOO of all known natural subpopulations, not including introduced extant site = 1337 km² (83% decline). These declines are largely historical and incorporate the addition of a new subpopulation resulting from recovery efforts. Some continuing declines are projected from shading brought on by fire suppression.
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Yes The IAO of all known natural subpopulations, not including introduced extant site = 156 km² (85% decline). These declines are largely historical and incorporate the addition of a new subpopulation resulting from recovery efforts. Some continuing declines are projected from shading brought on by fire suppression.
Is there an [observed, inferred, or projected] decline in number of subpopulations?	Yes, observed and projected
Is there an [observed, inferred, or projected] decline in number of “locations”*?	Yes, observed and projected
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes, observed and projected Observations suggest that habitat quality is declining due to shading (resulting from fire suppression), and overabundance of native and non-native species.
Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of “locations”*?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

* See Definitions and Abbreviations on COSEWIC web site and IUCN (March 2017) for more information on this term

Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	N Mature Individuals*
Whirlpool Gorge	6 stems
Grenadier Island (West), TINP	1335 stems
Endymion Island, TINP	1051 stems
Deathdealer Island	736 stems
Georgina Island West, TINP (cultivated origin)	651 stems
Total	**3743 stems**
*Mature individuals are approximated by stem count, as stems represent the smallest reproducing units within a clone (IUCN 2017).	

Population Sizes and Trends.

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations, or 10% within 100 years]?	Unknown, PVA not available.

Threats (High-Low; direct, from highest impact to least, as per IUCN Threats Calculator)

- Fire and Fire Suppression (7.1) – High-Low
- Problematic Native Species (8.2) – White-tailed Deer – Medium-Low

Invasive Non-native Species (8.1) – Low

Was a threats calculator completed for this species? Yes.

What additional limiting factors are relevant?
Reliance on buzz-pollination may be or become limiting in light of widespread pollinator decline in southeastern Canada.
Deerberry probably requires mycorrhizal associates; it is unknown if this limits suitable habitat.

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	New York State, S5
Is immigration known or possible?	Possible
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Probably
Are conditions deteriorating in Canada?[+]	Yes Habitat quality generally is deteriorating, as fires are suppressed and increasing areas of southern Ontario are becoming less suitable. High deer abundance and invasive shrubs are likely also significant in reducing conditions for the species' establishment and persistence in currently unoccupied potential habitat.

[+] See Table 3 (Guidelines for modifying status assessment based on rescue effect)

Are conditions for the source (i.e., outside) population deteriorating?	Unknown. Overall threats to habitat condition are probably similar, but declines have not been reported. This species remains widespread.
Is the Canadian population considered to be a sink?	No
Is rescue from outside populations likely?	No Considered unlikely due to low frequency of Deerberry in the areas immediately bordering regions, and decreasing habitat suitability due to invasive species and fire suppression

Data Sensitive Species

Is this a data sensitive species?	No

Status History

COSEWIC Status History: Designated Threatened in April 1994. Status re-examined and confirmed in November 2000 and November 2020.

Status and Reasons for Designation:

Status:	**Alpha-numeric codes:**
Threatened	Meets Endangered, B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v), but designated Threatened, B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v), because the species is not at risk of imminent extirpation.

Reasons for designation:
This long-lived shrub is found in Canada only in the Niagara and Thousand Islands regions of Ontario, at the northern edge of its range. Restoration and management efforts have resulted in a new subpopulation at Thousand Islands National Park. Other remaining subpopulations are currently threatened by shading (caused by fire suppression) and browsing by White-tailed Deer. One subpopulation is currently very small and not expected to persist. While meeting criteria for Endangered, this species was designated Threatened because four of the five extant subpopulations are protected through conservation ownership and management actions in recent years that have benefited the species. The long-term persistence of this species depends on continued conservation efforts.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. Although some loss of individuals can be inferred with the loss of subpopulations, there are too few data to produce an estimate of the magnitude of this decline.
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Endangered, B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v), with small EOO and IAO, only 5 locations, and continued declines observed and projected in EOO, IAO, number of locations, habitat quality, and numbers of mature individuals.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Species has fewer than 10,000 mature individuals and projected declines. However, there is uncertainty in the degree to which reintroductions may offset projected declines.

Criterion D (Very Small or Restricted Population): Not applicable. The total number of individuals and IAO exceeds thresholds. Although there are only 5 remaining locations, this species is not considered at risk of extinction within a very short period of time.
Criterion E (Quantitative Analysis): Not done.

PREFACE

Deerberry (*Vaccinium stamineum*) was first assessed as Threatened in 1994 due to loss of several historical subpopulations and low numbers of plants in some subpopulations, combined with low recruitment (Ford 1994). Since the most recent COSEWIC assessment of Deerberry in 2000, no new native subpopulations have been discovered. However, one new, self-sustaining intralimital subpopulation has been created at Thousand Islands National Park (TINP) as a result of restoration efforts. Therefore, the number of extant subpopulations in Canada is five. Other efforts to create or augment subpopulations have been unsuccessful to date. In total, six or seven subpopulations are believed to be extirpated.

COSEWIC HISTORY

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

COSEWIC MANDATE

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

COSEWIC MEMBERSHIP

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

DEFINITIONS (2020)

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

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

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

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

Environment and Climate Change Canada
Canadian Wildlife Service
Environnement et Changement climatique Canada
Service canadien de la faune
Canada

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

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Scientific Name: *Vaccinium stamineum* L.
Common Names: Deerberry, Airelle à longues étamines
Family Name: Ericaceae (heath family)
Major Plant Group: Angiosperm (eudicot flowering plant)

Throughout its range, Deerberry shows variability in many characters, and there has been much debate around the number of recognized taxa (Ford 1995). Vander Kloet's monograph on *Vaccinium* in North America (1988) and subsequent treatment in Flora of North America (2009) recognize one species with no infraspecific taxa. In Flora of the Southeast, Weakley (2015) recognizes six varieties of the species, but all Canadian records are var. *stamineum*.

Morphological Description

Deerberry is a low shrub in the Ericaceae family. It is upright and spreading, with shrubs growing up to 1 m tall. The plants frequently occur in small or extensive colonies (Vander Kloet 2009). The bell-shaped white to greenish-white flowers bloom in late May and early June in Ontario. Flowers are pendent on long stalks, and are arranged in clusters (cover figure). Mature fruits are blue and contain several seeds (Ford 1994). Deerberry is conspicuous in flower and in fruit, but vegetative plants can be overlooked or mistaken for other ericaceous shrubs, especially Pale Blueberry (*Vaccinium pallidum*), which can grow with Deerberry in Ontario.

Population Spatial Structure and Variability

Deerberry subpopulations across Eastern North America have been observed to harbour substantial genetic variation. A study of 445 individuals sampled from 21 subpopulations from Georgia to Ontario (all from distinct patches) revealed high levels of polymorphism at 36 Inter-Simple Sequence Repeat (ISSR) loci, with the proportion of loci polymorphic ranging between 0.39 and 0.69 (mean ± SE = 0.58 ± 0.01) (Yakimowski and Eckert 2008). Expected heterozygosity at the 21 subpopulations was estimated to be between 0.15 and 0.22 (mean ± SE = 0.18 ± 0.01). Genetic substructure between subpopulations was significant and made up 11% of the total genetic variation. Somewhat surprisingly, genetic diversity within subpopulations did not significantly decrease toward the northern margin of the species' distribution, nor did genetic differentiation between subpopulations significantly increase toward northern margins, suggesting that the highly clonal nature of this species at the northern range limit in Canada is not resulting in the Canadian population having severely low levels of genetic diversity.

Designatable Units

The Canadian population of Deerberry comprises a single designatable unit within the Great Lakes Plains Ecological Area (COSEWIC 2018).

Although the two regions occupied by Deerberry in Canada appear disjunct, they are both contiguous with the New York range to the south and are considered to represent range margins rather than distinct DUs. There is no genetic or morphological evidence, or evidence of differentiation by habitat, to support segregating the subpopulations of this taxon into distinct DUs (Yakimowski and Eckert 2008). There are documented records in the New York counties bordering Canadian subpopulations (BONAP 2014; NY Flora Atlas 2019).

Special Significance

Deerberry fruits are a food source for wildlife and have been used in the southern Appalachians for preserves. The plant has been considered for horticultural potential but is infrequently cultivated in the United States.

DISTRIBUTION

Global Range

Deerberry is known from the eastern United States and southern Canada (Figure 1). It ranges from Texas, Louisiana, and Florida in the south to New York, Vermont, and Ontario in the north.

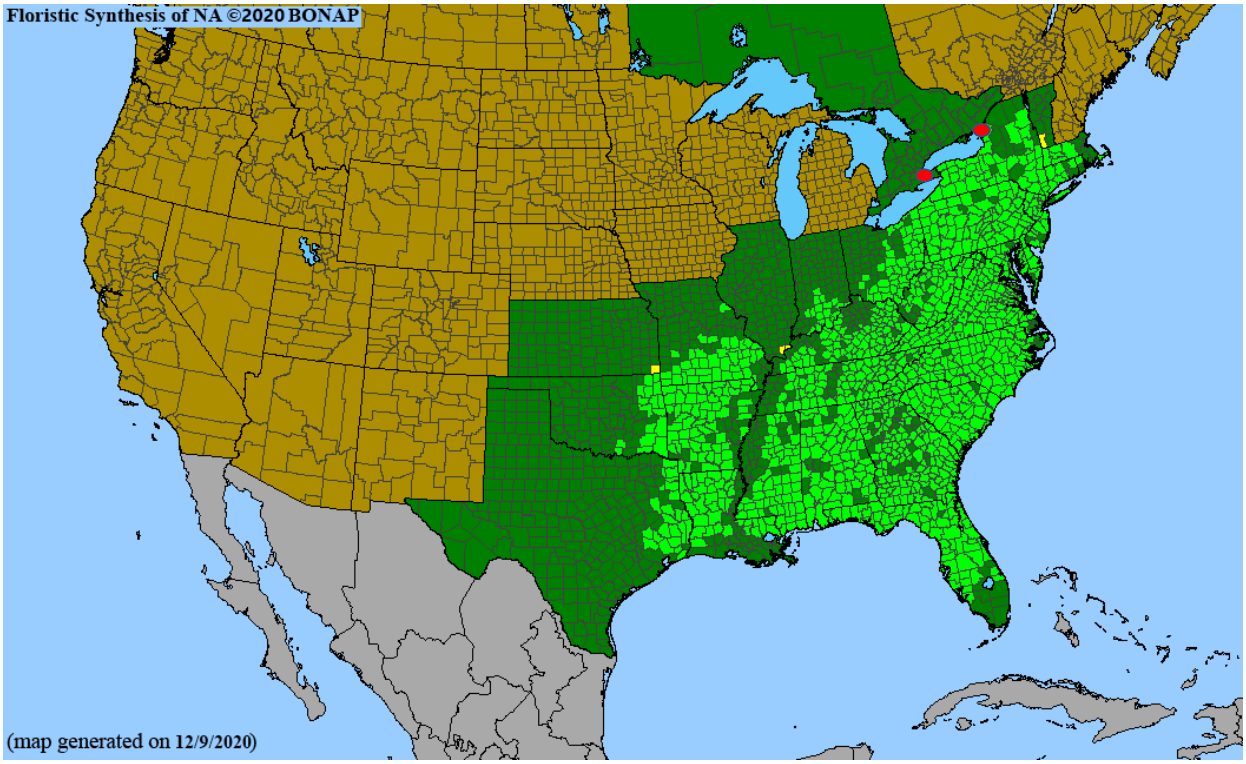

Figure 1 Distribution of Deerberry north of Mexico. Source: Biota of North America Project (BONAP, Kartesz 2020). Dark green indicates presence of the species in that state or province (but note that the resolution is at the county level for the US but at the provincial level for Canada). Light green indicates occupied US counties where the species is not rare for the state. Yellow indicates counties in which Deerberry is rare for the state. Approximate location of Canadian subpopulations shown with red dots. Tan and grey indicate areas where Deerberry has never been recorded.

Canadian Range

Canadian subpopulations represent the northern margins of this species' global range. Prior to 1994, 10-11 subpopulations were present in Canada. Currently, Deerberry occurs in Canada near the Niagara River (one extant subpopulation) and in the Thousand Islands area of the St. Lawrence River (four extant subpopulations, including one successful introduction within the species' occupied range, Figure 2, Tables 1 and 2, Appendix 1).

The only extant Niagara subpopulation occurs in the City of Niagara Falls near the Whirlpool Gorge lookout, and is managed by the Niagara Parks Commission (NPC). Three extant subpopulations are found on islands managed by Thousand Islands National Park (TINP; formerly known as St. Lawrence Islands National Park). One of the island subpopulations in TINP is a result of a successful introduction. A fifth extant subpopulation occurs on a privately owned island in the Thousand Islands. Subpopulations are defined by a distance of at least 1 km of unsuitable habitat (NatureServe 2014).

Six or seven subpopulations are considered extirpated, all in the Niagara Region (see explanation following). Guidelines for the identification of extirpated sites follow NatureServe (Hammerson *et al*. 2008). The Mewburn Road subpopulation was first reported in 1985 (Meyers 1985). The single clump (1 m^2, Ford 1994) along the Bruce Trail near Mewburn Road has not been observed there since 1992 despite search effort by Melinda Thompson in 2001 (Thompson pers. comm. 2019), and six person-hours surveying for this report (see **Sampling Effort**). Significant trail widening and soil compaction have been caused by the use of mountain bikes in this area, with large areas now consisting of compacted bare soil. Given that the single clump was thought to be threatened by trail construction over three decades ago (Meyers 1985) and has not been observed since despite search effort, it is believed to be extirpated.

The Brown's Point site is also considered extirpated (COSEWIC 2000; NHIC 2018). The site was considered extant by Meyer (1985), but despite targeted searches by Bruce Ford (1994) and a thorough inventory of the area by Mike Oldham (1995), Deerberry has not been reported. The report writer visited the site in 2018 and found the habitat deeply shaded.

The extirpation of the St. David's Gorge site was documented by Meyers (1985). Meyers also considered the Queenston site (south of the power plant) extirpated by habitat conversion. This area was thoroughly inventoried by Steve Varga in 1989 and the species was not rediscovered.

Locality details are vague for the remaining three records (Queenston Heights, Niagara-on-the-Lake, Niagara Falls), which have not been seen in half a century or more. The latter two are known only from specimens. It is possible that the Niagara Falls record represents the Whirlpool Gorge site above, or it may be an additional occurrence that no longer exists, but there is too little locality information to make sound conclusions. Because the Niagara Falls record is imprecise, it has not been mapped in Figure 2, and is not included in any IAO/EOO calculations. Because so little is known about this record, the number of extirpated subpopulations is considered to be either 6 or 7.

No documented evidence (i.e., no validated specimen) could be found for a Middlesex County report that was mapped in Soper and Heimberger (1982, see **Collections Examined**). It is assumed to be based on a misidentification (Oldham pers. comm. 2018; Van Hemessen pers. comm. 2018; Waldron pers. comm. 2018).

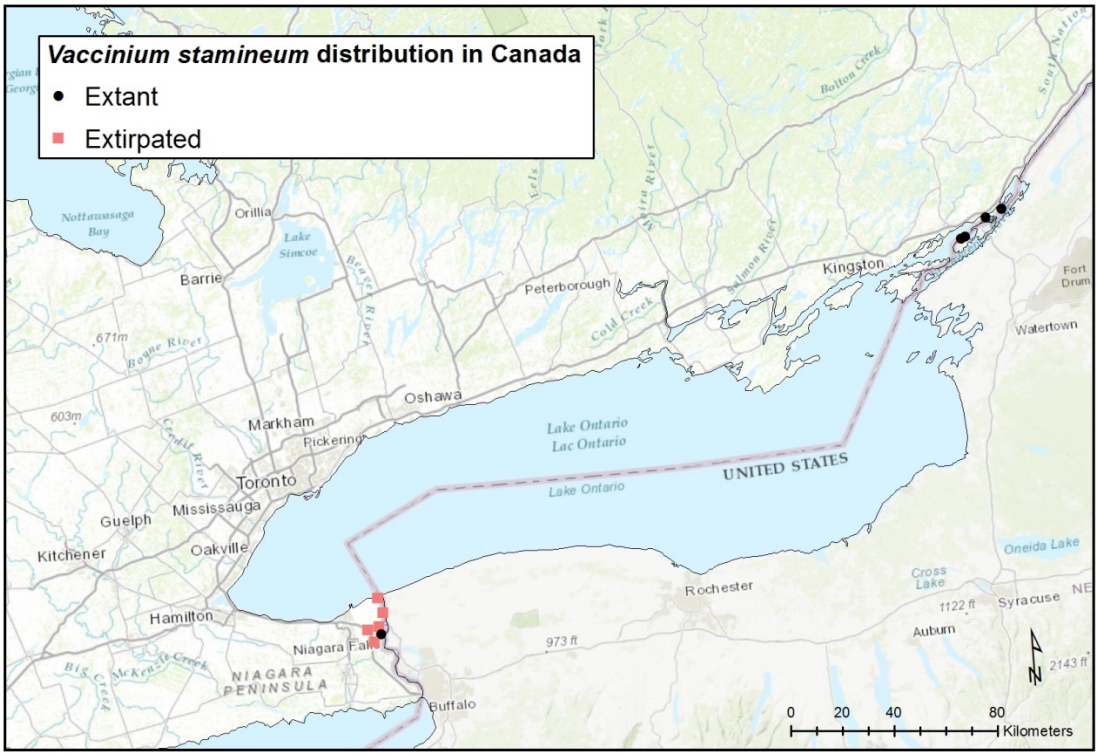

Figure 2. Distribution of Deerberry subpopulations (extant and extirpated) in Ontario, Canada.

Table 1. Location and status of known naturally occurring subpopulations of Deerberry in Canada. Detailed information including ownership and number of mature individuals is found in Appendix 1. A fifth extant subpopulation (Georgina Island West) is not included because it was recently planted. Sources: Meyers (1985), Ford (1994), COSEWIC (2000), NHIC (2018) and Bickerton (pers. obs.).

Subpopulation	County	First Obs	Last Obs	Current status
Whirlpool Gorge, Niagara Falls	Niagara Region	1884	2018	Extant
Grenadier Island (West)	Leeds and Grenville	1886	2018	Extant
Endymion Island	Leeds and Grenville	1992	2018	Extant
Deathdealer Island	Leeds and Grenville	1992	2018	Extant
Bruce Trail near Mewburn Road	Niagara Region	1985	1992	Extirpated
Brown's Point	Niagara Region	1985	1985	Extirpated
St. David's Gorge	Niagara Region	1886	1964	Extirpated
Queenston, S. of power plant	Niagara Region	1901	1960s	Extirpated
Queenston Heights	Niagara Region	1893	1953	Extirpated

Subpopulation	County	First Obs	Last Obs	Current status
Niagara-on-the-Lake	Niagara Region	1891	1898	Extirpated
Niagara Falls	Niagara Region	1896	1896	Extirpated, may not represent an additional subpopulation

Planted Subpopulations

Over the past two decades, staff at TINP have planted Deerberry at several sites. All plantings of Deerberry known in Canada were cultivated from seed sourced from *in situ* wild plants from West Grenadier Island by TINP and Queen's University staff, and planted as young seedlings (National Deerberry Recovery Team 2010; Van Wieren pers. comm. 2018, Lewis pers. comm. 2019). Of these, individuals in five sites persisted in 2018 (Table 2; for additional information see National Deerberry Recovery Team 2010).

An unknown number of seedlings was planted to augment the West Grenadier Island subpopulation in 1994. In the same year, seedlings were introduced to a new site on Lyndoch Island, where habitat was thought to be suitable. In 2001 and 2005, several hundred Deerberry plants were introduced to a site at Mallorytown Landing; at around the same time, plants were introduced on Hill Island (also in TINP). In 2010 following genetic studies by Dr. Chris Eckert and Sarah Yakimowski of Queen's University, 18 TINP seedlings (cultivated from seeds from West Grenadier Island) were planted at Whirlpool Gorge. These seedlings were planted approximately 100 m from the naturally occurring subpopulation and away from the escarpment edge, and were intended to augment the small subpopulation. Most recently, Deerberry from wild collected seed from West Grenadier Island plants were introduced to Georgina, Thwartway, and Camelot islands between 2009 and 2015 (Table 2), where no native Deerberry has previously been documented. All of these Deerberry plantings have not yet been observed in flower or fruit and do not appear to be spreading clonally; therefore, they cannot be said to be self-sustaining.

The exception is the Georgina Island West subpopulation. Here, Deerberry seedlings were planted in full sun directly into burned mineral soil following a prescribed burn in 2009 (Lewis pers. comm. 2018). Plants flowered within 3-5 years (Van Wieren pers. comm. 2018). By 2018, plants had grown into dense clonal patches and were flowering abundantly (Figure 3).

The introduction of Deerberry plants to Georgina Island can be considered successful, and by COSEWIC and IUCN guidelines, the Georgina Island West site qualifies for inclusion in this assessment (COSEWIC 2010; IUCN 2017). The subpopulation is an intralimital introduction (i.e., within Deerberry's known occupied range) that has persisted for more than five years since planting. It is sexually and asexually reproductive, capable of producing viable offspring (whether via clones or seeds). This subpopulation meets COSEWIC guidelines on manipulated populations in that it contributes to a net positive

impact on the species demonstrated by an increased population growth rate (COSEWIC 2010). Therefore, this subpopulation is included in all EOO, IAO, and mature individual calculations for Deerberry and brings the number of extant subpopulations to five.

Figure 3 Portion of successfully introduced subpopulation on a south-facing open shoreline on Georgina Island (West), June 2018. Note abundant white flowers at lower left and lower centre-right. Photo: H. Bickerton.

Table 2. Location and status of planted Deerberry sites in Canada.

Site	Manager	Planting year(s)	Current status
Whirlpool Gorge, Niagara Falls	NPC	2010	Extant, non-reproductive* in 2015 and 2018
Lyndoch Island	TINP	1994	Extant, non-reproductive in 2018
Hill Island	TINP	2000-2002	Dead since 2006 due to heavy deer browse
Mallorytown Landing	TINP	2001, 2005	Extant, non-reproductive in 2018
Thwartway Island	TINP	2012	Extant, non-reproductive in 2018
Georgina Island West – fire	TINP	2009	Extant, **reproductive in 2018**
Georgina Island East – no fire	TINP	2012	Extant, non-reproductive in 2018
Camelot Island	TINP	2015	Dead

*Non-reproductive means no evidence of either flowering or vegetative spread was observed.

Extent of Occurrence and Area of Occupancy

The extent of occurrence (EOO) for the 11 extant and extirpated native subpopulations of Deerberry in Canada (Table 1) is 1337 km^2, calculated using a minimum convex polygon. This is intended to be a snapshot of naturally occurring subpopulations. It does not include the successfully introduced and intralimital subpopulation on Georgina Island or the vague 1892 record from Niagara Falls. The current extent of occurrence (EOO) for the five extant subpopulations (including four native subpopulations and the new Georgina Island subpopulation) is 231 km^2. The change in the two calculated EOOs (original and current) represents a decline of 83% in the EOO in Canada within 3 generations. This is largely due to the loss of all but one subpopulation in the Niagara area. Despite the establishment and inclusion of a new subpopulation within the known range, declines in EOO remain large.

The original index of area of occupancy (IAO) for all known native subpopulations is 156 km^2, calculated using 2x2 km grid squares. The current IAO of the five extant subpopulations (including the established Georgina Island subpopulation) is 24 km^2 (Appendix 2). This represents a decline of 85% in the IAO in Canada within three generations.

Search Effort

In 2018, targeted surveys were completed at all four extant subpopulations, all introduced sites, and in two areas thought to represent the habitat of extirpated subpopulations (Mewburn Road and Brown's Point). For further information on 2018 surveys, see **Sampling Effort** below. Targeted censuses of Canadian Deerberry population were also completed in preparation for COSEWIC status reports by Bruce Ford in 1992 (Ford 1994) and by Mike Oldham in 2000 (COSEWIC 2000).

Since the 1990s, staff at TINP have annually monitored selected Deerberry stands for reproductive status and health. In 2010 and 2011, Brent Lewis and staff at TINP explored additional suitable habitat on West Grenadier and other park islands and no new subpopulations were found (Lewis pers. comm. 2019). In 2015, plants at the Niagara Whirlpool Gorge and Grenadier Island were monitored by Holly Bickerton and James Pagé with the Canadian Wildlife Federation (Bickerton and Pagé 2016).

General botanical surveys have occurred within the Deerberry range over many decades. The species was first collected in the Niagara area in 1798 (Ford 1995) and Deerberry has been sought after by local botanists (Meyers 1985). There is a long history of botanical exploration in Niagara (see Oldham 2010). Remnant sites in the Niagara area have been most recently surveyed by botanists including George Meyers (Meyers 1985), Steve Varga (Varga and Kor 1993), Mike Oldham and Natural Heritage Information Centre (NHIC) staff (Oldham 2010), Albert Garofalo, and Paul O'Hara (pers. comm. 2018).

In the Thousand Islands area, Deerberry was first collected on Wellesley Island (USA) by Macoun in 1876 (Brownell 1984; Ford 1995). Within the Thousand Islands National Park, general botanical survey has been undertaken over many decades, by botanists from

Agriculture Canada, the Canadian Museum of Nature, and Queen's University, and by park staff (Sutherland pers. comm. 2018). However, there has been very limited surveying on the numerous privately owned islands in the area. Additional Deerberry subpopulations may occur in the region, but remain undetected and undocumented.

HABITAT

Habitat Requirements

Across its range, Deerberry is most frequently found in dry to mesic open forests and woodlands, often in association with oak and pine (Hill 2002; NatureServe 2018). It has been reported as occurring "occasionally in moist upland peat" in New England (Wherry 1920).

In Ontario, Deerberry occurs in dry woods and on shorelines (Soper and Heimburger 1982; Ford 1994; COSEWIC 2000). It grows on both granitic-gneiss substrates in the Thousand Islands and on limestone soils of the Niagara Escarpment. Soils tend to be sandy with low organic content. In the Thousand Islands, the soil pH was acidic, ranging from 3.4-5.9. Soil depth was found to range from 0-61 cm (Ford 1994).

The Whirlpool Gorge site in Niagara Falls is found in Dry-Fresh Oak-Hardwood Deciduous Forest (ELC code FOD 1-4, Lynch unpublished data). The site now has >70% canopy cover with a mid-storey of Sugar Maple (*Acer saccharum*) and is more shaded than described in previous reports. This site is considered by some to be a remnant Black Oak savannah (National Deerberry Recovery Team 2010; Lindblad pers. comm. 2018).

Plants on the Grenadier Island site occur in open, rocky, mixed woods of 40-70% cover and in associated canopy gaps. The soil is thin, and the site is considered to be Pitch Pine Acidic Treed Rock Barren (RBT 3-1, National Deerberry Recovery Team 2010, Figure 4). On Endymion Island, all plants are found in rocky deciduous forest (cover >70%) dominated by Red Oak (*Quercus rubra*) and Shagbark Hickory (*Carya ovata*). On Deathdealer Island, Deerberry is found on an open granite shoreline with minimal soil cover, and plants occur in full sun with a southern exposure. At the newly established subpopulation on Georgina Island, plants are growing on an exposed, rocky, south-facing shoreline in full sun, with associated species such as Pitch Pine (*Pinus rigida*) and Pale Blueberry (*Vaccinium pallidum*).

Figure 4. Deerberry plants in canopy gap on Grenadier Island, June 2018.

All extant Canadian subpopulations are found near the moderating influence of the Niagara River or the St. Lawrence River.

Deerberry is often associated with burned sites and with known fire-tolerant species. For example, it is common in sandy and rocky areas of New Jersey and Pennsylvania where fires are frequent (Crowder 1982).

Habitat Trends

The steepest decline in habitat availability has occurred in the Niagara Region, which has been intensively developed for agriculture and urban growth. At least six, and possibly seven subpopulations (see Table 1), in Niagara Region are now extirpated.

Habitat quality and suitability for Deerberry has also generally declined across the Canadian range due to suppression of wildfire. Specifically, forest succession has led to shading of plants at Whirlpool Gorge and Endymion Island. Previous site descriptions and surveys describe the Whirlpool Gorge site in particular as an open woodland (Lindblad, pers. comm. 2018). Deerberry continues to persist at these sites, but flowering is either low or absent and many stems are likely senescent. Suppression of wildfire even in fire-prone or fire-dependent ecosystems has been widespread across southern Ontario for over a century, and suitable habitat for Deerberry has almost certainly declined as a result.

Habitat quality throughout the Thousand Islands and Niagara areas is also declining due to invasive, non-native species. At Whirlpool Gorge and on Endymion Island, invasive woody plants (i.e., Common Buckthorn (*Rhamnus cathartica*)) are threatening Deerberry. For the moment, non-native species have been successfully controlled by land managers and habitat quality has been restored (see **Threats and Limiting Factors**). However, these invasive species or others may reinvade, due to the abundance of propagules in southern Ontario and their frequent spread by wildlife.

BIOLOGY

Life Cycle and Reproduction

Deerberry is a perennial shrub that reproduces sexually and asexually. Deerberry mostly spreads clonally via rhizomes, sending multiple stems (ramets) above ground from adventitious buds. In this way, a genetic individual (genet) could theoretically reproduce indefinitely (de Witte and Stöcklin 2010). Deerberry plants are probably long-lived: individual plants in other species of *Vaccinium* have been estimated in the thousands of years (de Witte and Stöcklin 2010).

Successful sexual reproduction in Deerberry is less frequent. Yakimowski and Eckert (2007) found low flower production and seed set range-wide, with 46% of populations failing to produce seed. Seed set also varied widely in the two years of the study (Yakimowski and Eckert 2008). Seed set may also be limited by the fact that Deerberry, like other *Vaccinium* species, is probably self-incompatible (Vander Kloet 1988; Fröborg 1996). The number of seeds per berry ranges from 1 to 17 (Yakimowski and Eckert 2007). Nonetheless, genetic research also suggests that regular establishment from seed has occurred in most of these long-lived populations, at least in the past.

Bees are the most important pollinators of Deerberry flowers. Flowers are buzz-pollinated, a technique in which some types of bees vibrate a flower's anthers, efficiently releasing pollen. A study in central New York state concluded that Cranberry Oil Bee (*Melitta americana)* is Deerberry's primary pollinator, but this species is rarely observed in Canada (Cane *et al*. 1985; Payette 2013).

Information on the longevity of seeds in soil is not available, but seeds probably survive for at least a few years. Long-term experiments on 28 temperate species of *Vaccinium* showed an average seed longevity of 8.65 years, with seeds of five species surviving in soil for at least 15 years (Hill and Vander Kloet 2005).

Seedling recruitment in the wild appears to be infrequent and opportunistic. Seedlings are rarely observed in this species (Ford 1995; Kreher *et al*. 2000; Yakimowski and Eckert 2007). Seedling emergence may require small soil disturbances combined with high moisture levels and organic soil content (Eriksson and Fröborg 1996).

Deerberry's ability to reproduce both sexually and asexually has implications in determining the number of genetically distinct individuals. Patches may consist of many densely packed stems, with no way to distinguish the number of genetic individuals in the field. Fortunately, genetic work provides some insight. If vegetative spread were Deerberry's exclusive means of local spread, the proportion of distinguishable genets (PD) within a patch would be very low. However, Deerberry, like some other *Vaccinium* species, shows considerably higher genetic diversity at the patch level (Persson and Gustavsson 2001). This suggests that although seedling recruitment is infrequently observed, sexual reproduction may play a significant role in clonal *Vaccinium* populations (Persson and Gustavsson 2001). Studying 21 Deerberry sites range-wide, Yakimowski and Eckert (2008) found that out of every 100 stems, 58 showed a unique genetic profile (note that only one of these 21 sites is in Canada). In South Carolina, Kreher *et al*. (2000) surveyed one site for genetic variation using randomly amplified polymorphic DNA markers (RAPDs), and found the proportion of distinguishable genets to be 0.68.

Generation time is difficult to estimate with any accuracy for a long-lived clonal shrub with frequent asexual reproduction, especially in the absence of demographic or growth rate data. Generation time (the average age of parents in the current cohort) must average both asexually and sexually reproducing individuals, weighted according to frequency (IUCN 2017). Although estimates from growth ring analysis indicates that individual *Vaccinium* ramets can be long-lived (up to ~100 years; Flower-Ellis 1971; de Witte and Stöcklin 2010), clonal reproduction presumably reduces the average age of reproductive individuals by an unknown amount. Age at first flowering is not known for Deerberry, but *Vaccinium* species can flower as early as in their second year (Vander Kloet 1988).

To estimate Generation Time for Deerberry, Method 3 of the IUCN guidelines (2017, p. 27) has therefore been selected:

- Generation Time (GT) = age of first reproduction + [z * (length of the reproductive period)] where z is usually <0.5 depending on survivorship and the relative fecundity of young vs. old individuals (IUCN 2017).

For Deerberry, we conservatively assume z = 0.5, age of first reproduction = 2, length of reproductive period = 100. Therefore GT = 52 (or ~50 years). Note that this is an estimate for COSEWIC purposes only, and does not represent a conclusion based on empirical data. Because z = 0.5 is conservatively set at a maximum value, this may represent an overestimate.

Physiology and Adaptability

Like many other ericaceous shrubs, Deerberry is generally tolerant of fire. Skinner (2002) found that the effect of fire on Deerberry patches was complex and that the effects of fire may depend on factors including patch size, shape, and genetic composition. Both the co-occurring Early Lowbush Blueberry (*Vaccinium angustifolium*) and Pale Blueberry are well adapted to fire, sprouting readily from underground rhizomes following fire from adventitious buds (Tirmenstein 1991a, b). It has been suggested that Deerberry may even

require post-fire conditions to germinate (Crowder 1982; Ford 1995).

Similar to many other Ericaceae species, Deerberry probably has a symbiotic relationship with soil mycorrhizae, which aid in successful establishment and growth. Mutualistic relationships with soil mycorrhizae are well documented in the broadly distributed Ericaceae family (including *Vaccinium*), and are associated with acidic and nutrient-poor soils globally (Cullings 1996; Cairney and Meharg 2003). Ericoid ectomycorrhizae have been observed on *Vaccinium stamineum* roots in the central United States (Rothwell and Vogel 1982).

Dispersal and Migration

The fleshy Deerberry fruit is eaten by wildlife including songbirds, grouse, small mammals, and large mammals, such as White-tailed Deer (*Odocoileus virginianus*) and Black Bear (*Ursus americanus*; Sotala and Kirkpatrick 1973). Dispersal distances are presumably highly variable but could occasionally occur over tens or even hundreds of kilometres. Unconsumed fruits are dispersed locally by gravity and potentially by water.

Interspecific Interactions

The fruits of Deerberry are a valuable wildlife food in the core of the species' American range (Uttal 1987). The leaves are also frequently browsed by White-tailed Deer and Eastern Cottontails (*Sylvilagus floridanus*) in the central United States (Sotala and Kirkpatrick 1973). Deerberry is a known host of the native Blueberry Maggot (*Rhagoletis mendis*), which lays eggs in the fruits. Populations of this commercial pest are known from the Niagara area (Wainfleet Bog) and much of southern Ontario.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Observation data were obtained from the Natural Heritage Information Centre (NHIC 2018). In June 2018, the five extant subpopulations were surveyed for the presence of Deerberry by Holly Bickerton and staff from Parks Canada, the Niagara Parks Commission and/or the Ontario Ministry of Natural Resources and Forestry (OMNRF). All eight planted sites at TINP were also searched in 2018 by either Holly Bickerton or Brent Lewis of TINP. In June 2018, suitable habitat at the extirpated Mewburn Road site was searched by Holly Bickerton, Albert Garofalo, and Paul O'Hara, and Brown's Point was searched by Holly Bickerton. Search effort, including on-ground direct searches and counts, for the preparation of this report is estimated at 43 person-hours over five days.

Searches were conducted by walking through suitable habitat to locate plants. Where plants were found, plants or clonal groups of plants (clumps) were marked with flagging tape. The number of stems was counted or estimated following standard monitoring methods (Bickerton 2016) and their reproductive status recorded (i.e., flowering (or fruiting) or vegetative).

Abundance

In 2018, 3743 stems were counted and/or estimated at five extant subpopulations (Table 3). All calculations include the Georgina Island subpopulation, originating from cultivated plants and now self-sustaining. The number of stems with flowers or fruit varied between 0-61% (Table 3). Although the number of reproductive stems is then lower than the total stem counts recorded, it is noted that flower production in many *Vaccinium* species is dependent on canopy gaps and fire frequency (Dawe *et al*. 2017; thus, non-reproductive stems are here considered mature individuals).

Table 3. Abundance of Deerberry at five extant subpopulations.

Subpopulation	Total stems	No. stems in flower or fruit	% reproductive stems
Whirlpool Gorge	6	0	0%
Grenadier Island, TINP	1335	328	25%
Endymion Island, TINP	1051	78	7%
Deathdealer Island	736	446	61%
Georgina Island West, TINP (cultivated origin)	615	135	22%
Total	**3743**	**987**	**N/A**

The Whirlpool Gorge subpopulation is the most precarious with only six (naturally occurring) stems. One stem is rooted on the edge of the Niagara Escarpment and may be lost to erosion. At the other Canadian sites, patches are larger in area and appear well established.

Four additional planted sites contain a total of approximately 100 stems. No flowering or fruiting has been observed to date at these sites. There has been no observed increase in the number of stems, beyond what was originally transplanted, and no apparent clonal spread. Therefore, according to current IUCN and COSEWIC guidelines, they are not included in the total Canadian population.

Fluctuations and Trends

Six or seven of 10 (60 - 70%) of the naturally occurring Canadian subpopulations have been extirpated within the last 3 generations or 156 years (Table 1). Historical abundance at the extirpated subpopulations is unknown.

At the four extant sites that are naturally occurring, it is difficult to make direct comparisons across years due to changes in survey methods within sites. Ford (1994) estimated clump size (m^2) for the five sites that were extant in 1992 (one of which has not been observed since; Mewburn Rd., Table 1). Based on field observations by Melinda Thompson, native plants at the Niagara site have been stable since 2000. Regular observations by staff at TINP suggest that naturally occurring subpopulations there (Endymion Island, West Grenadier Island) are probably stable, or at least not decreasing. The number of "clumps" identified at Deathdealer Island and reported in COSEWIC 2000 appears stable.

At Whirlpool Gorge, unpublished field data suggest that there has been little change since 2001. One plant observed in 2015 could not be found in 2018; it is not known if it was missed or has not persisted (Lindblad pers. comm. 2018). The stability of subpopulations is somewhat expected due to the longevity of individuals; well-established clonal populations typically have high survival rates (de Witte and Stöcklin 2010).

Flowering rates at the shaded sites at Whirlpool Gorge and on Endymion Island (Table 3; 0% and 7%, respectively) are relatively lower than for open sites in full sun, such as Deathdealer Island (61%). It is possible that canopy closure at these sites may be reducing flowering and fruiting. In this way, shading may be limiting growth and establishment of introduced plants at shaded sites.

The most significant change to the Canadian population since the 2000 status report is the successful introduction of Deerberry in suitable habitat within its occupied range. One introduction now meets COSEWIC and IUCN criteria as a subpopulation, adding an estimated 357 genets (15%) and a new location to the overall Canadian population. In time, continued recovery efforts at other sites may lead to further increases.

Rescue Effect

Rescue from adjacent subpopulations in New York State is considered possible, but unlikely. Fruits may be widely dispersed by birds and large mammals, but the nearest reported sites in northern New York are most likely beyond the distance typically travelled by seed dispersers. There is one known occurrence in Wellesley Island (NY), approximately 5 km from the closest Ontario subpopulation (National Deerberry Recovery Team 2010). There are documented records across northern New York State, and it is frequently observed in the Finger Lakes area (New York Flora Atlas 2019; Johnson pers. comm. 2019).

Despite scattered occurrences in adjacent northern New York state, it is considered unlikely that fruits would be dispersed by fauna into its suitable habitat in Canada, where habitat quantity and quality are declining. Like other blueberries, Deerberry likely has a symbiotic relationship with soil mycorrhizae (see **Limiting Factors**). Its symbionts and their frequency and distribution in suitable Canadian substrates are unknown, but may present a limiting factor in the successful growth and germination of young plants. Observations of seedlings in the wild are very rare.

THREATS AND LIMITING FACTORS

The International Union for Conservation of Nature (IUCN) Red List unified threats classification system (Master *et al*. 2012) was used to assess threats to Deerberry (Appendix 2). The threats calculator method consists of scoring the scope, severity, and timing for each standard threat category; the overall threat impact is then calculated from these ratings. The assigned overall threat impact for Deerberry is High to Low, depending on management interventions (Appendix 2).

Fire and Fire Suppression (7.1, impact: high to low)

The suppression of natural wildfire is a threat to Deerberry in Canada. Like other blueberries, Deerberry benefits from the ecological effects of fire. Fire not only controls woody competitors and maintains open conditions in seral communities, but also promotes vigour through clonal growth. The success of the Georgina Island post-burn introduction suggests that fire may produce ecological conditions that improve early growth and development.

Fire suppression has occurred in the Niagara and Thousand Islands area for over a century, leading to natural succession and promotion of shade-tolerant species. Fire suppression has also negatively impacted a number of other species associated with Deerberry, notably Pitch Pine, but also including several provincially rare associates (Van Wieren pers. comm. 2018). Deerberry subpopulations at Whirlpool Gorge and Endymion Island are the sites most affected by the increased shading resulting from past fire suppression. Some patches on Grenadier Island are also becoming shaded. However, Parks Canada does not suppress naturally occurring wildfire at TINP except to preserve public safety and property. Further, staff have conducted prescribed burns within the park, including on Georgina Island, thus the threat of fire suppression is dependent on management. The open conditions on Deathdealer Island are maintained by ice scour along the shoreline and so fire suppression does not affect this subpopulation. Favourable post-fire conditions may have helped bring about the establishment of transplanted seedlings on Georgina Island.

Problematic Native Species (8.2, impact: medium-low)

White-tailed Deer are often abundant in some areas of TINP and throughout the Thousands Island region generally (Van Wieren pers. comm. 2018). As suggested by the plant's common name, deer are known to browse on leaves and fruits, especially in summer (Sotala and Kirkpatrick 1973). However, the impact of deer on Deerberry is very dependent on deer abundance, which is variable. Excessive deer browse has now eliminated much of the low woody and herbaceous vegetation in nearby areas of central and eastern Grenadier Island, and in other areas of TINP (Bickerton pers. obs. 2017, Sutherland pers. comm. 2018), yet there was no evidence of deer browse on Deerberry at the TINP locations in 2018. Heavy browsing has caused the failure of at least one

introduction attempt at TINP (Hill Island) and is thought to have contributed to the lack of success at several other sites (National Deerberry Recovery Team 2010).

Blueberry Maggot is native to North America and has recently spread into Ontario. It is considered an agricultural pest because it consumes blueberry pulp, rendering berries unmarketable (CFIA 2019). Ecological or population-level threats of this native species on Deerberry are unknown.

Invasive Non-native Species (8.1, impact: low)

Invasive plant species are not currently threatening any extant subpopulations, because of control efforts by the Niagara Parks Commission and Parks Canada. Common Buckthorn was an understory dominant shrub within the extant Deerberry patch at Whirlpool Gorge. Control starting in 2014 has virtually eliminated Buckthorn, with only occasional small seedlings in the understory (Lindblad pers. comm. 2018). Over the last five years, thick patches of aggressive Tatarian Honeysuckle (*Lonicera tatarica*) have been removed near Deerberry patches on Endymion Island (Lewis pers. comm. 2018). Parks Canada staff are also controlling a dense infestation of Garlic Mustard (*Alliaria petiolata*) found within 200 m of Deerberry plants on Grenadier Island. Maintaining this low level of threat requires the continued efforts of land managers. The scope and severity of this threat will change if active management changes.

Recreational Activities (6.1, impact: negligible)

Trails bisect or are adjacent to three of the five Deerberry subpopulations. Historically, recreation had an impact at some sites. Trampling and soil compaction on the Bruce Trail near Mewburn Road, Niagara Falls probably caused the extirpation of this small subpopulation. However, threats from trail use at extant sites (e.g., physical damage, soil compaction) have been reduced due to protection and trail re-routing at all sites. The heavily used trail to the Whirlpool Gorge lookout was previously threatening Deerberry plants, but has been re-routed and a barrier erected to prevent access to plants. One trail on Grenadier Island has been closed, and the site is annually monitored for impacts by park staff. A hiking trail next to plants on Endymion Island is infrequently used and no trampling of plants was evident. Past reports have suggested that patches on the privately owned Deathdealer Island were at risk to due recreational activities or landscaping, but there was no evidence of disturbance in 2018, and the current landowners are supportive of conservation (Van Wieren pers. comm. 2018).

Erosion (10.3 Avalanches/Landslides, impact: negligible)

The steep slope under the wooded Whirlpool Gorge site in Niagara Falls is likely to continue to erode. Significant soil slumping has been observed by comparing historical and current aerial photography (National Deerberry Recovery Team 2010). One of the three naturally occurring clumps at this site sits under a tree on the very edge of the escarpment. Although trees have been planted on the lower slopes to reduce slumping (National Deerberry Recovery Team 2010), it is likely that this natural process will continue and that

some plants will be lost over the long term. This threat was considered “negligible” in the Threats Calculator, because so few plants are affected.

Other Threats (impact: unknown)

This species is potentially impacted by pollinator loss (7.3, Other Ecosystem Modifications) but we do not know the extent of the role of pollinators in reproduction and there is little known regarding which groups of pollinators are important. The species is buzz-pollinated and so bumblebees (*Bombus* spp.) and other bee genera capable of buzz-pollination are presumed to be important.

As with many species that live near water bodies, climate change will probably impact the Canadian subpopulations of Deerberry to some degree (11.4 Storms and Flooding). Although the subpopulation on Deathdealer Island has already been observed to be periodically submerged, the severity of these events is largely unknown.

Limiting Factors

The probable association that Deerberry has with soil mycorrhizae (see **Physiology and Adaptability**) may limit its initial establishment and early growth.

As noted above, Deerberry is buzz-pollinated and therefore exhibits some degree of pollinator specialization. Given large-scale declines in the relative abundance and range contraction of some common bee species (e.g., Bumble Bees, up to 96% declines, Cameron *et al*. 2011), it is possible that efficient pollination is limited by the presence of certain pollinators.

Number of Locations

“Location” defines a geographically or ecologically distinct area in which a single event may affect all individuals of the taxon present. The predominant threat to extant viable Canadian subpopulations of Deerberry is probably fire suppression.

Although at least three of five extant subpopulations are affected by fire suppression (those managed by TINP), it is likely that each of the five subpopulations would be affected independently by a stochastic wildfire event and thus possible subsequent fire suppression. The TINP subpopulations occur on different islands separated by water barriers of at least one kilometre, and the Niagara subpopulation is disjunct by several hundred kilometres. At three sites in TINP, wildfire would not be suppressed if it occurred. The privately owned, seasonally occupied island site has plants within 1 km of a dock and boathouse; wildfire would be suppressed to the extent possible at this subpopulation. Therefore, it seems most likely that the five extant subpopulations represent five separate locations. Non-reproductive introduction and augmentation sites are not considered to be locations.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

Deerberry is listed as Threatened under the Ontario *Endangered Species Act, 2007* and the Canadian *Species at Risk Act*. It is also considered Endangered in Vermont and Illinois (Illinois ESPB 2015; Vermont Natural Heritage Inventory 2015).

Non-Legal Status and Ranks

NatureServe's Global Rank for this taxon is G5 and it is considered secure. Deerberry has a conservation rank of S1 (critically imperilled) in Ontario, Vermont, Illinois and Kansas. Deerberry is either secure (S5) or is unranked (SNR) in the 27 other states where it occurs (NatureServe 2018).

Habitat Protection and Ownership

Four of five extant subpopulations are protected on federal and provincial Crown lands managed by government agencies (Parks Canada and Niagara Parks Commission). The land occupied by one subpopulation is privately owned.

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BIOGRAPHICAL SUMMARY OF REPORT WRITER

Holly Bickerton is a biologist with over 20 years of field experience in southern Ontario. She holds a B.A.Sc. from McMaster University and a Masters in Environmental Studies from York University. She has undertaken ecological and species-at-risk work for the Ontario Ministry of Natural Resources and the Department of Environment and Heritage in South Australia. Since 2005, she has worked as an independent consulting ecologist, conducting flora and fauna inventories, vegetation mapping, invasive species assessments, ecological monitoring, and policy research. She has written or co-written COSEWIC status reports on four other vascular plants, and many other documents on rare and at-risk species.

COLLECTIONS EXAMINED

No herbarium collections were examined for the preparation of this report. Collections managers at Canadian Museum of Nature (CAN), University of Guelph (OAC), Royal Botanical Gardens (HAM), and University of Waterloo (WAT) were contacted to determine whether any collections from Middlesex County had been overlooked.

Appendix 1. Canadian subpopulations of the Deerberry, *V. stamineum.*

Subpopulation Name	Element Occurrence Number	County	Ownership	Selected Previous Records	Year of Most Recent Obs.	No. Mature Individuals (Year)	Comments
EXTANT							
Whirlpool Gorge	2062	Niagara Region	Niagara Parks Commission	2018 – Bickerton *et al.* 2015 – Bickerton *et al.* 2011 – B. Lewis 2010 – M. Oldham 2006 – M. Oldham 2001 – M. Thompson 1987 – S. Varga	2018	2018 – 6 stems in 3 clumps 2015 – 7 stems in 4 clumps 2011 – 3 stems 2006 – 3 patches 2001 – 9 stems in 3 clumps 1987 – 1 plant	Reported flowering or fruiting in 2006, 2010 and 2011. No flowering observed in 2015 or 2018.
Grenadier Island	2066	Leeds and Grenville	TINP	2018 – Bickerton *et al.* Annual monitoring by TINP 1994 – B. Ford	2018	2018 – 1335 stems 1993	Plants in open conditions were flowering in 2018.
Endymion Island		Leeds and Grenville	TINP	2018 – Bickerton *et al.* Annual monitoring by TINP	2018	2018 – 1051 stems	Little flowering in 2018, site shaded.
Deathdealer Island	11208	Leeds and Grenville	Private	2018 – Bickerton *et al.* 1993 – Oldham and Sutherland 1992 – Ford	2018	2018 776 stems 1993 – 3 clumps 1992 – 2 patches, <10 m^2	Site in full sun, plants fruiting abundantly in 2018.
Georgina Island West	N/A	Leeds	TINP	2018 – Bickerton *et al.* Annual monitoring by TINP	2018	2018 – 615 stems	9 seedlings planted in 2006 (including both east and west sites); 25 planted 2012; flowering and vegetatively reproducing in 2018. Meets IUCN and COSEWIC criteria for manipulated populations. Now considered an extant subpopulation, cultivated from native stock.
PLANTED SITES (extant only)							
Whirlpool Gorge	2062 (part)			2018 – Bickerton *et al.* 2015 – Bickerton *et al.* 2011 – Lewis	2018	2018 – 16 stems in 8 clumps (0 flowering)	18 seedlings planted in 2010 from TINP stock. No plants flowering or fruiting in 2015 or 2018.
Mallorytown Landing	N/A			2018 – Bickerton *et al.* 2015 – Bickerton *et al.*	2018	2018 – 27 stems (0 flowering)	Hundreds of seedlings planted 2001 and 2005, very low survival rate. No plants flowering or fruiting in 2015 or 2018.

Subpopulation Name	Element Occurrence Number	County	Ownership	Selected Previous Records	Year of Most Recent Obs.	No. Mature Individuals (Year)	Comments
Georgina Island East	N/A			2018 – Bickerton *et al*. Annual monitoring by TINP	2018	2018 – 36 stems (0 flowering)	Seedlings planted 2009 and 2012 following mechanical opening of woodland overstory. No plants flowering or fruiting in 2018.
Thwartway Island	N/A			2018 – B. Lewis Annual monitoring by TINP	2018	2018 – 17 "plants" (0 flowering), number of stems not counted	32 seedlings planted 2012. No plants flowering or fruiting in 2018.
EXTIRPATED							
Bruce Trail near Mewburn Road	11210	Niagara Region		2018 – not found (Bickerton *et al*.) 2001 – not found (Thompson) 1992 – Meyers	1994	1992 – 1 plant, 1m^2 2001 – Failed to find 2018 – Failed to find	Single clump of less than one m^2 along Bruce Trail last seen in 1992 (Ford 1994). Surveys of suitable habitat by several experienced botanists resulted in no observations; evidence of trail widening and vegetation loss, subpopulation believed extirpated.
St. David's Gorge	2063	Niagara Region	Unknown	1960s – Meyers and Yaki 1937 – Simmons, TRT	1960s	Unknown	Known to be extirpated. Rediscovered in late 1960s but in 1995 found extirpated by grazing and trampling (Meyers 1985).
Queenston, S. of power plant	2065	Niagara Region	Unknown	1960s – Meyer 1952 – Miller 1902 – Voaden 1901 – Camero	1960s	Unknown	A formerly well-known subpopulation with many observations and collections. Last observed 1960s. Area intensively botanized by Varga in 1989; no plants found.
Queenston Heights	11209	Niagara Region	Unknown	1953 – Miller 1893 – Macoun	1953	Unknown	Presumed extirpated.
Niagara-on-the-Lake	2070	Niagara Region	Unknown	1891 – Dearness, DAO 1898 – McCalla, DAO, MTMG	1898	Unknown	Exact location unknown, presumed extirpated.
Brown's Point, 4 km north of Queenston	2064	Niagara Region	Unknown	1985 – Meyers	1985	-	Site searched, no plants found in 1991 (Ford), 1995 (Oldham) and 2018 (Bickerton). Habitat extant; deeply shaded in 2018.
Niagara Falls	2072	Niagara Region	Unknown	1896 – Scott	1896	-	Single collection, exact location not known. May represent an additional site, or one of the Niagara Falls sites above.

Appendix 2. IUCN threats assessment on the Deerberry.

Species or Ecosystem Scientific Name	Deerberry (*Vaccinium stamineum*)			
Element ID	Elcode			
Date:	03/07/2019			
Assessor(s):	Holly Bickerton (report writer), Josh Van Wieren (PC), Shaun Thompson (TINP), Vivian Brownell, Joyce Gould, Sam Brinker, Bruce Bennett, Dan Brunton, Jana Vamosi, Dave Fraser (facilitator), Rosana Soares, Karen Samis			
References:	COSEWIC in prep; COSEWIC 2000; COSEWIC 1994			
Overall Threat Impact Calculation Help:			**Level 1 Threat Impact Counts**	
	Threat Impact		**high range**	**low range**
	A	Very High	0	0
	B	High	1	0
	C	Medium	1	0
	D	Low	0	2
	Calculated Overall Threat Impact:		High	Low
	Assigned Overall Threat Impact:		BD = High - Low	
	Impact Adjustment Reasons:			
	Overall Threat Comments		Deerberry is a long-lived clonal perennial. Mature individuals were estimated with total stem counts (which roughly correspond to ramets) and generation time was roughly estimated at 52 years (using IUCN formula method #3; age of 1st repro + 0.5(maximum age) so timeframe for severity of threats (3 generation=~156 years) is considered over the next 100 years (the maximum). 100% range in ON; 5 extant subpopns: 4 in protected areas (81% of stem count); 1 on private land (19%). One of these subpopulations (Georgina in TINP; seed source = Grenadier W) the result of a successful intralimital introduction (it is hard to deduce whether there is seed germination in this subpopulation but it is reproducing vegetatively and produces seed). Observed decline in the number of subpopns/EOs in 3 generations but % unknown. For scope, the percentage of the population at each subpopulation in terms of total stems is as follows: Whirlpool Gorge (0.2%), Grenadier W, TINP (35.3%), Endymion I. (27.8%), Deathdealer I. (19.5%), Georgina I. (17.2%). Range of High-Low in this Threats Calculator reflects that the threat level depends heavily on active management - it is Low if active management continues but High if it ceases.	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & commercial development		Negligible	Negligible (<1%)	Extreme - Serious (31-100%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	
1.1	Housing & urban areas		Negligible	Negligible (<1%)	Extreme - Serious (31-100%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	One subpopulation on private land (Deathdealer Island), is along a shoreline that would not be suitable for any new development (within 50 m of shore). Current owners aware of species' presence and support conservation. Potentially could incur threat due to change of landowner from construction of new dock or landscaping, but this threat is currently remote. Housing development has probably eliminated some of the subpopulations in the Niagara area within the last 3 generations, but this is a historical threat. While Deathdealer Island comprises 19% of stems, development would only affect segment of subpopulation. The Ontario ESA prohibits development within a 30-50 m setback and 90% of the subpopulation is within 50 m of shoreline.
1.2	Commercial & industrial areas						
1.3	Tourism & recreation areas						None of the sites in public ownership will be developed for tourism or recreational purposes due to legal protections.
2	Agriculture & aquaculture						
2.1	Annual & perennial non-timber crops						
2.2	Wood & pulp plantations						
2.3	Livestock farming & ranching						
2.4	Marine & freshwater aquaculture						
3	Energy production & mining						
3.1	Oil & gas drilling						
3.2	Mining & quarrying						
3.3	Renewable energy						
4	Transportation & service corridors						
4.1	Roads & railroads						No subpopulations occur along any roads or railways.
4.2	Utility & service lines						
4.3	Shipping lanes						
4.4	Flight paths						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
5	Biological resource use						
5.1	Hunting & collecting terrestrial animals						
5.2	Gathering terrestrial plants						Deerberry is not consumed by humans or cultivated as a crop; it has not been popular as an ornamental and is not known to have been collected from the wild.
5.3	Logging & wood harvesting						No forestry at any site.
5.4	Fishing & harvesting aquatic resources						
6	Human intrusions & disturbance		Negligible	Restricted (11-30%)	Negligible (<1%)	High (Continuing)	
6.1	Recreational activities		Negligible	Restricted (11-30%)	Negligible (<1%)	High (Continuing)	Lightly used trails traverse through subpopulations at West Grenadier Island and Endymion Island. Both sites are regularly monitored and actively managed by TINP staff. Heavy trail use at Whirlpool Gorge (lookout) was recently limited by permanent fencing to restrict trail users from the occupied habitat. Endymion was closed to public because of Deerberry, West Grenadier had 70% of the trails closed (still a trail and picnic area are close to the subpopulation) and the current TINP management plan has no proposed development. Scope is considered Restricted because threat affects a subset of trailside plants at these 3 sites which in total comprise 50% of the Canadian population (and this subset is an estimated 11-30%). Severity is negligible due to low risk of physical damage. At West Grenadier and Endymion, most plants are robust shrubs ~ 1 m high. Whirlpool Gorge plants are small and weak and therefore the most threatened by trail use. At Georgina, all of subpopulation is within 5 m of a trail. Deathdealer is on a shoreline, with no formal trail and is lightly used, so there is low potential for trampling. Proximity to trail is not an issue at Endymion, only ~15% Grenadier is within proximity of authorized trails. At ~ 10 m from trail, threats from trampling and accidental trail maintenance are reduced, yet campfires have been observed to have a negative impact on seedlings/young plants. West Grenadier could have a campfire, which could have an impact. There has been no fire out of control on that island in the last century, so it is a rare event. Fire could help this species as well.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
6.2	War, civil unrest & military exercises						
6.3	Work & other activities						
7	Natural system modifications	BD	High - Low	Large (31-70%)	Serious - Slight (1-70%)	High (Continuing)	
7.1	Fire & fire suppression	BD	High - Low	Large (31-70%)	Serious - Slight (1-70%)	High (Continuing)	This seral species appears to require open conditions and increases flowering after fire due to decreased cover; therefore the threat is fire suppression. Currently 2 subpopulations (Endymion and Whirlpool; 28%) are heavily shaded and most at risk; over the next 100 years (3 gen), sites on West Grenadier (making 3 subpopulations = 63% of plants) may also be threatened without fire management; therefore scope is large. Severity is difficult to estimate, so an uncertainty range of 1-70% was selected. Fire suppression is more of a threat than fire itself. Other subpopulations are rocky with shallow soil, and won't have issues with shading in the near future. It is currently unknown whether low flowering is a recent phenomenon (examining historical herbarium specimens may be helpful in this regard).
7.2	Dams & water management/use						
7.3	Other ecosystem modifications		Unknown	Unknown	Unknown	Moderate (Possibly in the short term, < 10 yrs/3 gen)	This species is potentially impacted by pollinator loss but we do not know the extent of the role of pollinators in reproduction and there is little known regarding which groups of pollinators are important. The species is buzz-pollinated and so bumblebees are presumed to be important.
8	Invasive & other problematic species & genes	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.1	Invasive non-native/alien species/diseases	D	Low	Small (1-10%)	Moderate - Slight (1-30%)	High (Continuing)	Current threat is low due to current control efforts at 3 subpopulations (Whirlpool, Endymion, West Grenadier Island). Within 3 generations, invasive pressure is predicted to continue or increase; both scope and severity will increase without continued management for (e.g.) Tatarian Honeysuckle, Buckthorn spp., Garlic Mustard (and other spp. yet to arrive...). The current level of active management appears to be reducing the impact of this threat. Managers were even able to go to Deathdealer 7-8 years ago and eradicate Tatarian Honeysuckle and it has not grown back. West Grenadier currently has few invasive shrub species yet Garlic Mustard is difficult to eradicate. Moderate-slight severity (and small scope) therefore selected to reflect uncertainty in whether active management will continue. Current and future scoring will change if active management changes.
8.2	Problematic native species/diseases	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	White-tailed Deer are present in TINP and this region (thus, this threat affects nearly all individuals in 4 subpopulations of Deerberry). There is debate on the severity of this threat as it depends on the rate that islands are occupied by deer in summer (pressure on islands has been observed to be highly variable); estimated as Moderate-Slight. Although there is no recent evidence of deer browse at any sites considered extant, Grenadier Island has seen increases in the deer population and other areas of the park have been heavily impacted by excessive browse. A planted subpopulation was browsed by deer when deer population size was very large, indicating that overabundant deer will impact younger plants but may have reduced impact on extant mature individuals. Damage caused presumably by a rabbit (probably Cottontail) led to the loss of 5-6 plants last year. Hemlock Woolly Adelgid has been infecting hemlocks at TINP but might be beneficial to Deerberry, in opening up the canopy. The native Blueberry Maggot Bee has expanded range and is now present throughout SW ON. It is unknown whether this species affects the survival or dispersal of the Deerberry (it is an agricultural pest which makes the berries unmarketable).

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.3	Introduced genetic material						The Whirlpool Gorge subpopulation was augmented with introduced genetic material but stock was from TINP. Most other plantings sourced from Grenadier, so all Canadian material. Does not appear to be a threat.
8.4	Problematic species/diseases of unknown origin						
8.5	Viral/prion-induced diseases						
8.6	Diseases of unknown cause						
9	Pollution						
9.1	Domestic & urban waste water						
9.2	Industrial & military effluents						
9.3	Agricultural & forestry effluents						
9.4	Garbage & solid waste						
9.5	Air-borne pollutants						
9.6	Excess energy						
10	Geological events		Negligible	Negligible (<1%)	Extreme - Serious (31-100%)	High (Continuing)	
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides		Negligible	Negligible (<1%)	Extreme - Serious (31-100%)	High (Continuing)	Threat in this category is via erosion which is naturally occurring along this sandy escarpment face but may be exacerbated by increased storm frequency and intensity. A few plants at Whirlpool Gorge subpopulation have been lost in the past due to erosion. In 3 generations it is possible that all naturally occurring plants in this subpopulation are lost due to erosion. Although this could be the loss of an entire subpopulation, the low number of stems means the scope is negligible. Severity has therefore been chosen as Extreme-Serious (31-100%).
11	Climate change & severe weather		Unknown	Restricted (11-30%)	Unknown	High (Continuing)	Unknown. Increased temperatures could have a positive effect on this species but this is entirely speculation. Rising water levels on the St. Lawrence could flood the Deathdealer Island subpopulation, which is < 1 m above the shoreline.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11.1	Habitat shifting & alteration		Unknown	Unknown	Unknown	High (Continuing)	Deerberry may be outcompeted but the scope of habitat shifting is unknown and likely negligible over the next 10 years. Finding ways of extrapolating 10 year estimates of impact for long-term processes remains a challenge.
11.2	Droughts		Unknown	Unknown	Unknown	High (Continuing)	More periods of drought may be predicted within Deerberry habitat but it is not currently known how drought will affect Deerberry.
11.3	Temperature extremes						Temperature itself is unlikely to be an issue for Deerberry.
11.4	Storms & flooding		Unknown	Restricted (11-30%)	Unknown	High (Continuing)	Water levels have been seeing record highs and could impact Deerberry. Rising water levels to the point that some Deerberry will be submerged is already likely on Deathdealer Island where subpopulation is <1 m from shoreline.
11.5	Other impacts						

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