COSEWIC
Assessment and Status Report

on the

Small White Lady's-slipper
Cypripedium candidum

in Canada

THREATENED
2014

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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

COSEWIC. 2014. COSEWIC assessment and status report on the Small White Lady's-slipper *Cypripedium candidum* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xii + 48 pp. (www.registrelep-sararegistry.gc.ca/default_e.cfm).

Previous report(s):

COSEWIC. 2000. COSEWIC assessment and update status report on the small white lady's-slipper *Cypripedium candidum* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 20 pp. (www.sararegistry.gc.ca/status/status_e.cfm)

Brownell, V.R. 1999. Update COSEWIC status report on the small white lady's-slipper *Cypripedium candidum* in Canada, *in* COSEWIC assessment and update status report on the small white lady's-slipper *Cypripedium candidum* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 1-20 pp.

Brownell, V.R. 1981. COSEWIC status report on the small white lady's-slipper *Cypripedium candidum* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 63 pp.

Production note:
COSEWIC would like to acknowledge Catherine Foster for writing the status report on Small White Lady's-slipper, *Cypripedium candidum* in Canada, prepared under contract with Environment Canada. This report was overseen and edited by Jeannette Whitton and Bruce Bennett, Co-chairs of the COSEWIC Vascular Plants Specialist Subcommittee.

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur le Cypripède blanc (*Cypripedium candidum*) au Canada.

Cover illustration/photo:
Small White Lady's-slipper — Photo credit: Anne Worley.

Catalogue No. CW69-14/203-2015E-PDF
ISBN 978-1-100-25614-6

COSEWIC
Assessment Summary

Assessment Summary – November 2014

Common name
Small White Lady's-slipper

Scientific name
Cypripedium candidum

Status
Threatened

Reason for designation
This orchid is known in Canada from Manitoba and Ontario where it grows mainly in tallgrass and mixed grass prairies. These sites require management to prevent encroachment of woody vegetation and to remain suitable for the orchid. Increased search effort has uncovered previously unknown populations in Manitoba, but many populations are small, and some have been lost in recent years. The discovery of additional populations, increased habitat protection, and active management for this species resulted in a change in status from Endangered to Threatened. Because individuals are slow to mature and require a fungal partner, the species is especially vulnerable to local extirpations. In addition to encroachment, the species is threatened by invasive plant species, alteration of hydrology, residential and commercial development, roadside maintenance and illegal collecting.

Occurrence
Manitoba, Ontario

Status history
Designated Endangered in April 1981. Status re-examined and confirmed in April 1999 and in May 2000. Status re-examined and designated Threatened in November 2014.

COSEWIC
Executive Summary

Small White Lady's-slipper
Cypripedium candidum

Wildlife Species Description and Significance

Small White Lady's-slipper is a perennial, clonal orchid. Each plant produces one to many stems that reach approximately 15 cm when in flower. Three or four simple clasping leaves alternate along each stem. Each flowering stem typically bears one white, pouch-shaped "slipper". In Canada, flowers typically appear between mid-May and mid-June. Fruits are produced by late summer and contain many small seeds.

Distribution

The current range of Small White Lady's-slipper extends across 18 states and two provinces. Less than 10% of its range is in Canada, with extant subpopulations occurring in southern Ontario and Manitoba. The Manitoba subpopulations are separated from those in Ontario by approximately 1,300 km. Subpopulations in Ontario also show a disjunction, with a single subpopulation in Hastings County separated by approximately 400 km from subpopulations on Walpole Island. Of the 39 known Canadian subpopulations, 22 are considered extant, and roughly half of these have few mature individuals.

Habitat

In Canada, Small White Lady's-slipper typically grows in remnant fragments of moist, calcareous native prairie openings. This includes patches of prairie remnants in roadside ditches surrounded by agricultural fields. Most sites appear to have some sub-surface water seeping through them. When on ridges or adjacent to trees or tall shrubs, its preferred aspect is south or west, as it is shade-intolerant. The subpopulation in Hastings County occurs in a fen.

Biology

Small White Lady's-slipper requires approximately three years to produce its first leaf and 12 or more years to produce its first flower. The species is capable of extended dormancy, surviving underground for as long as six years, until suitable conditions occur for above ground growth. In Manitoba, late spring frosts are known to reduce fruit production to 1 or 2% relative to usual yields. Although the microscopic wind-dispersed seeds can disperse thousands of kilometres, they require specific soil fungi to provide nutrients for successful germination.

Population Sizes and Trends

In Manitoba, there are approximately 22,000 mature individuals (flowering stems). In Ontario, there are approximately 536 mature individuals in the Hastings County subpopulation. Data are currently unavailable for the Walpole Island subpopulation. Because of the potential for extended below-ground dormancy, and because the number of flowering stems varies among individuals, there is a high degree of uncertainty associated with estimates of Small White Lady's-slipper abundance and therefore population trends are difficult to assess.

Threats and Limiting Factors

The most imminent, widely documented threats to Small White Lady's-slipper are related to loss, degradation and fragmentation of its prairie habitat. Natural and anthropogenic factors that contribute to ongoing habitat decline include encroachment by woody vegetation, invasive species, and urban development. Nine of Manitoba's 19 extant subpopulations are restricted to remnant prairie along roadsides. Plants in these habitats are subject to direct harm from activities such as mowing during flowering and fruiting seasons, maintenance of fence lines and utility cables, spraying of herbicides, and trampling. Illegal collecting is also more likely in these more accessible sites.

Natural limiting factors include light and moisture availability, low seedling survival, long time to maturity, low sexual reproductive rates, low genetic diversity, requirements for specific soil fungi and pollinators, competition with woody and weedy vegetation, browsing, late season frost, and hybridization. Hybridization with Yellow Lady's-slipper is known to occur throughout the North American Range. However, genetic assimilation of Small White Lady's-slipper by Yellow Lady's-slipper does not seem imminent where Small White Lady's-slipper is locally more abundant (most Canadian subpopulations).

Protection, Status, and Ranks

Small White Lady's-slipper was first assessed by COSEWIC and designated Endangered in 1981. The status was re-examined and confirmed by COSEWIC in April 1999 and in May 2000. Status was re-examined by COSEWIC in November 2014 and designated Threatened. Small White Lady's-slipper is currently listed as Endangered on Schedule 1 of Canada's *Species at Risk Act*. A draft national Recovery Strategy was submitted to Environment Canada in 2011 that includes designation of proposed critical habitat. It is listed as Endangered under Manitoba's *Endangered Species Act* and Ontario's *Endangered Species Act*, 2007.

Small White Lady's-slipper subpopulations occur on private, provincial, and First Nations lands. Most subpopulations are not adequately protected, either due to lack of awareness (often due to changes in land ownership/management) or lack of information and resources to manage habitat for the benefit of Small White Lady's-slipper.

TECHNICAL SUMMARY

Cypripedium candidum

Small White Lady's-slipper — Cypripède blanc

Range of occurrence in Canada: Manitoba, Ontario

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 (2008) is being used)	Likely > 12 years
Is there an observed, inferred, or projected continuing decline in number of mature individuals? Trend data cannot be inferred from stem counts, in part because plants may remain dormant in unsuitable conditions. In addition, recent data for Walpole Island subpopulations are unavailable, and trends in these large subpopulations would influence the overall trend in Canada.	Unknown
Estimated percent of continuing decline in total number of mature individuals within 5 years or 2 generations. Monitoring has not been consistent enough to allow trend estimation.	Unknown
Observed, estimated, inferred, or suspected percent reduction or increase in total number of mature individuals over the last 10 years, or 3 generations.	Unknown
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 clearly reversible and understood and ceased?	Not applicable
Are there extreme fluctuations in number of mature individuals? Fluctuations in the observed number of flowering stems are common, but these may reflect shifts between dormant, vegetative and flowering states, as well as uncertainty in estimates of flowering stems.	No

Extent and Occupancy Information

Estimated extent of occurrence	215,560 km²
Index of area of occupancy (IAO) (Based on 2x2 km grid)	164 km²
Is the population severely fragmented? Although subpopulations occur in a fragmented habitat, given the high dispersal ability of seeds and lack of genetic divergence detected among Manitoba and Ontario subpopulations, the Canadian population is not considered severely fragmented.	No
Number of locations* Estimate based on land ownership and potential for differential management of most significant threats (see Table 1 for Manitoba subpopulations)	22 - 40

Is there an observed, inferred, or projected continuing decline in extent of occurrence? Extent of occurrence has decreased in Ontario due to extirpations. A slight increase in Manitoba is due to increased search effort rather than newly established subpopulations.	Possibly
Is there an observed, inferred, or projected continuing decline in index of area of occupancy? Area of occupancy has declined in association with extirpations. The total appears to be increasing with the discovery of new subpopulations, but these are likely new discoveries, not newly established populations.	Yes
Is there an observed, inferred, or projected continuing decline in number of populations? Seventeen of 39 known subpopulations have become extirpated or are historical. Newly discovered subpopulations in Manitoba appear to have been present for at least a decade considering the presence and abundance of sexually mature individuals.	Yes
Is there an observed, inferred, or projected continuing decline in number of locations*? Extirpated subpopulations were distinct locations.	Yes
Is there an observed, inferred, or projected continuing decline in area, extent and/or quality of habitat? Habitat quality is subject to ongoing decline without proper management to prevent encroachment of woody vegetation.	Yes
Are there extreme fluctuations in number of populations?	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 presumed extant subpopulation)

Population	**N Mature Individuals (flowering stems)**
MANITOBA	
Kleefeld	59
Tall Grass Prairie Preserve	<16,899
Franklin west	52
Franklin south	24
Franklin east	8
Emerson	50
Carman	40
Tolstoi	301
Woodlands ditch	129
Lake Francis/Manipogo	>138
St. Laurent	>308

Woodlands trail	211
St. Laurent northwest	143
South of Brandon	<1200
Brandon Hills	<1000
Southeast of Brandon	619
Southeast of Brandon Hills	384
Oak Lake	26
Rounthwaite	81
ONTARIO	
Hastings County	Approximately 540
Walpole Island First Nation (A)**	Unknown
Walpole Island First Nation (B)** ** > 14,000 clumps were reported from Walpole Island in 2003, according to Environment Canada (2014)	Unknown
Total (incomplete due to lack of information for large Walpole Island subpopulations)	> 22,208

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

Threats (actual or imminent, to populations or habitats)

Encroachment by woody vegetation, invasive species, urban development, road allowance and utility maintenance activities, illegal collecting, and late spring frosts. Hybridization with Yellow Lady's-slipper occurs, but preliminary studies indicate that the impact on genetic integrity of Small White lady's-slipper is likely low.

Rescue Effect (immigration from outside Canada)

Status of outside population(s)?	Critically Imperilled in > 50% of US jurisdictions
Is immigration known or possible?	Possible
Would immigrants be adapted to survive in Canada?	Likely
Is there sufficient habitat for immigrants in Canada?	Likely in MB, Unlikely in ON
Is rescue from outside populations likely?	Unlikely

Data Sensitive Species

Is this a data sensitive species? Illegal collecting and trampling by orchid enthusiasts are concerns.	Yes.

Status History

COSEWIC: Designated Endangered in April 1981. Status re-examined and confirmed in April 1999 and in May 2000. Status re-examined and designated Threatened in November 2014.

Status and Reasons for Designation:

Status: Threatened	**Alpha-numeric code:** Does not clearly meet criteria, but designated Threatened because of small IAO, documented losses of subpopulations, declines in habitat quality, and life history characteristics.
Reasons for designation: This orchid is known in Canada from Manitoba and Ontario where it grows mainly in tallgrass and mixed grass prairies. These sites require management to prevent encroachment of woody vegetation and to remain suitable for the orchid. Increased search effort has uncovered previously unknown populations in Manitoba, but many populations are small, and some have been lost in recent years. The discovery of additional populations, increased habitat protection, and active management for this species resulted in a change in status from Endangered to Threatened. Because individuals are slow to mature and require a fungal partner, the species is especially vulnerable to local extirpations. In addition to encroachment, the species is threatened by invasive plant species, alteration of hydrology, residential and commercial development, roadside maintenance and illegal collecting.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not met. Insufficient data to quantify declines, especially given the unknown status of Walpole Island subpopulations.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not met. Although the IAO is below the threshold, there are more than 5 locations, the species is not considered severely fragmented, and there are no extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Not met. Number of mature individuals exceeds thresholds.
Criterion D (Very Small or Restricted Population): Not met. Thresholds for mature individuals and IAO are exceeded.
Criterion E (Quantitative Analysis): Not met. No quantitative analysis.

PREFACE

Since the last COSEWIC report, increased search effort has resulted in the discovery of 11 additional subpopulations in Manitoba, but no additions to the distribution in Ontario. These newly documented subpopulations appear to have been present for a number of years based on stem numbers and the presence of flowering individuals. However, most are relatively small roadside occurrences susceptible to threats. For previously known subpopulations, estimates of the number of mature individuals suggest increases at some subpopulations and declines or extirpation of others, but no overall trend in abundance is apparent. Recent information on Walpole Island First Nation subpopulations in Ontario is unavailable. A 2011 census of the one other extant Ontario subpopulation (Hastings County) reports greater numbers of mature individuals (Brinker 2011) than reported in a 2003 census of the same subpopulation (Solomon 2003). These results could in part be due to differences in survey methods. The status of the Norfolk County subpopulation has changed from Extant to Historical since the last COSEWIC report as it has not been observed there in the past 20 years. In 2012, the site was overgrown with woody and herbaceous vegetation. Extirpations of Canadian subpopulations are continuing, with two Manitoba populations presumed extirpated since the last update, and decreases in abundance have occurred at some large, well known subpopulations. No major changes to Small White Lady's-slipper threats are apparent, but there has been significant additional research done to characterize the extent and impact of hybridization with Yellow Lady's-slipper. A proposed national Recovery Strategy for Small White Lady's-slipper was posted on the SARA Registry in February of 2014.

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
(2014)

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 Canada / Environnement Canada

Canadian Wildlife Service / Service canadien de la faune

Canada

The Canadian Wildlife Service, Environment 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: *Cypripedium candidum* Muhl. ex Willd.
English common name: Small White Lady's-slipper
French common name: Cypripède blanc
Family: Orchidaceae (Orchid family)
Major plant group: Angiosperm (Monocot flowering plant)

Two varieties of the Yellow Lady's Slipper (*Cypripedium parviflorum)* are reported to hybridize with Small White Lady's-slipper in Canada; var. *pubescens* and var. *makasin* (NatureServe 2012). Hybrids between Small White Lady's-slipper and *C. parviflorum* var. *pubescens* have been named *C. x andrewsii* nothovar. *favillianum*. Hybrids between Small White Lady's-slipper and *C. parviflorum* var. *makasin* have been named *C. x andrewsii* nothovar. *andrewsii*. However, a continuum of yellow and hybrid phenotypes has been found in both Manitoba and Ontario subpopulations (Worley *et al.* 2009; Worley pers. comm. 2012). Analysis of genetic variation from amplified fragment length polymorphism (AFLP) markers did not show any distinction between varieties of *C. parviflorum,* thus the two hybrid designations in Sheviak (2002) cannot easily be applied in Manitoba and Ontario subpopulations (Worley pers. comm. 2012).

Figure 1. Small White Lady's-slipper (Image courtesy Missouri Botanical Garden http://www.botanicus.org).

Morphological Description

Small White Lady's-slipper is a perennial orchid that spreads clonally, with above ground stems arising from different points along branching rhizomes (Curtis 1954). Flowering stems grow to a height of 11 - 40 cm (Sheviak 2002). In Manitoba and Hastings County, Ontario, flowering plants typically reach approximately 15 cm in height (Solomon 2003; Borkowsky pers. comm. 2012). In Manitoba, plants growing under excessive thatch (20 - 25 cm), have been known to reach a maximum of 25 - 30 cm (Borkowsky pers. comm. 2012). Each individual plant may produce one or a clump of many above ground stems during a growing season, each with three or four simple clasping leaves alternating along the stem. Note that the term "stem" is equivalent to the terms "crown", "shoot", and "ramet" as used by various authors in the literature. The term "clump" is used to denote what searchers interpret to be a plant, genet or genetic individual. Leaves are 7 – 20 cm long, and 0.9 - 5.3 cm wide (Sheviak 2002). If conditions are unfavourable plants (genets) may remain underground for one or more years (Shefferson 2006). In a given year plants that emerge may produce only non-flowering stems or one or more flowering stems (up to 60 in Wisconsin, Curtis 1946). Each flowering stem bears one, rarely two, flowers (Figure 1). The white, pouch-shaped "slipper" is small (1.7 - 2.7 cm long) with purplish veins or spots. The surrounding twisted, green to brownish-yellow petals and sepals are also typically streaked or spotted with reddish purple. The peak flowering period in any given year is dependent on weather and site conditions, such as recent burns and amount of thatch. In Canada, flowers typically appear between mid-May and mid-June. Fruits are capsules produced by late summer and contain thousands of microscopic seeds.

Although typically smaller, Small White Lady's-slipper is similar in appearance to the extremely variable Yellow Lady's-slipper. According to Sheviak (2002) Yellow Lady's-slipper flowers may be pale to deep yellow, or very rarely white. Hybrids between Small White Lady's-slipper and Yellow Lady's-slipper may produce creamy, yellow, or white flowers. Flowers of hybrid and Yellow Lady's-slipper may fade to white over the blooming period (Sheviak 2002). According to a genetic and morphological study conducted by Worley *et al.* (2009) plant height, and flower size and colour can aid in distinguishing among Small White Lady's-slipper, Yellow Lady's-slipper, and hybrids. Small White Lady's-slipper tends to be shortest with the smallest, whitest flowers. Hybrids tend to be intermediate in height, flower size and flower colour. Small White Lady's-slipper is also characterized by an elliptical staminode (modified, sterile stamen), whereas Yellow Lady's-slipper tends to have a spade shaped or triangular staminode. Hybrid morphology was found to be highly correlated with genetic evidence of hybrid ancestry, but some apparently morphologically pure individuals were also found to have genetic evidence of hybrid ancestry (Worley *et al.* 2009). In samples from four sites, these cryptic hybrids were more likely to have been classified morphologically as Yellow Lady's-slipper than as Small White lady's-slipper, but it is not clear whether this is generally true. These results suggest that backcrossing of hybrids with Small White Lady's-slipper and Yellow Lady's-slipper further complicates field identification.

Population Spatial Structure and Variability

Recent studies using AFLP genetic fingerprints have not shown any distinction between Manitoba and Ontario subpopulations of Small White Lady's-slipper, but additional sampling of subpopulations and markers is needed to confirm or refute these results (Worley *et al.* 2009; Worley pers. comm. 2012).

In Michigan, genetic variation in Small White Lady's-slipper populations was low based on analysis of allozyme variation (Case 1994). Twelve loci were analyzed from 107 individuals in five populations. Genetic diversity, measured as expected heterozygosity, was low at both the species level (5.4%) and population level (5%). However, Case (1994) cited very different results from an allozyme survey in Brandon, Manitoba (Actor 1984), where Small White Lady's-slipper co-occurs with Yellow Lady's-slipper and their hybrids. Expected population level heterozygosity was 34%, 37% and 37% respectively. Similarly, isozyme analyses of 21 loci by Klier *et al.* (1991) resulted in higher heterozygosity values from five mixed populations in Iowa (Small White Lady's-slipper = 15% to 30%, Yellow Lady's-slipper = 28% to 35%, hybrids = 31% to 35%) versus nine populations consisting only of Small White Lady's-slipper (5% to 11%). These results suggest that where the two species co-occur, low levels of gene flow and subsequent introgression result in higher heterozygosity than found in pure parental populations.

In Canada, Small White Lady's-slipper typically co-occurs with Yellow Lady's-slipper (all Manitoba subpopulations and the Ontario subpopulation for which data are available (MB CDC 2010; Brinker 2011; MB CDC 2012)). Worley et al. (2009) sampled 182 plants from four subpopulations in Manitoba (#9, 10, 11, and 12), and scored these for eight morphological characters and 1061 AFLP loci to assess differences among Small White Lady's-slipper, Yellow Lady's-slipper, and suspected hybrids. Of the 182 individuals sampled 29% had mixed ancestry, though the authors caution that they explicitly sampled all suspected hybrids (based on morphology), so that the frequency of hybrids is likely inflated in their samples. Results from Worley *et al.* (2009), and others from the United States (Klier *et al.* 1991; Walsh 2008) indicate that backcrossing and introgression between Small White Lady's-slipper and Yellow Lady's-slipper are bi-directional. Despite documented hybridization, the two species appear to be maintaining their morphological distinctions, even in mixed populations, but the mechanisms that account for this are not known (Worley *et al.* 2009).

Designatable Units

Previous assessments of Small White Lady's-slipper have recognized a single designatable unit in Canada (Brownell 1999, COSEWIC 2000). Manitoba and Ontario subpopulations are separated by more than 1,300 km, and occur in distinct Ecological Areas. Most Manitoba subpopulations occur in COSEWIC's Prairie Ecological Area, although some extend eastward, coming close to the Boreal Ecological Area. Ontario subpopulations occur in the Great Lakes Plains Ecological Area, but there is a large disjunction between the subpopulation on Walpole Island and the subpopulation in Hastings County, which is near the boundary of the Boreal Ecological Area.

COSEWIC guidelines for recognition of designatable units rest on two criteria: discreteness and evolutionary significance. In the case of Small White Lady's-slipper, there are three potential units to consider: Manitoba subpopulations (Prairie), Walpole Island subpopulations (Great Lakes Plains), and the Hastings County (Ontario) subpopulation (Hastings).

The most distinct entity within Small White Lady's-slipper appears to be the Hastings County subpopulation. This locality is the most ecologically distinct, occurring in an open calcareous fen near the border of the Boreal Ecological Area, separated by roughly 400 km from other Ontario subpopulations. Analysis of AFLP marker variation indicates that although not genetically distinct, this subpopulation is less variable than other surveyed subpopulations, which may reflect a longer history of isolation. Individuals at this site are also smaller in stature, but it is not yet known whether this is due to genetic and/or environmental effects (Ford pers. comm. 2013). Thus, to date there is indirect evidence of distinctness for the Hastings subpopulation, based upon observed morphological differences in the field, and a currently disjunct distribution separating this occurrence from other extant subpopulations. Historical Ontario occurrences have been reported that indicate a previously more scattered distribution eastward than occurs at present.

Subpopulations in the two other portions of the Canadian distribution (Manitoba Prairie and Ontario Great Lakes Plains) occur in prairie habitats, and despite their wide separation in Canada, they are connected via the fragmented prairie remnants in the adjacent U.S. states. AFLP marker analysis indicates no significant differences between these regions in Canada (Ford pers. comm. 2013), but additional markers may resolve finer scale differences not detected by AFLPs (Worley pers. comm. 2014). The Ontario and Manitoba prairie subpopulations could be considered discrete entities based on the separation between the regions in Canada. However, the separation of Ontario and Manitoba prairies subpopulations is not a natural disjunction, instead representing separate extensions of a previously continuous U.S. range into Canada. Direct evidence of ongoing gene flow between these regions in Canada is, however, lacking, as is evidence of ongoing indirect gene flow via populations in the U.S. A second argument for distinctiveness could be based on occupying distinct COSEWIC National Ecological Areas (Great Lakes Plains and Prairies, respectively). However, significant heterogeneity exists within Ecological Areas, and the specific prairie/savannah habitats occupied by Small White Lady's slipper represent similar areas within the more broadly distinct Ecological Areas and share a number of broad attributes. Nearly all occurrences are in open areas in tallgrass or mixed grass prairie habitat, and all sites have high water tables, especially in spring. While there are site-to-site differences in ecological features, these tend to vary continuously along several environmental axes rather than clearly distinguishing Ontario and Manitoba prairie subpopulations.

The case for evolutionary significance of the three entities described above is equivocal. To date there is no evidence of deep infraspecific genetic divergence. There is significant site-to-site variation in ecological settings of subpopulations, and it is likely that the Hastings County population is at one extreme of this variation. Similarly, there are habitat features that differ between the median Ontario and Manitoba prairie conditions. Nonetheless, while the ecological setting on Walpole Island is somewhat distinct from that of the prairie populations in Manitoba, these sites are within the continuum of settings known for the species outside Canada.

Based on current evidence, it is suggested that Small White Lady's-slipper in Canada remain a single designatable unit at this time, recognizing that a better understanding of patterns of genetic and ecologically relevant variation could result in recognition of multiple units in the future. Nonetheless, each of the three portions of the species' distribution (as well as subpopulations within these regions) is likely to contribute significant conservation value to the total Canadian population.

Special Significance

Small White Lady's-slipper is an indicator of remnant native prairie habitat, where it co-occurs with other Canadian species at risk. It is at the northern limit of its range in Manitoba where it survives despite frequent and widespread damage from late spring frosts. It serves as an excellent species for studying hybridization between a species at risk and a more common species, particularly in relation to changing habitats. As a rare orchid, it is admired by orchid enthusiasts in Canada and elsewhere.

DISTRIBUTION

Global Range

Small White Lady's-slipper is native to eastern North America (Fig. 2). Its current range extends across 18 states and two provinces. In the United States, it is considered extant in Alabama, Connecticut, Illinois, Indiana, Iowa, Kentucky, Maryland, Michigan, Minnesota, Missouri, Nebraska, New Jersey, New York, North Dakota, Ohio, South Dakota, Virginia, and Wisconsin, and extirpated from Pennsylvania (Butler pers. comm. 2012; NatureServe 2012; Walz pers. comm. 2012). It is no longer considered extirpated from New Jersey (Walz pers. comm. 2012) or Missouri (Butler pers. comm. 2012) as previously reported by Brownell (1999).

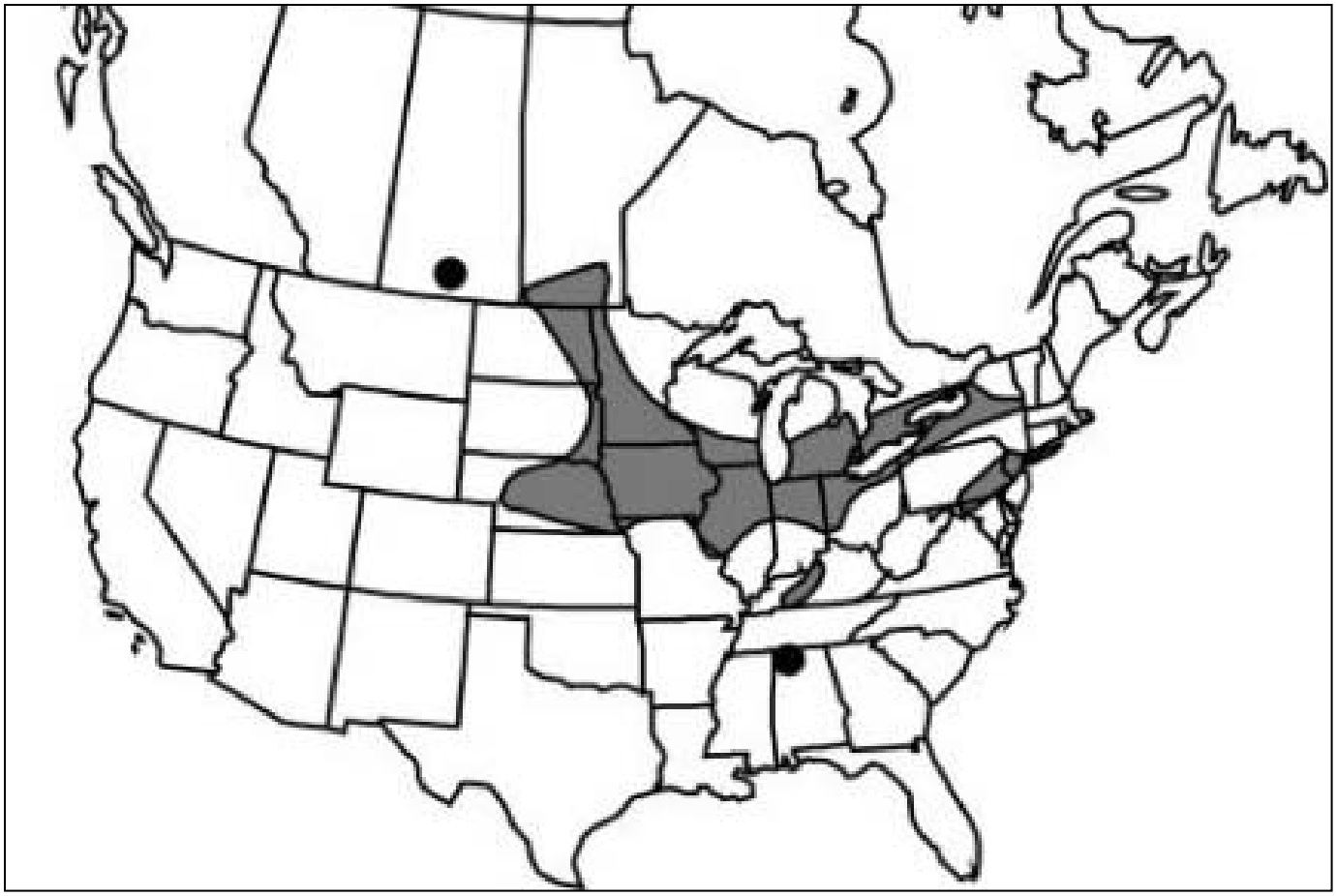

Figure 2. Global Small White Lady's-slipper distribution (Sheviak 2002). Map may be generalized and, in order to represent the probable range, parts of states or provinces may be shaded even though documentation of occurrence there may be lacking. Presence in a state or province may be indicated by a single dot.

Canadian Range

In Canada, extant subpopulations of Small White Lady's-slipper occur in Manitoba and Ontario. Less than 10% of the global range of the species is in Canada. The species has likely always been uncommon in Canada (Brownell 1981), although it may have been more widespread in the prairies of Manitoba prior to European settlement (Punter 1999). The Manitoba subpopulations are separated by approximately 1,300 km from those in Ontario. Most Manitoba subpopulations occur in COSEWIC's Prairie Ecological Area, although some extend eastward into the Boreal Ecological Area. Ontario subpopulations occur in the Great Lakes Plains Ecological Area, although one is near the boundary of the Boreal Ecological Area. Vascan (2013) assigns the status "native" in Saskatchewan, Manitoba, and Ontario.

In this status report subpopulations are considered distinct if separated by at least 1 km, as per NatureServe's (2002) definition of an element occurrence. This is equivalent to the term "site" used in the last Small White Lady's-slipper COSEWIC update (Brownell 1999).

Saskatchewan

The species was collected from one area in Saskatchewan in 1895 (Fig.1). The locality information is vague and the habitat type ("near a spring") has not been surveyed (Keith pers. comm. 2013). The Saskatchewan Conservation Data Centre currently ranks it as Possibly Extirpated. It has not been reported in the province since the original collection and they have not surveyed for it (Keith pers. comm. 2012). No information is available for this collection, and therefore, no further inference is made about the possible occurrence of the species in this region.

Manitoba

Small White Lady's-slipper was first collected from Manitoba in 1904. Most extant subpopulations have been discovered since 1980 due to increased search effort. Of the 28 documented subpopulations, 19 are considered extant (Table 1). The others are considered extirpated or historical. Based on extirpated and historical subpopulations, a slight range contraction has occurred in northeastern Manitoba (Fig. 3). The known range has expanded to the west and south since the last COSEWIC assessment but this is most likely a reflection of increased search effort rather than actual range expansion. Note that there is an erroneous report of Small White Lady's-slipper from Pembina Hills. Neither Scoggan (1957, 1978) nor Marshall (1989) reports it from Pembina Hills (Punter 1999).

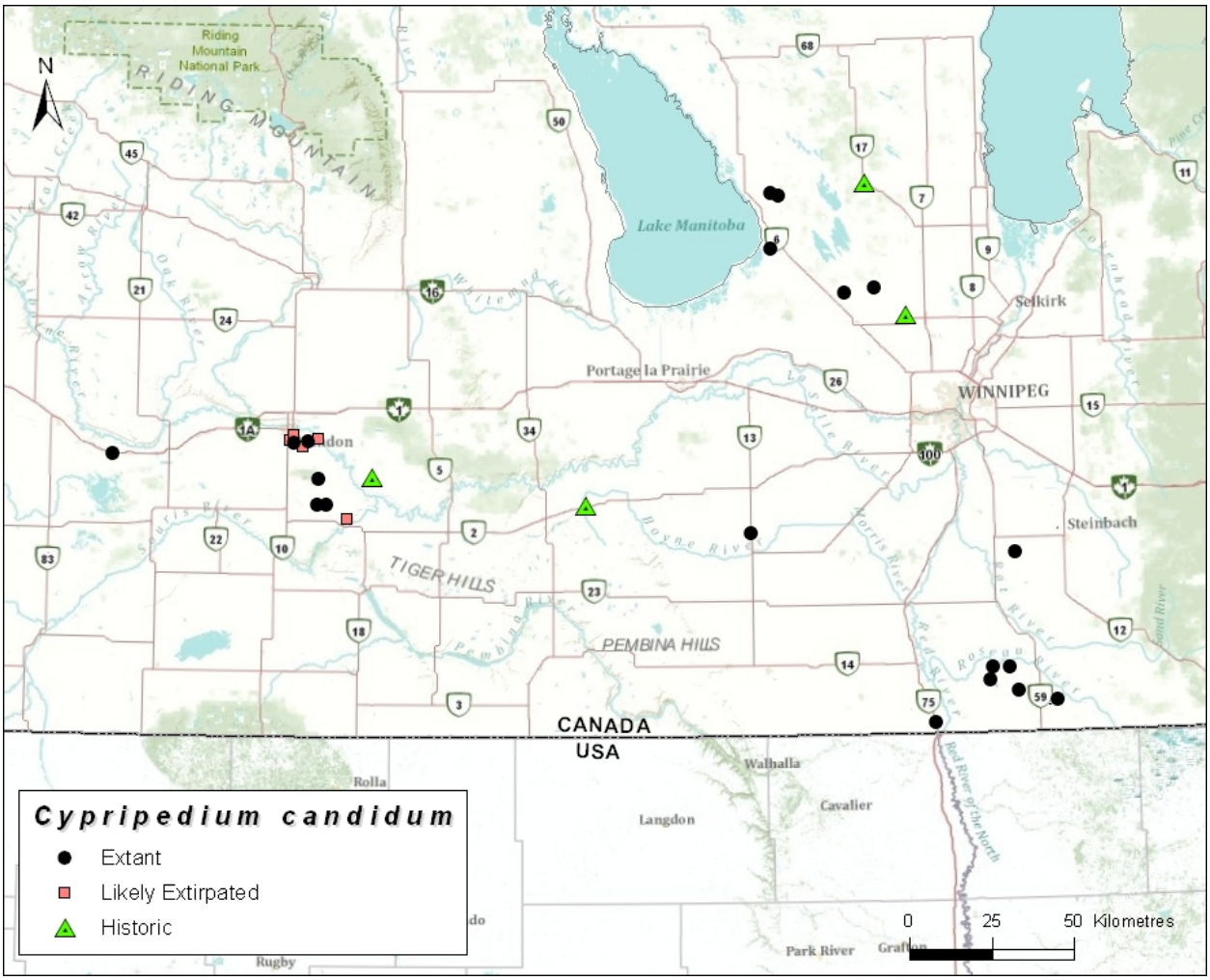

Figure 3. General localities and status of Manitoba Small White Lady's-slipper subpopulations.

Table 1. Manitoba Small White Lady's-slipper subpopulations.

El. Occ. ID	Subpopulation	First Observed	Last Observed	Status	Comments
1202	1. Kleefeld	1980	2012	Extant	Provincial roadside. One location.
4164	2. Tall Grass Prairie Preserve	1993	2012	Extant	Preserve and provincial roadsides. Different areas within the preserve are subject to different management regimes. Roadside locations are affected by different landscape contexts. At least four locations.
446	3. Franklin west	1999	2011	Extant	Provincial roadsides. Two locations.
2311	4. Franklin south	1999	2011	Extant	Private property and provincial roadsides. Possibly extirpated from private property where trampling from cattle has been reported. Four to five locations.

El. Occ. ID	Subpopulation	First Observed	Last Observed	Status	Comments
389	5. Franklin east	1999	2011	Extant	Provincial roadsides. Possibly extirpated from one roadside location. One to two locations.
5540	6. Emerson	2001	2009	Extant	Remnant prairie between provincial roadside and railway. One location.
5539	7. Carman	2008	2012	Extant	Provincial roadside. One location.
5271	8. Tolstoi	2008	2012	Extant	Private property. Remnant prairie surrounded by agriculture. One location.
431	9. Woodlands ditch	1966	2012	Extant	Provincial roadside. One location.
86	10. Lake Francis/Manipogo	1983	2012	Extant	Private property (remnant prairie with periodic burns and shrub removal surrounded by pastureland, and edge of golf course), and provincial right-of-way. Three locations.
3748	11. St. Laurent	1995	2011	Extant	Private property (remnant prairie areas, annually hayed until recently purchased, and one location, which may no longer be extant) and provincial roadside(s), which may no longer be extant. At least one location.
390	12. Woodlands trail	1998	2012	Extant	Private property (trail sides along old rail bed). Management and adjacent landscape differs among occupied areas. At least three locations.
4868	13. St. Laurent northwest	2005	2010	Extant	Private property and undeveloped provincial right-of-way. Two locations.
4173	14. South of Brandon	1954	2012	Extant	Private property, provincial property managed by Manitoba Conservation, and provincial roadsides. Likely extirpated from some private property and roadside locations. Five to eleven locations.
3061	15. Brandon Hills	1993	2012	Extant	Private property (Conservation Agreement with periodic grazing, burning, haying, weeding) and provincial roadsides. At least three locations.
3156	16. Southeast of Brandon	1997	2012	Extant	Private property and provincial roadsides/right-of-way. Potentially seven locations.
4959	17. Southeast of Brandon Hills	2007	2012	Extant	Private property and provincial roadsides. Three to four locations.
5305	18. Oak Lake	2008	2012	Extant	Remnant prairie between federal roadside and railway. One location.
6599	19. Rounthwaite	2011	2012	Extant	Provincial roadside. One location.
2039	20. Brandon ditch	1997	1998	Extirpated	Provincial roadside. Last observed in 1998 (15 stems, flowers killed by frost). None found in 2004, 2006, 2009 or 2012. Habitat no longer appears appropriate.

El. Occ. ID	Subpopulation	First Observed	Last Observed	Status	Comments
2422	21. Brandon Assiniboine R.	1994	1994	Extirpated	Locality uncertain. Last observed in 1994 (1 stem, overgrown with woody vegetation). None found and no suitable habitat in potential localities searched in 2006.
n/a	22. Brandon area north	1993	Unknown	Extirpated	Reported in 1993 from an area that is now a residential and industrial development.
n/a	23. Brandon area west	Unknown	Unknown	Extirpated	Reported from an area that is now developed. Area searched in 1996 but none found.
n/a	24. Stonewall area	1904	1904	Historical	Locality details unknown. Specimen housed at University of Manitoba Herbarium. Searches have been conducted in the general area but none found. This area should be revisited. Searches need to be conducted in consecutive years due to the sporadic appearance of small populations.
n/a	25. Inwood area	1938	1938	Historical	Locality details unknown. Specimen housed at University of Manitoba Herbarium. Searches have been conducted in the general area but none found. There is potential in the area.
n/a	26. Aweme area	1906	1907	Extirpated	Reported within 16 km of Aweme but locality details unknown. Areas near Aweme have been searched by the MB CDC and others but none have been found. The large Brandon Hills subpopulation is approx. 16 km from Aweme and may be the one referred to by this report.
n/a	27. Treherne	1980	1980	Extirpated	A small population observed along a road allowance in 1980 has not been seen since that time.
n/a	28. Wawanesa	Unknown	Unknown	Extirpated	Locality details vague (horse pasture west of Wawanesa). Area searched in 1993 and 1998 but none found and habitat did not look good.

Sources: Hohn 1994; Parsons *et al.* 1994; Punter 1999; MB CDC 2012; Punter pers. comm. 2012; Worley pers. comm. 2012; Murray pers. comm. 2012; MB CDC 2010; landowners/managers pers. comm. Note that “El. Occ.” refers to an Element Occurrence, following the CDC designation.

Ontario

Small White Lady's-slipper was first collected from Ontario in 1903. According to the Ontario Natural Heritage Information Centre (ON NHIC 2012) no new subpopulations have been documented in Ontario since 1979. Of the 11 Ontario subpopulations on record, five are considered extirpated, three historical, and three extant (Table 2). As a result, the range within Ontario has contracted (Fig. 4). One of the three remaining Ontario subpopulations is located in a provincial protected area. The other two occur on Walpole Island First Nation lands. The status of previously known subpopulations on Walpole Island First Nation lands may have changed, or new subpopulations may have been discovered, but recent data are currently unavailable.

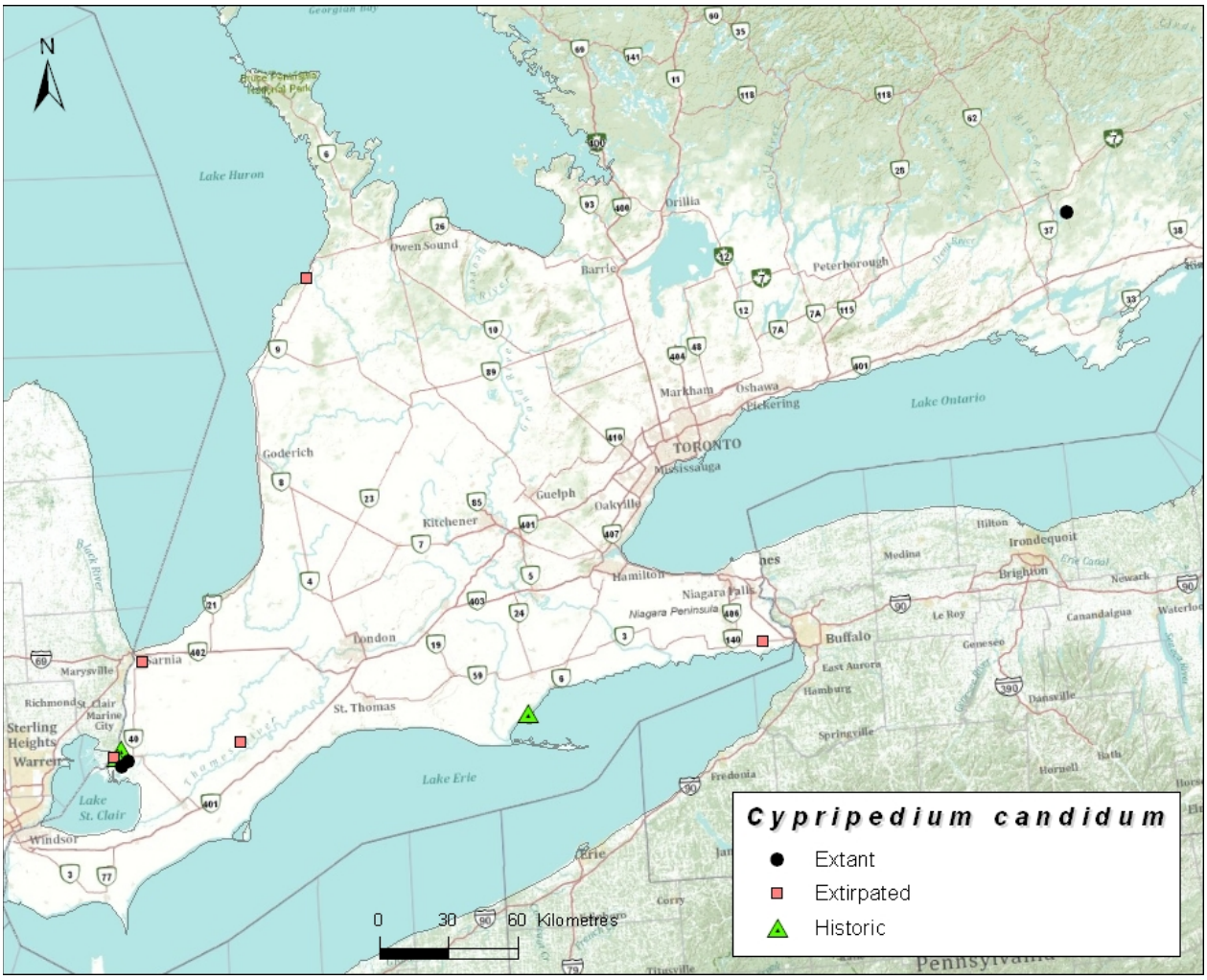

Figure 4. General localities and status of Ontario Small White Lady's-slipper subpopulations.

Table 2. Ontario Small White Lady's-slipper subpopulations.

El. Occ. ID	Subpopulation	First Observation	Last Observation	Status	Comments
5977	29. Hastings County	1979	2012	Extant	Protected area. 150-200 stems in 1979 and 1997, 638 stems (248 flowering) in 2003, unknown total stems (536 flowering) in 2011. One location.
3276	30. Walpole Island First Nation (A)	1908	1997	Extant	Walpole Island First Nation. Recent data unavailable. Possibly one location.
3280	31. Walpole Island First Nation (B)	1908	1990	Extant	Walpole Island First Nation. Recent data unavailable. Possibly one location.
3275	32. Walpole Island First Nation (C)	1908	1986	Historical	Walpole Island First Nation. Recent data unavailable.
3281	33. Walpole Island First Nation (D)	1908	1986	Historical	Walpole Island First Nation. Recent data unavailable.
5976	34. Walpole Island First Nation (E)	1908	1988	Historical	Walpole Island First Nation. Species not observed during a 1997 survey. More recent data unavailable.
3277	35. Norfolk County	1925	1993	Historical	Provincial protected area. Counts from 1984 to 1987 ranged from to 141 to 37 stems. One plant last observed in 1993. Overgrown with woody and herbaceous vegetation in 2012.
3279	36. Point Edward	1905	1914	Extirpated	Exact locality unknown. Specimens housed at TRT and OAC. According to Brownell (1999) "area is highly urbanized now".
3282	37. Port Elgin	1903	1903	Extirpated	Exact locality unknown. Presumably private land. Specimen housed at CAN. According to Brownell (1999) "almost certainly no longer extant".
7414	38. Crystal Beach	Unknown	Unknown	Extirpated	Exact locality unknown. Presumably private land. Mentioned in Whiting and Catling. 1986. Orchids of Ontario. p. 29. According to Brownell (1999) "presumably extirpated since the area is highly developed."
92835	39. Bothwell	1924	1924	Extirpated	Private land. Referred to by Saunders in his 1926 article in Canadian Field-Naturalist 40(2):112-113. According to Brownell (1999) "almost certainly extirpated since this area is highly agricultural now and natural areas remaining have been fairly well botanized."

Sources: ON NHIC 2012; Brinker pers. comm. 2012; Brinker 2011; Brownell 1999.

Extent of Occurrence and Area of Occupancy

The extent of occurrence (EO) of Small White Lady's-slipper subpopulations in Canada is approximately 215,560 km^2.

The index of area of occupancy (IAO) was calculated based on a grid with a cell size of 2 km x 2 km. The total IAO in Canada is 164 km^2. Within Manitoba it is 144 km^2. However, it is important to note that most subpopulations in Manitoba are very small such that the actual area occupied is less than 2 km^2. Within Ontario the IAO is 20 km^2, including 16 km^2 on Walpole Island and 4 km^2 in Hastings County.

Search Effort

The Manitoba Conservation Data Centre (MB CDC) has conducted Small White Lady's-slipper surveys since the late 1990s and has documented the number of sites searched for new subpopulations since the early 2000s. Approximately 165 sites have been searched for Small White Lady's-slipper by the MB CDC since the last COSEWIC update in 1999. In addition to on-the-ground searches, many hours have been spent talking to landowners about sites with potentially suitable habitat. Various researchers, consultants, and other interested individuals have also searched for new, and surveyed known, subpopulations. Some results have been reported to the MB CDC but search effort is typically not reported.

The proportion of potential habitat searched is unknown. Some predictive modelling has been attempted in Manitoba using available GIS data. One new subpopulation was found in 2005 as a result of analyzing elevation, land use, soil data, and aerial photos, in addition to interviewing landowners about past and current land uses (Foster and Hamel 2006). Collicutt and Morgan (2010) were unable to find any geophysical features that were strongly associated with the presence of Small White Lady's-slipper. Murray (2010) found a total of 11,147 ha of potential Small White Lady's-slipper habitat in the south Interlake region of Manitoba. Garner (2010) found a total of 727 ha of potential Small White Lady's-slipper habitat in Manitoba, ranked from low to very high (136 ha low, 423 ha moderate, 158 ha high, 10 ha very high). In 2010, the MB CDC searched 11 sites based on the latter model but no new subpopulations were found (Friesen and Murray 2011).

In preparation for this status report, seven subpopulations were surveyed by C. Foster, in addition to those surveyed by the MB CDC and others. A new subpopulation was recently reported in Manitoba but has not yet been confirmed (Ames pers. comm. 2012). Sam Brinker, with the ON NHIC, surveyed the Hastings County, Ontario subpopulation and searched the Norfolk County occurrence. Two additional reports of Small White Lady's-slipper subpopulations exist in the ON NHIC database. However, there is insufficient information to confirm identity and they are outside the known range, thus are not considered element occurrences (ON NHIC 2012). No additional information on Small White Lady's-slipper search effort is maintained by ON NHIC. The Walpole Island Heritage Centre monitors subpopulations on Walpole Island First Nation lands but data are currently unavailable.

HABITAT

Habitat Requirements

In Canada, Small White Lady's-slipper typically grows in moist prairie habitats but also grows in a fen in Hastings County, Ontario. In Manitoba, Small White Lady's-slipper grows in remnant fragments of moist, calcareous native prairie openings. This includes prairie remnants occurring in roadside ditches surrounded by agriculture. Most sites appear to have some sub-surface water seeping through them. They are often situated among small Trembling Aspen (*Populus tremuloides*) stands and have sparse shrub cover. They are also sometimes associated with sedge fens in adjacent lower-lying areas. It is possible that Small White Lady's-slipper may not grow in very wet fens in Manitoba due to lower spring temperatures of the water (Punter pers. comm. 2012). Topography is often slightly undulating ridges and swales with Small White Lady's-slipper preferring the ridge slopes. It also has a tendency to grow along edges of tree lines and shrub thickets at some sites, which may be related to snow cover and spring soil moisture. One local farmer stated that they grow where "the snow lies deep and the grass grows poor" (Punter pers. comm. 2012). When on ridges or adjacent to trees or tall shrubs its preferred aspect is south or west, as it is shade-intolerant. Soils where Small White Lady's-slipper grows in Manitoba are strongly to moderately calcareous sandy loam to loam over glacial till, derived from Paleozoic or Mesozoic rock (may also be silt, or clay to fine sandy loams or gravelly to fine sandy loams). They are moderately to imperfectly drained (may also tend towards somewhat poorly or more well-drained) (MB CDC 2010; Punter pers. comm. 2012).

Shrub cover includes Shrubby Cinquefoil (*Dasiphora fruticosa*), Wolf Willow (*Elaeagnus commutata*), Prickly Rose (*Rosa acicularis*), Western Snowberry (*Symphoricarpos occidentalis*), and willows (*Salix* spp.). The herb layer is often characterized by species indicative of calcareous soils and native prairie such as Yellow Star-grass (*Hypoxis hirsuta*), Common Lousewort (*Pedicularis canadensis*), alexanders (*Zizia* spp.), Northern Grass-of-parnassus (*Parnassia palustris*), Hoary Puccoon (*Lithospermum canescens*), Blue-eyed Grass (*Sisyrinchium montanum*), Big Bluestem (*Andropogon gerardii*), Indian Grass (*Sorghastrum nutans*), sedges (*Carex* spp.), and horsetails (*Equisetum spp.*). Yellow Lady's-slipper, and hybrids between this species and Small White Lady's Slipper are typically found within or near Small White Lady's-slipper sites. Invasive species associated with Small White Lady's-slipper include Smooth Brome (*Bromus inermis*), Leafy Spurge (*Euphorbia esula*), Common Dandelion (*Taraxacum officinale*), and Canada Thistle (*Cirsium arvense*).

In Ontario, the Hastings County subpopulation grows in an open calcareous fen surrounded by Eastern White Cedar (*Thuja occidentalis*) and Tamarack (*Larix laricina*). It is a groundwater discharge area characterized by a high water table and organic soils. Open areas are dominated by mosses, sedges, and herbaceous plants characteristic of highly calcareous soils. Plants associated with this site are provided by Brownell (1981).These areas are interspersed with shrubby hummocks, treed islands, and marl pools. As with prairie habitats, Small White Lady's-slipper is often closely associated with edges of trees and shrubs, such as Shrubby Cinquefoil (Imrie *et al.* 2005; Brinker 2011).

The other Ontario subpopulations occur on Walpole Island First Nation and grow in Tallgrass Prairie and Oak Savannah ecosystems. The savannahs are described as transitional between prairie and forest. Both prairie and savannah vegetation types are considered S1 in Ontario. A combination of high rainfall and a high water table hastens woody encroachment at these sites. However, most of the prairies have had regular burns and are in excellent condition (Bowles 2005). Plants associated with these sites are provided by Brownell (1981).

Species at risk associated with Small White Lady's-slipper are provided in Appendix 1.

Habitat Trends

Loss of native prairie to agriculture, development, and natural succession has drastically reduced the amount of suitable habitat available to support Small White Lady's-slipper in Canada (Brownell 1981; Brownell 1999; Samson *et al.* 2004; Bowles 2005; Koper *et al.* 2010). In Manitoba, over 99% of the historical range of tall-grass prairies has been converted to other cover types, usually agricultural (Samson and Knopf,1994 cited in Koper *et al.* 2010). Koper *et al.* (2010) resurveyed remnant tall grass prairie patches previously surveyed in 1987-1988 and found that 37% of 65 patches had either been converted to non-prairie or severely degraded by invasive species by 2006. Declines in size and quality were more pronounced in smaller patches (<21 ha). Sixty-one additional patches were newly surveyed, 18 of which were based on the presence of rare prairie plants, including Small White Lady's-slipper. Sixty-six percent of the 111 patches surveyed by Koper *et al.* (2010), were smaller than 21 ha. Based on evidence of changes over time and observed effects of patch structure they state that it seems probable that most remaining northern tall-grass prairies in Manitoba are not self-sustaining or likely to persist over time. Smaller patches continue to disappear through loss of suitable habitat due to invasive species, natural succession to forest, and conversions to agricultural lands. Foster (2008) illustrates woody encroachment at the Woodlands trail subpopulation between 2005 and 2007.

In Ontario, less than 1% of the original prairies remain since European settlement (Bowles 2005). One of the largest remnants is at Walpole Island First Nation, where prairies have been reduced by approximately 36% in the last 25 years. Demands for infrastructure and housing on Walpole Island First Nation continue to increase (Bowles 2005). Brownell (1984) examined aerial photographs from 1945, which showed that the area occupied by Small White Lady's-slipper at the Norfolk County subpopulation was treeless at that time. Based on communications with R. Landon, it appears that the nearby cattail and sedge marsh was burnt every March and hayed by local farmers until the 1930s. Small White Lady's-slipper occurred throughout the open area bordering the cedar woods and marsh and also along sides of a stream locally known as Hellmer's Creek. By 1984, the area adjacent to the marsh had changed to Poison Sumac thicket and open habitat to the north (occupied only by hybrids) had succeeded to mixed forest and old field.

Habitat trends for the Hastings County subpopulation are not known.

BIOLOGY

Much of the information below comes from research on Small White Lady's Slipper in the United States. Small White Lady's-slipper is at the edge of its range in Canada and may face additional challenges. For example, generation time may increase at the northern range edge where consecutive years of favourable conditions are less likely. Curtis (1943) found reproduction rates of *Cypripedium* species to be higher near the centre of their range. Similarly, Falb and Leopold (1993) reported smaller Small White Lady's-slipper plants, with fewer flowers and fruits, in New York than in the central portion of its range in Wisconsin, Illinois and Iowa.

Life Cycle and Reproduction

Curtis (1943) studied natural germination and seedling development in *Cypripedium* species in the United States. Initial stages of Small White Lady's-slipper seedling development were found at a depth of three to five cm. He suggests that seeds may take several years to reach these depths through natural action of rain and snow melt. Alternatively, they may require a period of time for soil to build up and bury seeds to a suitable depth. *Cypripedium* seed coats are resistant to wetting, and seed longevity is at least eight years under artificial dry storage conditions. Over a four-year period, only 14 seedlings were found during intensive searches of two large Small White Lady's-slipper colonies (5,500 and 1,500 stems) in central Wisconsin. Based on field observations and known rates of rhizome growth for *Cypripedium*, it was estimated that seedlings of Small White Lady's-slipper require 12 or more years to produce the first flower (Curtis 1943).

Curtis (1954) reports results of flower production by *Cypripedium* species in the United States over two decades. Under favourable conditions flower buds are initiated in late summer of the year preceding flower production. Year to year flower production by Small White Lady's-slipper from 1933-1952 was variable, with 33% to 78% of stems producing a flower in a colony in the central portion of its range in Wisconsin. Falb and Leopold (1993)

reported 36.5% flower production at the periphery of its range in New York in 1989 and 1990. Shefferson and Simms (2007) reported 47% flower production from 2000 to 2005 in Illinois, near the central portion of its range. Flower production based on data collected in Manitoba averages above 50% (MB CDC 2010). However, this may be an overestimate because surveys often focus on flowering stems. Non-flowering plants can be difficult to find under thatch and cannot be positively distinguished from Yellow Lady's-slippers and hybrids in the field. Detailed surveys at the Hastings County, Ontario subpopulation reported 40% flower production (Solomon 2003; Imrie *et al.* 2005).

If flowers survive and are successfully pollinated, they produce capsules containing thousands of microscopic, wind-dispersed seeds by late summer. As with flower production, fruit production can be variable from year to year. Curtis (1954) reported average fruit production (fruit/stem) by Small White Lady's-slipper to range from 5% to 27% in Wisconsin from 1938 to 1941. Falb and Leopold (1993) reported 12% fruit production in New York from 1986 to 1990. Shefferson and Simms (2007) reported 10% fruit production in Illinois from 2000 to 2005. Fruit production is not commonly reported for Canadian subpopulations. In Manitoba, late spring frosts are known to reduce fruit production to 1 or 2% per total number of flowering stems (Punter 1999). Of 400 plants examined at a Walpole Island First Nation subpopulation in 1979, 23% had pollen grains deposited on the stigma (Brownell 1981). Flab and Leopold (1983) state that low fruit production of Small White Lady's-slipper is typical compared to other orchids, which can produce twice as many fruit capsules or more.

Small White Lady's-slipper also reproduces vegetatively, budding from two- or three-year-old rhizomes to produce additional stems, thereby increasing resource acquisition (Curtis 1943). Curtis (1954) states that *Cypripedium* plants can be "potentially immortal". Because average age of mature individuals is unknown, it is not possible to estimate generation time. However, it is likely well above 12 years, the estimated time it takes for a Small White Lady's-slipper to produce its first flower (Curtis 1954).

Physiology and Adaptability

Minimum rainfall is thought to limit the westward distribution of Small White Lady's-slipper (Bowles 1983). Seeds require a constant supply of water for germination (Curtis 1943). Long-term survival is also thought to be dependent on a high water table (Falb and Leopold 1993). Habitat preferences in Canada suggest that Small White Lady's-slipper is adapted to microsites with groundwater movement. It is also shade-intolerant (Brownell 1981). Falb and Leopold (1993) reported significantly higher irradiance values (approximately two times higher) for multi-stemmed, flowering plants versus single stemmed, non-flowering plants. For long-term survival Small White Lady's-slipper requires habitat disturbance, such as appropriately timed burning or mowing, to keep woody vegetation from encroaching. In the absence of such disturbances, Small White Lady's-slipper can be out-competed by encroaching vegetation (Curtis 1946; Brownell 1981).

Due to its relatively early spring growth and flowering period, Small White Lady's-slipper is susceptible to late spring frosts. Frost damage to leaves and flowers is often observed in Manitoba subpopulations, affecting both photosynthetic capacity and seed production (MB CDC 2010, Punter 1999).

Small White Lady's-slipper can undergo periods of vegetative dormancy, whereby rhizomes survive underground waiting for more suitable conditions for above-ground growth (Curtis 1943; Falb and Leopold 1993; Shefferson 2006; Shefferson and Simms 2007). In an 11-year study in Illinois, the longest period of dormancy for Small White Lady's-slipper was six years, during which time at least 40% of the plants experienced dormancy (Shefferson 2006). The degree to which Small White Lady's-slipper plants may use dormancy as a coping mechanism in Canada is unknown. Fluctuations in monitoring data from the Manitoba Tall Grass Prairie Preserve (Borkowsky pers. comm. 2012) compared to climate data (Agriculture and Agri-Food Canada 2012) suggest that dormancy may occur in response to low spring temperatures or dry conditions.

In vitro seed germination of Small White Lady's-slipper from two Manitoba sites was investigated by De Pauw and Remphry (1993). Over a 20-week period, germination success was highest (approaching 50% of seeds inoculated) for seed collected eight weeks after pollination. Initial germination success was only slightly higher with a two-week period of cold storage at 4 C°.

Seeds collected from two subpopulations in Ontario have been successfully propagated by A. Anderson, University of Guelph. Three plants were raised from the Norfolk County subpopulation (Anderson 1993 cited in Brownell 1999) and were surviving in his garden as of the last COSEWIC report (Brownell 1999). One plant was raised from Walpole Island First Nation seed and grew to flowering size in nine years (Anderson pers. comm. 1997 cited in Brownell 1999). More recently Environment Canada issued a permit to collect fruit capsules for the purpose of studying seed viability, germination conditions and rates, and eventual planting of propagated plants to protected restoration sites on Walpole Island First Nation (Environment Canada 2008a).

Transplantation of mature plants was attempted more recently. In fall 2011, the MB CDC moved 126 Small White Lady's-slipper stems (approximately 20 plants) from the Woodlands ditch subpopulation (#9) to the Woodlands trail subpopulation (#12) in order to determine transplantation success (Murray pers. comm. 2012). Stem counts for the transplants increased from 126 (2011) to 160 (2012). Further monitoring is required to determine longer-term success of this transplantation experiment. A permit was also issued to transplant some plants from a construction site to a protected site on Walpole Island First Nation (Environment Canada 2009), but the outcome of this is not known.

Dispersal and Migration

Small White Lady's-slipper capsules contain thousands of microscopic seeds as is typical of orchids (Curtis 1954). Orchid seeds are carried by wind and can disperse thousands of kilometres (Jersakova and Malinova 2007). However, they require suitable

environmental conditions for both the seed and the fungus upon which it depends for successful germination. Furthermore, seedling survival and fruit production is typically low. Therefore, the primary mode of population growth is through localized spreading of plants by vegetative reproduction. Seeds that are successful in establishing new subpopulations must first disperse over fragmented habitat and find a new site that meets the multiple requirements over the many years it takes to reach maturity. This has resulted in subpopulations that are often fragmented by large areas of unsuitable habitat. However, given high dispersal ability of seeds and lack of genetic divergence detected among Manitoba and Ontario, Canadian subpopulations are not considered to be severely fragmented.

Interspecific Interactions

Small White Lady's-slipper seeds lack food stores (endosperm) to initiate germination; hence associations with specific mycorrhizal fungi are required to support seedling development, and possibly during periods of adult dormancy (Shefferson 2006, Curtis 1943). A species of *Moniliopsis* has been isolated from the roots of Small White Lady's-slipper near Tolstoi, Manitoba (subpopulation #2) (Zelmer 1994). Fungal groups associated with Small White Lady's-slipper samples from Illinois and Kentucky include Tulasnellaceae, Thelephoraceae, and *Phialophora* (Shefferson *et al.* 2005). *Rhizoctonia subtilis* has also been isolated from Small White Lady's-slipper (Curtis 1939 cited in Zelmer 1994).

Small White Lady's-slipper relies on specific insects for pollination, and flower shape promotes cross-pollination. Catling and Knerer (1980) found Andrenid and halictine bees, 6-7mm long, to be the most important pollinators of Small White Lady's-slipper during a study of a Walpole Island First Nation subpopulation in Ontario. *Andrena ziziae* and *Halictus confusus* were among the most common bees. Insects observed within Small White Lady's-slipper flowers or with Small White Lady's-slipper pollen were *Andrena ziziae*, *Spechodes* sp., *Nomada* sp., a beetle (Elateridae), a hymenopterous parasite (Chalcididae), *Augochlorella striata*, *Halictus (Seladonia) confusus*, *Dialictus rohweri*, *D. atlanticus*, and *D. pilosus*.

Small White Lady's-slipper flowers do not produce nectar as a reward for visiting insects. The group of pollinating bees observed by Catling and Knerer (1980) are not host specific and were found on flowers of numerous other plant species that do produce nectar. Furthermore, halictine bees have a longer life cycle than andrenid bees and require flowering plants beyond those that overlap the flowering period of Small White Lady's-slipper. Thus sexual reproduction of Small White Lady's-slipper may indirectly depend on the presence of a diversity of flowering species throughout the growing season. Several studies have shown a decrease in pollinator diversity due to habitat fragmentation (see Ouborg *et al.* 2006). Thus low fruit production may be partly related to the small fragmented nature of suitable habitat for Small White Lady's-slipper.

Negative interspecific interactions include competition with encroaching woody vegetation and invasive species. Browsed leaves and stems of Small White Lady's-slipper plants are not uncommon (MB CDC 2010) and may result in lower fruit production. Browsing of Small White Lady's-slipper plants observed by Falb and Leopold (1993) was

thought to be from rabbits. Hybridization with Yellow Lady's-slipper may also have potential to negatively affect the genetic integrity of Small White Lady's-slipper, as well as potentially reducing the number of intraspecific offspring produced **(see Limiting Factors).**

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Survey methods are extremely variable for this species. Following IUCN guidelines (IUCN 2010), vegetatively and sexually reproducing units within a clone should be counted in estimating the number of mature individuals. However, such information is not typically available for this species. It is often difficult to determine where an individual plant ends and another begins for this clonal species, resulting in high degrees of uncertainty when estimating number of genetic individuals, and even more unclear how to determine whether a segment of a genetic individual is capable of vegetative reproduction. Abundance measures range from detailed counts of flowering and non-flowering stems per clump (estimated genetic individual) to rough estimates of visible flowering stems only. Flowering stems are most commonly reported because flowers are required to differentiate Small White Lady's-slippers from Yellow Lady's-slippers and hybrids. Even with flowers there is often a high degree of uncertainty about the identity of Small White Lady's-slippers versus hybrids (MB CDC 2010). Furthermore, late spring frosts are not uncommon and result in brown withered flowers. Therefore, abundance estimates in frost years have an even higher degree of uncertainty. Even when similar methods are used, differences in search effort or timing of visits may result in very different abundance estimates, because the flowering period is typically less than two weeks. For example, in 2012 the MB CDC (2012) estimated 250 flowering stems on May 30 at one site within subpopulation #16, whereas Krindle (pers. comm. 2012) estimated 619 flowering stems on June 1 at the same site. Because many of the values provided are single point estimates it is not possible to estimate the expected error or fluctuation in counts within and among sites and years. Similarly, the expected fluctuation in flowering stem counts due to environmental fluctuations among years is not known.

For the purposes of this status assessment, abundance estimates are reported as number of total stems and number of flowering stems. These estimates do not include non-flowering plants for which identity could not be confirmed or flowering plants for which identity was uncertain (e.g. suspected hybrids). The number of flowering stems is used as an index of number of mature individuals. Buds not yet in full bloom, but growing among other Small White Lady's-slipper stems, were included in the number of flowering stems. Aborted flowers were excluded.

It should also be noted that because Small White Lady's-slipper takes approximately 12 years or more to produce its first flower (Curtis 1954), total abundance is expected to be underestimated by stem counts. Its ability to undergo one or more years of dormancy can also result in underestimates of population size and inferences of fluctuations.

Abundance

A current estimate of the total number of mature individuals in Canada is not available because recent data from Walpole Island First Nation subpopulations are unavailable. In Manitoba, there are approximately 22,000 mature individuals, based on recent flowering stem estimates. Abundance estimates and comments for the 19 extant Manitoba subpopulations are provided in Table 3. In Ontario, 536 flowering stems were counted at the Hastings County subpopulation in 2011 (Table 2). A permit including a census of Small White Lady's-slipper on Walpole Island First Nation, was issued for 2008 – 2010 (Environment Canada 2008a), but it is not known whether the census was completed nor what the resulting counts were. According to Bowles (2005), less than 10% of the Canadian population occurs on Walpole Island First Nation lands. However, the recovery strategy for Small White Lady's-slipper includes more than 14,000 clumps (plants/genets) as of 2003 (Environment Canada 2014), which would suggest as much as 50% of the total Canadian population occurs in this area. This discrepancy cannot currently be resolved.

Table 3. Manitoba Small White Lady's-slipper subpopulation abundance.

Subpopulation	First Obs.	Most recent estimate of total number of stems/ Number flowering stems (year)	Comments and Trends
1. Kleefeld	1980	152/59 (2012)	Total/flowering stems: 681/318 (1986), 683/293 (1987), 568/394 (1988), 552/135 (1989), 593/223 (1990), 507/? (1992), 598/? (1996), 600/? (1997), 522/391 (1998), 373/156 (1999), 279/193 (2000), 250/175 (2001), 264/188 (2003), 340/175 (2004), 266/139 (2009), 152/59 (2012).
2. Tall Grass Prairie Preserve	1993	<34 491/<16 899 (2012)	Likely less than 1997 abundance (34 491 stems), based on monitoring plots.
3. Franklin west	1999	67/52 (2012)	Total/flowering stems: ?/47 (1999), ?/20-30 (2000), 111/66 (2006), 187/63 (2008), 31/17 (2009), 97/82 (2010), 67/52 (2012).
4. Franklin south	1999	38/24 (2012)	Total/flowering stems: 82/35 (1999), 74/57 (2000), 10/3 (2001), 0 - too early (2006), 12/11 (2008), 17/10 (2009), 22/19 (2010), 38/24 (2012).
5. Franklin east	1999	18/8 (2011)	Last confirmed at previously mapped area in 2000. Unsure if Small White Lady's-slippers or hybrids in 2006. Only Yellow Lady's-slippers observed at previously mapped area in 2011. However, a new occupied area was discovered just over 1 km away in 2011.Total/flowering stems: 55/47 (1999), ?/8 (2000), 18/8 (2012).

Subpopulation	First Obs.	Most recent estimate of total number of stems/ Number flowering stems (year)	Comments and Trends
6. Emerson	2001	72/50 (2009)	Total/flowering stems: 39/29 (2001), 0 (2002), 0 (2003), 72/50 (2009). Yellow-lady's-slippers more abundant.
7. Carman	2008	40?/40? (2012)	Relatively newly reported subpopulation lacking data. Total/flowering stems: ? (2008), 0 - hybrids only (2010), ?/23 (2011), ?/40 (2012). Some uncertainty associated with a count of 40 in 2012 reported by a citizen familiar with the locality of plants from previous years. Other researchers visiting this site on the same day and next day did not confirm presence of Small White Lady's-slipper. Yellows and hybrids are much more abundant and a late spring frost damaged flowers.
8. Tolstoi	2008	462/301 (2012)	Relatively newly reported subpopulation lacking data. Approximately 68 plants - 47 in bud and 10 in flower (June 10, 2008), approx. 240 plants in bloom (June 20, 2008), approx. 150 stems - about half blooming (2009), approx. 106 plants - 462 stems/301 flowering stems (2012).
9. Woodlands ditch	1966	214/129 (2012)	Total/flowering stems: 66/43 (1993), approximately 200 clumps with an average of 3 stems per clump (1997), 78/34 (1998), 57/? (1999), 72/53 (2000), 128/99 (2001), 338/243 (2005), 267/153 (2007), 629/352 (2008), 228/164 plus 60 stems, which included hybrids (2009), <100/17 (2010), 571/382 (2011), 214/129 (2012). NOTE: 126 stems were removed in 2011 for a transplantation experiment (to subpopulation #12). Abundance of remaining stems decreased from 445 (2011) to 214 (2012).
10. Lake Francis/Manipogo	1983	>200/>138 (2012)	Total/flowering stems: 159/28 (1993), 80/29 (1998) 26/14 (2003), ?/10-15 but past prime (2010), 249/191 (2012).
11. St. Laurent	1995	1375/>308 (2009)	Several fragmented areas make up this subpopulation. Abundance estimates are lacking for entire subpopulation in any one year. Some stem counts reported below may not include all occupied areas. Total/flowering stems: 1677/615 (1998), 1776/973 (1999), >3085-3485/>2630-3030 (2001), >3000/? (2005), 1375/>308 (2009). Note: 2009 estimate does not include all occupied areas.

Subpopulation	First Obs.	Most recent estimate of total number of stems/ Number flowering stems (year)	Comments and Trends
12. Woodlands trail	1998	319/211 (2012)	Total/flowering stems: 166/158 (1999), 161/75 (2000), >266/168 (2005), no count because mostly done blooming but definitely fewer than 2005 (2007), >176/48 (2008), >146/22 (2009), 27/19 (2010), 45/25 (2011), 319/211 (2012). NOTE: 126 stems were transplanted to this subpopulation in 2011 (from subpopulation #9). Abundance of original stems increased from 45 (2011) to 159 (2012). Abundance of transplanted stems increased from 126 (2011) to 160 (2012).
13. St. Laurent northwest	2005	>287/143 (2010)	Total/flowering stems: 1938/1413 (2005), >287/143 (2010). Note: All visible stems not counted in 2010.
14. South of Brandon	1954	>1200/<1200 (2011/2012)	Several fragmented areas make up this subpopulation. Abundance estimates are lacking for entire subpopulation in any one year. Decreasing/disappearing in some areas and increasing/appearing in others. Overall no major trends in abundance apparent but number of areas and/or area of occupancy may be decreasing.
15. Brandon Hills	1993	1000s/<1000s (2010)	Several fragmented areas make up this subpopulation. Abundance estimates are lacking for entire subpopulation in any one year. Overall no major trends in abundance apparent.
16. Southeast of Brandon	1997	>619/619 (2012)	Several fragmented areas make up this subpopulation. Abundance estimates are lacking for entire subpopulation in any one year. Overall no major trends in abundance apparent but number of areas and/or area of occupancy may be decreasing.
17. Southeast of Brandon Hills	2007	504/384 (2012)	Total/flowering stems: 83/? (2007), >600/? (2008), >762/>398 (2011), 504/384 (2012).
18. Oak Lake	2008	74/26 (2012)	Total/flowering stems: 20/? - severe frost damage (2009), 189/141 (2010), 309-329/279 (2011), 74/26 (2012).
19. Rounthwaite	2011	81/27 (2012)	Total/flowering stems: 60/46 (2011), 81/27 (2012).

Sources: MB CDC 2012; Worley pers. comm. 2012; Krindle pers. comm. 2012; Ames pers. comm. 2012; Borkowsky pers. comm. 2012; MB CDC 2010; Punter 1999.

Fluctuations and Trends

The last COSEWIC update written in 1999 estimated 36,260 stems in Manitoba based on data from the early 1980s to 1997 (Brownell 1999). An update supplement for Manitoba (Punter 1999) estimated 42,879 stems (21,629 flowering) based on more recent surveys from 1997 and 1998. The current stem estimate for Manitoba is approximately 42,000 (22,000 flowering). There is a high degree of uncertainty associated with this estimate. A recent census has not been conducted at the Manitoba Tall Grass Prairie Preserve, which accounts for approximately 80% of Manitoba's population. Excluding uncertainty associated with the Manitoba Tall Grass Prairie Preserve and subpopulations discovered since 1998, abundance has decreased by 67% from 8388 stems (4,721 flowering) to 5,760 stems (4,037 flowering).

There is insufficient data available to determine trends in Small White Lady's-slipper abundance in Ontario. The last COSEWIC update estimated 6,450 stems in Ontario distributed among 1,400 clumps (Brownell 1999). An estimate of over 140,000 plants on Walpole Island First Nation was provided in an explanation for issuing a permit in 2009 (Environment Canada 2009), but this may be in error as it does not agree with any previous estimates, which include an estimate of > 14,000 clumps in 2003 (Environment Canada 2014). The terms "individuals", "clumps", and "plants" are not defined in earlier sources resulting in difficulties making comparisons. Numbers reported for the Hastings County subpopulation have increased since the last COSEWIC assessment (Table 2). There may be differences in survey methods that account for differences in numbers reported.

Fluctuations in numbers reported are common within subpopulations. This can result from actual fluctuations in counts of above-ground, flowering individuals due to mortality or from apparent fluctuations due to dormancy and reduced flowering. Apparent fluctuations can also result from differences in search effort and reporting methods. Due to fluctuations, inconsistent methods, and gaps in survey years it is difficult to detect trends in subpopulations. Estimates across survey years in Manitoba are provided in Table 3. While some subpopulations are now reportedly larger than when they were first discovered, others show evidence of decreases. Overall fewer subpopulations show evidence of increasing than decreasing. Few subpopulations have sufficient data to suggest real trends.

The Manitoba Tall Grass Prairie Preserve (subpopulation #2) has been monitoring Small White Lady's-slipper annually since 1997 using consistent search effort, methods, and representative plots (Borkowsky pers. comm. 2012). As with other subpopulations, fluctuations are common (Fig. 5). Causes of these fluctuations are unknown but may be related to weather, management activities, and interactions between the two. For example, decreases in abundance in 2009 are associated with lower than normal spring temperatures (Agriculture and Agri-Food Canada 2012). Increases in 2010 are associated with higher than normal rainfall and temperatures late in the 2009 growing season and in the spring of 2010. Decreases in 2012 are associated with unusually dry, warm conditions from late summer 2011 through winter and spring of 2012.

Prescribed burns and wildfires occur relatively frequently at the Manitoba Tall Grass Prairie Preserve. Burns are used to manage excessive thatch accumulation and encroachment by woody vegetation but intense fires may damage rhizomes (Worley pers. comm. 2012). Fires may also contribute to earlier flowering, which makes them more susceptible to spring frosts. In 2012, the greatest decrease was in plot A. The combination of dry weather and a hot wildfire may have contributed to earlier than usual flowering and severe damage from frost in late May. Differences in wildfire severity across the landscape may be partially responsible for differences among plots. Previous to 1997, stem counts at the Manitoba Tall Grass Prairie Preserve are thought to have increased due to a number of factors including weather, management, and increased counting efficiency (Borkowsky pers. comm. 2012). The interactions between weather fluctuations and management regimes are complex, and their effects on Small White Lady's-slipper remain unknown.

The Kleefeld subpopulation (#1) has been monitored fairly regularly and consistently since 1986, and appears to be decreasing (Fig. 6). Portions of this subpopulation were damaged by recreational vehicles in 2008. Moreover, in September 1998 this area was extensively damaged as a result of fence maintenance activities, and in 1997 more than 10% of stems were dug up (Punter 1999; MB CDC 2010). Abundance estimates have never returned to pre-disturbance estimates at this subpopulation.

The two Woodlands subpopulations (#9 and 12) have also shown some interesting fluctuations and trends, although they have not been surveyed as consistently. The Woodlands ditch subpopulation (#9) appears to have been fluctuating, yet stable to increasing over the past 15 years (Fig. 7). Even after removal of 126 stems in 2011 for a transplantation experiment, the 2012 count is still greater than most early counts. High abundance within this subpopulation is associated with areas where mowing occurs later in the season and has potential to disperse seed, versus areas where mowing begins earlier in the season and has potential to remove flowers (Proctor pers. comm. 2008; MB CDC 2010). Conversely, the nearby Woodlands Trail subpopulation (#12) has been decreasing since 2005 in association with encroachment by woody species and thatch accumulation (Foster 2008; Krause Danielsen and Friesen 2009). Recent management activities (woody vegetation removal in 2010 and a spring burn in 2011) may be partially responsible for a notable increase in 2012. Excluding transplants from the ditch (#9), stem counts at the trail (#12) increased from 42 (2011) to 159 (2012). This brings abundance back up to early stem estimates from 1999 and 2000. Including transplants, the 2012 count is the highest ever recorded at this subpopulation.

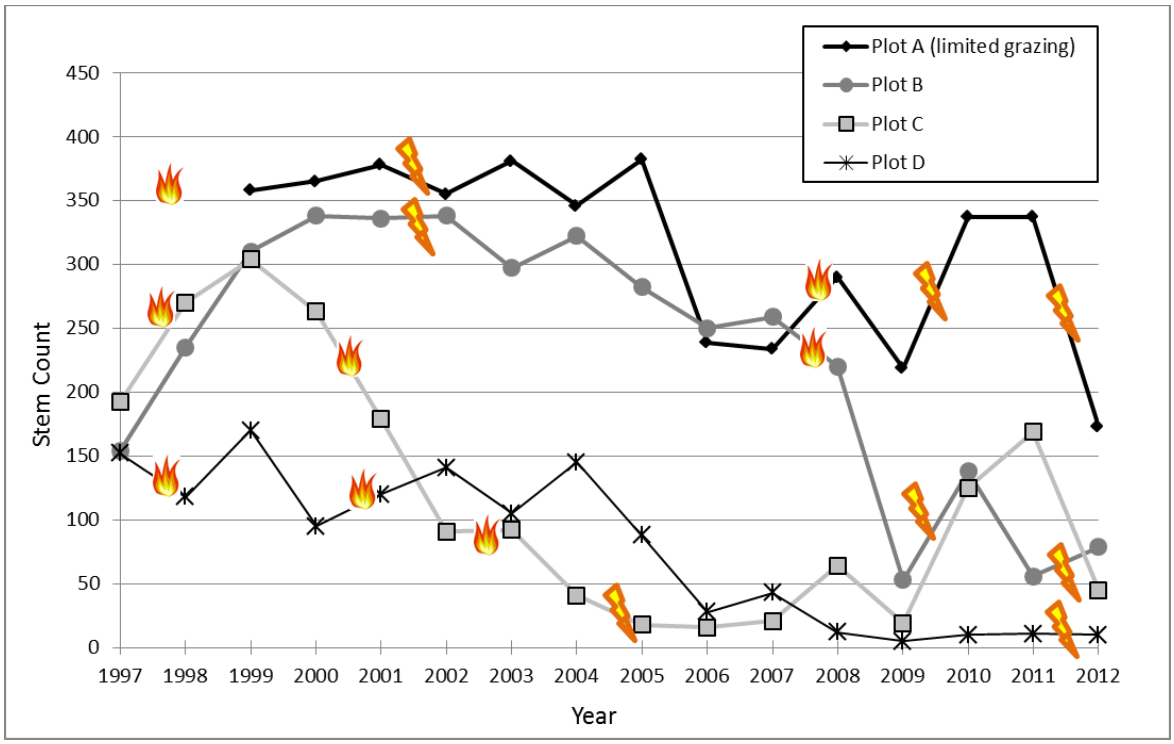

Figure 5. Manitoba Tall Grass Prairie Preserve Small White Lady's-slipper monitoring plot stem counts. Prescribed burns denoted by fire symbol. Wildfires denoted by lightning bolt. (Source: Borkowsky pers. comm. 2012.)

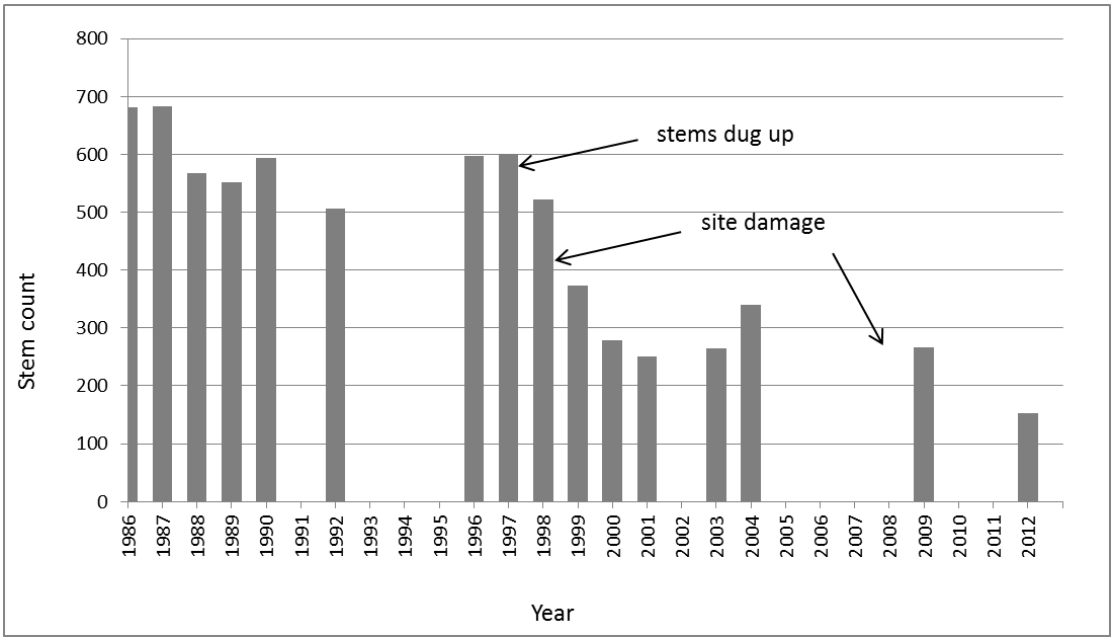

Figure 6. Kleefeld, Manitoba Small White Lady's-slipper stem counts. (Source: MB CDC 2012.)

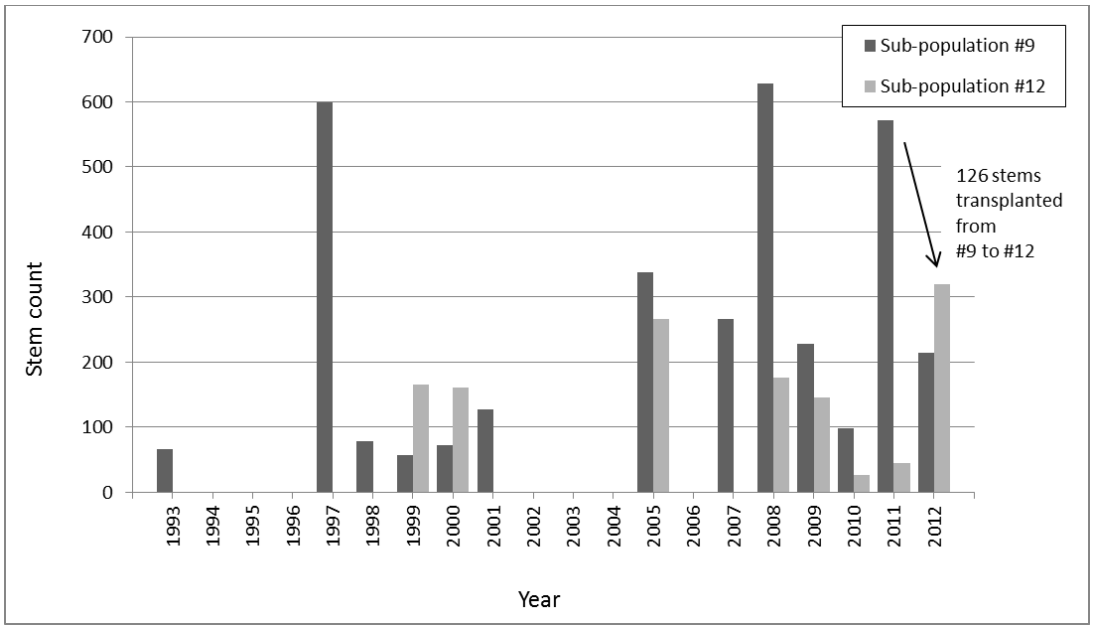

Figure 7. Woodlands, Manitoba Small White Lady's-slipper subpopulations #9 and #12 stem counts. (Source: MB CDC 2012.)

The St. Laurent subpopulation (#11) had been increasing with regular fall haying. Since ownership changed and regular fall haying ceased, abundance appears to have been decreasing (Roberts pers. comm. 2012). However, an accidental fire burned the entire area in 2012, which may result in future increases in abundance.

In addition to abundance estimates, changes in area occupied or extirpations can be an indication of trends in abundance. For example Brandon subpopulations #14 and #16 are composed of several occupied areas. Some appear to be growing in size, while others appear to be disappearing. Areas occupied by Small White Lady's-slipper subpopulations appear to be more stable than abundance estimates from year to year (MB CDC 2010). The newly discovered subpopulations appear to have been present for a number of years considering the stem numbers and presence of flowering individuals. Therefore they do not likely reflect newly established sites.

Rescue Effect

Long-distance dispersal of seed from the United States to Canada is possible. Immigrants would likely be adapted to survive in Canada. Small patches of suitable habitat may be available in Manitoba, although successful establishment requires the presence of specific symbiotic fungi and suitable environmental conditions to survive to maturity. Suitable habitat is not likely available in southern Ontario, as it is mostly agricultural with very few suitable sites available for colonization (Oldham pers. comm. 2013). The status of Small White Lady's-slipper in adjacent United States jurisdictions is as follows: North Dakota – S2S3, Minnesota – S3, and Michigan - S2. In Minnesota the species occurs in Kittson County, USDA 2012) the border of which is less than 10 km from the Tall Grass

Prairie Preserve. In Michigan it occurs in St. Clair County, which borders Ontario near the Walpole Island First Nation subpopulations (USDA 2012). The Walpole island First Nation subpopulations are less than 5 km from the St. Clair County border.

THREATS AND LIMITING FACTORS

Threats Due to Loss, Degradation and Fragmentation of Habitat

The most imminent, widely documented threats to Small White Lady's-slipper in North America are related to loss, degradation and fragmentation of habitat (Brownell 1981). A number of natural and anthropogenic factors contribute to the continuing decline in quality and quantity of suitable habitat in Canada as summarized below. Beneficial habitat management may restore some naturally degraded habitat in the future. However, anthropogenic fragmentation and loss of habitat have been occurring on a large scale and are, for the most part, irreversible.

Encroachment by Woody Vegetation and Excessive Thatch Accumulation (IUCN: Natural System Modifications: Fire Suppression and Other Ecosystems Modifications)

Small White Lady's-slipper habitat becomes increasingly degraded by encroaching woody vegetation and excessive thatch accumulation in the absence of historical disturbances such as fire and grazing. Encroachment by woody vegetation and thatch accumulation are the most commonly reported threats to Canadian subpopulations (Brownell 1981; Brownell 1999; Punter 1999; MB CDC 2010). Small White Lady's-slipper is limited by light and moisture availability, which decrease with encroaching woody vegetation. Curtis (1946), states that control of competing shrubs is essential for maintenance or increase of Small White Lady's-slipper populations. Thatch is associated with decreased light quality and quantity, and increased variation in surface temperatures (Facelli and Pickett 1991; Sletvold et al 2010).

Conversely, appropriately timed burning, grazing, or mowing helps prevent woody vegetation encroachment and thatch accumulation, and has been associated with more stable or increasing subpopulations such as the Manitoba Tall Grass Prairie Preserve (#2), Woodlands ditch (#9), Lake Francis (#10), St. Laurent (#11), Woodlands trail (#12) pre-2005, Brandon Hills (#15), and Walpole Island First Nation subpopulations (Brownell 1999; MB CDC 2010; Worley pers. comm. 2012).

Empirical evidence of causal linkages between encroachment or thatch and Small White Lady's-slipper declines in Canadian subpopulations is difficult to demonstrate due to complex life history traits and difficulties detecting trends based on the data collected. One of the annually monitored plots (D, Fig. 5) at the Manitoba Tall Grass Prairie Preserve has not burned since 2001. It has been associated with excessive thatch accumulation (25 - 30 cm) and a decrease in stem counts since 2004 (C. Borkowsky pers. comm. 2012). Two nearby burned plots (B and C, Fig. 5) started off with similar abundance to the unburned plot when monitoring began in 1997. The burned plots have shown increases and

decreases in abundance but remain more abundant than the unburned plot. In 2010, the burned plots responded well to good conditions and produced 138 and 125 stems versus 10 stems at the unburned plot. Decreases in abundance associated with woody vegetation encroachment and thatch accumulation are also apparent at the Woodlands trail subpopulation (#12) (see Population Fluctuations and Trends section).

Some thatch cover may, however, benefit Small White Lady's-slipper. Brownell (1981) cites Correll (1950) suggesting that Small White Lady's-slipper prefers a "fairly thick layer of litter". In Manitoba, the insulating effect of thatch could protect plants from late spring frosts by delaying shoot growth and flowering in early spring. For example, the St. Laurent northwest subpopulation (#13) has been noted to have a very heavy thatch layer and bloom later than the St. Laurent subpopulation (#11), which is less than 2km away but had been regularly hayed (MB CDC 2010). Similarly, the unburned Manitoba Tall Grass Prairie Preserve plot blooms earlier than the others (Borkowsky pers. comm. 2012). Thatch left behind from mowing has also been cited as a threat to roadside subpopulations (MB CDC 2010). However, high thatch accumulation has been reported at the Woodlands ditch subpopulation (#9), which appears to be stable to increasing.

In Ontario, the Norfolk County subpopulation has decreased (possibly to the point of extirpation) in association with succession and the associated increase in woody vegetation (Brownell 1981; Brownell 1984; Brownell 1999; Brinker 2011). Succession was also noted to be clearly changing the open habitat at the Hastings County subpopulation in 2008 (Brdar pers. comm. 2011). A study of this subpopulation conducted in 2003 stated that small shrubs did not appear to affect the amount of sunlight reaching Small White Lady's-slipper, but plants tended to occur on the southwest aspect of taller shrubs. Solomon (2003) indicated that encroachment by tall shrubs would likely have an impact although succession is extremely slow in fens. It has been anecdotally noted that an increase in woody vegetation is a possible threat, especially on the northern part of the site (Brdar pers. comm. 2013). However, Imrie *et al.* (2005) did not find evidence of woody encroachment adversely affecting this Small White Lady's-slipper subpopulation. Indeed, the most recent stem count is higher than past stem counts (Brinker 2011), although it is unclear whether these are reflective of an ongoing trend.

Invasive Species

Invasive species have been reported as a threat to most Canadian subpopulations (Punter 1999; MB CDC 2010). Nine of Manitoba's 19 extant subpopulations are restricted to remnant prairie along roadsides, which are particularly susceptible to the spread of invasive species through anthropogenic means. Several roadside subpopulations associated with thick growth of Smooth Brome (*Bromus inermis*) near Brandon, Manitoba appear to have been extirpated (#20) or have declined in area (portions of #14 and 16). The highly invasive Leafy Spurge (*Euphorbia esula*) is also a concern where it grows in association with Small White Lady's-slipper in western Manitoba (Brandon and Carman). It may prefer drier microsites but could affect plant diversity upon which Small White Lady's-slipper depends to attract pollinators.

Residential and Commercial Development: Housing and Urban Areas

Although less widespread, urban development is an ongoing threat and tends to introduce other threats such as spread of invasive species, trampling, illegal collecting, utility maintenance, and changes in hydrology. Highway, residential, and industrial development in the Brandon area has resulted in the extirpation of Small White Lady's-slipper from several areas (subpopulations #22, 23, and loss of portions of #14). Additional anticipated development has potential to further threaten Small White Lady's-slipper south of Brandon (MMM Group 2012). In Ontario, demands for infrastructure and housing on Walpole Island First Nation continue to increase (Bowles 2005). A permit was recently issued to transplant some plants from a construction site to a protected site on Walpole Island First Nation (Environment Canada 2009).

Alteration of Hydrology (IUCN: Natural Systems Modification: Dams and Water Management/Use)

Alteration of hydrology is a natural and anthropogenic threat to Small White Lady's-slipper. At the Manitoba Tall Grass Prairie Preserve, a beaver dam has expanded a wetland into an area where counts have dropped substantially since the late 1990s (Borkowsky pers. comm. 2012). Water level changes may also be partially responsible for encroachment of woody vegetation into Small White Lady's-slipper habitat at the Norfolk County subpopulation in Ontario (Brownell 1999). Water pH and nutrient loading may have also been affected in that area due to an upstream fish hatchery (Brownell 1984). Residential development south of Brandon, Manitoba has recently affected hydrology in an area occupied by Small White Lady's-slipper (Greenall pers. comm. 2011). While stem counts appear to suggest increases in that area, these may reflect differences in methodology. In addition, further development is anticipated nearby (MMM Group 2012). Effects of further development on hydrology, and Small White Lady's-slipper in this area, are unknown.

Road Allowance and Utility Maintenance (IUCN: Transportation and Service Corridors: Roads and Railroads)

Mowing during peak blooming periods has potential to remove flowers and decrease sexual reproductive output in roadside subpopulations. At the Woodlands ditch subpopulation (#9) lower abundance is associated with areas mowed early in the season (see Population Fluctuations and Trends section). Conversely, fall mowing of a portion of the Brandon Hills subpopulation (#15) appears to have drastically increased orchid density in that area, perhaps by dispersing seeds (Worley pers. comm. 2012). Ditch maintenance activities, such as dredging, also have potential to alter hydrology as well as damaging plants and/or habitat.

Maintenance of fence lines and utility cables along roadsides has also been reported as a threat (Punter 1999; MB CDC 2010). Fence line maintenance activities resulted in extensive damage to the Kleefeld subpopulation (#1) in 1998. As noted in the Population Fluctuation and Trends section abundance estimates have never reached pre-disturbance estimates. The Woodlands ditch subpopulation (#9) may have been impacted by installation of utility cables (Punter 1999) but abundance has been stable to increasing since that time (MB CDC 2012).

Herbicide/Pesticide Application

There is evidence of herbicide spraying at two roadside subpopulations in Manitoba. At the Kleefeld subpopulation (#1) a couple of Small White Lady's-slipper plants were brown and wilted from being sprayed in 2004. At the other (#17) it was likely a broadleaf herbicide as the Small White Lady's-slipper plants did not appear to be damaged. While the direct effects may have been minimal there may be additional indirect effects, because Small White Lady's-slipper is dependent on other species to attract its pollinators. The effect of herbicides on fungi upon which Small White Lady's-slipper depends is unknown.

Additional Threats

Trampling (IUCN: Human Intrusion and Disturbance: Recreational Activities)

Recreational vehicles have been reported as a threat to several subpopulations (MB CDC 2010). The two largest patches at the Kleefeld subpopulation (#1) were ripped up in 2008. Trampling of plants by nature enthusiasts and/or researchers has also been reported as a threat to the Hastings County, Ontario, subpopulation (Brdar pers. comm. 2008), although counts for this subpopulation have been increasing (Table 2). Trampling concerns following very wet weather resulted in fieldwork at Walpole Island First Nation subpopulations being cancelled in 2011 (Jacobs pers. comm. 2011).

Illegal Collecting (IUCN: Biological Resource Use: Gathering Terrestrial Plants)

Holes where Small White Lady's-slipper plants had previously been recorded have been observed repeatedly from numerous subpopulations, particularly along roadsides (#1, 11, 12, 14, and 16) (MB CDC 2010). At the Kleefeld subpopulation (#1) approximately 75-100 of 600 stems were dug up in 1997. At the St. Laurent subpopulation (#11) four of nine clumps had been dug up within a day or so of the initial observation. Digging of plants was also reported in 1988 and 1997 at Walpole Island First Nation (Brownell 1999).

Both direct threats to plants, and indirect threats associated with habitat degradation, are often related to changes in ownership/management and lack of awareness. Some Rural Municipalities responsible for managing roadsides (subpopulations #2, 3, 4, 5, and 9) have been provided with maps of occupied areas and management recommendations (Foster 2008). However, changes in ownership/management and lack of awareness are a continuing challenge.

Limiting Factors

In addition to being limited by specific requirements discussed under Habitat and Biology, above, impacts related to frost during the flowering season and hybridization with Yellow Lady's-slipper are discussed below.

Vulnerability to Late Frost

Frost is a natural limiting factor faced by Small White Lady's-slipper at the northern edge of its range in Canada, particularly in Manitoba. Frost-damaged Small White Lady's-slipper plants were reported in 1993, 1998, 2009, and 2012. Following frost in 1993, of ten subpopulations surveyed, less than 1% of flowers produced fruit. Following frost in 1998, none of the subpopulations surveyed produced fruit except one; the Manitoba Tall Grass Prairie Preserve, where only 2% of flowers produced fruit (Punter 1999). In 2009 frost damaged flowers were reported from subpopulations in all regions of Manitoba where Small White Lady's-slipper is known to occur (MB CDC 2010). In 2012, Small White Lady's-slipper bloomed earlier than usual due to an early, warm spring, and was then hit by frost in late May. At many areas visited in 2012, all flowers were severely frost damaged and not expected to produce any seed (Borkowsky pers. comm. 2012; MB CDC 2012; Worley pers. comm. 2012). The degree to which timing or severity of late spring frosts may be impacted by climate change is unknown.

Hybridization

Hybridization with Yellow Lady's-slipper is often cited as a threat to the genetic integrity of Small White Lady's-slipper subpopulations in Canada (Brownell 1999; Punter 1999; MB CDC 2010). The opportunity for hybridization is widespread, having been reported from all Manitoba subpopulations, the Hastings County and Norfolk County, Ontario subpopulations, and Walpole Island First Nation (Brownell 1984; MB CDC 2010; Brinker 2011; MB CDC 2012; ON NHIC 2012).

Worley *et al.* (2009) state that genetic assimilation of Small White Lady's-slipper by Yellow Lady's-slipper does not seem imminent based on a study of four subpopulations studied in Manitoba (# 9, 10, 11, and 12). Genetic and morphological analysis showed that the two parental populations remain genetically distinct in sympatry, and that most hybrids can be correctly identified as such based on morphology. However, some individuals identified as pure parentals based on morphology show genetic evidence of hybrid ancestry (Worley *et al.* 2009). These results suggest that the parental species are able to persist despite the opportunity for hybridization, but the mechanisms for maintaining genetic integrity are not known (Worley *et al.* 2009). In these subpopulations high local abundance of Small White Lady's-slipper may reduce its susceptibility to gene flow from Yellow Lady's-slipper. However, there are several areas in Manitoba where Yellow Lady's-slipper is much more abundant than Small White Lady's-slipper (subpopulations #36 and 7, and portions of #14, 16, and 17). None of these sites has been subject to genetic analysis to date.

Results from other subpopulations in Manitoba and Ontario are forthcoming. Worley *et al*. (2009) suggest that comparisons of the ecological requirements of hybrids and parents, and their relative fertilities are needed to determine whether extirpation through genetic assimilation is likely for Small White Lady's-slipper in Canada. More recently, several indices of reproductive success have been examined in the two parental species and their hybrids, including pollen viability, fruit set, and production of ovules and mature seeds. Small White Lady's-slipper has the lowest measures with regard to all of these, Yellow Lady's-slipper the highest, and hybrids are intermediate (Worley pers. comm. 2012).

Walsh (2008) conducted ITS (Nuclear-ribosomal internal transcribed spacers) analyses in an Ohio wildlife area where Yellow Lady's-slipper was thought to have been extirpated from a site that now supports a large subpopulation of Small White Lady's-slipper (approx. 6000) along with hybrids. He postulates that hybridization events (either genetic swamping or competition with the hybrids) may have played a role in the extirpation of Yellow Lady's-slippers and that there is no evidence to suggest that the presence of hybrids has had any adverse effect on the vast Small White Lady's-slipper subpopulations in the wildlife area studied.

Potential threats from hybridization in Canada may differ among subpopulations depending on the relative local abundance of Small White Lady's-slipper versus Yellow Lady's-slipper. Currently Small White Lady's-slipper is more locally abundant than Yellow Lady's-slipper at most subpopulations. However, encroaching vegetation has the potential to favour the more shade-tolerant Yellow Lady's-slipper, which could potentially affect gene flow direction and rates.

Number of Locations

Threats associated with loss and degradation of habitat are likely the most serious plausible threats. However, the type of threat likely to have the most impact on each subpopulation is unknown and will ultimately depend on the landscape context and management of each. Likely threats, such as encroachment by woody vegetation and invasive species, are not likely to act at once across multiple subpopulations, because the action of these threats is impacted by management (including fire management). Factors affecting such threats, such as land management and landscape processes, act on a small scale and differ among subpopulations. Therefore, in Manitoba, there are at least nineteen locations; one for each extant subpopulation. Additional locations may be considered for subpopulations that cover areas of different land use or land management. For example, some subpopulations cover private land owned by different individuals, and multiple roadsides adjacent to different land use/land management regimes. There are potentially over 50 locations. However, presence at some locations within a subpopulation has not been confirmed for many years and some locations may be extirpated. In Ontario, there are two or three locations: one in Hastings County and two, or possibly one, on Walpole Island. Because threats on Walpole Island have not been assessed recently, there is uncertainty as to the most imminent threat at the two subpopulations. Tables 1 and 2 indicate the potential number of locations for each subpopulation.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

Small White Lady's-slipper was first assessed by COSEWIC and designated Endangered in 1981. The status was re-examined and confirmed by COSEWIC in April 1999 and in May 2000 (COSEWIC 2000). Status was re-examined by COSEWIC in November 2014 and designated Threatened. Small White Lady's-slipper is currently listed as Endangered on Schedule 1 of Canada's *Species at Risk Act*. A draft national Recovery Strategy was submitted to Environment Canada in 2011, in which critical habitat was proposed. It is listed as Endangered under Manitoba's *Endangered Species Act* (Manitoba Conservation 2012) and Ontario's *Endangered Species Act, 2007* (Ontario Ministry of Natural Resources 2012). Under the provincial acts it is unlawful to harm individuals or damage its habitat. As a member of the Orchid family, it is included in Appendix 2 of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) (UNEP-WCMC 2011). It is not listed under the United States *Endangered Species Act* (USFWS 2012).

Non-Legal Status and Ranks

Small White Lady's-slipper has not yet been assessed for the IUCN (International Union for Conservation of Nature) Red List of Threatened Species (IUCN 2012). The NatureServe network's global, national and subnational conservation status ranks are provided in Table 4 (also Fig. 2). Globally, and nationally in the United States and Canada, it is considered G4 / N4 / N2, respectively. As a COSEWIC designated Endangered species, the Canada and provincial General Status ranks are automatically 1 (At Risk) (CESCC 2011).

Table 4. Small White Lady's-slipper Conservation Status Ranks (NatureServe 2012).

Region	NatureServe Rank	Conservation Status
Global	G4	Apparently Secure
Canada	N2	Imperilled
United States	N4	Apparently Secure
Manitoba	S2	Imperilled
Ontario	S1	Critically Imperilled
Saskatchewan	SH	Possibly Extirpated
Pennsylvania	SX	Extirpated
Alabama, Kentucky, Maryland, Missouri, Nebraska, New Jersey, New York, Ohio, South Dakota, Virginia	S1	Critically Imperilled
Illinois, Indiana, Michigan	S2	Imperilled
North Dakota	S2S3	Imperilled-Vulnerable
Iowa, Minnesota, Wisconsin	S3	Vulnerable

Habitat Protection and Ownership

All Small White Lady's-slipper subpopulations occur on private, provincial, or First Nations lands (Tables 1 and 2). Nine of Manitoba's 19 subpopulations are restricted to provincially owned roadsides, which are managed by rural municipalities. One subpopulation (#18) occurs adjacent to the TransCanada Highway in Manitoba but there is uncertainty regarding whether or not the plants occur on private or crown land (Murray pers. comm. 2012). In Manitoba, the largest subpopulation occurs on the Manitoba Tall Grass Prairie Preserve, which is managed for numerous rare species, including Small White Lady's-slipper. Properties supporting Small White Lady's-slipper are owned by the Manitoba Habitat Heritage Corporation and Nature Conservancy of Canada (Borkowsky pers. comm. 2012). The Brandon Hills subpopulation (#15) is currently the second largest in Manitoba and is secured by a Conservation Agreement between a private landowner and the Manitoba Habitat Heritage Corporation. It has been managed for the benefit of Small White Lady's-slipper by the landowner for generations and is one of the healthiest subpopulations in Manitoba. A small portion of one of the Brandon subpopulations is owned and managed by Manitoba Conservation, although decreases in abundance have been reported since 1998, possibly due to encroaching woody vegetation and invasion by weedy species (MB CDC 2010). Other subpopulations in Manitoba receive little or no protection, either due to lack of awareness (often due to changes in land ownership/management) or lack of knowledge and resources to manage habitat for the benefit of Small White Lady's-slipper.

The Hastings County, Ontario, subpopulation occurs within a protected area regulated under the Provincial Parks and Conservation Reserves Act. It has been monitored by Ontario Parks and others. All other extant Ontario subpopulations occur on Walpole Island First Nation lands. In 2001, the Walpole Island First Nation Band Council and Environment Canada signed a Conservation and Recovery Agreement committing to produce a multi-species recovery strategy for the Walpole Island Ecosystem. In 2005, a further agreement was signed outlining Species at Risk Recovery Activities to be undertaken by Walpole Island First Nation and Environment Canada (Bowles 2005).

ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED

Sam Brinker is greatly acknowledged by the author for conducting fieldwork in Ontario in preparation of this report. Clint Jacobs and Jane Bowles are also appreciated by the author for agreeing to conduct fieldwork on Walpole Island First Nation, although wet weather in 2011 did not permit fieldwork due to trampling concerns. The author extends thanks to Jeff Anderson, Marusia Foster and Bob Foster for their generous field assistance in Manitoba, in preparation of this report. Vivian Brownell is acknowledged for writing the first COSEWIC status report (Brownell 1981) and last update in 1999 (Brownell 1999). The author extends thanks to Liz Punter for writing the Update Supplement (Punter 1999) and for her extensive efforts documenting and sharing Small White Lady's-slipper information in Manitoba. Funding for this report was provided by Environment Canada through

COSEWIC. Special thanks are offered from the author to landowners who have granted property access and provided information over the years. Many other individuals contributed information, for which the author is grateful, and are included below.

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COLLECTIONS EXAMINED

No herbarium specimens were examined during preparation of this update status report.

Appendix 1. Species at Risk associated with Small White Lady's-slipper (MB CDC 2010, Bowles 2005).

Species Name	SARA Designation
Vascular Plants	
Climbing Prairie Rose (*Rosa setigera*)	Special Concern
Colicroot (*Aletris farinosa*)	Threatened
Common Hop-tree (*Ptelea trifoliata*)	Threatened
Dense Blazing Star (*Liatris spicata*)	Endangered
Eastern Prairie Fringed-orchid (*Platanthera leucophaea*)	Endangered
Gattinger's Agalinis (*Agalinis gattingeri*)	Endangered
Skinner's Agalinis (*A. skinneriana*)	Endangered
Pink Milkwort (*Polygala incarnata*)	Endangered
Riddell's Goldenrod (*Solidago riddellii*)	Special Concern
Rough Agalinis (*A. aspera*)	Endangered
Showy Goldenrod (*Solidago speciosa*)	Endangered
Western Prairie Fringed-orchid (*Platanthera praeclara*)	Endangered
White Prairie Gentian (*Gentiana alba*)	Endangered
Willowleaf Aster (*Symphyotrichum praealtum*)	Threatened
Invertebrates	
Dakota Skipper (*Hesperia dacotae*)	Threatened
Monarch Butterfly (*Danaus plexippus*)	Special Concern
Poweshiek Skipperling (*Oarisma poweshiek*)	Threatened
Birds	
Henslow's Sparrow (*Ammodramus henslowii*)	Endangered
Northern Bobwhite (*Colinus virginianus*)	Endangered
Sprague's Pipit (*Anthus spragueii*)	Threatened

Species Name	SARA Designation
Reptiles	
Spotted Turtle (*Clemmys guttata*)	Endangered
Butler's Gartersnake (*Thamnophis butler*)	Endangered