COSEWIC
Assessment and Status Report

on the

Spotted Wintergreen
Chimaphila maculata

in Canada

THREATENED
2017

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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

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Previous report(s):

COSEWIC. 2000. COSEWIC assessment and update status report on the spotted wintergreen *Chimaphila maculata* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 6 pp.

White, D.J. 1998. Update COSEWIC status report on spotted wintergreen *Chimaphila maculata* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 1-6 pp.

Kirk, D.A. 1987. COSEWIC status report on the spotted wintergreen *Chimaphila maculata* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 36 pp.

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For additional copies contact:

COSEWIC Secretariat
c/o Canadian Wildlife Service
Environment and Climate Change Canada
Ottawa, ON
K1A 0H3

Tel.: 819-938-4125
Fax: 819-938-3984
E-mail: ec.cosepac-cosewic.ec@canada.ca
http://www.cosewic.gc.ca

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Spotted Wintergreen in flower. Photo by Jenny McCune, with permission.

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COSEWIC
Assessment Summary

Assessment Summary – April 2017

Common name
Spotted Wintergreen

Scientific name
Chimaphila maculata

Status
Threatened

Reason for designation
This low-growing perennial plant is restricted to sandy soils in southern Ontario. Since the last assessment, this species has been found at two new sites and lost at two others. The overall population has remained fairly stable but the five subpopulations are under threat from recreational activities and the possibility of wildfire.

Occurrence
Ontario, Quebec

Status history
Designated Endangered in April 1987. Status re-examined and confirmed Endangered in April 1998 and in May 2000. Status re-examined and designated Threatened in April 2017.

COSEWIC
Executive Summary

Spotted Wintergreen
Chimaphila maculata

Wildlife Species Description and Significance

Spotted Wintergreen (*Chimaphila maculata*) is a small, low-growing, evergreen perennial that is woody at the base and spreads by rhizomes to form colonies. Each stem consists of a whorl of thick, blue-green, toothed leaves with a white stripe along the mid-rib and white areas extending from the mid-rib. Topping the whorl of leaves is a stalk supporting one to five nodding white or pinkish flowers. In a given year, only some of the stems in a subpopulation produce flowers. The rounded seed capsules become erect after flowering, and contain numerous tiny seeds.

Distribution

Spotted Wintergreen occurs in eastern North America, Mexico, and Central America. Its range in eastern North America extends from southern Michigan and Ontario, east to southern New Hampshire and Maine, and south to Mississippi and northern Florida. Historically, Spotted Wintergreen was more widely distributed in southern Ontario and into southwestern Quebec. It is now restricted to a few subpopulations in southern Ontario and is considered extirpated in Quebec.

Habitat

Spotted Wintergreen is a woodland understorey species typically associated with dry–fresh oak and oak–pine mixed forests and woodlands. The plant tends to occur on well-drained sandy soils free of coarse fragments, with low organic content and poor nutrient status.

Biology

Spotted Wintergreen flowers in late July to early August. It can reproduce either clonally or by seed. As stems arise from creeping rhizomes, clumps or contiguous groupings of stems likely represent ramets rather than unique genetic individuals. The tiny, dust-like seeds in this family are dispersed mainly by wind.

Population Sizes and Trends

In Canada, there are currently five extant subpopulations. Surveys between 2011 and 2014 show a total Canadian population of at least 3587 (~3600) stems. The number of genetic individuals is not known, although it is presumably smaller. Previously reported population sizes are in the vicinity of a few hundred stems; however, two of the extant subpopulations (and several smaller sites) have been discovered since the most recent status report, and both are significantly disjunct from other extant sites. These probably do not represent newly established subpopulations, but may reflect increased survey effort and reporting of observations. Most sites known since around 2000 have remained at least stable, while some have increased in abundance and extent, evidenced by regular monitoring.

There are additionally two historical and six extirpated subpopulations. There is a possibility that plants persist at either historical site. Most of the extirpated records are only known through vague locality or population information and have never been relocated. One small subpopulation discovered near Montréal in 1992 may have been planted and is now believed to be extirpated.

Threats and Limiting Factors

Recreational activities are probably the predominant threat to extant subpopulations of Spotted Wintergreen; however, fire has the potential to have the greatest impact as this species appears to not persist after fire. Most extant sites are in public ownership and are protected from loss due to development but many sites are publicly accessible, and a few may be vulnerable to ATV damage and soil compaction from adjacent walking trails. Many sites do not appear to have any imminent threats, although their small size and spatial extent make them vulnerable to even localized disturbances. Invasive species are present at or near a few sites, but do not appear to negatively affect ramet (or shoot) numbers within these subpopulations. Habitat degradation (e.g., by garbage dumping) may also have limited impacts on some Spotted Wintergreen subpopulations. This species may be limited to some degree by its dependence on soil mycorrhizae and its reproductive biology.

Protection, Status, and Ranks

Spotted Wintergreen was first assessed as Endangered by COSEWIC in 1987. This status was re-examined and confirmed in 1998 and 2000. The species is currently listed as Endangered under the *Species at Risk Act* and under Ontario's *Endangered Species Act* (ESA). The species and its habitat in Ontario are protected under the ESA. The global conservation status rank for Spotted Wintergreen is G5, secure. In Canada, Spotted Wintergreen is ranked N2 (imperilled). In Ontario, it is ranked S2 and in Quebec is it ranked SX. Spotted Wintergreen is considered secure (N5) in the United States, but within the U.S., it is considered critically imperilled (S1) in Illinois, and imperilled (S2) in Vermont, Maine, and Mississippi. The species is also legally protected in Illinois, where it has been designated as Endangered.

TECHNICAL SUMMARY

Chimaphila maculata

Spotted Wintergreen

Chimaphile maculée

Range of occurrence in Canada (province/territory/ocean): Ontario (extirpated in Quebec)

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines(2011) is being used) *The minimum age to germination and flowering estimated to be at least 2-3 years. However, the ability of the species to reproduce vegetatively suggests the average age of mature individuals is probably at least 10 years, and possibly much older.*	Unknown, but likely at least 10 years, and possibly longer
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals? *Comparisons of all subpopulations over two time points suggest that since 2000, the number of mature individuals (approximated by stem count) is certainly stable and is probably increasing. Two new subpopulations (and several sites within others) have been discovered in the last decade, although this probably reflects increased survey effort. Since the last status report (~15 years or 1.5 generations), one subpopulation has been extirpated and two others are now historical, although these represent very few mature individuals within the total population.*	No
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [increase] in total number of mature individuals over the last [10 years, or 3 generations]. *Two new subpopulations have been documented, but these may not represent new sites. Several previously known and monitored sites show significant increases in the number of stems and in occupied area since 2000. Within the last 10 years, two subpopulations are now considered historical but may still exist, and one has probably been lost.*	Population stable to increasing

[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations]. *If surveys and planned habitat management are continued at Turkey Point and St. Williams Forest, the total number of stems may continue to increase.*	Possibly increasing
[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?	N/A
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence (EOO) – current	1952 km²
Index of area of occupancy (IAO) (Always report 2 x 2 grid value).	28 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?	Unknown
Number of "locations" (use plausible range to reflect uncertainty if appropriate) *Five extant subpopulations; multiple threats but fire is likely the most significant threat to most of the population and is likely to be variable in intensity and area of impact, hence a range of plausible locations.*	7-9
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence? *Significant decline due to loss of some locations. See report for a discussion of methods of calculating both past and current EOO values.*	Yes
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy? *See report for a discussion of methods of calculating both past and current IAO values.*	Yes, 22% decline observed since 2000.

Is there an [observed, inferred, or projected] continuing decline in number of subpopulations? *Two subpopulations are considered "historical", but may still exist. The Quebec subpopulation is not included since it is considered to have been introduced.*	Yes
Is there an [observed, inferred, or projected] continuing decline in number of "locations"?	Yes
Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat?	Unknown
Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of "locations"∗?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each subpopulation)

Subpopulation 1 – St. Williams Forest (2012)	2065 stems[1]
Subpopulation 2 – Turkey Point Area (2012)	928 stems
Subpopulation 3 – Fishers Glen Area (2012, 2013)	579 stems
Subpopulation 4 – Perry Road, Wainfleet (2012)	5 stems
Subpopulation 5 – Ojibway Park, Windsor (2014)	10 stems
Total	**~3600[2] stems**

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years]	Not done

[1] Stem counts are an index of population abundance. The number of mature individuals is not known, but is presumably lower than stem counts for this clonal plant. For St. Williams Forest subpopulation, 2065 represents a minimum estimate, because new patches have been found following habitat restoration in 2014, 2015, and 2016. Revised counts are not yet available but it is likely that this number has increased (Heagy pers. comm. 2016).

[2] Rounded to reflect uncertainty in estimates of larger patches.

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

Was a threats calculator completed for this species? In March 2016. See Appendix 1. Participants: Del Meidinger (co-chair), Kristiina Ovaska (Facilitator), Holly Bickerton (writer), Karen Timm and Joanna James (Secretariat), Sean Blaney, Andy MacKinnon, Joyce Gould, Melinda Thompson, Audrey Heagy, Mike Oldham, Jenny McCune Recreational activities and habitat degradation present the most likely threats to Canadian subpopulations; however, fire has the potential for the greatest impact. Other minor threats include the possibility of development on private lands, as well as fire suppression. Invasive species are present at low levels within habitat, but their impact is unknown.

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada? *In the adjacent northern states of Maine and Vermont, populations appear to be increasing, with recent new reports; however, Spotted Wintergreen may also have been under-reported in the past (Cameron pers. comm. 2015; Popp pers. comm. 2015). Spotted Wintergreen is a common plant in dry oak and pine woodlands in southern New England and is particularly abundant along the Atlantic Coastal Plain in southern New England (see Atlas of the Flora of New England, Angelo and Boufford 2016).*	Stable, and possibly increasing
Is immigration known or possible?	Possible, but low probability overall
Would immigrants be adapted to survive in Canada?	Probably
Is there sufficient habitat for immigrants in Canada?	Yes
Are conditions deteriorating in Canada? *The two largest sites are publicly owned and are undergoing habitat restoration leading to observed population increases. Three additional subpopulations have been recently discovered or rediscovered. The Fisher's Glen and Perry Road (Wainfleet) sites are thought to be of poor viability with habitat possibly deteriorating.*	Overall no, but some local declines
Are conditions for the source population deteriorating?	Stable and possibly increasing
Is the Canadian population considered to be a sink?	No
Is rescue from outside populations likely? *Recolonization from populations outside Canada is possible, as Spotted Wintergreen is present in adjacent Michigan and New York, and dust seeds may travel long distances. Establishment may be limited by the presence of compatible soil mycorrhizae.*	Possible

Data Sensitive Species

Is this a data sensitive species?	No

Status

COSEWIC: Designated Endangered in April 1987. Status re-examined and confirmed Endangered in April 1998 and in May 2000. Status re-examined and designated Threatened in April 2017.

Status and Reasons for Designation:

Recommended Status:	**Alpha-numeric code:**
Threatened	B1ab(i,ii,iv)+2ab(i,ii,iv)
Reasons for designation: This small, low-growing perennial plant is restricted to sandy soils in southern Ontario. Since the last assessment, this species has been found at two new sites and lost at two others. The overall population has remained fairly stable but the five subpopulations are under threat from recreational activities and the possibility of wildfire.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not met. The number of mature individuals (approximated by stem count) is stable.
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Threatened B1ab(i,ii,iv)+2ab(i,ii,iv); EOO (1952 km²) and IAO (28 km²) meet the threshold for Endangered but the number of plausible locations (7-9) meets the Threshold for Threatened. Declines observed in EOO, IAO and in number of locations/subpopulations due to loss of small historical occurrences. Continuing loss is possible due to recreational activities and possibility of fire. The population is not severely fragmented and does not undergo extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Not met. The small population (3600 stems) meets Threatened threshold but cannot infer future declines of 10% based on recent population data so C1 does not apply. Subpopulation sizes and number of mature plants do not meet threshold for C2—one subpopulation exists with over 1000 mature plants; and no single subpopulation comprises all of population. There is not an extreme fluctuation in mature individuals.
Criterion D (Very Small or Restricted Population): Not met.
Criterion E (Quantitative Analysis): Not done.

PREFACE

Spotted Wintergreen (*Chimaphila maculata*) was assessed as Endangered in 1987 because it was known from very few localities in Canada (Kirk 1987). The main threats to Spotted Wintergreen were thought to be trampling and recreational pressure (COSEWIC 2000). Since the most recent COSEWIC assessment of Spotted Wintergreen in 2000, several sites have been rediscovered and two new subpopulations have been located. Surveys from 2011-2014 suggest that the abundance of Spotted Wintergreen, indicated by stem counts, is certainly stable, and may be increasing. Overall population size and trends are somewhat difficult to determine due to differences in survey effort and counting methods in the last two decades.

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 (2017)

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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TABLE OF CONTENTS

List of Figures

List of Tables

List of Appendices

WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Scientific Name: *Chimaphila maculata* (L.) Pursh

Synonyms: *Chimaphila maculata* (L.) Pursh var. *maculata*, *Pyrola maculata* L., *Chimaphila maculata* var. *dasystemma* (Torrey ex Rydberg) Kearney & Peebles

English Common Names: Spotted Wintergreen, Mottled Pipsissewa, Striped Wintergreen, Striped Prince's Pine

French Common Name: Chimaphile maculée

Major Plant Group: Eudicot flowering plant

Family: Ericaceae

Spotted Wintergreen, *Chimaphila maculata*, is one of five species in the genus *Chimaphila*, three of which occur in Canada. Common Pipsissewa, *Chimaphila umbellata*, overlaps in range with Spotted Wintergreen, but the species are distinct and no hybrids have been documented.

Morphological Description

Spotted Wintergreen is a small, low, rhizomatous evergreen perennial that is woody at the base (Figure 1). Plants can rarely reach heights of 50 cm (Freeman 2009), but Ontario plants are generally less than 20 cm in height. Each shoot bears several whorls of smooth blue-green lanceolate or ovate-lanceolate sharply toothed leaves from 2.5-7 cm long with prominent white venation including a central white stripe. Individual stems support a terminal cluster of one to five white or pinkish nodding flowers up to 2 cm wide (Kirk 1987; Standley *et al.* 1988). The fruit is a roundish capsule up to 1 cm across (Freeman 2009). Seeds are small (0.4–0.6 mm long, 0.1–0.2 mm wide), and wingless (Kirk 1987). The seeds of Spotted Wintergreen are believed to be dispersed by wind, and possibly by water (Amador *et al.* 2013).

Genetic individuals (genets) can spread via rhizomes, so that a patch of stems may represent one or more genetic individuals. Standley *et al.* (1988) assumed that clumps of stems represented single clones, and found an average clump size of 16 stems (range: 1-90 stems) based on two populations in southern Massachusetts.

Spotted Wintergreen is similar to Common Pipsissewa; the two species appear to have similar habitat requirements and often co-occur where their ranges overlap. They differ in that Common Pipsissewa has very shiny solid green oblanceolate leaves, which lack the diagnostic central white stripe and white veins on the upper surface. DNA barcoding techniques are available to successfully distinguish among the five *Chimaphila* species globally (Liu *et al.* 2013).

Figure 1. *Chimaphila maculata* fruiting [credit: M. Thompson].

Population Spatial Structure and Variability

All extant subpopulations are in southwestern Ontario, with most plants occurring in Norfolk County. Two recently discovered subpopulations in Niagara Region and the City of Windsor are disjunct from the remaining extant sites in Norfolk County by 75 and 200 km respectively. Although genetic work has not been completed, it is possible that habitat fragmentation may contribute to restricted gene flow and reduced genetic diversity. However, not enough is known about the population biology of the species to determine the minimum habitat patch size or number of individuals necessary to support a long-term viable population, and it is not known whether the Canadian population is severely fragmented.

Designatable Units

A single designatable unit is recognized for Canada. The Canadian population is known only from the Great Lakes Plains National Ecological Area (COSEWIC 2014). There is no evidence or recognition of genetic or morphological differences within this species. Spotted Wintergreen does demonstrate considerable variation morphologically across its North American range, but this does not appear to be correlated to geography (Freeman 2009).

Special Significance

Ethnobotanical studies have reported a number of food and medicinal uses of the genus *Chimaphila* among many groups of North American Indigenous peoples, as well as early European settlers (Moerman 1998; Pengelly and Bennett 2011).

Spotted Wintergreen is one of five species in the genus *Chimaphila* worldwide. Members of *Chimaphila* are partial mycoheterotrophs, meaning that their seedlings require fungal hosts to germinate and develop, and mature plants photosynthesize but can also receive supplementary nutrition via mycorrhizae (Massicotte *et al.* 2008; Hynson *et al.* 2009; Johannson and Eriksson 2013).

DISTRIBUTION

Global Range

Spotted Wintergreen is native to eastern North America, Mexico, and Central America. Its range in eastern North America extends from central Michigan and southern Ontario, east to southern New Hampshire and Maine, and south to Mississippi and northern Florida. The western limits appear to be in western Kentucky and Tennessee, and eastern Illinois. Spotted Wintergreen also ranges from Central America, through Mexico to southern Arizona (Figure 2).

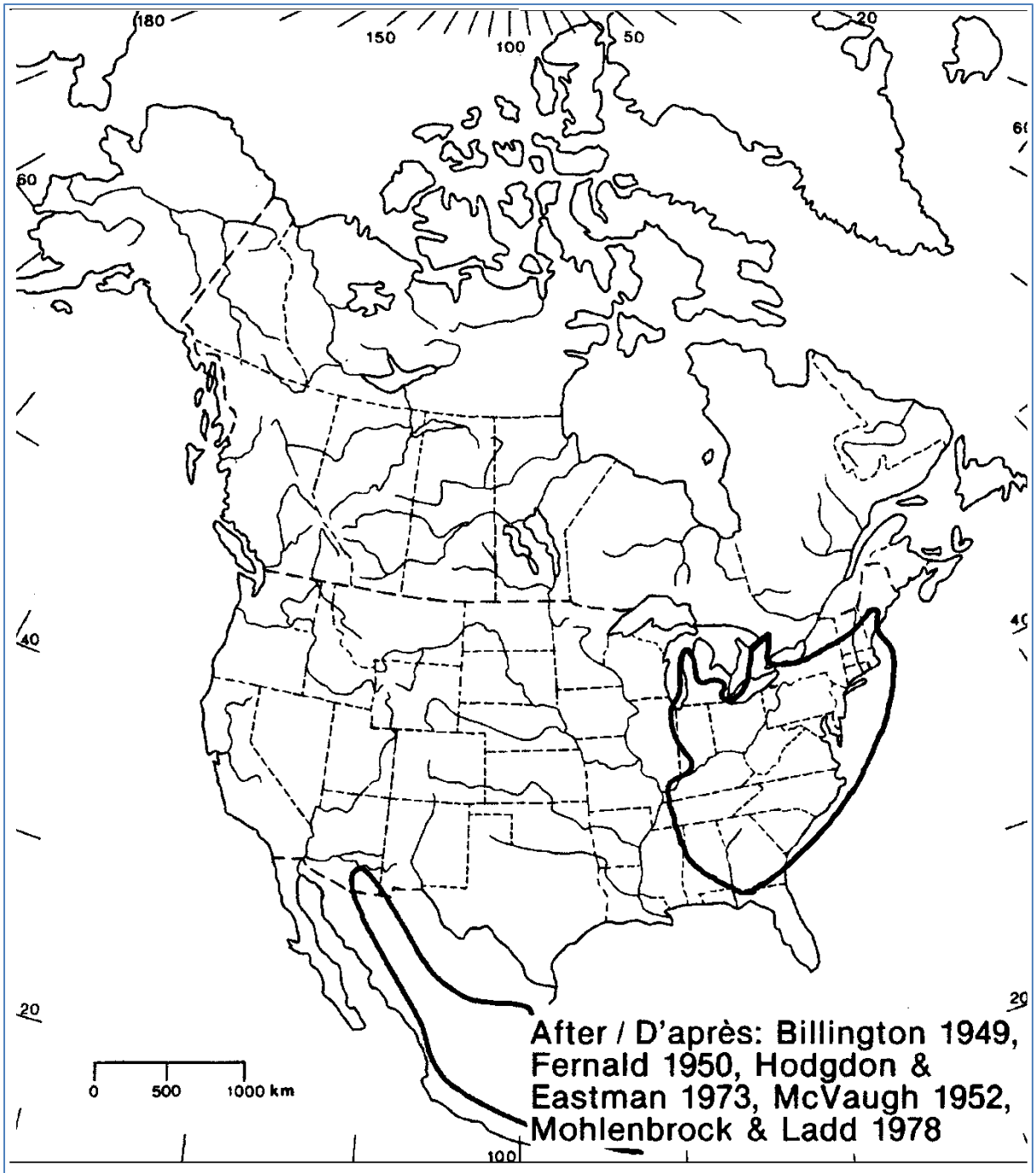

Figure 2. Natural Distribution of *Chimaphila maculata* in North America (after Haber & Keddy, 1984).

Figure 2. North American Range of *Chimaphila maculata* (after Haber and Keddy 1984; Kartesz 2015).

Canadian Range

Canadian subpopulations[3] occur in southern Ontario, at the northern edge of the range of Spotted Wintergreen. The total Canadian distribution likely represents less than 1% of the global species' range. A single disjunct subpopulation was found near Montréal, Quebec and is considered likely to have been introduced. All five extant subpopulations are in Ontario, with almost the entire Canadian population found in Norfolk County (Figure 3).

Historically, Spotted Wintergreen was likely more widely distributed in southwestern and southcentral Ontario. It is considered extirpated from five sites in the Niagara and Muskoka areas (NHIC 2015; see Table 1). Little is known about these subpopulations, which are known only from old specimens with vague locality information.

A now-extirpated Quebec subpopulation is considered likely to have been introduced. Two stems were observed in Deux-Montagnes in southwestern Quebec in 1992; no plants have been observed since 2000, and the species is considered extirpated (Jacobs 2001). This subpopulation is considered likely to have been introduced because the site has a history of use by the Mohawk people, and Spotted Wintergreen is regarded as an important medicinal plant by many First Nations peoples (Labrecque pers. comm. 2015; Sabourin pers. comm. 2015). The subpopulation is also many hundreds of kilometres distant from other native subpopulations.

Table 1. Subpopulation[4] Counts of Spotted Wintergreen Stems

SITE NAME	OWNERSHIP	PREVIOUS RECORDS (most, but not all)	YEAR of most recent observation	2011-2014 ABUNDANCE (#stems)	COMMENTS
EXTANT SUBPOPULATIONS					
ST. WILLIAMS FOREST (EO 5501)				**2065 stems**	
Manester Tract A	Provincial Crown Land	1986 – 14 plants (D. Sutherland) 2007 – 25 stems (R. Gould) 2009 – 25 stems (R. Gould) 2012 – not found (M. Thompson)	2009	25 stems	Included in total because population probably persists (Gould pers. comm. 2015).
Manester Tract B	Provincial Crown Land	1988 – 2-3 plants (P. Carson) 2001 – 23 plants (D. Jacobs, M. Thompson) 2002 – 5 stems (R. Gould) 2005 – 36 stems (R. Gould) 2007 – 5 stems (R. Gould) 2009 – 36 stems (R. Gould) 2012 – 23 stems (M. Thompson)	2012	23 stems	

[3] Here, subpopulations are used consistently with COSEWIC standards (2015). In the case of Spotted Wintergreen, they are considered synonymous with element occurrences (NatureServe 2015). Occupied areas within subpopulations are referred to in this report as "sites." See further discussion in **Number of Locations**.

[4] The term "Subpopulation" as used here following COSEWIC terminology, is equivalent to "Population" in the 2015 federal recovery strategy.

SITE NAME	OWNERSHIP	PREVIOUS RECORDS (most, but not all)	YEAR of most recent observation	2011-2014 ABUNDANCE (#stems)	COMMENTS
Manester Tract C	Provincial Crown Land	1994 – 3 plants (M. Gartshore) 1997 – 3 plants (M. Gartshore) 2000 – 9 plants (1 flowering, M. Thompson, D. Jacobs). 2001 – 8 stems (M. Thompson, D. Jacobs) 2004 – 12 stems (R. Gould) 2007 – 25 stems (R. Gould) 2009 – 25 stems (R. Gould) 2012 – 1 stem (M. Thompson)	2012	1 stem	In 2012, unable to find any other plants in the vicinity. Possible that a larger patch was missed, and this represents a solitary stem of a new subpopulation.
Nursery Tract	Provincial Crown Land	1985 – < 20 plants (M. Gartshore). 1985 – 41 plants (12 flowering, D. Kirk). 1989 – 36 plants (M. Oldham). 1997 – 100 plants (est.) (M. Gartshore) 1997 – 87 plants (15 flowering, D. White) 2000 – 406 plants (~203 flowering, M. Thompson *et al.*) 2001 – ~500 plants (D. Jacobs, M. Thompson). 2003 – 948 stems (R. Gould) 2005 – 1893 stems (R. Gould). 2012 – ~2000 stems (M. Thompson).	2012	~2000 stems	
St. Williams Forest (new)	Provincial Crown Land	2014 – 16 stems (J. McCune)	2014	16	
TURKEY POINT AREA (EO 5502)				**928 stems**	
Turkey Point Tract A	Provincial Crown Land	2009 – 7 stems (R. Gould) 2012 – 9 stems (M. Thompson)	2012	9 stems	
Turkey Point Tract B	Provincial Crown Land	2004 – 7 stems (R. Gould) 2007 – 8 stems (R. Gould, A. Woodliffe) 2012 – 7 stems (M. Thompson)	2012	7 stems	
Turkey Point Tract C	Provincial Crown Land	2004 – 3 stems (R. Gould) 2007 – 13 stems (R. Gould, A. Woodliffe) 2012 – 4 stems (M. Thompson) 2014 – 42 stems (M. Gartshore, J. Chambers)	2012	4 stems	
Turkey Point Tract D	Provincial Crown Land	2007 – 2 stems (R. Gould) 2010 – 13 stems (R. Gould) 2010 – 22 stems (D. White)	2010	-	Not relocated in 2012, evidence of ATV use. Possibly extirpated.
Turkey Point Tract E	Provincial Crown Land	2010 – 500 stems (D. White) 2012 – not found (M. Thompson) 2014 – at least 500 stems (M. Gartshore)	2014	500 stems	Not relocated in 2012 but in 2014 Mary Gartshore completed a partial count of this "very large" population at 256 stems. Based on conversation with Audrey Heagy, assumed to be stable (possibly increasing) and reported at previous count.

SITE NAME	OWNERSHIP	PREVIOUS RECORDS (most, but not all)	YEAR of most recent observation	2011-2014 ABUNDANCE (#stems)	COMMENTS
Turkey Point Tract F	Provincial Crown Land	2012 – 34 stems (R. Gould *et al.*)	2012	34 stems	
Turkey Point Provincial Park A	Provincial Park	2011 – 1 stem (S. Brinker and M. Oldham)	2011	1 stem	
Turkey Point Provincial Park B	Provincial Park	2012 – 200 stems (R. Gould)	2012	200 stems	
Turkey Point Provincial Park C	Provincial Park	2012 – 6 stems (R. Gould)	2012	6 stems	
Normandale	Private (Church Camp)	1996 – 10-15 stems (M. Gartshore) 2000 – 80 plants (D. Jacobs *et al.*) 2001 – 130 plants (M. Thompson *et al.*) 2005 – 165 stems (R. Gould) 2012 – 163 stems (M. Thompson)	2012	163 stems	
Normandale – new site	Private (Church Camp)	2014 – 4 plants (2 flowering, J. McCune)	2014	4 stems	
FISHERS GLEN AREA (EO 5503)				**579 stems**	
Fishers Glen Conservation Area	Long Point Region Conservation Authority	1921 (T. Ivey) 2000 – 23 plants (D. Leadbeater, K. Ursic) 2001 – 12 plants (M. Thompson) 2002 – 14 stems (unknown) 2003 – 20 stems (unknown) 2005 – 16 stems (unknown) 2006 – 7 stems (R. Gould) 2007 – 51 stems (R. Gould) 2012 – 166 stems (M. Thompson) 2013 – "at least" 529 stems (B. Draper, R. Gould; combined counts)	2013	529 stems	
Spooky Hollow ANSI	Hamilton Naturalists' Club	1968 (F.H. Montgomery) 1984 – not found (D. Kirk) 2011 – approx. 50 stems (M. Thompson)	2013	50 stems	Surveyors unknown.
PERRY ROAD WOODLOT (WAINFLEET) (EO 92678)				**5 stems**	
Perry Road Woodlot, Wainfleet area, Niagara Region	Private	2007 – 7 stems (T. Staton, S. Brinker, M. Oldham) 2012 – 5 stems (M. Thompson)	2012	5 stems	On municipal right-of-way, ownership unclear.
OJIBWAY PARK (EO 115386)				**10 stems**	
Ojibway Park	City of Windsor	2014 – 10 stems (M. Oldham)	2014	10 stems (M. Oldham)	

SITE NAME	OWNERSHIP	PREVIOUS RECORDS (most, but not all)	YEAR of most recent observation	2011-2014 ABUNDANCE (#stems)	COMMENTS
HISTORICAL POPULATIONS					
Trout Creek (EO 13044)	Unknown	1991 – 3 stems (D. Sutherland) 1997 – not found (D. White)	1991	-	Possibly overlooked in 1997 (COSEWIC 2000)
Wasaga Beach Provincial Park (EO 5506)	Provincial Park	1975 – 6 plants (Van Stam and T. Reznicek) 1989 – not found (D. Brunton) 1991 – not found (B. Bowles *et al.*) 1992 – not found (B. Bowles *et al.*) 1995 – observed (NHIC database) 1995 – not found (M. Oldham *et al.*) 2000 – not found (B. Bowles *et al.*) 2001 – not found (B. Bowles *et al.*)	1995	-	Opinion differs over the likelihood of rediscovering the species at this site.
EXTIRPATED SUBPOPULATIONS					
Niagara Parks System (EO 92208)	Unknown	None	1895	-	Observation; Exact location unknown.
Simcoe (EO 5504)	Unknown	None	1949		Collection; Exact location unknown.
Fort Erie (EO 5505)	Unknown	None	1863		Collection; Exact location unknown.
Hamilton (EO 5507)	Unknown	None	1886		Collection; Exact location unknown.
Baysville, Muskoka District (EO 5511)	Unknown	None	1904	-	Collection; Exact location unknown.
Parc national d'Oka, Quebec (EO 5702)	Provincial Park	1992 – 2 stems (Sabourin *et al.*) 2000 – 1 stem 2002 – not found 2006 – not found	2000	-	Considered likely to have been introduced. Considered extirpated due to absence despite searches. Habitat is present and reasons for disappearance are unknown.

Extent of Occurrence and Area of Occupancy

The index of area of occupancy (IAO) and the extent of occurrence (EOO) were not calculated for the previous status report (COSEWIC 2000). Therefore, past and current values have been calculated for this report. All were calculated by the COSEWIC Secretariat based on the best available data provided by provincial Conservation Data Centres—the IAO is based on using a 2 km x 2 km grid.

For the current IAO and EOO, only currently extant subpopulations (2012-2014) were included in calculations (see Table 1).

For the 2000 IAO and EOO, the two now-historical subpopulations (Wasaga Beach and Trout Creek) were included, because they would have been considered extant in 2000, based on NatureServe standards. The Quebec subpopulation was not included since it is presumed to have been introduced. Finally, all subpopulations and observations that have been newly documented since 2000 (e.g., Ojibway Park, Wainfleet) are also included in the 2000 calculations, even though they had not been observed at this time. This assumes that they were extant but undiscovered in 2000. Although it cannot be known whether this is true, it is considered a cautious approach.

Based on these assumptions, the current (2012-2014) IAO for Spotted Wintergreen in Canada is 28 km^2. The IAO for Spotted Wintergreen from 2000 is 36 km^2. These values indicate a decline of 22%.

The current (2012-2014) extent of occurrence (EOO) is 1,952 km^2. The EOO for Spotted Wintergreen from 2000 is 29,340 km^2. This represents a 93% decline in area. This large decrease in EOO reflects the loss (or probable loss) of the disjunct subpopulation in Wasaga Beach (see Figure 3, circle with ‘x’ east of Georgian Bay).

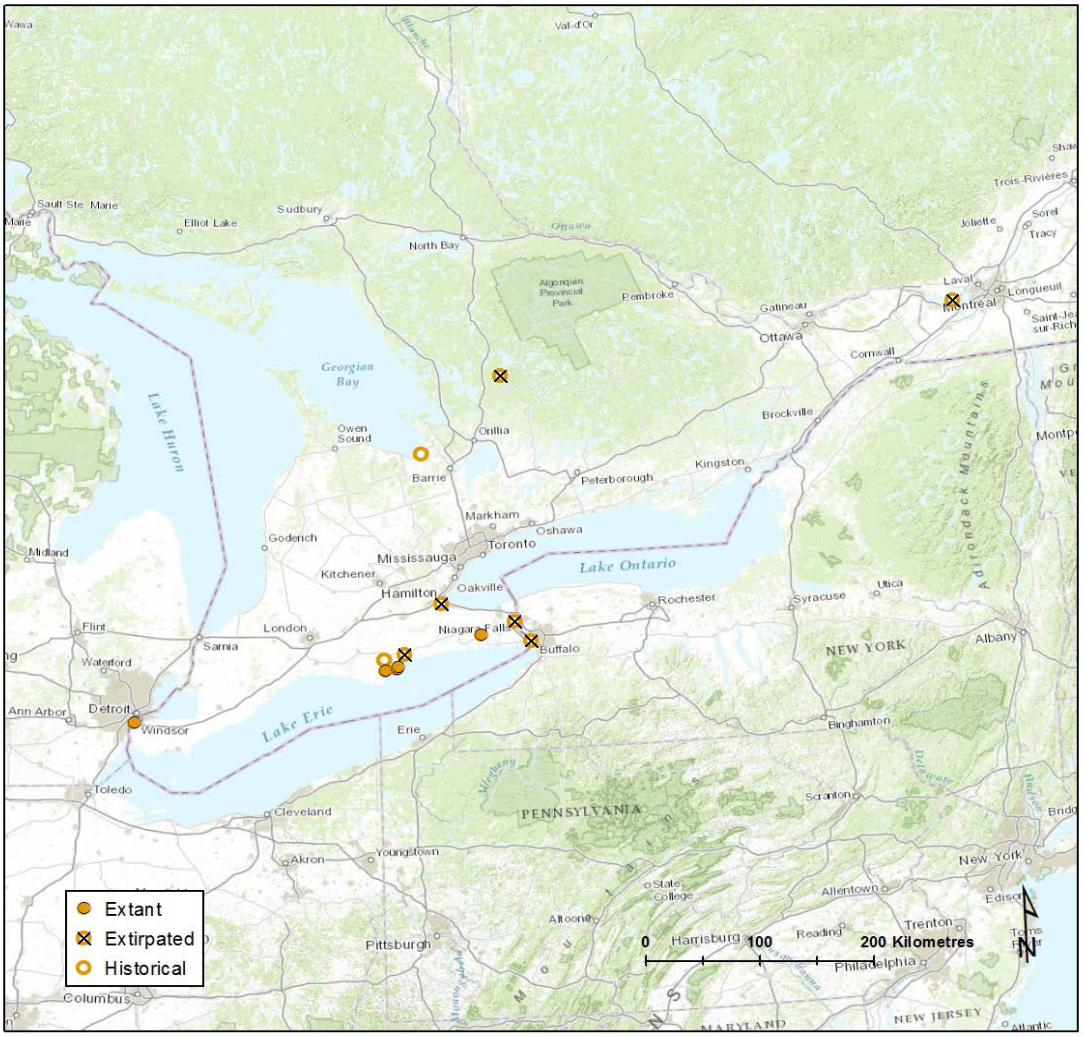

Figure 3. Subpopulations of Spotted Wintergreen in Canada. This figure shows all documented subpopulations in Canada to date. Sources: NHIC 2015, CDPNG 2015.

Search Effort

In preparation for this status report, 12 sites in four of the known subpopulations (Table 1) were visited by Melinda Thompson between August and October, 2012. Each site was searched for at least one hour, sometimes with multiple observers. Three additional sites in the Turkey Point and Fishers Glen subpopulations were surveyed by Ron Gould in 2012. Population data for one Turkey Point site (2011 survey) were provided by Sam Brinker and Mike Oldham. Survey information for Spooky Hollow ANSI (2011, 2013) was provided by the Hamilton Naturalists' Club. The estimated 2011-2013 search effort for this species is a minimum of 25 person-hours. The Windsor subpopulation was discovered by Paul Pratt in June 2014.

Several sites, especially within the Turkey Point area, are newly reported in this status report, and reflect substantial increased survey effort over the past decade. Since the last status report, Spotted Wintergreen habitat in the Turkey Point and St. Williams area has been surveyed as a result of local conservation initiatives (e.g., White 2012). It is not possible to quantify this search effort, which has not focused exclusively on Spotted Wintergreen.

Over the past century, many of the remaining natural areas in southwestern Ontario, including the Ojibway Park area, have been well surveyed botanically. The recent discovery of two subpopulations at sites where Spotted Wintergreen was not previously known is somewhat unexpected.

Historical sites (Wasaga Beach and Trout Creek) were not surveyed in preparation for this status report, due to time limitations and the fact that these sites had previously been searched by others unsuccessfully. Searches for Spotted Wintergreen have been undertaken in the Wasaga Beach area by Dan Brunton in 1988 (Brunton 1989), Bob Bowles and others in 1991, 1992, 2000, and 2001 (Bowles 2001). A 1995 observation in Wasaga Beach Park by Heather Stewart was not relocated by Mike Oldham, Wasyl Bakowsky, and Don Sutherland. In the 2001 season, Bowles (2001) and several other botanists comprehensively searched three sites in the Wasaga Beach area and concluded that there were no plants present. Since 2001, Ontario Parks staff have occasionally surveyed the area without locating any plants (Chambers pers. comm. 2015). Still, habitat probably exists at both of the historical sites, and it remains possible that plants could be found there (Oldham pers. comm. 2015). The Trout Creek subpopulation has not been visited since 1997, and nothing is known of its status. Because of the elapse of time, this subpopulation is considered “extirpated” by the NHIC and in the federal recovery strategy for the species (Environment Canada 2015). This may be the case; however, here it is considered “historical” since habitat has not been recently surveyed.

Considering the broad distribution of all documented records from Windsor to Muskoka and potentially into western Quebec, it is possible that other suitable but unsurveyed areas exist, particularly in southcentral Ontario.

HABITAT

Habitat Requirements

Throughout its range, Spotted Wintergreen typically occurs in pine or oak-pine mixed forest and woodland habitats (NatureServe 2015). In Canada, recent and available field observations have confirmed that the species is a woodland understorey species typically associated with dry–fresh oak and oak-pine mixed forests and woodlands (Ursic *et al.* 2010). These communities typically have semi-closed canopy conditions with an overstorey of Eastern White Pine (*Pinus strobus*), Red Oak (*Quercus rubra*), Black Oak (*Quercus velutina*), and American Beech (*Fagus grandifolia*), and a groundcover layer of Common

Pipsissewa, Partridgeberry (*Mitchella repens*), Wild Lily-of-the-valley (*Maianthemum canadense)*, Bracken Fern (*Pteridium aquilinum*) and Wild Sarsaparilla (*Aralia nudicaulis*). Several patches occur within or on the edges of old plantations consisting of Red Pine (*Pinus resinosa*) or Eastern White Pine, especially at St. Williams' Conservation Reserve (Thompson pers. obs. 2012; Heagy pers. comm. 2015).

Spotted Wintergreen subpopulations appear to occur in sites with a relatively narrow (and acidic) pH range, although site-specific information on pH levels is not available. The species prefers an average soil pH below 6 (Eastman 1976; Kirk 1987).

Based on the available information (Ursic *et al.* 2010), key habitat characteristics for Spotted Wintergreen include:

- Association with natural or artificial (i.e., plantations) dry to fresh oak-pine or oak dominated forests and woodlands
- Limited presence of other groundcover species
- Partial shade
- Acidic surface soil conditions (soil pH 4.2 to 6.0)
- Well-drained soils and sites
- Nutrient poor soil conditions

Spotted Wintergreen appears to prefer partially shaded conditions. In North Carolina, Fraver (1994) found that *C. maculata* increased in percent cover within 10 x 10 m plots towards the edge of an edge-to-interior gradient within deciduous forests. The related Common Pipsissewa reportedly persists in dense shade, but with reduced flowering and fruit-set, and an increase in clonal propagation (Lundell *et al.* 2015). Plants in dappled as opposed to deep shade appear to bear more flowers (Heagy pers. comm. 2015). There is speculation that canopy closure may have contributed to the decline of one site in the St. Williams Forest subpopulation, although the threshold at which declines may occur is unknown. Further study of light tolerance will be completed at St. Williams Conservation Reserve in 2016 (Heagy pers. comm. 2015).

Spotted Wintergreen probably does not tolerate fire well, although it may benefit from the effects of fire. In a Tennessee study, Zimmerman (2006) found that *C. maculata* did not persist following prescribed burns at his six study sites. Two related pyroloid species (*Chimaphila menziesii, Pyrola picta*) reportedly disappeared from plots following prescribed fires in a mixed conifer forest in California (Rocca 2009). Studies in the United States have shown that both *C. menziesii* and *C. umbellata* have a moderate to high probability of being killed by fire (Matthews 1994a,b). To date, Spotted Wintergreen has been successfully protected from prescribed burns undertaken at Turkey Point and St. Williams Conservation Reserve. In managed restoration areas of Norfolk County (e.g., Turkey Point Provincial Park and St. Williams), the management approach is to protect Spotted Wintergreen from prescribed burns (Gould pers. comm. 2015).

Spotted Wintergreen is a partial mycoheterotroph, meaning that it depends on the presence of soil mycorrhizae to germinate, develop, and possibly to persist in shaded conditions (see Physiology and Adaptability, below).

Habitat Trends

Canadian subpopulations of Spotted Wintergreen are situated in areas where sufficient habitat for natural expansion is available in the adjacent environment. Dry-fresh oak and oak-pine mixed forests and woodlands are not uncommon within the species' range in Ontario, although several of the areas with suitably sandy substrate have been converted to agriculture or plantation. One subpopulation (Ojibway Park) is surrounded by urban development and is limited in extent.

BIOLOGY

Several aspects of the biology of Spotted Wintergreen remain unclear, including the relative contribution of clonal spread versus recruitment through seeds. Mycorrhizal associations also appear to be important for this species, as they are for many members of the Ericaceae (Massicotte *et al.* 2008; Johansson and Eriksson 2013).

Life Cycle and Reproduction

In southern Ontario, Spotted Wintergreen flowers in mid-July for approximately 17 days. Fruiting tends to occur in August with the capsule splitting and releasing its abundant seeds, many of which persist in the capsule into the next spring (Kirk 1987; Ursic *et al.* 2010).

As is the case for many clonal plants of the forest understory, there is no information on the generation time of Spotted Wintergreen or related taxa. At a minimum, flowering individuals are probably at least 2-3 years old. However, in clonal plants, genets continually produce new ramets from underground rhizomes and older ramets senesce. Using recent molecular methods, genet longevity in many tree and shrub species has been found to be significantly greater than previously thought. In some clonal shrubs, genet age may range from decades to even thousands of years (de Witte and Stöcklin 2010). Generation time, or the average age of a mature reproductive individual, may be averaged in clonal taxa to account for both asexually and sexually reproducing individuals in the population (IUCN 2010). Generation time for Spotted Wintergreen can be conservatively estimated at a decade, although it could be substantially longer.

The pollination biology of Spotted Wintergreen has been examined by Standley *et al.* (1988), who studied sympatric populations of Spotted Wintergreen and Common Pipsissewa in a Massachusetts deciduous forest. This study found that the species partially overlap in flowering time (with different peaks in early to mid-July), and are both visited primarily by bumble bees (*Bombus* species). In this study, Spotted Wintergreen was visited primarily by Confusing Bumble Bee (*Bombus perplexus*), while Common Pipsissewa was

visited by Two-spotted Bumble Bee (*B. bimaculatus*), Half-black Bumblebee (*B. vagans*) and Confusing Bumble Bee. Many of the northern European Pyrolaceae are primarily buzz-pollinated by *Bombus* species, although evidence is conflicting whether plants in the genus *Chimaphila* are among these (Knudsen and Oleson 1993). No studies have been found that have investigated this question.

Standley *et al.* (1988) report that Spotted Wintergreen is self-compatible, but pollinator exclosures revealed that they require pollinators for seed set (i.e., they do not regularly self fertilize).

Physiology and Adaptability

Seeds of species in the tribe Pyroleae (family Ericaceae) are described as “dust seeds” containing minimal nutrient reserves, and, as with orchids, ultimately dependent on fungal symbionts for germination and seedling development (Johansson and Eriksson 2013). Evidence of colonization of roots by fungal mycorrhizal associates has been found in several other members of this tribe, and individual species of ectomycorrhizal fungi are known from several pyroloids, including the congeneric Common Pipsissewa (Zimmer *et al.* 2007; Massicotte *et al.* 2008). It can be presumed that Spotted Wintergreen also hosts mycorrhizal associates, although the fungal species remains unknown.

Fungal symbionts likely contribute to nutrient exchange for the developing embryo, and also provide an additional source of nutrition for mature photosynthetic green plants. It has been demonstrated that several pyroloid species from both North America and Europe can gain nitrogen and, to a lesser degree, carbon via mycorrhizal fungi (Tedersoo *et al.* 2007; Zimmer *et al.* 2007). The ability to obtain organic nitrogen and carbon through symbionts apparently allows these species to supplement energy provided through photosynthesis, and therefore to tolerate the low levels of sunlight of a shaded forest understorey (Zimmer *et al.* 2007). It has been proposed that root fungi, particularly ectomycorrhizal fungi, could also link these species to carbon flows from surrounding trees (Tedersoo *et al.* 2007).

Despite the possible advantages conferred by this partial mycotrophic strategy, pyroloids may also be more sensitive to disturbances, such as logging, anthropogenic nitrogen deposition, or non-native earthworm invasion, which can alter mycorrhizal fungal composition in soils (Hale *et al.* 2006; Zimmer *et al.* 2007). In general, mycotrophs have been shown to be sensitive to disturbances, in part because they rely on specific microhabitat features, such as deep litter layers and moisture levels (Halpern and Spies 1995; Lindh and Muir 2004).

Both Spotted Wintergreen and the related Common Pipsissewa are known to be difficult to propagate from seed (Cullina 2000; Pengelly and Bennett 2011), perhaps owing to their association with fungal mycorrhizae.

Dispersal and Migration

Spotted Wintergreen is capable of reproducing either vegetatively, or from seed (Standley *et al.* 1988). Determining the precise number of clones or individuals within a subpopulation would require excavation or genetic analysis, which has yet to be done for this species. Clumps can consist of few to several hundred stems, so a subpopulation consisting of several hundred stems represents an unknown number of genetic individuals (Standley *et al.* 1988).

The tiny seeds of pyroloids are likely dispersed by wind, and possibly by rain, as the dehisced capsules are appropriately shaped for splash-cup dispersal of seeds (Amador *et al.* 2013). Although the Canadian population flowers and produces seed regularly, it has been hypothesized that low seed viability and dispersal must be limiting intrinsic factors to population growth, because unoccupied habitat is readily available at most extant sites (Kirk 1987). It is also possible that other, poorly understood factors (e.g., the presence of mycorrhizal fungi) limit germination and establishment.

Interspecific Interactions

As described above, Spotted Wintergreen probably depends on mycorrhizal associates, although the species and nature of the association remains unclear (Boullard and Ferchau 1962; Largent *et al.* 1980; Massicotte *et al.* 2008).

Spotted Wintergreen is likely mainly pollinated by bumble bees (Standley *et al.* 1988). Recent widespread declines in abundance of common bumble bee species have been observed throughout North America (Williams *et al.* 2014). The potential effect of this on Spotted Wintergreen pollination is not known.

Although Common Pipsissewa is known to share Spotted Wintergreen's range and habitat, even to a microsite level, the two species do not interbreed. It is unclear whether or not the more common species is capable of competitively excluding Spotted Wintergreen (Standley *et al.* 1988). There are no known herbivores or seed predators for Spotted Wintergreen, though some have been suggested (Ursic *et al.* 2010).

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Each subpopulation was visited for a minimum of one hour during the preparation of this report. Where previously reported plants could not be located, an additional hour was spent searching on a separate day. Stems were counted at all subpopulations. No information was collected on the number or proportion of stems that were flowering; many sites were visited outside the flowering period. At this time, there is no information available to estimate the number of mature individuals this represents.

In the past, reliable, accurate, and current census information on subpopulations of Spotted Wintergreen was incomplete or lacking. Inconsistencies in survey methods as well as the naming and geographical referencing of subpopulations prevented comparative analyses of trends. Recent improvements in quality and frequency of searches have improved the knowledge of the species and enabled a better understanding of the population trends at each extant location.

Abundance

The current known distribution of Spotted Wintergreen in Canada consists of five extant subpopulations in Ontario (Figure 3) that support a minimum of 3600[5] stems (Table 1). The total number of mature individuals is not known, but is probably less than this number by an unknown factor. Many, but not all, of these stems (ramets) may flower and become reproductive,[6] although they may also be part of the same genetic individual. No data are available on the percentage of reproductive stems during 2012-2013 surveys. The mean number of stems per genetic individual has not been estimated for Spotted Wintergreen.

Recent discoveries (2010-2016) at St. Williams Conservation Reserve will likely increase this total. Several new sites have been identified at St. Williams during 2014 and 2015 fieldwork (Heagy pers. comm. 2015, 2016). These are considered as new sites within existing subpopulations at St. Williams and Turkey Point. In 2016, most previously known patches were found, and new patches continue to be located (Heagy pers. comm. 2016).

Of the five extant subpopulations (=EOs), the three found in Norfolk County (St. Williams Forest, Turkey Point area, and Fishers Glen area) constitute almost the entire Canadian population. Only 15 stems have been reported between the other two extant subpopulations (i.e., Perry Road Woodlot in Niagara Region, and Ojibway Park in Windsor).

Based on thorough fieldwork, Bowles (2001) concludes that the Wasaga Beach subpopulation, including one well-documented site and two credible reports, is likely no longer extant. He suggests that this could be due to successional changes in the habitat. Opinion differs on the likelihood of rediscovering Spotted Wintergreen at Wasaga Beach. Although some habitat is present at both historical subpopulations, plants have only ever been observed in small number (i.e., fewer than 10 plants each), and even their rediscovery is unlikely to significantly change the total Canadian abundance.

Fluctuations and Trends

It is difficult to quantify trends in abundance with confidence. Most early counts (pre-2000) refer to “plants” rather than “stems,” and may not be comparable with later surveys. Survey effort has also increased, especially in Norfolk County.

[5] The total has been rounded to reflect uncertainty, especially in estimates of larger patches.
[6] I.e., become reproducing units, according to the COSEWIC definition.

Totals for the Canadian subpopulations were not provided in previous status reports (Kirk 1987; COSEWIC 2000) due to limited survey data, but they were certainly much lower (i.e., a few hundred “plants”). In the more recent Ontario Recovery Strategy, Ursic *et al.* (2010) report approximately 2700 stems, based on 2007 surveys of a similar number of subpopulations (excluding Turkey Point Provincial Park and the Windsor subpopulation).

A review of stem counts at all subpopulations (see Table 1) also suggests that the Canadian population has increased somewhat since about 2000, when more detailed and standardized counts became available. Although some sites have not been relocated in recent surveys, abundance at others, such as the Nursery Tract at St. Williams Forest, appears to have substantially increased since 2000. The reasons for this are not known, but could be related to increased light penetration at some sites. This may be the result of any of several factors, including canopy thinning, prescribed burning, defoliation by European Gypsy Moth (*Lymantria dispar dispar*), and the establishment of the Emerald Ash Borer (*Agrilis planipennis*) (Gould pers. comm. 2015). Substantial increases in stem counts at one site (Nursery Tract) have followed the closure of ATV and horse trails to the area.

Two subpopulations, and several new sites within the other three subpopulations, have been discovered since the 2000 status report. This should be interpreted cautiously. Although it is possible that these sites have become established and that the population of Spotted Wintergreen is increasing, most recent discoveries probably reflect increased survey effort and reporting, particularly in Norfolk County. Some are probably rediscoveries of older records, thought to be extirpated. The recently discovered Ojibway Park subpopulation in Windsor is one exception. This well-known natural area has been extensively botanized over many decades, and the discovery of a fairly conspicuous species next to a trail was unexpected. It is possible that this subpopulation was recently established (Oldham pers. comm. 2015).

The Parc national d’Oka site in Quebec is newly reported in this status report. This subpopulation consisted of one plant (two stems) when it was discovered in 1992. Following unsuccessful surveys in 2002 and 2006, it is now presumed extirpated. The cause of the disappearance is unclear, because suitable areas of habitat remain, and threats are believed to be low (Centre de données sur le patrimoine naturel du Québec 2015). It is considered likely to be an unsuccessful introduction.

The Canadian population of Spotted Wintergreen does not exhibit “extreme fluctuations” in population abundance.

Across the species’ American range, populations are apparently relatively stable, with no major declines reported (NatureServe 2015). In the adjacent northern states of Maine and Vermont, populations appear to be increasing, with recent new reports; however, Spotted Wintergreen may also have been under-reported in the past (Cameron pers. comm. 2015; Popp pers. comm. 2015).

Rescue Effect

The likelihood of natural colonization of Spotted Wintergreen from the United States is possible, especially in extreme southwestern Ontario. The species has been reported from three counties in adjacent Michigan (Reznicek *et al.* 2011), within perhaps 50-100 km of the newly discovered Windsor site. Although dust seeds are able to remain airborne for long periods of time, and may travel long distances, the vast majority are deposited within a few metres of the seed source (Arditti and Ghani 2000; Johansson *et al.* 2014). It is plausible that the Windsor subpopulation may have become established recently from an U.S. source.

Other populations in the United States occur more distantly to the south, across lakes Erie and Ontario. Spotted Wintergreen has been documented in northern Ohio (SNR, not ranked) and New York (S4, apparently secure) (NatureServe 2015). Sites in Vermont and Maine are restricted to the southern portions of these states, at least 200 km from Quebec (Kartesz 2015; Popp pers. comm. 2015).

THREATS AND LIMITING FACTORS

The IUCN threats calculator (Master *et al.* 2012) was used to assess threats to Spotted Wintergreen (Appendix 1). The threats calculator method consists of scoring the scope, severity, and timing for each standard threat category; the overall threat impact is then computed from these ratings.

The assigned overall threat impact for Spotted Wintergreen is Medium – Low. The combination of two separate Low impact threats and two Medium – Low impact threats resulted in an overall calculated threat impact of High – Medium. However, because each of the threat impacts was deemed to be at the low end of the range, this calculated rank was adjusted to Medium – Low (Appendix 1).

Headings in the following narrative correspond to categories or subcategories of the threats calculator, in the approximate order of their perceived importance.

Threats

Recreational Activities (6.1)

Disturbance associated with recreational activities probably constitutes the main threat to Spotted Wintergreen. This includes impacts from ATV use, mountain biking, horseback riding, and hiking. The majority of sites are located on public land. Several of these (e.g., sites in St. Williams Conservation Reserve and at Turkey Point Provincial Park) are accessible to ATVs and/or mountain bikes, and several patches lie in close proximity to active trails (Gould pers. comm. 2015). Similar threats by ATV use have been noted in past reports (Kirk 1987; COSEWIC 2000; White 2010). Kirk (1987) noted that ATV use may have resulted in the extirpation of the Simcoe subpopulation. One Turkey Point site was not relocated in 2012, and may have been lost to ATV use (Thompson pers. obs. 2012).

The risk to Spotted Wintergreen and other species at risk within the St. Williams Conservation Reserve and Turkey Point Provincial Park is decreasing, as unauthorized trails are closed and rehabilitated, and monitoring has increased (Gould pers. comm. 2015; Heagy pers. comm. 2015). Still, it is difficult to monitor and enforce trails in such a large area with significant recreational pressure, and closing trails has proven difficult (Gould pers. comm. 2015). Many sites (e.g., in St. Williams, Turkey Point, Ojibway Park) are near walking trails and could be affected by trampling or soil compaction.

Problematic Native Species (8.2)

Abundant native species such as White-tailed Deer (*Odocoileus virginianus*) and reintroduced Wild Turkey (*Meleagris gallopavo*) may browse or excavate populations of Spotted Wintergreen. Recently, a patch of Spotted Wintergreen disappeared overnight at the Spooky Hollow site and is thought to have been browsed by White-tailed Deer. An exclosure has since been placed over the patch, which has effectively protected the small population (Beck pers. comm. 2016). Foraging by Wild Turkey has caused forest floor disturbance at the St. Williams site (Gould 2001). Scratching and uprooting behaviour of Wild Turkeys could damage rhizomes of Spotted Wintergreen (Gould pers. comm. 2015), although direct evidence of this has not been observed.

Fire and fire suppression (7.1)

The suppression of fire, and resulting natural succession leading to shaded conditions, may threaten Spotted Wintergreen. Shadier sites appear correlated with decreases in flowering in Common Pipsissewa, and natural succession is implicated in its decline in Europe (Lundell *et al.* 2015). Some Ontario Spotted Wintergreen sites at a later successional stage (e.g., Fisher's Glen) may not be thriving; observations over 15 years in Ontario suggest that Spotted Wintergreen colonies often benefit when light levels increase, such as following localized blowdowns or canopy defoliation (Gould pers. comm. 2015). Still, colonies of Spotted Wintergreen appear to persist for long periods of time at shadier sites and are able to reproduce vegetatively. The effects of light levels and/or natural succession on Spotted Wintergreen have not been studied.

Due to the accumulation of thick leaf litter, high-intensity natural wildfire can break out in areas where fire has previously been suppressed. Such high-intensity fires may also threaten this species, because it is not believed to be fire-tolerant (Zimmerman 2006; Gould pers. comm. 2015).

Residential & commercial development (1)

Although widespread land clearance has occurred within this species' range in the past, loss of habitat to land development or agriculture is probably now a minor threat. Most extant sites are found on land that is either publicly owned, or owned by conservation organizations, and guided by management plans. These are protected in varying degrees from development. Two sites are believed to be privately owned (Table 1). Either site could be inadvertently destroyed, especially if owners are unaware of the presence of the species on the property.

Logging and Wood Harvesting (5.3)

Forestry was probably a significant threat in the past. In New England, Duguid *et al.* (2013) found that *C. maculata* abundance declined following timber harvest and soil scarification within study plots. It has been shown that the related Common Pipsissewa and two other mycotrophs decreased in frequency following forest thinning treatments (Davis and Puettman 2015). Logging occurred at one of the two privately owned sites about a decade ago, and Ontario Ministry of Natural Resources and Forestry (OMNRF) district office staff were consulted to ensure protection of the Spotted Wintergreen population (Gould pers. comm. 2015). Although no formal monitoring has occurred, the number of stems observed at this site appears to have remained constant.

Invasive species (8.1)

Few invasive plant species have been reported from Spotted Wintergreen habitat (Thompson pers. obs. 2012; Oldham pers. comm. 2015). One newly discovered site at St. Williams Conservation Reserve occurs underneath a large and spreading patch of Little-leaved Linden (*Tilia cordata*). Other invasive species near some Norfolk County sites include Spotted Knapweed (*Centaurea stoebe* ssp. *micranthos*), Multiflora Rose (*Rosa multiflora*), and Garlic Mustard (*Alliaria petiolata*) although to date these have not invaded occupied Spotted Wintergreen habitat (Gould pers. comm. 2015; Heagy pers. comm, 2015).

Non-native, invasive insects may have an effect on Spotted Wintergreen, although it is not clear whether this constitutes a threat. Changes in forest light levels, caused by the death of ash trees due to the Emerald Ash Borer and defoliation by the European Gypsy Moth, may be beneficial at some shaded sites, but detrimental in other cases (Gould pers. comm. 2015). Hemlock Woolly Adelgid (*Adelges tsugae*) has also been found to result in losses of Spotted Wintergreen in North Carolina (Ford *et al.* 2012). Although not yet present in Spotted Wintergreen range, Hemlock Woolly Adelgid has been found in southern Ontario and is expected to spread (Canadian Forest Service 2013).

Garbage and Solid Waste (9.4)

Garbage dumping has been observed at the Wainfleet site (Ursic *et al.* 2010), and sometimes occurs along trails and roadsides in St. Williams Conservation Reserve (Heagy pers. comm. 2016). Unauthorized dumping could occur at any site, regardless of ownership. Although such degradation may be localized, several subpopulations occupy only a few square metres, and elimination of an entire subpopulation is possible.

Other Ecosystem Modifications (7.3)

Almost all Spotted Wintergreen sites are now on land managed for conservation purposes. In particular, the former St. Williams provincial tree nursery, largely consisting of plantation pine, is now managed as a Conservation Reserve, and is being restored to oak-pine savanna habitat through thinning of plantation pines. Restoration work is guided by biologists with expertise in vegetation management following a management plan, and the maintenance and/or restoration of Species at Risk habitat is a primary consideration (White 2010). Currently, thinning does not occur within 30 m of Spotted Wintergreen habitat. In 2016, surveys of extant Spotted Wintergreen sites will be used to develop management recommendations to guide future plantation thinning and oak savanna restoration (Heagy pers. comm. 2015). In contrast to Logging and Wood Harvesting, and Wildfire, habitat management techniques such as canopy thinning and prescribed burning are not believed to threaten Spotted Wintergreen because their use is carefully controlled and monitored.

Climate Change (11)

Climate warming may affect this species, although it is uncertain whether this will have a positive or negative effect on Spotted Wintergreen. In an experimental study in North Carolina, Marchin (2014) found that a 2°C summer warming resulted in reproductive failure in Spotted Wintergreen. Probable effects of climate change, such as elevated CO_2 levels, drought, and increased temperatures, can also alter the abundance of mycorrhizal fungi and their interactions with host plants in a variety of ways (Drigo *et al.* 2008; Compant *et al.* 2010). However, Spotted Wintergreen ranges into Central America. Several new reports of Spotted Wintergreen in Ontario, Vermont, and Maine suggest that it is not currently decreasing at the northern edge of its range and may be increasing (Cameron pers. comm. 2015; Popp pers. comm. 2015).

Potential and Speculative Threats

Because mycorrhizal fungi appear to be an obligate associate of pyroloid species, pollution that changes fungal composition and abundance could have an impact on associated vascular plants. Pyroloid plants are known to be sensitive to increases in atmospheric nitrogen deposition, which is associated with a reduction in fungal diversity (Wallenda and Kotke 1998). Other forms of pollution have been found to alter the diversity and species composition of forest mycorrhizal fungi (Arnolds 1991; Peter *et al.* 2001). It is unknown whether this affects Canadian subpopulations.

Non-native earthworms are considered invasive across eastern North America and have been shown to have considerable impacts to the forest understory and plant composition (Hale *et al.* 2006, 2008). It is possible but unknown whether earthworms are present in the dry forest and woodland habitats where Spotted Wintergreen has been found.

Although there has been evidence of collection in the past (White 1998 cited in Ursic *et al.* 2010), it is not currently considered to be a significant threat (Gould pers. comm. 2015). No evidence of collection has been observed for many years, despite detailed work on the species, and the market value of this species as a medicinal plant is reportedly low (NatureServe 2015).

Limiting Factors

Spotted Wintergreen's dependence on fungal hosts to complete germination and development may limit populations, especially the establishment of new colonies. For the related Common Pipsissewa and several other pyroloids, microsite availability was found to be an important limiting factor for plant recruitment (Johannson and Eriksson 2012).

Number of Locations

Several threats occur in the area occupied by this species, but the threat affecting the largest proportion of the population is likely fire. Recreation activities and impacts by deer and turkey are localized and are unlikely to rapidly affect a large proportion of the population. Although its overall impact is low based on a threat assessment, fire appears to be the most significant plausible threat. Although the number of forest patches where this species occurs are few, they all occur in a rural landscape, with some in Provincial Parks or Conservation Areas, so firefighting response is likely to be rapid. It seems reasonable to assume a limited area would be impacted in any one fire; how large an area is unknown. Because of the uncertainty involved, a range in the number of locations is probably appropriate.

For this report, Canadian "subpopulations" are considered to be synonymous with element occurrences[7]. The Ontario element occurrences have been recently re-analyzed (Craig pers. comm. 2015), and some subpopulations that were previously separate (e.g., several in Norfolk County, especially at St. Williams Forest and Turkey Point) have been consolidated. There are presently five extant element occurrences (EOs), with about 19 known sites overall. Note that this breakdown of EOs and subpopulations has been updated from those in previously published recovery strategies (Ursic *et al.* 2011; Environment Canada 2015).

[7] The element occurrence is a data standard developed by NatureServe to represent a consistent approach to the identification of subpopulations. For plants, element occurrences are based on their distance from one another (with the standard distance usually 1 km), and consider the suitability of habitat between them (NatureServe 2015).

Two of the EOs, Ojibway Park and Perry Road, each consist of only one patch of plants with a small number of individuals, so they comprise **two** locations. The other three EOs have multiple sites. The known sites within St. Williams Forest EO extend about 1.3 km north to south, and about 600 m east to west, with most of the subpopulation at one site. This EO could be considered **one or two** locations, as wildfire extending over a kilometre is possible but unlikely. The known sites at Turkey Point extend over 3 km east to west and about 2 km north to south. One site is separated from the others by over a kilometre (Turkey Point Tract F), so it could be one location. Using the assumption that a fire is unlikely to extend over several kilometres, the rest of this EO is two or more locations. Assuming two locations for Turkey Point, plus one for Turkey Point Tract F, results in **2-3** locations for the entire Turkey Point area. The Fishers Glen EO extends over 2.7 km east to west, with 1.7 km between two known sites. **Two** locations seem reasonable here, based on the distance between sites. The plausible range of locations for Spotted Wintergreen in Canada is considered to be **7-9** assuming that wildfire is the most significant plausible threat and making assumptions on fire response.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

Spotted Wintergreen was first assessed by COSEWIC in 1987 as Endangered. This status was re-examined and confirmed in 1998 and 2000. The species was listed on *Species at Risk Act* (SARA) Schedule 1 as Endangered in 2004. The species is also listed as Endangered in Ontario under the *Endangered Species Act, 2007*, and a provincial Recovery Strategy has been finalized (Ursic *et al.* 2010). Under the ESA, the species and its habitat in Ontario receive protection. A federal addition to the provincial recovery strategy has also identified critical habitat for this species under the federal SARA (Environment Canada 2015).

Non-Legal Status and Ranks

NatureServe (2015) ranks Spotted Wintergreen as G5 (secure; last reviewed in 2001). The species is ranked N5 (secure) in the United States and N2 (imperiled) in Canada. The species is ranked S2 (imperiled) in Ontario and SX (presumed extirpated) in Quebec. In the U.S., subnational ranks for Spotted Wintergreen include: S1 – critically imperiled (Illinois), S2 – Imperiled (Maine, Vermont and Mississippi), S3 – vulnerable (Indiana and Arizona), S4 – apparently secure (New York), and S5 – secure (New Jersey, Delaware, District of Columbia, Virginia, West Virginia, Kentucky and North Carolina). It is not ranked in the remaining 13 states in which it occurs.

Habitat Protection and Ownership

Of the five extant subpopulations, four are found entirely or mostly on publicly owned lands (i.e., Crown Land, Provincial Parks or Conservation Areas). These areas are protected from development, although they may be subject to numerous other disturbances including ATV use and trampling. A portion of the Turkey Point subpopulation (Normandale site) is privately owned and is operated as a children's summer camp. The Niagara Region subpopulation occurs on private land, which could be subject to development.

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- Mike Oldham, Botanist, Natural Heritage Information Centre, OMNRF
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BIOGRAPHICAL SUMMARY OF REPORT WRITERS

Holly Bickerton is a biologist with over 15 years of experience in southern Ontario. Holly holds a BASc from McMaster University and a Masters in Environmental Studies from York University. She has worked in ecology and species at risk 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. Holly conducts flora and fauna inventories, vegetation mapping, invasive species assessments, ecological monitoring, and policy research. She has previously authored two COSEWIC status reports, and many other documents on rare and at-risk species.

Melinda Thompson has completed a Master's thesis on Bird's-foot Violet (*Viola pedata* L.), examining optimal microhabitat characteristics in Ontario tallgrass prairie remnants. In addition to completing her MSc, she has been involved in numerous Species at Risk projects with the Ontario Ministry of Natural Resources as a Species at Risk Biologist. Over the past 13 years, she has authored or co-authored reports related to species management and recovery in Ontario and Canada for 9 different plant species. She sits on several Recovery Teams, and has extensive experience working with rare species in Ontario.

COLLECTIONS EXAMINED

No collections were examined in the preparation of this report.

Appendix 1: Threats Classification Table for Spotted Wintergreen.

THREATS ASSESSMENT WORKSHEET

Species or Ecosystem Scientific Name	Spotted Wintergreen
Element ID	**Elcode**
Date:	07/03/2016
Assessor(s):	Del Meidinger (co-chair), Kristiina Ovaska (Facilitator), Holly Bickerton (author), Karen Timm and Joanna James (Secretariat), Sean Blaney, Andy MacKinnon, Joyce Gould, Melinda Thompson, Audrey Heagy, Mike Oldham, Jenny McCune
References:	Draft COSEWIC status report (Feb 2016) (prepped by co-chair)

Overall Threat Impact Calculation Help:

		Level 1 Threat Impact Counts	
Threat Impact		**high range**	**low range**
A	Very High	0	0
B	High	0	0
C	Medium	2	0
D	Low	2	4
	Calculated Overall Threat Impact:	High	Medium

Assigned Overall Threat Impact:	**CD = Medium - Low**
Impact Adjustment Reasons:	Each major threat at low end of range, so adjusted downward.
	Generation time unknown; at least 10 years (Note: depending on how mature individuals are considered, generation time could be calculated differently. For purposes for this call, the group considered 10 years as the generation time.). From Recovery Strategy: Although many threats to this species have been suggested, there has been little documentation or research on their effects on the Spotted Wintergreen subpopulations in Canada (Ursic et al. 2010). With so little empirical evidence on the threats affecting Canadian subpopulations, it is difficult to determine which of these represent the primary threats, or whether they can be adequately avoided or mitigated. Over 60% of subpopulations ever reported in Canada are now considered extirpated; in most cases, the reasons for the declines are unclear.
	5 extant subpopulations (proportion of stems): St. Williams Forest (57.4%), Turkey Point (25.9%), Fishers Glen (16.2%), Perry Road (0.1%), Ojibway Park (0.3%)

	Threat	Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & commercial development	D	Low	Small (1-10%)	Serious - Slight (1-70%)	Moderate (Possibly in the short term, < 10 yrs)	

	Threat	Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1.1	Housing & urban areas	D	Low	Small (1-10%)	Serious - Slight (1-70%)	Moderate (Possibly in the short term, < 10 yrs)	Two private sites are 4.8% of population. Severity is variable, depending upon activity. Timing is possible but not necessarily ongoing. Sites are mostly rural and the one site close to a development is an occasionally used camp. If camp sold, could be developed, especially along lakeshore. NOTE Scope is closer to the 1% range of this estimate.
1.2	Commercial & industrial areas						
1.3	Tourism & recreation areas						
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						
4.2	Utility & service lines						
4.3	Shipping lanes						
4.4	Flight paths						
5	Biological resource use		Negligible	Negligible (<1%)	Serious - Slight (1-70%)	Moderate (Possibly in the short term, < 10 yrs)	
5.1	Hunting & collecting terrestrial animals						
5.2	Gathering terrestrial plants		Negligible	Negligible (<1%)	Serious - Slight (1-70%)	Moderate (Possibly in the short term, < 10 yrs)	Evidence of collection in past; not considered a current threat. Showy attractive plant but difficult to cultivate.

	Threat	Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
5.3	Logging & wood harvesting		Negligible	Negligible (<1%)	Unknown	High (Continuing)	Scope is perhaps negligible as <5% private but one of these logged in past 10 years. Impact of logging 10 yrs ago negligible. It is possible that selective harvest is not a threat, but in fact opens the canopy and can stimulate flowering. It has not been demonstrated, and this is why SWCR follows a recommendation not to thin within 30m. May be beneficial and promote flowering (western spp. have an alternate mode & don't necessarily benefit). A study by Jenny McCune that looked at predicted sites to see whether Spotted Wintergreen was there or not found that sites without plants were associated with high shrub cover of species that respond to increased light (spicebush and *Sambucus*). Canopy gaps created by logging may have adverse effects due to increased shrub cover, but this is speculative at this point. One area is in a woodlot, also logging may occur on private lands. Church camp site is aware of the species and did not mention any logging plans summer 2016. Wainfleet site is also aware of the plant. NOTE: thinning for conservation at St. Williams will be considered under 7.3. Further prescribed burns at this location will be considered under 7 as well.
5.4	Fishing & harvesting aquatic resources						
6	Human intrusions & disturbance	CD	Medium - Low	Restricted (11-30%)	Moderate - Slight (1-30%)	High (Continuing)	
6.1	Recreational activities	CD	Medium - Low	Restricted (11-30%)	Moderate - Slight (1-30%)	High (Continuing)	Impacts from ATV use, mountain biking, horseback riding and hiking. Plant is small; there is potential from mortality from some of these activities, although many sites are away from trails. Risk decreasing where unauthorized trails closed and rehabilitated--but closure not always successful. Scope is potentially large but severity unknown--used range. St Williams: some plants close to trails at some sites. One site at Ojibway park is within 1m of the trail. If there is mowing or any modifications to the trail, e.g., widening, this would have impacts.
6.2	War, civil unrest & military exercises						
6.3	Work & other activities						Research activities were discussed but as overall impacts very low to neutral, it was not scored.

	Threat	Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
7	Natural system modifications	D	Low	Restricted - Small (1-30%)	Moderate - Slight (1-30%)	High (Continuing)	
7.1	Fire & fire suppression	D	Low	Restricted - Small (1-30%)	Moderate - Slight (1-30%)	High (Continuing)	Wildfires and fire suppression and subsequent increased shading may impact colonies; however, vegetative reproduction may allow subpopulations to persist. Observations indicate that colonies benefit when light levels increase, e.g., defoliation or local blowdown. Uncertainty in proportion of population potentially impacted. Fire suppression is ongoing, but fires have been recorded each year (have been quickly put out in the past--Forest patches are near populated areas). Turkey Point and St. Williams both undergo prescribed burning. This species is not very resistant to fire. Input from Ron Gould (OMNR): there should also be consideration that opening up conditions too much from high intensity or frequency of fires would not generally be consistent with preferred habitat within its range, and could favour the growth of herbaceous competition.
7.2	Dams & water management/use						
7.3	Other ecosystem modifications		Not a Threat	Large (31-70%)	Neutral or Potential Benefit	High (Continuing)	Habitat restoration, i.e., thinning and prescribed burning for conservation at St. Williams and Turkey Point. This species is considered in habitat restoration work at both sites. Potential impact of introduced earthworms to soil conditions was discussed but thought that majority of sites may be too dry to consider - impact may be unknown but potentially negative.
8	Invasive & other problematic species & genes	CD	Medium - Low	Pervasive - Large (31-100%)	Moderate - Slight (1-30%)	High (Continuing)	
8.1	Invasive non-native/alien species		Unknown	Small (1-10%)	Unknown	High (Continuing)	Restricted in area and no real evidence of impact. Invasive plants present in areas, but very low incidence at sites surveyed; dry sandy soils not easily invaded; mountain bike trails at some sites may encourage invasives; probably >1% scope.

	Threat	Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.2	Problematic native species	CD	Medium - Low	Pervasive - Large (31-100%)	Moderate - Slight (1-30%)	High (Continuing)	Wild Turkeys (recently re-introduced) have caused damage to the forest floor in nearby areas, but to date there is no evidence of direct impacts to Spotted Wintergreen. Turkeys are considered as a threat here as their populations have increased as a result of human activities. At Spooky Hollow, some plants disappeared overnight and deer-browsing was the reason; exclosures have been successful - cameras have recorded presence of turkey and deer (unknown impacts). Exclosure at Spooky Hollow has allowed site to recover from deer browsing.
8.3	Introduced genetic material						
9	Pollution		Negligible	Negligible (<1%)	Extreme - Serious (31-100%)	High (Continuing)	
9.1	Household sewage & urban waste water						
9.2	Industrial & military effluents						
9.3	Agricultural & forestry effluents						
9.4	Garbage & solid waste		Negligible	Negligible (<1%)	Extreme - Serious (31-100%)	High (Continuing)	Garbage dumping has happened at least at one site; roadside dumping occurs frequently & one roadside population is vulnerable.
9.5	Air-borne pollutants						Pollution (increased nitrogen levels) can impact associated mycorrhizal fungi, but unknown whether there is an impact. Highly speculative & little evidence at this point, so not included as a threat. Unknown whether 2013 closing of Nanticoke Generating Station is of potential negative or positive impact.
9.6	Excess energy						
10	Geological events						
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides						
11	Climate change & severe weather		Not Calculated (outside assessment timeframe)	Pervasive (71-100%)	Unknown	Low (Possibly in the long term, >10 yrs)	Potential impact but unknown as species occurs in a wide climatic range.

	Threat	Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11.1	Habitat shifting & alteration						
11.2	Droughts						
11.3	Temperature extremes						
11.4	Storms & flooding						