March 2020

Standardized Survey Protocol for Small White Lady's-slipper (*Cypripedium candidum*)

Prepared for

The Ministry of the Environment, Conservation and Parks through the Species at Risk Stewardship Program

north-south ENVIRONMENTAL

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Cover Photo: Small White Lady's-slipper (*Cypripedium candidum*)

Photo By: Pauline K. Catling

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Standardized Survey Protocol for Small White Lady's-slipper (*Cypripedium candidum*)

1. Introduction

The protection of Species at Risk (SAR) and their habitat requires comprehensive and up-to-date knowledge of species identification, classification, distribution, occurrence, abundance, habitat and threats. When detailed occurrence data are unavailable, field surveys are necessary to determine if a species is present at a site and ascertain its abundance and threats in order to implement SAR protection. However, many SAR are rare, occur at low densities and may be cryptic making detection difficult. Furthermore, some plant species may form hybrids with closely related species or can remain dormant for extended periods of time, which increases the challenges associated with confirming presence and evaluating the status of the population. This survey protocol has been developed to address the need for reliable, consistent and science-based survey methods in Ontario for Small White Lady's-slipper (*Cypripedium candidum* Muhl. ex Willd.), a terrestrial herb in the family Orchidaceae. The need for is a standardized survey protocol for this species is emphasized as a high priority in the Small White Lady's-slipper Government Response Statement (Government of Ontario 2016).

This document reviews existing information on Small White Lady's-slipper including identification, distribution, ecology, hybridization and threats. The proposed survey protocol is based on the best available scientific information at the time of publication, including information from several botanists with expertise on this species. The survey protocol should be reviewed, and if appropriate refined, should new information become available. This document contains information reviewed through a comprehensive literature search and information gathered from consultation with experts (See **Appendix 1** for a list of experts). This document presents a science-based survey protocol that identifies:

- How to evaluate potential habitat and determine study locations;
- How to complete a visual encounter survey;
- How to assess hybridization;
- How to assess habitat quality and potential threats;
- How to establish a long-term study; and
- How to record and report data collected.

Determining if there is habitat present under the *Endangered Species Act, 2007* (ESA) (general or regulated habitat) or the *Species at Risk Act*, 2002 (SARA) at a site is a complex process that is not limited to presence/ absence surveys. For example, even at sites where survey results are negative,

general or regulated habitat of a species at risk may still be present based on (1) nearby occurrences of the species (e.g., on an adjacent property) or (2) the manner in which the habitat is defined within a regulation, (3) habitat description or (4) policy. This document provides a protocol for surveying potential Small White Lady's-slipper sites (as defined here) and monitoring known subpopulations; however, it does not include consideration of whether habitat is protected under the ESA or SARA or a delineation of regulated habitat. This protocol is meant to be used by field biologists with expertise in botany who have acquired all relevant permits and permission for property access to complete surveys of Small White Lady's-slipper.

2. Species Information

2.1. Identification

Small White Lady's-slipper (*Cypripedium candidum*) is a terrestrial perennial orchid that grows 11 to 40 centimetres (cm) high (Sheviak 2002; Coleman 2019; FNA 2019a). It is erect with 3 to 4 (occasionally 5) clasping, alternate leaves from the proximal or medial portion of the stem (Coleman 2019; FNA 2019a). Leaves are 7 to 20 cm long and 0.9 to 5.3 cm wide (Sheviak 2002). Small White Lady's-slipper usually produces a single flower but can occasionally produce two (Coleman 2019). The small slipper-shaped flowers have a white lip 17 to 27 millimetres (mm) wide and spirally twisted petals that are 23 to 46 mm by 3 to 5 mm. Petals and sepals are green to pale brownish yellow with spotting and striped with reddish brown madder (FNA 2019a). The staminode is yellow with red dots (Coleman 2019). The fruit is an ellipsoid capsule containing thousands of dust-like seeds (Ostile 1990). **Figure 1** shows the flower morphology of slipper orchids (Ohio Department of Natural Resources 1987).

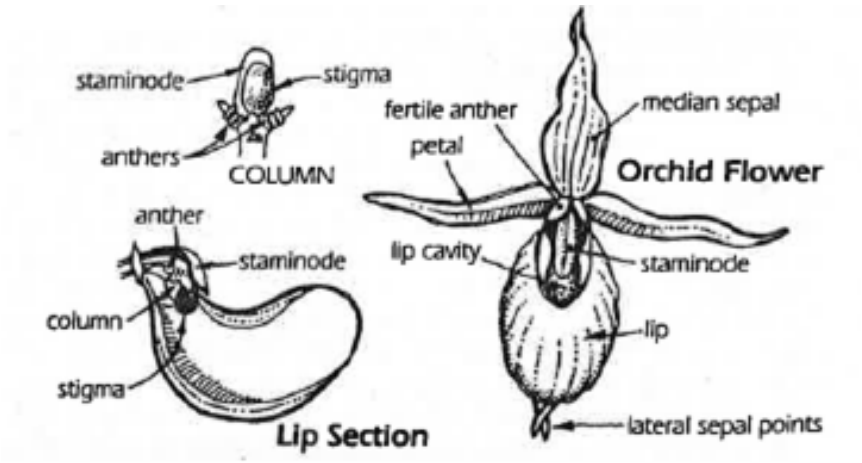


Figure 1. Flower morphology of slipper orchids (Ohio Department of Natural Resources 1987).

Genetically identical clumps are referred to as genets and stems originating from them are called ramets (Harper 1977). Genets may contain 3 to 60 ramets growing up from a rhizome (Curtis 1946). A study by Bowles (1983) found average genet size varied between 4.37 to 14.1 ramets per genet. Populations in fen habitats typically have fewer ramets per genet than those in prairie habitats (Brownell 1984). **Figure 2** illustrates the root system of Small White Lady's-slipper (Bowles 1983). Death of rhizome sections connecting ramets creates closely isolated genets in a manner of vegetative reproduction (Curtis 1954; Caroll et al. 1984). This is further discussed in **Section 2.4** below.

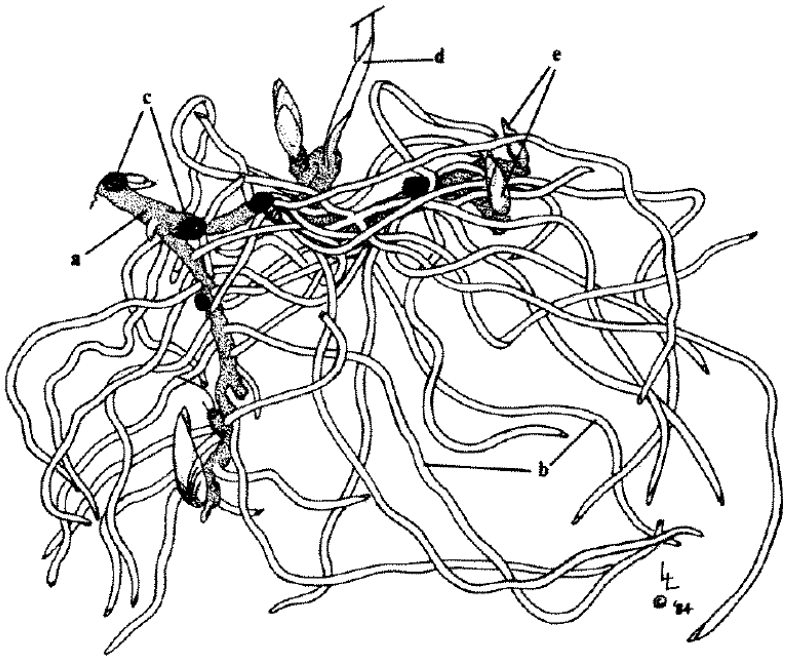


Figure 2. Root system of Small White Lady's-slipper a) branching rhizome b) lateral roots c) ramet scar d) current ramet e) perennating bud (Bowles 1983).

2.1.1. Similar Species and Hybridization

Coleman (2019) provides descriptions of all *Cypripediums* in the United States and Canada. Mountain Lady's-slipper (*C. montanum*) is a tall lady's-slipper with white flowers, which does not overlap in the existing range of Small White Lady's-slipper in Canada (FNA 2019). California Lady's-slipper (*C. californicum*) has many white flowers and does not overlap in range (FNA 2019). Three varieties of Yellow Lady's-slipper (*C. parviflorum* var. *makasin, C. parviflorum* var. *parviflorum* and *C. parviflorum* var. *pubescens*) are similar in appearance to Small White Lady's-slipper and overlap in range. The variety *C. parviflorum* var. *parviflorum* does not occur as far north as Canada. The variety *C. parviflorum* var. *exiliens* only occurs in Alaska and northwestern Canada (Sheviak 2010; Coleman 2019) and does not overlap in range. The variety *C. parviflorum* var. *makasin* is the smallest of the varieties that occurs in Ontario and has the most overlap in measurements (**Table 1**).

Small White Lady's-slipper blooms slightly earlier than Yellow Lady's-slipper and occurs in areas with more sun than Yellow Lady's-slipper. These species can hybridize in years when blooming overlaps in areas where habitats merge or pollinators visit adjacent occurrences (Sheviak 1974; Bowles 1983). As Yellow Lady's-slipper flowers age they can fade to a lighter colour and may even appear white (Sheviak 2002). Small White Lady's-slipper is believed to hybridize with *C parviflorum* var. *makasin* (reported erroneously as *parviflorum*) and *C. parviflorum* var. *pubescens* creating the hybrids *C.* × *andrewsii* and *C.* × *favillianum*, respectively (FNA 2019). Hybrids have the ability to cross and backcross with parental or hybrid individuals, producing individuals with an entire array of phenotypic and genotypic variability (Ostile 1990). One of these backcross hybrids was named *C.* × *landonii* (*favillianum* × *makasin*); however, this nomenclature is not formally accepted, and it is typically recognized as a nothosubspecies of × *andrewsii* (Coleman 2019). Hybrids have been noted in Norfolk County and Hastings County although they are more abundant in Norfolk (Brinker 2011). Backcrossing has been noted in Ontario. (Brownell 1981). **Table 1** provides a comparison of characteristics between Small White Lady's-slipper, similar species and hybrids.

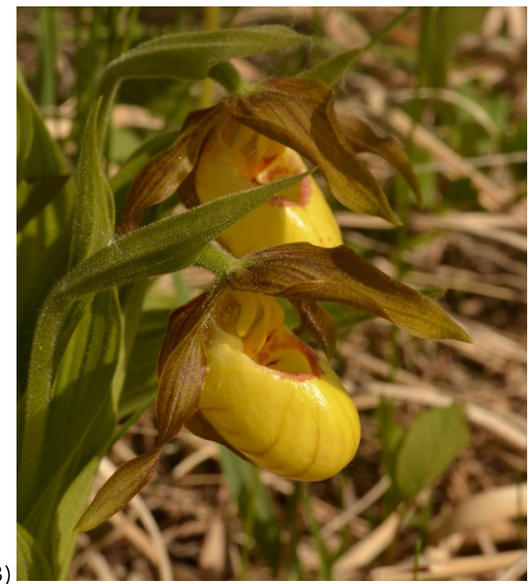
Flower colour of hybrids between Small White Lady's-slipper and Yellow Lady's-slipper is variable and may include creamy, yellow or white flowers (Sheviak 2002). Variation in colour is shown in **Figure 3**; however faded flowers may be difficult to identify based on colour. Hybrid morphology was found to be highly correlated with genetic evidence of hybrid ancestry (Worley et al. 2009). Floral dimensions are the smallest in Small White Lady's-slipper and largest in Yellow Lady's-slipper, with hybrids having intermediate measurements that overlap with both species. Orchid size has been noted to differ between certain subpopulations but is mostly uniform across its range (Anderson 2017).

Brownell (1984) suggested that the colour of the lip and shape of the staminodia are considered good characters to distinguish hybrids. Small White Lady's-slipper have elliptical staminodes. All varieties of Yellow Lady's-slipper have spade-shaped or triangular staminodes (Worley et al. 2009). A Study by Worley et al. (2009) noted that the following characters show variation among taxa:

- slipper colour (on a scale from 1 to 8 based on a paint colour chart),
- leaf curvature (scale from 1 to 5, where 1= flat, 3=boat shaped, 5=folded along midvein),
- plant height (cm),
- leaf length (cm),
- leaf width (cm),
- slipper width (mm),
- slipper length (mm),
- petal length (mm), and
- staminode shape.

Slipper colour is the trait with the least amount of overlap between species and hybrids (Worley et al. 2009)

A) 

B) 

C) 

D) 

E) 

Figure 3. Colour variation between A) Yellow Lady's slipper (*C. parviflorum*), hybrids (B, C and D) and E) Small White Lady's-slipper (*C. candidum*).

Note: Some hybrids (and backcrossed hybrids) may appear even lighter than as depicted in Figure 3D.

Table 1. Comparison of characteristics of Small White Lady'-slipper, similar species and hybrids. [1][2][3][4] Shaded rows include taxa not found in Ontario.

Species	Flower colour	Plant Height	Leaves	Sepal	Petal	Lip	Staminoide	Stigma
Small White Lady's-slipper (*C. candidum*)	Lip white; Sepals green to pale brownish yellow, usually suffused with dark reddish brown or madder; Petals same color as sepals	11-40 cm	Leaves 3–4 (–5); erect-ascending; blade lanceolate or elliptic to oblanceolate, 7–20 × 0.9–5.3 cm	dorsal sepal ovate to ovate-lance-acuminate, 15–35 × 7–13 mm; lateral sepals connate avg l=27.5 mm avg w=9.5 mm	spreading to somewhat deflexed, spirally twisted or spiral-undulate, lanceolate to linear-lanceolate; l=23-46 mm (avg=33) avg w=3.5 mm; opening to the pouch is rounded except for a small acute notch at its forward edge	obovoid or oblance-ovoid to oblance-fusiform l=17-27mm (avg=21.5) w=13 mm d=12.5 mm	lanceoloid or oblong-lanceoloid to ellipsoid	avg l=3.6 mm avg w=3.4 mm
Mountain Lady's-slipper (*C. montanum*)	Lip white, rarely suffused with magenta; Sepals greenish, suffused, often heavily with reddish brown or madder, rarely clear green; Petals same color as sepals	25–71 cm	Leaves 4–6, erect, ascending, or spreading; blade suborbiculate or broadly ovate to elliptic-lanceolate, 3.3–17 × 2.5–9.5 cm; slightly fuzzy	dorsal sepal lance-acuminate to elliptic-lance-acuminate, 33–60 × 8–16 mm; lateral sepals connate	spreading-deflexed, spirally twisted, linear to linear-lanceolate, 36–77 × 3–5 mm	obovoid or oblance-ovoid to oblance-fusiform, 19–33 mm	lanceoloid to broadly ovoid or ellipsoid-ovoid	-
Yellow Lady's-slipper (*C. parviflorum* var. *makasin*)	Lip rather pale to deep yellow; sepals greenish or yellowish; sepals and petals usually suffused with dark reddish brown or madder; Petals same color as sepals; Staminode yellow with reddish dots	Under 40 cm	Leaves (2-) 3-5 erect to spreading; blade orbiculate or broadly ovate to elliptic-lanceolate, 5.2–18.5 × 1.6–14.3 cm; uppermost entirely tubular bract is glabrous or with very few hairs	dorsal sepal suborbiculate or ovate to ovate-lance-acuminate, 19–80 × 7–40 mm; lateral sepals connate	horizontal to strongly descending, commonly spirally twisted or undulate, sometimes flat, linear-lanceolate to lance-ovate or oblong, 24–97 × 3–12 mm l=15-29 mm	oblance-ovoid l=15-29 mm	cordiform-ovoid, deltoid, lance-ovoid, or ovoid-oblong	-

[1] FNA. 2019. FNA: Orchidaceae: Cypripedium. FNA Vol 26. Accessed January 2020: http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=109046
[2] Fuller, A.M. 1932. *Cypripedium andrewsii*: A natural Cypripedium hybrid from Wisconsin. Rhodora 34:97-101
[3] Curtis, J.T. 1932. *Cypripedium favillianum*: A new Cypripedium hybrid. Rhodora 34:239-243.
[4] Coleman, R. 2018. The Cypripediums of the United States and Canada, Part I. The native Orchid Conference Journal 2019, 16.2: 2-21.

Species	Flower colour	Plant Height	Leaves	Sepal	Petal	Lip	Staminoide	Stigma
Yellow Lady's-slipper (*C. parviflorum* var. *parviflorum*)	Lip rather pale to deep yellow; sepals and petals greenish or yellowish, densely and minutely spotted with dark reddish brown or madder and appearing uniformly dark (rarely coarsely spotted and blotched)	70-70cm	Leaves 4-5, spreading; blade orbiculate to lance-elliptic to ovate or obovate, 9–19 × 2.5–9 cm; uppermost entirely tubular bract is densely to conspicuously silvery-pubescent	dorsal sepal suborbiculate or ovate to ovate-lance-acuminate, 19–80 × 7–40 mm; lateral sepals connate avg l=30.5 mm avg w=13mm	horizontal to strongly descending, commonly spirally twisted or undulate, sometimes flat, linear-lanceolate to lance-ovate or oblong, 24–97 × 3–12 mm avg l=38.5 mm avg w=4.5 mm	oblance-ovoid l=22-34 mm (avg=23) avg w=13.5 mm avg d=14 mm	cordiform-ovoid, deltoid, lance-ovoid, or ovoid-oblong	avg l=4,5 mm avg w=3.5 mm
Yellow Lady's-slipper (*C. parviflorum* var. *pubescens*)	Lip rather pale to deep yellow; Sepals greenish or yellowish, sepals unmarked to commonly spotted with reddish brown or madder, rarely extensively blotched; Petals greenish or yellowish	70-70 cm	Leaves 3-5, erect to spreading; blade orbiculate or broadly ovate to elliptic-lanceolate or oblanceolate, 7.9–20.9 × 1.5–12 cm; uppermost entirely tubular bract is densely to conspicuously silvery-pubescent	dorsal sepal suborbiculate or ovate to ovate-lance-acuminate, 19–80 × 7–40 mm; lateral sepals connate avg l=47.5 mm avg w=19 mm	horizontal to strongly descending, commonly spirally twisted or undulate, sometimes flat, linear-lanceolate to lance-ovate or oblong, 24–97 × 3–12 mm avg l=63.5 mm avg w=6.5 mm	oblance-ovoid l=20-54mm (avg=42.5) avg w=23.5 mm avg d=27 mm	cordiform-ovoid, deltoid, lance-ovoid, or ovoid-oblong	avg l=7.5 mm avg w=5.5 mm
Yellow Lady's-slipper (*C. parviflorum* var. *exiliens*)	Lip golden yellow; Sepals and petals are dull green-tan with small clusters of rust-colored spots rather than the uniform color or dense patterns of stripes or blotches found on the other varieties	Under 40 cm	Leaves 3-5, lanceolate-elliptic, ascending, arched and spreading from lower stem with sheathing base; uppermost entirely tubular bract is glabrous or with very few hairs	-	27-45 mm	16 -26 mm	cordiform-ovoid, deltoid, lance-ovoid, or ovoid-oblong	-
Hybrid Yellow (*C. parviflorum* var. *pubescens*) and White (*C. candidum*) Lady's-slipper (*C.* × *favillianum*)	Lip colour variable, creamy white to yellow, turning white when mature, striped inside and spotted around orifice with magenta-violet; Sepals and petal yellowish-green, striped with brown; Staminodium yellow	28-40 cm	Blade ovate-lanceolate, acute	avg l=33 mm avg w=15.5 mm	avg l=41 mm avg w=5 mm	avg l=30 mm avg w=17.5 mm avg d=18 mm	-	avg l=5.5 mm avg w=5 mm

Species	Flower colour	Plant Height	Leaves	Sepal	Petal	Lip	Staminoide	Stigma
Hybrid Yellow (*C. parviflorum*) and White (*C. candidum*) Lady's-slipper (*C.* × *andrewsii*)	Lip colour variable and intermediate between two parents, creamy white to pale yellow coloured, conspicuously striped on the interior with violet; Sepals and petals pale brown or greenish, much suffused with purple madder; Staminodium orange-yellow	16-40 cm	Blade oval-lanceolate, acute	Ovate-lanceolate l=25-37 mm (avg= 31.5) avg w=11.5 mm	Lanceolate l=30-40 mm (avg=34) avg w=4mm	l=20-25 mm (avg=21.5) avg w=12.5 mm avg d=13 mm	-	avg l=4.5 mm avg w=3 mm

2.2. Distribution

Small White Lady's-slipper is native to midwestern and eastern North America (**Figure 3**). Its current range extends across 18 states and two provinces. In Canada, it occurs in southern Ontario and southern Manitoba. Small White Lady's-slipper is Endangered in both provinces. In the United States, the species occurs in Alabama, Connecticut, Illinois, Indiana, Iowa, Kentucky, Maryland, Michigan, Minnesota, Missouri, Nebraska, New Jersey, New York, North Dakota, Ohio, South Dakota, Virginia, and Wisconsin (COSEWIC 2014). Small White Lady's-slipper is ranked as "Rare" in Indiana, Threatened in Illinois, Michigan and Wisconsin and Endangered in Kentucky, Maryland, New Jersey, New York and Ohio (USDA 2019). The species is considered extirpated from Pennsylvania and Saskatchewan (COSEWIC 2014).

Figure 4. Global Range of Small White Lady's-slipper (*Cypripedium candidum*) (Sheviak 2002; FNA 2019a). Image represents historic range, within which it may be extirpated in places.

As of the most recent COSEWIC update (COSEWIC 2014), the Canadian population includes 19 confirmed existing subpopulations in Manitoba (**Figure 5**) and two existing subpopulations in Ontario, which occur in two counties (**Figure 6**).

Historically, Small White Lady's-slipper occurred in six counties in Ontario including Bruce, Hastings, Kent, Lambton, Norfolk and Niagara (Brownell 1981). The subpopulations in Bruce, Kent, Norfolk and

Niagara counties are considered extirpated (NCC 2020). **Table 2** outlines the status of existing and historic Ontario subpopulations. One existing Ontario subpopulation occurs on land owned by the provincial government and is protected within a Provincial Nature Reserve. Two subpopulations have been known to occur on by Walpole Island First Nations, but their status has not been confirmed for over 20 years.

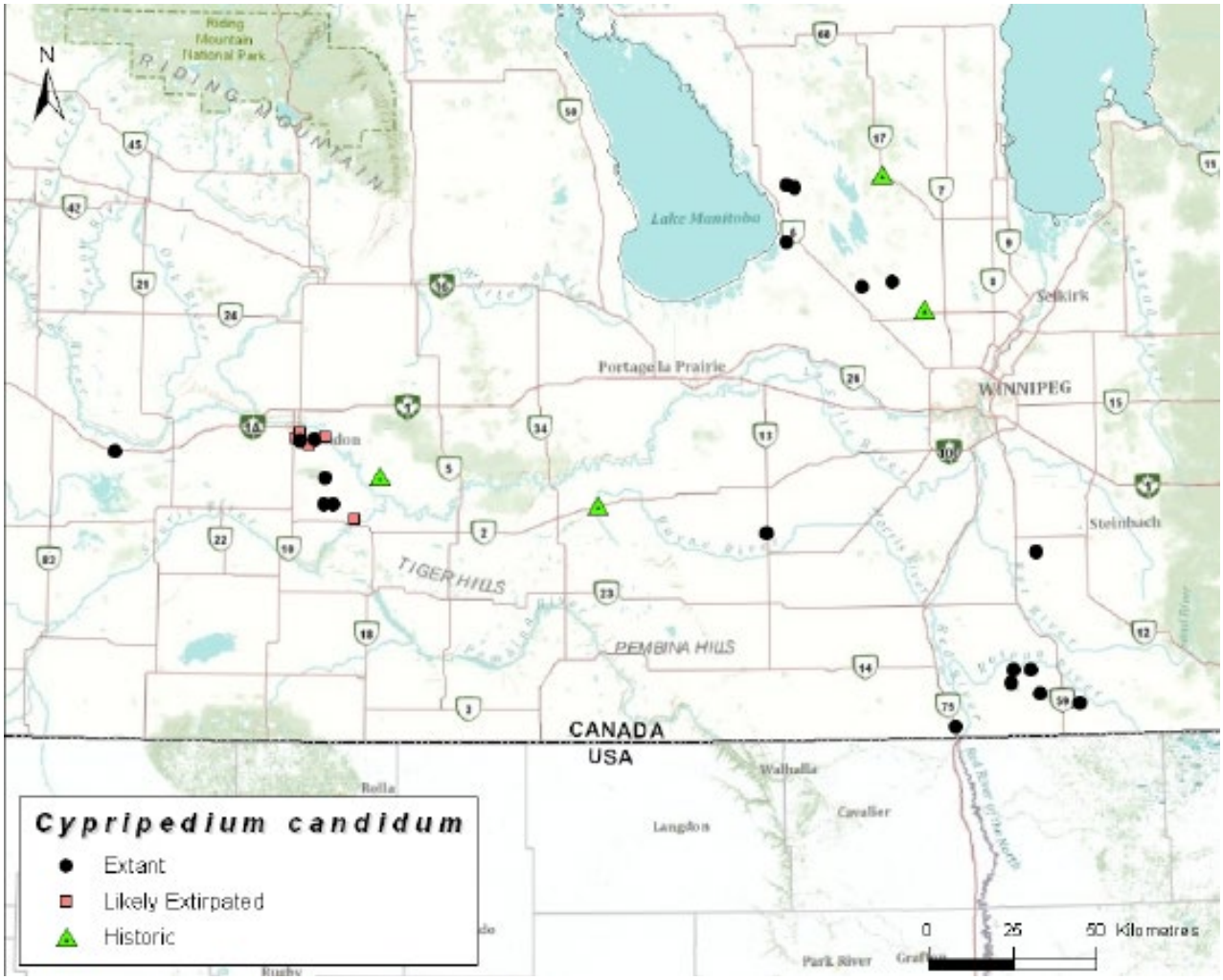


Figure 5. Distribution of Small White Lady's-slipper (*C. candidum*) locations in Manitoba (COSEWIC 2014).

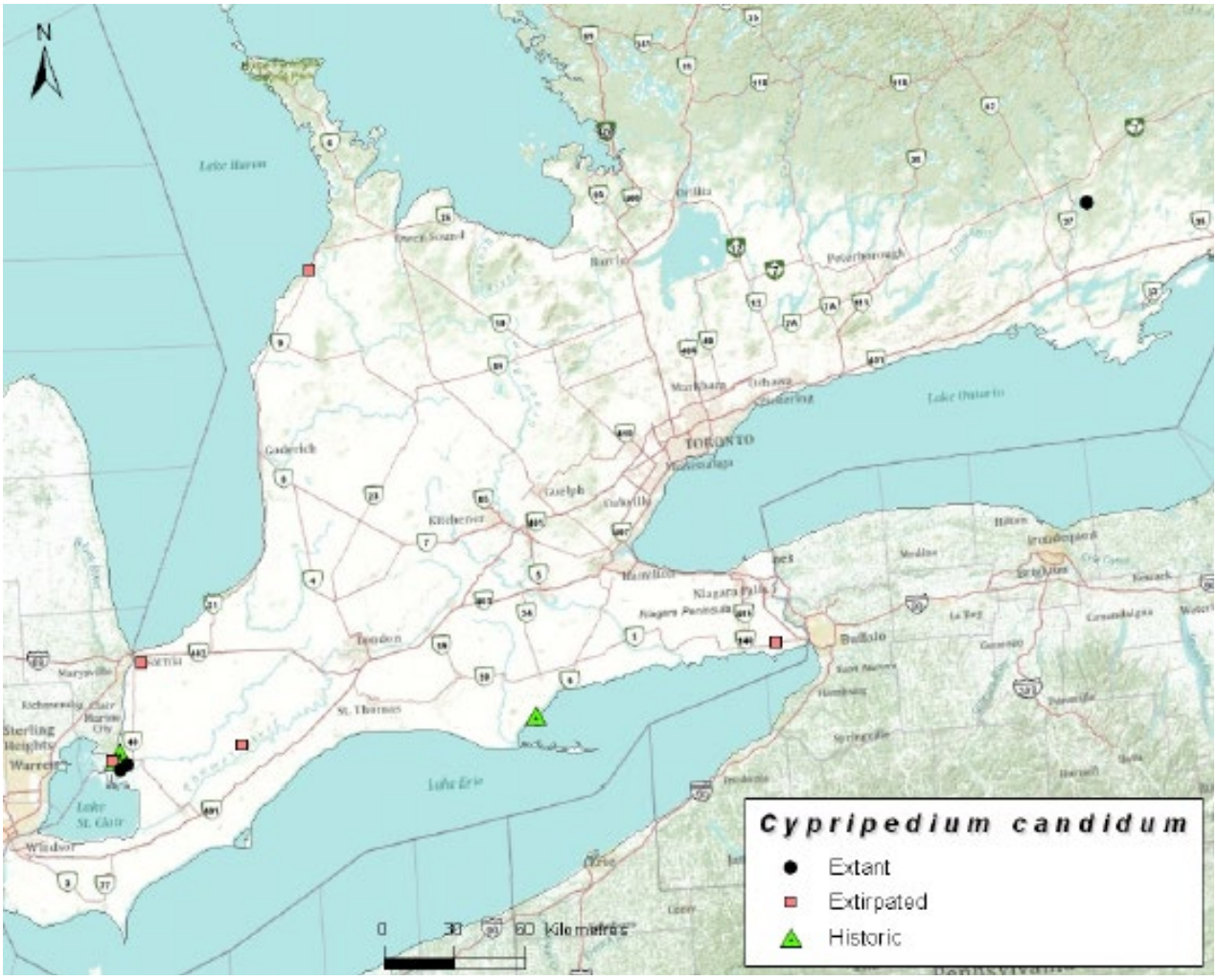


Figure 6. Distribution of Small White Lady's-slipper (*C. candidum*) locations in Ontario (COSEWIC 2014).

Table 2. Ontario Small White Lady's-slipper subpopulations[5]

El. Occ. ID	Subpopulation	First Observation	Last Observation	Status	Comments
5977	29. Hastings County	1979	2011	Extant	Protected area. 150-200 stems in 1979 and 1997, 248 flowering (638 stems) in 2003, 383 flowering individuals (469 flowering stems; 531 total stems) in 2011 (Brinker 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)	1925	1988	Historical	Walpole Island First Nation. Species not observed during a 1997 survey. More recent data unavailable
3277	35. Norfolk County	1905	1993	Historical	Provincial protected area. Counts from 1984 to 1987 ranged from to 141 to 37 stems (Brownell 1984; Kirk 1990). One plant last observed in 1993 (Geomatics International 1995). Overgrown with woody and herbaceous vegetation in 2011 and no plants were observed (Brinker 2011).

[5] Table adapted from: 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).

El. Occ. ID	Subpopulation	First Observation	Last Observation	Status	Comments
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."

Note: Personal communication with A. Worley (2020) disclosed that Small White Lady's-slipper was observed at four sites in the Walpole Island area in 2008. However, it is unclear if these were within the subpopulations noted above or represent additional sites. For this reason, the table above has not been updated to include this.

2.3. Habitat

Throughout its global range, Small White Lady's-slipper occurs in a variety of habitats, including limestone glades, dry hill prairies, wet to mesic prairies and savannahs, sedge meadows and alkaline fens (Curtis 1946; Bowles 1983; Brownell 1984; Kalisz and Thiede 1989; FNA 2019a). The common soil characteristics of habitats throughout its range are relatively high pH and high calcium (Bowles 1983). This species has very high light requirements, and most occurrences are found in open habitats and very rarely in semi-shaded habitats such as thickets and woodlands (Sheviak 1974; Bowles 1983). Generally, the species occurs in relatively undisturbed habitats, but plants occasionally spread into nearby disturbed sites such as railroad rights-of-way, roadsides and old fields (Bowles 1983). In the western portion of its North American range, Small White Lady's-slipper occurs primarily in prairie habitats. Conversely, in the eastern portion of its range, it more frequently occurs in fens (Ostile 1990). In Manitoba, Small White Lady's-slipper grows in remnants of moist, calcareous open prairie habitats but may also grow in roadside ditches adjacent to agricultural areas (COSEWIC 2014). In Ontario, the species occurs in wet to mesic tallgrass prairies and calcareous fens (Brownell 1981).

2.3.1. Limestone Glades, Dry Hill Prairies, Barrens and Bluffs

Subpopulations of Small White Lady's-slipper in Alabama, Kentucky and Maryland are found in rocky limestone glades, dry hill prairies, barrens and bluffs (Ostile 1990; Weakley 2012). A few occurrences in Iowa and Minnesota are found in dry hill prairies (Ostile 1990). These habitats are drier than the typical wet to mesic habitats of this species in the core of its range. Associate species in these drier sites include Little Bluestem (*Schizachyrium scoparium*), Eastern Redcedar (*Juniperus virginiana*), Northern Red Oak (*Quercus rubra*), White Oak (*Q. alba*), Dwarf Chinquapin Oak (*Q. prinoides*), Black Maple (*Acer nigrum*), Downy Serviceberry (*Amelanchier arborea*), Carolina Rose (*Rosa carolina*), Fragrant Sumac (*Rhus aromatica*), Hop-hornbeam (*Ostrya virginiana*), Eastern Redbud (*Cercis canadensis*), Oak Sedge (*Carex pensylvanica*), Butterfly Milkweed (*Asclepias tuberosa*), Yellow Pimpernel (*Taenidia integerrima*), American Dittany (*Cunila origanoides*), Hoary Puccoon (*Lithospermum canescens*), Cut-leaved Goldenrod (*Solidago arguta*), Tall Larkspur (*Delphinium exaltatum*) and Woodland Sunflower (*Helianthus divaricatus*) (Ostile 1990). Most occurrences of Small White Lady's-slipper in these drier habitats are at the southern fringe of the species' global range. Although barrens and bluffs with some of the same associate species occur in Ontario, Small White Lady's-slipper has never been reported from these habitats in Ontario. Dry hill prairie habitats do not occur in Ontario.

2.3.2. Fen

Some subpopulations of Small White Lady's-slipper in Illinois, Indiana, Iowa, Michigan, Minnesota, New York, North Dakota, Ontario and Wisconsin occur in alkaline fen habitats (Ostile 1990). The fens in which Small White Lady's-slipper can be found are always alkaline, having a pH greater than 8.0, and are often described as containing deposits of marl (Brownell 1981; Chapman 1981; Ostile 1990).

Marl in these systems is formed by calcium carbonate precipitation from groundwater which can form deep calcareous deposits and raise pH substantially, limiting the growth of many plants (Murphy and Wilkinson, 1980). The high pH of these wetlands promotes the survival of Small White Lady's-slipper and other calciphiles. In fens that support Small White Lady's-slipper, the associate species which are most frequently mentioned in the literature include Lesser Tussock Sedge (*Carex diandra*), Prairie Sedge (*C. prairea*), Tussock Sedge (*C. stricta*), Shrubby Cinquefoil (*Dasiphora fruticosa*), Kalm's Lobelia (*Lobelia kalmii*), Balsam Ragwort (*Packera paupercula*), Fen Grass-of-Parnassus (*Parnassia glauca*), Hoary Willow (*Salix candida*), Marsh Fern (*Thelypteris palustris*), Northern White Cedar (*Thuja occidentalis*) and Golden Alexanders (*Zizia aurea*) (Brownell 1981; Ostile 1990).

In Ontario, the Hastings County subpopulation grows in an open calcareous fen (Brownell 1981). The habitat in Hastings County includes ephemeral marl pools with *Sphagnum* moss hummocks with sedges, grasses and reeds (Luciuk 1974). Islands with Eastern White Cedar (*Thuja occidentalis*) and Tamarack (*Larix laricina*) are interspersed in the habitat (Luciuk 1974). Drainage down a low gradient slope is restricted to being slow and internal (Luciuk 1974). In Norfolk County, the largest subpopulation historically occurred in an alkaline fen on tussocks of sedges and Ostrich Fern (*Matteuccia struthiopteris*) (Brownell 1984). In 1981, this area was dominated by Poison Sumac (*Toxicodendron vernix*) and only the hybrid *C.* x *andrewsii* was found. A smaller subpopulation of hybrids was found in a clearing to the northwest of the fen. In 1993 a single Small White Lady's-slipper was found separate from the historic location (Geomatics International 1995). population. Brownell (1981) provided a list of associate species of Small White Lady's-slipper from fen communities in Hastings and Norfolk County, Ontario (see **Appendix 2**). The Hasting County site and Bergen Swamp, N.Y. have Creeping Juniper (*Juniperus horizontalis*) and Twig Rush (*Cladium mariscoides*) as associates (P. Catling pers. comm. 2020).

Figure 7. Small White Lady's-slipper (C. candidum) growing in prairie remnant.

2.3.3. Tallgrass Prairie, Sedge Meadows, Savannah and Parkland

Subpopulations of Small White Lady's-slipper in Illinois, Indiana, Iowa, Manitoba, Minnesota, Nebraska, North Dakota, South Dakota, Wisconsin, Michigan, Ohio and Ontario occur in wet to mesic tallgrass prairie communities. Some subpopulations in Illinois and Ontario occur in complexes of wet to mesic prairie and sedge meadow communities (Brownell 1981; Taft and Solecki 1990). In Ontario, several subpopulations on Walpole Island occur in wet to mesic tallgrass prairies, sedge meadows and oak savannah communities. Brownell (1981) provided a list of associate species of Small White Lady's-slipper from prairie communities on Walpole Island (see **Appendix 2**). In Manitoba, most subpopulations occur in wet to mesic prairies, but several subpopulations occur in Trembling Aspen (*Populus tremuloides*) parkland mosaics with intermixed wet sedge meadows or in disturbed habitats such as roadsides with prairie soils (Ostile 1990; C. Murray pers. comm. 2020).

In wet to mesic prairie and sedge meadow communities that support Small White Lady's-slipper, the associate species which are most frequently mentioned in the literature include Big Bluestem (*Andropogon gerardii*), Woolly-fruited Sedge (*Carex lasiocarpa*), Buxbaum's Sedge (*C. buxbaumii*), Bastard Toadflax (*Comandra umbellata*), Yellow Stargrass (*Hypoxis hirsuta*), Virginia Mountain-mint (*Pycnanthemum virginianum*), Little Bluestem (*Schizachyrium scoparium*), Indian Grass (*Sorghastrum nutans*), Prairie Cordgrass (*Sporobolus michauxianus*) and Golden Alexanders (*Zizia aurea*) (Brownell 1981; Ostile 1990; Taft and Solecki 1990).

2.4. Ecology

2.4.1. Life Cycle

Dispersed seeds enter the soil with rain or melting snow. Soil gradually accumulates over time and developing plants (protocorms) are typically found at a depth of 3 to 5 cm, a depth which would require more than one year to reach with water percolation being the primary vector (Curtis 1943). Seeds are assumed to germinate in the spring or summer (Mergen 2006). A protocorm (term for the stage between germination until the seeding develops a shoot tip with leaves) develops rhizoids (simple roots) that become infected with mycorrhizal fungi (Mergen 2006). The mycorrhizal fungi support the protocorm with nourishment until it can photosynthesize its own food (Mergen 2006). Developing plants take two years to produce their first aerial leaf and seedling mortality is high (Curtis 1943; Bowles 1983). Curtis (1943) noted that 84% of seedlings were one year old, but only 0.5% of seedlings were four years old.

The first aerial leaf typically develops 3 years after germination with emergence of mature flowering shoots after 7 to 13 years (Curtis 1943; Kalisz and Thiede 1989). Small White Lady's-slipper blooms in May to early June with leaves being in peak condition in June (Curtis 1943; Bowles 1983). Flowers last an average of 7 days and up to 10 days (Bowles 1983, Ostile 1990). Capsules form in June or early July and dehisce (release seeds) in September or early October, releasing thousands of minute seeds

(Brownell 1981; Ostile 1990). Seeds may require being under soil for up to six months before germination can occur (Mergen 2006). Soil drainage and constant temperature have been noted as important factors in germination for Yellow Lady's-slipper (Mergen 2006) and are expected to be important for germination of Small White Lady's-slipper seeds as well. Seeds have been noted to remain viable in dry storage for at least 8 years and may be long-lived in the seed bank (Brownell 1981; Mergen 2006).

Perennating buds develop at the base of the current season's growing shoot. Buds are initiated in late spring and develop through summer. Buds go dormant over winter and start to grow again in April (Ostile 1990). Buds elongate to produce an aerial stem. If multiple buds develop the rhizome can grow in multiple directions (Ostile 1990). As the growing end of the rhizome elongates the older end may decay, separating genetically identical ramets (Ostile 1990).

If conditions are unfavourable, plants may enter dormancy during the growing season and go without sprouting for one or more years at a time (Curtis 1954; Kull 2002; Shefferson 2006). The maximum length of dormancy is suspected to be three to four years (Falb and Leopold 1993).

2.4.2. Mycorrhizal Association

Mycorrhizal fungal association is an example of mutualism where soil fungi contribute nutrition to a plant and the plant provides photosynthetically fixed carbon to the fungi through the root system (Shefferson et al. 2007).

The seeds of lady's-slipper orchids are extremely small and all nourishment in the seeds is quickly used up after germination, so the plant is dependent on an endophytic fungus entering the root system, which helps nourish the seedling (Ohio Department of Natural Resources 1987). Because of this the reproduction of Small White Lady's-slipper by seed is limited by its dependence on mycorrhizal interaction.

Lady's-slipper orchids associate exclusively with fungi in the Tulasnellaceae family (Shefferson et al. 2007). Studies suggest that mycorrhizal specificity in *Cypripedium* is an evolved trait rather than a lack of opportunity to associate with other hosts (Shefferson et al. 2007). Species noted to be fungal associates of lady's-slipper orchids include *Russula* spp., *Tulasnella deliquescens* and *Hygrocybe cantherellus*. Small White Lady's-slipper and Yellow Lady's-slipper share overlap in fungal associations (Shefferson et al. 2007). The mycorrhizal associates of lady's-slipper orchids vary throughout life stages (Shefferson et al. 2007). It is suspected that mycorrhizal associations remain important during the mature life of the plant and contribute to survival during dormancy periods (Shefferson et al. 2007).

2.4.3. Pollination

Small White Lady's-slippers do not reward pollinators in that they offer no nectar or edible pollen (Pearn 2012). Rewardless species are dependent on mimicry and the ability of the co-flowering community to attract foraging pollinators (Johnson et al. 2003, Internicola et al. 2007, 2008, Duffy and Johnson 2011).

"Semi-trap" flowers promote cross-fertilization (Ohio Department of Natural Resources 1987; Anderson 2017). The sac-like pouch of the lip acts like a landing platform for potential pollinators (Brownell 1981). Pollinators enter at the lip cavity into the pouch and are prevented from exiting the same way by the recurved rim surrounding the entrance and must exit the flower through a channel at the rear of the pouch on either side of the column. While entering the flower, pollen collected during previous visits is brushed off as the pollinator squeezes past the stigma and new pollen is deposited on the pollinator's back while it pushes past the anthers before exiting (Ohio Department of Natural Resources 1987). Pollinators that are too large to exit have to chew their way out of the flower or may die within the trap (Ohio Department of Natural Resources 1987; Anderson 2017).

Rewardless species may experience variation in pollination success across their range (Shefferson and Simms 2007, Pearn 2012, Walsh et al. 2014) and from year to year due to variability in co-flowering community composition and pollinator species present (Anderson 2017). Generally, in the northern parts of Small White Lady's-slipper's range more flies and large-bodied bees are present during flowering period and the lack of small pollinators of appropriate size may reduce seed set of Small White Lady's-slipper in northern sites (Anderson 2017).

Studies on the pollination of Small White Lady's-slipper have focused on comparing pollinators present during flowering with exit route size (Pearn 2012; Anderson 2015; Anderson 2017). Studies noted Small White Lady's-slipper and Yellow Lady's-slipper being visited by potential pollinators of the genera *Odontomyia, Eristalis, Eupeodes, Helophilus, Lejops, Paragus, Toxomerus, Andrena, Apis, Halictus* and *Lasioglossum* (Catling and Knerer 1980; Brownell 1981; Pearn 2012; Anderson 2015; Anderson 2017). A study in Ontario noted *Augochlorella striata, Halictus confusus, Dialictus rohweri, D. atlanticus* and *D. pilosus* carrying Small White Lady's-slipper pollen on their dorsal thorax. Additionally, *Andrena ziziae, Specodes* sp. and *Nomada* sp. were found inside Small White Lady's-slipper flowers (Catling and Knerer 1980). Due to differences in exit route size, not all pollinator species that visit both Small White Lady's-slipper and Yellow Lady's-slipper can be potential pollinators that would contribute to hybridization (Pearn 2012).

2.4.4. Fruit set

Orchids characteristically have low fruit set and pollination can be a limiting stage in orchid reproduction (Kalisz and Thiede 1989). Kalisz and Thiede (1989) found that, of the plants that

flowered, those that set fruit did not differ in size from those that didn't indicating that fruiting is not limited by available resources.

A study on Small White Lady's-slipper by Curtis (1954) noted 60% of Small White Lady's-slipper ramets flowered. Bowles (1983) noted that 39.7% to 91.5% of ramets flowered suggesting differences occur at the site level. Fruit set is low in Small White Lady's-slipper with 10 to 16% of flowers developing fruit (Kalisz and Thiede 1989; Pearn 2012; Anderson 2015), suggesting that fruit set is pollen or pollinator-limited (Shefferson and Simms 2007). In Yellow Lady's-slippers, fruit set ranges from 50 to 90% of flowers (Pearn 2012; Anderson 2015). A study by Anderson (2017) indicated that fruiting success of Small White Lady's-slipper was substantially higher in southern subpopulations. Anderson (2017) noted that across all sites surveyed, 2-84% of genets and 2 to 69% of ramets set fruit. The cause of difference in fruit set between sites is not evident but may be due to a combination of factors including environmental conditions, pollinator species present and co-flowering species present (Anderson 2017).

Precipitation during the flowering season had a negative effect on fruiting success (Anderson 2017). Plants fruiting in a given year were more likely to flower in the subsequent year than non-fruiting plants (Shefferson and Sims 2007).

2.5. Status

The global rank of the species is G4 (Apparently Secure) (OMNRF 2016). It is considered uncommon but not rare globally; however, there is some cause for long-term concern due to declines. The species was first assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 1981 and designated as Endangered in Canada. COSEWIC re-assessed Small White Lady's-slipper as Endangered in 1999 and 2000. In 2014, COSEWIC reassessed the species as Threatened (COSEWIC 2014).

Under the *Endangered Species Act* of 1971, Small White Lady's-slipper was first designated as Endangered in Ontario in 1977 (Brownell 1981). The species was re-assessed as Endangered in Ontario in 2004 and 2015 under the *Endangered Species Act, 2007* (Government of Ontario 2020). It is also listed as Endangered under the federal *Species at Risk Act*, 2002, and Manitoba's *Endangered Species and Ecosystems Act*, 1993. A status report, recovery strategy and government response statement (Government of Ontario 2014; 2016; 2020) have been produced for Small White Lady's-slipper in Ontario.

Due to a lack of recent data the number and size of extant subpopulations in Ontario is uncertain. The 1999 COSEWIC update estimated 6,450 stems in Ontario with 1,400 genets over all populations (Brownell 1999). Estimates of the subpopulations on the Walpole Island First Nation Reserve (Lambton County) has been debated with conflicting numbers from various sources and no recent data are

available (COSEWIC 2014). The Hastings County population was estimated as 638 and 536 stems in 2003 and 2011, respectively (COSEWIC 2014).

No status has been given for hybrids (*Cypripedium x andrewsii*) in Ontario and the protection it is afforded under existing legislation is uncertain. Generally, the treatment of SAR plant hybrids in Ontario is inconsistent in regard to protection (E. Snyder pers. comm. 2020).

2.6. Threats and Limiting Factors

2.6.1. Habitat Loss and Degradation

Small White Lady's-slipper has historically been imminently and directly threatened by habitat loss, habitat degradation and changes to hydrology (COSEWIC 2014). In the Great Lakes region, extensive colonies with hundreds of Small White Lady's-slipper were historically removed by drainage and cultivation (Brownell 1981). Historically the drainage of wetlands and wet prairie habitats for conversion to agricultural lands caused drastic declines to this species and was the leading cause of its decline (Curtis 1946; Brownell 1981; Bowles 1983). A large prairie site near Walpole Island with a large population of Small White Lady's-slipper was protected by the Michigan Nature Association until the lease ran out and it was converted to agricultural lands. Other subpopulations in the Walpole area have been disturbed by agriculture, development, dumping of dredged material and building of dykes. The species has not been recorded from these sites since the 1980s (P. Catling pers. comm. 2020). This anthropogenic disturbance is large in scale and for all practical intents irreversible (COSEWIC 2014).

Adjacent development activities and increased urbanization in the areas surrounding the sites may impact the species through habitat degradation (water contamination, sedimentation, invasive species, etc.) and changes in hydrology (lower water table from water usage, altering surficial flow from ditching, etc.). Urbanization and resultant increases in human populations in areas surrounding Small White Lady's-slipper sites may increase foot traffic to the sites and thus increase the risk of illegal collecting and trampling. Encroachment into the native habitat by adjacent residences may also impact the species through habitat degradation or removal.

Regular maintenance of roads and other infrastructure (hydro lines, telecommunication lines, etc.) in the vicinity of sites may degrade the existing habitat through chemical sprays and salt runoff (Landplan Collaborative Ltd. 1986) and also encroach on habitat. However, removal of woody vegetation from hydro corridors and other linear infrastructure appears to benefit some orchid species with high light requirements and is conceivably beneficial to this species. Many occurrences of native orchids in the United States are found along roadsides, trails or hydro lines maintained by machinery (P. Catling pers. comm. 2020).

Beavers (*Castor canadensis*) have the capacity to alter hydrology of fen habitats by creating dams upstream. Although this is a natural occurrence it has the potential to cause population declines.

2.6.2. Fire Exclusion and Woody Succession

Drainage of wet prairies and fen habitats may be a direct cause of population decline and may also contribute to encroachment of woody vegetation (Ostile 1990). Habitat succession by shrubs and excessive accumulation of thatch can have a negative impact on the species (Curtis 1946; COSEWIC 2014). Woody succession and excessive thatch have been noted as the most commonly reported threats to Canadian subpopulations (COSEWIC 2014). Increasing woody vegetation decreases the light and moisture levels that are optimal for growth of Small White Lady's-slipper (COSEWIC 2014). Extirpation of the Norfolk County subpopulation is attributed to woody succession as a result of alteration of drainage patterns (Brownell 1981). The habitat of the Hastings County subpopulation is currently undergoing change due to woody succession; however, attempts to evaluate this threat have ceased due to the damage surveys did to the sensitive fen habitat (C. Brdar pers. comm. 2020). A study suggested that succession in the fen habitat should be slow (Landplan Collaborative Ltd. 1986); however, changes in the hydrological regime may make it more susceptible to rapid succession. Diverting water flow, lowering of the water table due to increased withdrawal from urbanization or an increased water uptake from invasive species may all contribute to increasing the rate of succession (P. Catling pers. comm. 2020).

Fire suppression in prairie habitats contributes to woody succession and excessive thatch build-up. Controlled burns are being used to manage multiple subpopulations in Manitoba and at Walpole Island First Nation (COSEWIC 2014). Management is further discussed in **Section 2.7** below.

2.6.3. Invasive Species

Invasive species is a widespread issue in Canada and a threat to most Canadian subpopulations of Small White Lady's-slipper (COSEWIC 2014). Subpopulations in Manitoba that occur along roadsides are more susceptible to introduction of non-native species. Smooth Brome (*Bromus inermis*) and Leafy Spurge (*Euphorbia esula*) are of particular concern in Manitoba (COSEWIC 2014).

In Ontario, Purple Loosestrife (*Lytrhum salicaria*) has been noted to occur in the vicinity of Small White Lady's-slipper habitat at both extant populations (Brownell 1981; Landplan Collaborative Ltd. 1986). Common Reed (*Phragmites australis*) was noted as an associated plant in Hastings County (Brinker 2011). Glossy Buckthorn (*Rhamnus frangula*) and Common Reed are expected to be of particular concern (P. Catling pers. comm. 2020). Additional non-native species may also be of concern.

2.6.4. Agricultural Practices

Subpopulations of Small White Lady's-slipper in Manitoba and the United States occur on agricultural lands or along roadsides and are susceptible to negative impacts from overgrazing and haying. Plants

occurring in these areas may experience direct harm from spraying of insecticide or herbicide, mowing during flowering or before fruit is mature, maintenance of fence lines, dredging ditches and trampling from cattle or equipment (COSEWIC 2014). Mowing or haying has a negative effect on the species if it disrupts flowering or if it occurs before fruit is mature (Ostile 1990). Mowing after fruit is mature may aid in distribution of seeds (COSEWIC 2014). Chemical sprays can have direct negative effects on plants through damage to the leaves or flowers or may have indirect effect on the species through reducing co-flowering species to attract pollinators and reducing number of pollinators present in the area. The effect of chemical sprays on fungal associates has not been determined but may also be of concern (COSEWIC 2014).

The Hasting's County subpopulation in Ontario does not occur on a site with ongoing agricultural practices; however, agricultural practices historically occurred at Walpole Island and the current land-use in this area is unknown. Adjacent or upstream agricultural practices may have negative influences such as changes in hydrology, contamination of water and decrease in number of available pollinators.

2.6.5. Illegal Collection and Ad-hoc Trails

Illegal collection by gardeners, orchid enthusiasts and researchers has been noted to occur across the range of Small White Lady's-slipper (Brownell 1999; COSEWIC 2014). This direct removal of individual plants directly reduces subpopulation size, decreases the genetic diversity within subpopulation and damages the habitat. Illegal collection is more likely to occur in accessible sites (COSEWIC 2014). The subpopulations in Ontario are now isolated and not accessible by official public trails. Wildlife photographers, nature enthusiasts and researchers creating ad-hoc trails into the habitat may lead to direct trampling of the plants and habitat degradation (COSEWIC 2014). Attempts to restrict access to the Hastings County subpopulation include a low wire fence that has been in place for 20 years; however, impacts from unsanctioned access remains an issue since the fencing is low and doesn't really limit access (C. Brdar and W. Bakowsky pers. comm. 2020). Limiting access into these habitats can decrease appreciation, public awareness and desire to protect the species (P. Catling pers. comm. 2020).

In some cases, orchids have been observed to benefit from the levels of disturbance associated with trails (Catling and Kostiuk 2011; Catling 2012); however, this may not be the case will all species or in all habitat types and the amount of disturbance can be difficult to control when public access is permitted. It is worth noting that the single Small White Lady'-slipper plant of found during the Geomatics International (1995) study of the Norfolk County subpopulation was found on a Royal Fern (*Osmunda regalis*) hummock along a sparsely used trail in a dense thicket (Geomatics International 1995; M. Sharp pers. comm. 2020). Many variables including substrate type, substrate moisture, intensity and frequency may impact the severity of trampling as an impact. Small White Lady's-slipper is generally expected to be intolerant of trampling and the disturbances trails would create (V.

Brownell pers. comm. 2020). It is recommended that access to smaller subpopulations be restricted due to the higher impact of population decline.

2.6.6. Genetic Isolation

Existing subpopulations in Ontario are separated by approximately 475 km. Genetic variability in the species is low and a low number of individuals in a subpopulation may lead to inbreeding suppression (Ostile 1990). Small White Lady's-slipper produced fewer viable seeds when self-crossed or crossed with siblings, which could further reduce sexual reproduction rates in genetically isolated populations. Low sexual reproduction rates, decline of pollinators, fragmentation of populations and small population size may all contribute to the slow decline of genetically isolated occurrences.

2.6.7. Hybridization

Hybridization has the potential to jeopardize the genetic integrity of a species when hybrids are fertile and have overlapping ecological requirements of the parent species (Worley et al. 2009). Back crossing of hybrids with parental species can lead to introgression and the extinction of the species through genetic assimilation (Rieseberg 1991; Barrett and Kohn 1991; Worley 2009). This threat is higher when a parent species occurs in small, isolated subpopulations (Worley 2009). Comparison of the fertility and ecological requirements of hybrids and parent species is necessary to assess the potential for extinction through genetic assimilation (Worley et al. 2009). A comparison of sexual reproductive success (pollen viability, fruit set and production of ovules and mature seeds) in the parent species and hybrids showed that Yellow Lady's-slipper had the highest reproductive success, Small White lady's-slipper had low reproductive success and hybrids had intermediate reproductive success (Pearn 2012). Genetic assimilation has been proposed as a potential cause of the species' extirpation from Norfolk County, Ontario. Hybrids have been noted at existing subpopulations in Lambton and Hastings County (Brownell 1981; COSEWIC 2014).

2.6.8. Herbivory

Herbivory over multiple sites in western North American was noted to be between 0 to 3%; however, this rate was based on a three week span between flowering and fruit set (May-June) and the actual rate between flowering and seed maturation could be higher (Anderson 2017; A. Worley pers. comm. 2020). Herbivory by White-tailed Deer (*Odocoileus virginianus*) and insects has been noted. Deer eat the flowers off the stem (P.K. Catling pers. obs. 2014). Insects have been noted eating the leaves and flowers. Although not considered herbivores, large pollinators that cannot fit through the exit may chew their way out of the trap and prevent further pollination (Anderson 2015; Anderson 2017) or get trapped and block the pollinator passage (P. Catling pers. comm. 2020).

2.6.9. Environmental Conditions

Small White Lady's-slipper is susceptible to frost damage due to its early blooming period and preference for open habitats (Worley et al. 2009). Frost damage at the beginning of the flowering period can kill the flowers and prevent pollination from occurring (COSEWIC 2014). Frost damage leads to brown wilted flowers (COSEWIC 2014). If damage to the leaves is minimal, plants may be able to perform photosynthesis for the season (Ostile 1990). The influence of climate change on the severity and frequency of late spring frosts is unknown (COSEWIC 2014). Climate change has the potential to impact Small White Lady's-slipper through variable environmental conditions such as unusual spring frosts, flooding and drought. A site in Lambton County, Ontario has experienced flooding and erosion from high water levels of the St. Clair River and was noted to change the community composition. Extreme flooding or drought events may cause significant declines that take 20 years to recover from (V. Brownell pers. comm. 2020). It is expected that the population size will increase slowly after a significant population decline (death of individual plants) due to weather events. Contrastingly if the weather event is not severe enough to cause a population decline but does lead to individuals entering a dormancy period, population numbers may appear to 'bounce back' instantaneously after a bad flowering year (V. Brownell pers. comm. 2020).

It has been suggested that a fairly thick thatch layer may protect plants from frost damage (Brownell 1981; COSEWIC 2014); however, this needs to be weighed against the negative impacts of thatch accumulation and woody succession (**Section 2.6.2**) when determining management needs.

2.7. Management

Management actions must consider the ecology and reproductive biology of the species and the factors affecting each phase of the species life cycle (Bowles 1983). Management objectives should include a) maintenance of larger subpopulations or b) recovery of smaller subpopulations to a stable level (Bowles 1983). For large subpopulations, management and protection of the natural vegetation community should ensure survival (Bowles 1983). In order to protect the habitat of Small White Lady's-slipper, a sufficient amount of upland habitat must be protected to ensure water infiltration is clear of contamination and groundwater manipulation (Ostile 1990). Suitable habitat for pollinators should also be protected to maintain the adjacent pollinator populations (Ostile 1990). Artificial pollination may be used to enhance seed production and reduce this as a limiting factor in population growth (Bowles 1983). If vegetative spread can be supplemented by seedling establishment, the long-term survival of smaller population can be increased (Bowles 1983). For smaller subpopulations, active management may be needed to assist in maintaining or increasing the population size.

Studies have indicated that burning or mowing (to reduce woody encroachment and thatch cover) can promote flowering in the following years. A study by Curtis (1946) outlines the differences between mowing in spring (mid-late April: before stem emergence) and late summer (late August-

early September: as typical of hay meadow agronomic practices). Mowing was done by hand with pruning shears. Mowing was found to be effective at increasing the population size of subpopulations affected by encroaching shrubs. Spring mowing increased population size slightly more than fall mowing.

Prescribed burning is a common method for management of woody succession and excessive thatch buildup at prairie populations of Small White Lady's-slipper in Manitoba and Ontario (COSEWIC 2014). A subpopulation in Ontario located in remnant prairie habitat is known to be burned regularly (W. Bakowsky pers. comm. 2020). Individuals in areas that have been burned have been noted to bloom earlier than those in areas that have not experienced burns (COSEWIC 2014). This can be due to increased solar radiation in the exposed areas and the fact that blackened soil warms quicker than unblackened soil (W. Bakowsky pers. comm. 2020). Although both mowing and burning have been observed to increase flowering in subsequent years, management decisions still need to weigh potential negative impacts to the species such as loss of insulation to frost damage and thatch piles created by mowing (COSEWIC 2014).

Monitoring methodology should take into consideration management being implemented at the site since markers should be able to withstand fire or mowing activities if necessary.

3. Overview of Past Survey Methods

Survey methods are extremely variable for this species (COSEWIC 2014), in part owing to the different objectives of various studies and resources available. Particular difficulties occur with distinguishing individual plants (genets) and hybrids (COSEWIC 2014). Severe late spring frosts, which damage flowers, make distinguishing species in the field challenging (COSEWIC 2014). The short flowering season, long time to reach maturity, ability to go dormant and seasonal variability are additional challenges in surveying Small White Lady's-slipper.

3.1. Selecting Sites

The Manitoba Conservation Data Centre has used a predictive habitat model based on biology, ecology and satellite imagery to locate potentially suitable habitat for Small White Lady's-slipper (Friesen and Murray 2010). The predictive model was largely based on soil types and was able to locate areas with suitable soil conditions near existing subpopulations; however, it did not take current land-use into consideration (Friesen and Murray 2010). New sites in Manitoba have been located by driving along the road in suitable habitat (K. Newman and C Murray pers. Comm. 2020). Road sites in Manitoba tended to align with grassland areas where the roads cut across slight linear depressions, which may indicate subsurface water flow and seasonal surface water runoff (C. Murray pers. comm. 2020).

A review of ortho imagery and land-use layers to determine if land -use is compatible is important when selecting sites. Due to the high human population density of southern Ontario and its history of development as well as the rarity of suitable habitat, finding a new roadside occurrence of Small White Lady's-slipper is highly unlikely. It is more likely that any new occurrences will be found on private lands adjacent to or near existing or historic subpopulations. Permission to access private land, including lands owned by First Nations, must be acquired prior to completing surveys.

Historic and recent aerial photography could be used to determine potentially suitable habitat in the vicinity of historic and existing subpopulations. Aerial photography may also be used to determine if habitat at historic sites is still suitable before field visits are completed.

3.2. Methods

3.2.1. Quantifying Abundance

3.2.1.1. Survey Timing

Surveys during flowering season are required to distinguish similar species and hybrids (COSEWIC 2014). A cooperative survey effort in Manitoba completes standardized comprehensive surveys every few years. A comprehensive survey of all sites occurring every few years was preferable to annual surveys where survey effort and the sites surveyed were variable each year (C. Murray pers. Comm. 2020). In the United States, monitoring programs at Small White Lady's-slipper sites may be annual, opportunistic or periodical. Monitoring programs in the United States are run by different groups including state governments, volunteer stewardship groups and the Nature Conservancy. Having surveys be completed by various organizations without a standardized protocol may affect the consistency of the data collection and frequency of surveys (Ostile 1990). Surveys in Ontario have typically been completed in early June during peak flowering and vary between one survey in a single year to surveys in three consecutive years (Brownell 1984; Landplan Collaborative Ltd. 1986; Kirk 1990; Geomatics International 1995).

3.2.1.2. Methods

Abundance counts of flowering ramets or genets is the most common method due to the improved ability to distinguish flowering specimens (COSEWIC 2014). The number of flowering genets is used as an estimate of mature individuals (COSEWIC 2014). Total abundance is expected to be underestimated by flowering genet counts due to the species' ability to enter dormancy and because the species typically takes 12 years to reach maturity (COSEWIC 2014). A previous study attempted to age Small White Lady's-slipper orchids by digging plants up and counting stems and leaf scars (Kalisz and Thiede 1989). The study found that plant age can be accurately estimated based on height and number of leaves, although distinguishing clones from individuals above ground is challenging (Kalisz and Thiede 1989). To quantify the size/age structure within a subpopulation, plant height and number

of leaves (plants with 1 to 2 leaves and shorter than 12 cm were considered seedlings) was recorded by Kalisz and Thiede (1989).

Basic information collected for an occurrence should include area occupied by plants, area providing suitable habitat, number of genets, number of flowering ramets, number of vegetative ramets, list and description of all threats within and adjacent to area occupied by plants, description of adjacent land use and condition of the site, with optional monitoring of fruiting ramets (V. Brownell and P. Catling pers. comm. 2020).

United States

In Michigan a study used 1 m by 1 m permanently marked quadrats to monitor Small White Lady's-slipper (Kalisz and Thiede 1989). Numbered aluminum tags were placed at individual stems to allow for relocation of plants (Kalisz and Thiede 1989). The study by Kalisz and Thiede (1989) collected data on total stems censused, percent flowering stems in the subpopulation, total number of fruit censused, percent fruiting (fruits/stems), reproductive success (fruits/flowers), stem height (cm) and leaf number. Kalisz and Thiede (1989) recorded fruit development from mid July to late October.

A co-operative effort to survey Small White Lady's-slipper in Minnesota tracked the size and extend of Small White Lady's slipper across various sites in the context of management activities and environmental conditions (Anderson and Ruby 2012). The surveys in Minnesota followed the Chicago Botanic Gardens, Plants of Concern Monitoring Protocol (Chicago Botanic Garden 2012). Plants were considered distinct individuals if separated by 15 cm or more (Anderson and Ruby 2012). The protocol recorded spatial data, number of individuals (reproductive and not), plant associates, threats and management concerns/needs. Any activities on the sites (burning, woody vegetation removal, invasive species removal, mowing/haying, etc.) were noted. Individual counts of flowering and non-flowering genets were further subdivided into plant size classes: single stemmed individuals, small clumps (2 to ≤ 10 stems), and large clumps (>10 stems) (Anderson and Ruby 2012). Where Small White lady's-slipper co-occurred with Yellow Lady's-slipper only flowering individuals were counted, as distinguishing the two species based on vegetative characteristics is unreliable. Population demographics were recorded through permanent plots. At larger sites priority was given to counting individual plants over completing population demographics studies (Anderson and Ruby 2012). The tracks function of a GPS was used to record which areas were surveyed (Anderson and Ruby 2012). Soil condition was recorded as "dry", "moist-drained", "saturated" or "flooded" (Anderson and Ruby 2012). Anderson and Ruby (2012) and Chicago Botanic Garden (2012) provide example field sheets for data collection.

A recent document by Light and Gregg (2017) provides a long-term tracking protocol and suggested approach for terrestrial orchids. The methodology suggests that clonal species, such as Small White Lady's-slipper, required advanced techniques to differentiate individual genets and suggests that

counting ramets may be used as an approximation (Light and Gregg 2017). The protocol recommends tracking 200 to 300 individuals for 10 years. The recommended methodology employs the use of numbered tags (placed consistently in relation to the individual; e.g., 1 cm to the north) to permanently mark individuals and stipulates that all tagged individuals should be relocated in each subsequent survey event and noted as emergent or non-emergent (Light and Gregg 2017). For emergent individuals the protocol recommends differentiating between mature and juvenile individuals to observe changes in population demographics over time so that it can be determined if replacement occurring in the subpopulation or if a decline is expected (Light and Gregg 2017). The protocol emphasizes the use of GPS, maps and photographs for assisting in the relocation of individual plants. Triangulation using a central landmark or transect is noted as an optimal way to locate individual plants as part of an ongoing monitoring program (Light and Gregg 2017). The protocol suggests monitoring climate and site characteristics so that this can be related to orchid abundance or emergence. The protocol suggests monitoring daily precipitation, minimum and maximum daily temperature, date of first frost and date of last frost so that this can be related to the orchids' blooming dates (Light and Greg 2017).

Canada

In the past, surveys have assessed abundance through detailed counts of flowering and non-flowering stems or rough estimates of flowering stems. A more recent methodology completed counts of numbers of flowering plants (genets). Most counts in Manitoba have been completed using click counters and in more recent years have used tablets with ArcCollector software (K. Newman and C Murray pers. comm. 2020). The Manitoba Conservation Data Centre has completed surveys of Small White Lady's-slipper since the late 1990s. Manitoba Conservation and partners have developed a standardized comprehensive protocol for surveying Small White Lady's-slipper. For small occurrences (50 or fewer plants), a precise count of flowering and non-flowering stems is completed. For larger occurrences (more than 51 plants), only the number of flowering plants is recorded. The edge of the occurrence is marked by flags and plants are counted in a systematic 2 m grid. Plants are considered to be individuals if separated by 20 cm or more (K. Newman and C Murray pers. comm 2020). This methodology is consistent with Shefferson (2006), who assumed that sprouts within 20 cm were of the same genet based on previous research by Kull (1995; 1999) on the branching patterns. Hybrids are recognized by having a creamy to yellowish lip (K. Newman pers. comm. 2020).

A study by Anderson (2015) used one 30 m transect and two 50 m transects at one site. Anderson (2017) used two 25 m transects (separated by at least 4 m) at each site that was surveyed. At each site between 30-50 individuals were surveyed (S. Anderson pers. comm. 2020). In both studies, the transect was marked by permanent wooden stakes and the distance of genets along the tape measure and distance away from the tape measure was recorded to facilitate relocation. Genets within 2 m of the centre of the transect on either side were included in the study. Genets between 1-2 m from the centre of the transect were marked with a galvanized nail and copper tag so that they

could be relocated using a metal detector (Anderson 2015; Anderson 2017; C. Murray pers. comm. 2020). Genets within 1 m of the centre of the transect were determined to be easy enough to relocate using the distance along / from the transect and were not tagged (C. Murray and S. Anderson pers. comm. 2020). A cluster of ramets was assumed to be a genet if they all occurred within 10 cm of each other (Anderson 2015). Floral measurements were taken using calipers to the nearest 0.1 mm and vegetative dimensions were measured with a ruler to the nearest 1 mm (Worley et al. 2009). Paint colour charts were used to quantify slipper colour and distinguish hybrids (Worley et al 2009; Anderson 2015). Anderson (2015) returned three weeks after the flowering period ended to determine fruit set.

Ontario

In Hastings County, Ontario, a study by Landplan Collaborative Ltd. (1986) recorded numbers of Small White Lady's-slipper as individual plants; however, they noted only ten individual plants that year. Studies by Brownell (1984) and Geomatics International (1995) on a subpopulation of hybrids in Norfolk County determined the type of hybrid and recorded the number of genets, ramets and flowers for each type of hybrid. Geomatics International (1995) completed surveys over two seasons and marked individual genets in the first year. Notably only two individuals were not located in the following season and this was attributed to them being vegetative or non-emergent. Geomatics International (1995) used electrophoretic analysis to confirm if an individual was a hybrid or Small White Lady's-slipper. A follow up study by Kirk (1990) on the same subpopulation counted number of stems and number of flowering stems over two years.

The most recent survey completed in Ontario included both Hastings County and Norfolk County subpopulations (Brinker 2011). A reconnaissance survey was completed prior to the full census to determine flowering status. The names of all surveyors, person hours and area covered was noted for each survey location. Surveys were informal, intuitive traverses of suitable habitat. Locations where individuals were found were searched more systematically. Flagging tape was used to temporarily mark locations of each flowering stem during the survey and locations of each individual plant were recorded by GPS. The total number of flowering individuals (genets) and the number of flowering stems (ramets) per individual were recorded. Individuals were classified by a separation distance of 20 cm. Slipper colour was recorded for each flowering *Cypripedium* plant. Methods for documenting flower colour followed Worley et al. (2009), which used a numeric scale from 1 to 8, with 1 being pure white and 8 being deep yellow. A paint colour chart from the "Clean & Playful" series produced by C-I-L were used (**Figure 8**). Non-flowering individuals were also counted but not included in final numbers (Brinker 2011).

A survey of the Ontario subpopulations has not been completed since the Brinker (2011) survey, and there are no recent data or survey methods available from Walpole Island.

3.2.2. Classifying Associated Vegetation

A previous survey of a site with Small White Lady's-slipper in Ontario by Landplan Collaborative Ltd. (1986) provided detailed descriptions of environmental and floristic conditions of the entire site containing the subpopulation as well as the surrounding area. Community descriptions were based on nine visits across three sessions (spring, summer and fall) and are similar to those used in Ecological Land Classification for Southern Ontario (Lee et al. 1998).

Quantitative sampling using 0.5 m or 1 m quadrats placed at each group of genets has been used to determine cover and frequency of associated vegetation (Brownell 1984; Kalisz and Thiede 1989).

3.2.3. Threat Assessment

The Nature Conservancy in the United States has produced a document with a standard method for evaluating the quality (A=excellent, B=good, C=marginal, D=poor) of an occurrence based on population size and vigor, habitat size and condition and to some extent threats (Ostile 1990). The methodology was largely subjective with no quantifiable scale thus limiting its utility for repeated measurement by different observers, and the categories of population and habitat size were larger than what can be expected in Ontario. The methodology did provide separate rankings for occurrences in prairies and fens (Ostile 1990).

Surveys in Minnesota noted threats such as invasive species, woody encroachment, grazing and trampling (Anderson and Ruby 2012). A percent cover for all invasive species and woody species was recorded on a scale (<1-10%, 11-25%, 26-50%, 51-75%, 75-100%). The percent of the population that is grazed or trampled was described using the same percent cover scale (Anderson and Ruby 2012).

The Chicago Botanic Garden (2012) methodology recorded percent cover of invasive species on a different scale (none, 1-20%, 21-40%, 41-60%, 61-80%, 81-100%) than woody encroachment. Percent cover of woody encroachment was recorded separately for <1 m tall and >1 m tall categories on a percent cover scale (none, 1-25%, 26-50%, 51-75%, 76-100%). Additionally, threats to the populations such as deer browse, erosion, authorized trails and unauthorized trails were evaluated on a percent cover scale (none, 1-25%, 26-50%, 51-75%, 76-100%) (Chicago Botanic Garden 2012).

Figure 8: Paint colour chart to visually assess slipper colour (Brinker 2011)

Funding and limited experience of observers reduces the reliability of threat evaluations from the surveys undertaken by the Manitoba Conservation Data Centre and these evaluations have been largely subjective (C. Murray pers. comm. 2020). Since the species is known to be sensitive to water level, and past declines at the Manitoba sites have been observed due to changes in drainage, this may be an important parameter to include (K. Newman pers. comm. 2020). However, surveys in Manitoba by the Conservation Data Centre do not monitor water table fluctuations, water quality or water chemistry to determine if these factors are changing in a way that threatens Small White Lady's-slipper. At each site surveyed in Manitoba, general notes on site condition and threats are always taken (K. Newman pers. comm. 2020).

The Department of Fisheries and Oceans Canada (2014) developed a guidance document for assessing threats, ecological risk and ecological impacts to SAR. The document outlines a two-step process for evaluating threats that includes an assessment of the threat to the subpopulation and to the species overall. Each threat is evaluated based on the likelihood of occurrence, level of impact and causal certainty (DFO 2014).

COSEWIC (2012) has a guidance document for completing a threats classification and assessment calculator for researchers completing status reports or status report updates. The COSEWIC guidelines for assessing threats include an assessment on the potential for natural phenomena (flooding, drought, etc.) and anthropogenic activities to cause population declines. Threats are characterized in terms of scope, severity and timing and include observed, inferred and predicted threats (COSEWIC 2012). Threat impact is determined from scope and severity (COSEWIC 2012). Nature Serve has also produced a guiding document for status assessment that follows the same threat assessment format as COSEWIC (2012), which is originally based on Salafsky et al. (2008) (Master et al. 2012). Since this method is widely accepted and is being used to assess the species across Canada it is considered the best for maintaining consistency and practical application. Relevant pages of the COSEWIC guidelines have been included in **Section 5.2.7**.

The Ecological Land Classification for Southern Ontario (Lee et al. 1998) includes a section on ranking various disturbances. The intensity (none, light, moderate, heavy) and extent (none, local, widespread, extensive) of each type of disturbance is ranked from 0 to 3. The score for each disturbance is determined by multiplying the intensity and extent ranks (Lee et al. 1998).

Ontario Parks developed and implemented a protocol in 2005 for assessing the impacts of woody succession on Small White Lady's-slipper using transects and circular plots that quantify woody vegetation cover (Imrie et al. 2005). Plant counts were completed using transects set 1 m apart. For each plant (flowering and non-flowering), the height, phenology and number of leaves were recorded. Monitoring for woody succession used eleven 5 m plots placed throughout the study area. Each 5 m plot had a 1 m nested plot inside. Plots were placed along a transect at the closest flower to each 10 m interval. Percent cover and height of all herbaceous vegetation was recorded in the 1 m

plot and percent cover and height of all woody vegetation was measure in the 5 m plot (E. Barkley pers. comm. 2020). Vegetation was assigned to a category based on stratification. and included: low shrub (<1 m), high shrub (>1 m), graminoid, herbaceous, and moss. The percentage of surface water or non-vegetated marl was also recorded in each plot. The stems of all Small White Lady's-slipper were counted in the 5-meter plot to obtain the density of Small White Lady's-slipper in the plot (E. Barkley pers. comm 2020). This methodology exacerbated trampling of the habitat and was never repeated (C. Brdar pers. comm. 2020).

Past surveys of Small White Lady's-slipper in Ontario have not used a standardized methodology for quantifying threats and the assessment of threats, if completed, has been largely subjective.

3.2.4. Site Condition

Ranking systems for the condition of sites or occurrences have been developed by NatureServe (NatureServe EO Data Standard 2002) and (Henson and Bakowsky 2014). This methodology has been adapted and is included in **Section 5.2.7**.

4. Recommended Areas to Search

4.1. Locations

Consultation with stewards at Walpole Island First Nations is urgently needed to:

- request access for surveys and monitoring of the Walpole Island subpopulations,
- request data collected by Walpole Island First Nations from the past 20 years in order to update subpopulation abundance information,
- exchange information about methods used and their success or challenges,
- exchange information about management activities and their success, and
- incorporate local knowledge into the survey protocol.

Survey work within Ontario's provincial parks and conservation reserves requires authorization under the Provincial Parks and Conservation Reserves Act through a research authorization.

The sites of historical subpopulations of Small White Lady's-slipper (Crystal Beach, Bothwell, Port Elgin and Point Edward) and adjacent areas with suitable habitat could be searched to determine if suitable habitat still exists although the chance of rediscovery is remote and this is probably not a good use of limited resources. As first step might be to undertake a targeted search to determine if suitable habitat exists. If suitable habitat is located, then it should be re-searched periodically. Landowners with potentially suitable habitat near existing and historical subpopulations should be contacted to assess presence or gain property access.

Due to the slim chance of re-locating Small White Lady's-slipper in historic locations where it is thought to be extirpated, the priority should be surveying the areas where the species was most recently observed including Walpole Island, areas along Lake St. Clair and in eastern Ontario marl fens (Hastings County) and Norfolk County. The last known occurrence in Norfolk County was noted to be overgrown with woody vegetation in 2011 and was described as possibly unsuitable for *Cypripedium* (Brinker 2011). The site is now dominated by tall shade tolerant herbaceous vegetation that would shade and compete with Small White Lady's-slipper (Brinker 2011). However, it was noted that the thick vegetation could cause *Cypripedium* plants to be overlooked and the search effort may not have been sufficient for such a large area (Brinker 2011). This is supported by the chance discovery of a single plant in a relatively small opening in a shrub thicket during the Geomatics International (1995) study (M. Sharp pers. comm. 2020). This site should be re-surveyed and if the species or hybrids are found, thinning of woody vegetation at this site should be executed as soon as possible.

4.2. Process

The general process should include:

1. Identify target/ candidate sites,
2. Determine land ownership/management,
3. Contact land-owners to obtain local knowledge, and
4. If ground truthing is needed, gain necessary permissions.

To identify target/candidate sites, an experienced field surveyor familiar with Small White Lady's-slipper and their habitats should look at Google Earth/ aerial photos before a drive-by or field surveys are completed. The following criteria can be used to prioritize sites for field surveys:

- appears to be suitable habitat from aerial photography and/or landowner information;
- proximate to known or historic locations (with priority given to areas adjacent to more recently observed subpopulations);
- site has low-lying wet/ moist areas such as stream beds or runoff channels for rain or snowmelt; and/or
- a species distribution suggests high probability of occurrence.

It is recommended that ground truthing of target and candidate sites be completed by an experienced field biologist with botanical knowledge and that caution be taken to avoid habitat disturbance.

5. Standardized Survey Protocol

5.1. Considerations for Developing a Standardized Survey Protocol

5.1.1. Purpose

The purpose of this survey protocol for Small White Lady'-slipper is to ensure consistent data collection and reporting of:

- presence/absence,
- population size,
- population demographics,
- habitat,
- hybridization,
- threats, and
- site condition.

5.1.2. Protocol Refinement

The monitoring protocol here is based on the review of the available literature on Small White lady's-slipper, consultation with the various experts who contributed advice and knowledge, and our own experience monitoring various plant species, including Small White Lady's-slipper. However, an adaptive approach is recommended whereby the field protocol is refined and improved as data are collected, especially during the collection of baseline data. It is recommended that individuals who undertake the field work comment on the protocol and indicate where it was difficult to apply and to make suggestions for improvement. Given the substantially different distributions of plants in the three Ontario subpopulations the authors have visited in the field, it is recognized that the monitoring protocol may need to vary among the three sites. However, in making refinements, it is essential that the overall objectives of monitoring population size and health, and documenting threats, be adhered to in order to provide sufficient consistency among sites to allow comparison of data and draw conclusions about the status, protection needs and management requirements of the Ontario population.

5.1.3. Timing

In order to develop a standardized survey protocol for Small White Lady's-slipper, the ecology of the species was considered. Since flowers are considered the only positive identification feature for Small White Lady's-slipper, and flowers are relatively short-lived and prone to degradation by weather, surveys must occur during peak flowering period (E. Barkley, K. Newman and C. Murray pers. comm. 2020). Flowering period may vary from year to year but typically occurs from late May to early June for Ontario subpopulations. The number of stems censused at flowering time may be smaller than the number of stems post-flowering since non-flowering ramets may emerge later (Kalisz and Thiede

1989), and the potential for this should be noted when field surveys are undertaken. It is understood that counts during flowering period likely underestimate population size due to the timing of the survey, inability to confidently identify non-flowering individuals, as well as the species' ability to remain dormant.

5.1.4. Management Activities

If active habitat management, such as burning, mowing, or invasive species removal is occurring, monitoring should track management activities and monitor the success of management prescriptions. Mowing and burning on a site can also affect how accurately and thoroughly surveys can be undertaken since it makes it easier to find and count plants (Anderson and Ruby 2012). For this purpose, it is important to be aware and record management activities that have occurred at the site so that data can be interpreted when compared to other sites where management does not occur.

If prescribed burns are part of management activities, a metal stake (such as rebar) is proposed for marking transect locations. If mowing is occurring, rebar should not be used to mark transects for safety reasons. If wooden stakes are used in mowed areas, they should be clearly marked so they can be avoided during management activities. Additional adaptations may be determined on a site-by-site basis depending on the management activities occurring.

5.1.5. Habitat and Species Sensitivity

The species and the habitats in which Small White Lady's-slipper occur are highly sensitive and long-term damage can easily occur if surveys are not conducted carefully. Due to the high sensitivity of habitats, monitoring of this species should be carried out by a highly experienced, qualified and careful individual (C. Brdar pers. comm. 2020). If researches are careful disturbances such as trampling can be minimized; however, collecting a wide range of data, such as flower measurements, increases the risk of impact. Risk of trampling may be increased in wet conditions and if orchids occur in high density, are obscured by thatch or other vegetation or are not fully emerged (A. Worley pers. comm. 2020).

Confidentiality of the surveys is of utmost importance in order to prevent trampling and illegal removal of plants. Although some orchids may benefit from disturbance, there is no indication that Small White Lady's-slipper would and there is no way to quantify or control how much disturbance would be too much for the species to withstand. Due to this uncertainty and the small size of remaining subpopulations in Ontario, it is highly recommended that volunteer programs or citizen science for monitoring the subpopulations in Ontario not be implemented. The locations of subpopulations should not be shared with the public.

Searches/ surveys in fen communities, such as in Hastings County need to take the utmost care to prevent damage to the habitat (C. Brdar pers. comm. 2020). This is to prevent trampling of Small

White Lady's-slipper and other sensitive and/or significant species present. It is recommended that binoculars be used to assist with surveying for presence/absence so that candidate plants can be assessed before detailed examination and less area needs to be trampled.

5.1.6. Frequency of Survey

A standard protocol for monitoring terrestrial orchids recommends monitoring the subpopulation for five to ten consecutive years (Light ang Gregg 2017). However, due to the sensitivity of the habitat, it is recommended that to initiate the long-term monitoring program the subpopulation be surveyed for three to five consecutive years to provide baseline data that determines annual variation. Three years was advised as the absolute minimum required to determine abundance considering environmental factors; however, five years would be more statistically valid (V. Brownell and A. Worley pers. comm. 2020).

There was variation in recommendations for how often surveys should be completed after baseline data had been collected. Suggestions included:

- Surveys should not take place more than once every 5 to 10 years due to the sensitivity of the species and the extensive damage to the habitat that occurs during a survey (E. Barkley and C. Brdar pers. comm. 2020). Optimal blooming years should be chosen for surveying. It is recommended that an accessible patch be checked to determine if the flowering year is optimal before entering sensitive habitats for monitoring (C. Brdar pers. comm. 2020).
- Average years and poor years should still be surveyed as they would be representative of the typical number and show how low the numbers of flowering individuals may go (V. Brownell pers. comm. 2020). In this respect it is recommended that a minimum of three consecutive years be used to collect baseline data followed by definite schedule of surveys every 5 years. Seasonal weather conditions (rainfall and temperature) and soil moisture should be recorded so that years may be compared (V. Brownell pers. comm. 2020).
- Unbiased information on emergence and flowering in a variety of conditions would be the most informative (A. Worley pers. comm. 2020).
- Annual monitoring is required in order to provide detailed information to inform management and to ensure that the subpopulation is not eliminated by fast developing threats, such as Buckthorn encroachment and invasion by Common Reed (P. Catling pers. comm. 2020).

Trying to schedule surveys based on predicting good flowering years poses a challenge since surveys should occur during peak flowering, and this can't be accurately predicted without field work. Thus, it is difficult to determine good flowering years and allocate funds for surveys for any given year (C. Brdar pers. comm. 2020). Scheduling regular surveys after the collection of baseline data and relating this to weather and soil moisture levels should provide a more accurate estimate of population demographics over time (V. Brownell pers. comm. 2020). Regular surveys may be easier to allocate funds for and plan fieldwork. If the location of the subpopulation is known and the view is not

impeded, binoculars or a telescope can also be used to scan the habitat for blooms each year to confirm presence/ absence and to determine if there are any immediate threats to the subpopulation.

It is recommended that population demographics surveys be completed every five years after baseline data is collected. A survey period of five years on average is recommended since small sized subpopulations may experience setbacks over a short period of time. This survey period was supported through consultation with experts (V. Brownell and A. Worley pers. comm. 2020). Where possible, an accessible patch of the subpopulation should be checked annually to confirm that the species is still present, and that no severe and imminent threats are occurring that would extirpate the species from the site. If the accessible patch is not located, then additional patches should be searched until presence is confirmed. These quick field checks may suggest the need for more frequent full surveys if declines are noted.

5.1.7. Survey Effort

Survey effort should be recorded at each site surveyed regardless of whether Small White Lady's-slipper is located during the survey. This will facilitate interpretation of data from surveys of different subpopulations and provide an indication of confidence that can be places on findings of declines and or extirpation (i.e. it will allow assessment of whether results are the result of a lack of effort). The monitoring protocol has been designed so that the entire methodology can be completed within one day per subpopulation. This does not include the time required to search for additional sites or re-locate historic populations, which may differ greatly by subpopulation. Additional days in the field may be needed to plan or setup the long-term monitoring protocol for the first time. A survey team of 1 to 2 people is recommended to reduce impact to habitat.

5.1.8. Qualifications of Surveyors

Surveyors should have experience completing field vegetation surveys and the ability to identify plants. Surveyors should have a thorough understanding of the ecology and physical characteristics of Small White Lady's-slipper and the associated hybrids, as well as the habitat in which it occurs in so that they can evaluate threats and habitat quality.

5.2. Field Methodology

5.2.1. Records Review

A thorough review of past records and field reports should be carried out prior to field surveys. Historic records can assist in scoping the field surveys and allow for survey routes to be planned to prevent unnecessary habitat damage. All relevant data on the site should be acquired including maps, coordinates, photos, descriptions, etc. These data should be included in the reporting to facilitate future surveys.

5.2.2. Data Collection

Baseline data should be collected at each site over three to five consecutive years. Subsequent to the collection of baseline data, surveys should be completed every five years. Data collection during baseline data surveys and the following 5-year surveys will include:

- determining the area of occurrence (**Section 5.2.3**);
- estimating population size (**Section 5.3.4**);
- completing a population demographics study on the entire (small subpopulations) or a subset of the subpopulation (large subpopulations) (**Section 5.2.5**);
- describing the associated plant community (**Section 5.2.6**);
- evaluating threats and site conditions (**Section 5.2.7**);
- tracking weather conditions (rainfall and temperature) during periods of bud development, prior to flowering period and during flowering period (**Section 5.2.8**); and
- recording soil moisture during blooming period (**Section 5.2.8**).

In years where surveys are not scheduled to be completed subpopulations should still be checked to note presence/absence and assess the potential for threats that could extirpate the subpopulation. During these presence/absence checks data do not need to be collected on area of occurrence, population abundance, population demographics or associated plant community (with the exception of recording non-native/ invasive species as a threat).

To distinguish hybrids from Small White-lady's-slipper, paint or flower colour charts (such as that used by the Royal Horticultural Society, Pantone or a commercial interior paint chart as in **Figure 8**) should be used to quantify lip colour of each genet. Additional criteria as discussed in **Section 2.1.1** should also be used if the identification of a plant as a true species or hybrid is in question. If hybrids occur within the study area, non-flowering genets should be noted as *Cypripedium* sp. to clarify that the individual cannot be confirmed as a Small White Lady's-slipper or a hybrid. These genets should also be tagged and mapped so that previously collected data can be related to species if they bloom during a survey year.

5.2.3. Determining Area of Occurrence

It is recommended that the area of suitable and adjacent habitat be thoroughly and systematically examined. This method involves using professional expertise to determine areas where the species may occur and surveying any new locations. This method should be based on a combination of background review (where the species was seen previously at a site) and expertise (what areas currently look suitable).

Plants within 30 m of each other should be grouped together as an occurrence. This is to maintain consistency with surveys completed in Manitoba. For small occurrences (occupying less than 5 m^2), a GPS waypoint should be taken. For larger occurrences (occupying more than 5 m^2), a GPS unit or

tablet should be used to delineate a polygon around all observed flowering plants. A centroid location for the occurrence should be recorded. The distribution of plants within the area of occurrence should be described and illustrated on a map as "dense patch", "sparse patch" or "individual". A patch should be considered as a group of genets. To document the changes over time, the area of occurrence should be mapped out each time surveying is undertaken. Locations of hybrids within or adjacent to the area of occurrence should also be mapped.

5.2.4. Population Size

Once the extent of species occurrence in an area is determined, individual plants (genets) should be counted systematically. As recommended by previous studies and literature (Kull 1995; Kull 1999; Shefferson 2006; K. Newman and C Murray pers. comm 2020), ramets separated from each other by 20 cm or more should be considered separate genets. The total number of flowering genets at the site should be counted for each occurrence.

Genets of both Small White Lady's-slipper and hybrids should be counted in order to determine if hybrids are becoming more abundant at a site over time.

5.2.5. Population Demographics

If not part of a larger genet, ramets with 1 to 2 leaves that are also less than 12 cm in height should be considered seedlings and should be counted as individual plants (Kalisz and Thiede 1989). Genets included in the population demographics monitoring study should be marked with galvanized nails and numbered tags so that they can be found later with a metal detector. In subsequent years, new genets in the area of study that do not have tags should be marked. Likewise, tags located where a genet has disappeared should be noted, but not removed, as if the genet is merely dormant (i.e., has not died), it may re-appear in the future. Tags should be consistently placed on the north side of the genet 5 cm from the centre of the most exterior ramet. It is recommended that where possible the soil be dug into lightly with a finger before placement to ensure orchid rhizomes are not present. This placement is to prevent damage of the orchid rhizomes and to make tag location consistent so that the genets can be relocated and referenced easily. However, it is noted that ramets may be ephemeral and that the ramet that served to locate the tag may disappear, thus the tag may only provide an approximate location for the genet and some observer interpretation will be required. Locations of each marked genet should be recorded with a GPS or tablet and mapped. To increase precision a submetere accurate GPS, such as BlueSX, is recommended if possible. In some cases, especially in small populations (<50 genets), it may be beneficial to produce small sketch showing the location the ramets of a limited number of genets as well as the location of the tag, to aid in future location of ramets and interpretation of data. Documentation with photos is also recommended.

If the use of nails and tags is not desirable at the site, the transect method as described for large subpopulations could be used to sample the subpopulation regardless of its size. Using this method

can allow for individual plants to be located based on distances along and from a transect line as described below under the protocol for large populations.

As with the individual counts (**Section 5.2.4**), genets of both Small White Lady's-slipper and hybrids should be included in order to determine if hybrids are becoming more abundant at a site over time.

5.2.5.1. Small Subpopulations (50 or fewer individuals)

If subpopulation size is small (50 or fewer individuals), the entire subpopulation should be included in the population demographics study and all flowering and non-flowering genets should be marked. In subsequent years, additional genets found should be marked and included in the study. Both emergent and non-emergent marked individuals should be located and recorded as "emergent" or "non-emergent". Individuals should categorized as "flowering", "non-flowering" or "seedling". The average number of ramets per genet should be calculated using all genets up to a maximum of 20 (including flowering and non-flowering).

In the case of small populations, the population demographics study data will provide actual population size data (flowering genet counts) since all of the genets are counted and categorized.

5.2.5.2. Large Subpopulations (51 or more individuals)

If subpopulation size is large (51 or more individuals) and individual counts are not feasible, a sampling approach is recommended. Where the distribution of plants within the subpopulation is relatively compact, two permanent 25 m long transects should be sufficient to provide an estimate of recruitment and mortality. If the subpopulation is dispersed over a large area, additional transects or an extension of the transects is recommended in order to capture approximately 50 Small White Lady's-slipper individuals. It is recommended that transects be positioned at least 4 m apart and in various locations within the occurrence so that demographics at the edge and in the centre of the site can be compared and related to woody succession. The transects should be permanently marked with wooden stakes or rebar (or other site appropriate method, such as a significant and obvious landmark) and GPS coordinates should be recorded at both ends. If a landmark (such as a tree) is used it is recommended that compass direction and distance from the landmark be recorded as accurately as possible and reference photos with the transect set up be taken and included in the report. The transect should be placed so that it minimizes damage to the habitat. Transects may be placed to include or not include hybrids at the discretion of the surveyor. If hybridization is prevalent at the site, it is recommended that hybrids be included in the survey.

In the first year of surveying, all genets within 2 m on either side of each transect should be marked by GPS and tagged if desired. Within the first 1 m from the central transect measurements are very accurate for locating individuals and up to 2 m is considered accurate but should be considered a maximum for ease of relocation (S. Anderson and A. Worley pers. comm. 2020). In subsequent years, new genets should also be marked and included in the study. Distance along the transect and from

the transects should be recorded for each genet in the study. For each survey year, emergent and non-emergent individuals should be located and recorded as "emergent" or "non-emergent". Emergent genets should be categorized as "flowering", "non-flowering" or "seedling". The average number of ramets per genet should be recorded for 20 random genets (including flowering and non-flowering).

Not including tags for individual plants does create a margin for error and removes the ability to locate them easily with a metal detector. Using the transect method without nails has other advantages including:

- less hardware in the ground and reduced potential damage to the species through nail placement (if the species is very dense),
- lower risk of poaching, which could occur from marked individuals,
- accurate marking even in fens habitats where the nails may become shifted in the sphagnum due to frost heave or flooding.

5.2.5.3. Identifying Hybrids

For flowering individuals of questionable genetic identity, the following should be noted and compared to those of known identity: slipper colour (on a scale from 1 to 8 based on a paint colour chart), leaf curvature (scale from 1 to 5, where 1= flat, 3=boat shaped, 5=folded along midvein), plant height (cm), leaf length (cm), leaf width (cm), slipper width (mm), slipper length (mm), petal length (mm) and staminode shape. Photos of the plant and floral parts should be sent to an expert (such as a vascular plant specialist from the Natural Heritage Information Centre, National Museum of Canada or Agriculture Canada, or a professor specializing in orchid research) if the identity is still questionable. Ensure that the location of the plant is recorded using GPS so it can be relocated if necessary.

Identification of hybrids with DNA has been used previously (Worley et al 2009; Geomatics International 1995) and may be used to confirm genetic identity if the funds are available. The process should include DNA extraction, PCR reactions and sequencing (A. Worley pers. comm. 2020). DNA labs at the University of Calgary and University of Guelph are recommended for DNA analysis (A. Worley and V. Brownell pers. comm. 2020). Previous work in Ontario confirmed the presence of a single individual Small White Lady's-slipper in Norfolk County with electrophoretic analysis of five enzymes completed at the University of Guelph (Geomatics International 1995). DNA extraction and genetic analysis was also completed by Anne Worley, Joshua Pearlman and Bruce Ford in 2008 on the population in Hastings County (A. Worley pers. comm. 2020).

5.2.6. Associated Plant Community

In order to evaluate woody succession over time, the percent cover of each vegetation layer (tall shrub, low shrub, herbaceous, moss) within the area of occurrence should be recorded and the most abundant (i.e. dominant) species in each layer should be listed. Layer values may add to over 100%

due to overlapping layers. Height and cover codes should be used to describe the community structure and composition (See example datasheet in **Appendix 3**). Percent cover of soil, rock, leaf litter and thatch should also be noted. Photos of the community should be taken in the four compass directions from a central point at the occurrence. The location where the photos were taken should be recorded by GPS or tablet.

If Yellow Lady's-slippers or hybrids are present, the abundance of co-flowering ramets of each Lady's-slipper species and hybrids should be estimated in relation to total number of flowering Lady's-slipper ramets on site following the codes: R=Rare, O=Occasional, A=Abundant, D=Dominant. This can only be used to provide a rough estimate of hybridization potential based on the relative abundance of each species, as there are a host of other variables that may influence hybridization (e.g., pollinator abundance, variations in phenology, etc.). The relative abundance of the species at the site and the changes over time should be used to an overview of changes and provide some idea of the potential threat of assimilation.

The abundance of all non-native species in the area of occurrence should be estimated (1 = 1-2 plants, 2 = 3-5, 3 = 6-20, 4 = 21-50, 5 = 51-100, 6 = 100+) and distribution (L=localized, O=occasional, P=scattered patches, W=widespread). Species considered invasive in Ontario based on Weediness Index[6], exotic status (SE5) in the NHIC Database[7] or other invasive species list[8],should be noted. Location (using GPS or tablet) of invasive species should be recorded using a GPS or tablet. Polygons of larger patches of invasive species should be delineated. An estimate of total percent cover of non-native species over the entire area occupied by SWLS should be recorded.

5.2.7. Evaluating Threats

All threats to the habitat and species in and adjacent to the area of occurrence should be noted and ranked according to the COSEWIC guidelines for evaluating threats (COSEWIC 2012). Relevant pages of the COSEWIC guidelines have been included below. Where possible, the location and extent of threats should be mapped using a GPS or tablet. Where threats are not mappable (e.g., changes in hydrology, widespread distribution of an invasive plant species, evidence of widespread herbivory), they should be described. Adjacent land-uses should also be described.

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[6] Oldham et al. 1995. Floristic Quality Assessment System for Southern Ontario. Natural heritage Information Centre, Ontario Ministry of Natural resources. Perterborough, ON. 17pp.
[7] NHIC Database Available at: https://www.ontario.ca/page/get-natural-heritage-information
[8] Such as those developed by conservation authorities: CVC Invasive Species Lists and Factsheets https://cvc.ca/wp-content/uploads/2012/09/cvc-appendix-landowners-guide-to-invasives.pdf

5.2.7.1. COSEWIC Threat Evaluation

The text below within this section (Section 5.2.7) was taken directly from page 9-12 of the COSEWIC guidelines for threats classification (COSEWIC 2012). Table numbers have been altered to fit this document.

Scope of a Threat

Scope is defined herein as the proportion of the species or ecosystem that can reasonably be expected to be affected by the threat within 10 years with continuation of current circumstances and trends (**Table 3**). Current circumstances and trends include both existing as well as potential new threats. The 10-year timeframe can be extended for some longer-term threats, such as global warming, that need to be addressed today. For species, scope is measured as the proportion of the species' population in the area of interest affected by the Threat. For ecosystems, scope is measured as the proportion of the occupied area of interest affected by the Threat. If a species or ecosystem is evenly distributed, then the proportion of the population or area affected is equivalent to the proportion of the range extent affected by the threat; however, if the population or area is patchily distributed, then the proportion differs from that of range extent.

Table 3. Scoring the scope of identified threats. Typically assessed within a 10-year timeframe.

Scope of threats scoring	
Pervasive	Affects all or most (71–100%) of the total population or occurrences
Large	Affects much (31–70%) of the total population or occurrences
Restricted	Affects some (11–30%) of the total population or occurrences
Small	Affects a small (1–10%) proportion of the total population or occurrences
Negligible	Affects a negligible (< 1%) proportion of the total population or occurrences

Severity of a Threat

Within the scope of the threat, severity is the level of damage to the species or ecosystem from the threat that can reasonably be expected with continuation of current circumstances and trends (including potential new threats) (**Table 4**). Note that severity of threats is assessed within a 10-year or three-generation timeframe, whichever is longer (up to 100 years).

For species, severity is usually measured as the degree of reduction of the species' population. Surrogates for adult population size (e.g., area) should be used with caution, as occupied areas, for example, will have uneven habitat suitability and uneven population density. For ecosystems, severity is typically measured as the degree of degradation or decline in integrity (of one or more key characteristics).

Table 4. Scoring the severity of a threat (within a 10-year or three-generation timeframe, whichever is longer [up to 100 years]).

Severity of threats scoring	
Extreme	Within the scope, the threat is likely to destroy or eliminate the occurrences of an ecological community, system, or species, or reduce the species population by 71–100%
Serious	Within the scope, the threat is likely to seriously degrade/reduce the affected occurrences or habitat or, for species, to reduce the species population by 31–70%
Moderate	Within the scope, the threat is likely to moderately degrade/reduce the affected occurrences or habitat or, for species, to reduce the species population by 11–30%
Slight	Within the scope, the threat is likely to only slightly degrade/reduce the affected occurrences or habitat or, for species, to reduce the species population by 1–10%
Negligible	Within the scope, the threat is likely to negligibly degrade/reduce the affected occurrences or habitat or, for species, to reduce the species population by < 1%.
Neutral or Potential Benefit*	Within the scope, the "threat" is likely to improve or not affect occurrences or habitat or, for species, to be neutral or to improve (a net benefit) the species population by > 0%).

*Threat may have some localized negative effects, but overall is thought to not affect or be a benefit to the species. For example, a forest fire may directly affect some individuals of a browsing ungulate, and produce a short term loss of habitat, however, over the three generation time window there is a benefit to the population as a whole due to regeneration of browse species post fire.

Impact of a Threat

Threat impact (or magnitude) is the degree to which a species or ecosystem is observed, inferred, or suspected to be directly or indirectly threatened in the area of interest. The impact of a threat is based on the interaction between assigned scope and severity values, and includes categories of very high, high, medium, and low.

Threat impact reflects a reduction of a species population or decline/degradation of the area of an ecosystem. As shown in **Table 5**, the median rate of population reduction or area decline for each combination of scope and severity corresponds to the following classes of threat impact: very high (75% declines), high (40%), medium (15%), and low (3%).

Table 5. The relationship of threat impact and population reduction or ecosystem decline or degradation

		Scope (%)			
		Pervasive	**Large**	**Restricted**	**Small**
Severity (%)	**Extreme**	50–100	22–70	8–30	1–10
	Serious	22–70	10–49	3–21	1–7
	Moderate	8–30	3–21	1–9	0.1–3
	Slight	1–10	0–7	1–3	< 1

Very High; High; Medium; Low

It is not always possible to assign an impact category of very high, high, medium, or low to a threat. For a complete list of impact categories, see **Table 6**. These additional categories include:

- Negligible: when the value for scope or severity is negligible.
- Unknown: used when impact cannot be determined (e.g., if values for either scope or severity are unknown).
- Not a Threat: when severity is scored as neutral or a potential benefit.
- Not Calculated: impact is not calculated if threat is outside the assessment timeframe (e.g., timing is insignificant/negligible or low, as threat is only considered to be in the past).

Table 6. Using scope and severity to derive the impact of a threat

		Pervasive	**Large**	**Restricted**	**Small**	**Negligible**	**Unknown**
Severity	**Extreme**	Very high	High	Medium	Low	Negligible	Unknown
	Serious	High	High	Medium	Low	Negligible	Unknown
	Moderate	Medium	Medium	Low	Low	Negligible	Unknown
	Slight	Low	Low	Low	Low	Negligible	Unknown
	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Unknown
	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
	Neutral or Potential Benefit	Not a threat	Not a threat	Not a threat	Not a threat	Not a threat	Unknown

Very High; High; Medium; Low

Timing of a Threat

Although timing (immediacy) is recorded for threats, it is not used in the calculation of threat impact. However, threat impact is not calculated for threats where timing values are low or negligible. See **Table 7** for guidance on determining the timing of the threat

Table 7. Scoring the timing of a threat.

	Timing of threats scoring
High	Continuing
Moderate	Only in the future (could happen in the short term [< 10 years or three generations]), or now suspended (could come back in the short term)
Low	Only in the future (could happen in the long term), or now suspended (could come back in the long term)
Insignificant/Negligible	Only in the past and unlikely to return, or no direct effect but limiting

5.2.8. Ranking Site Condition

An overall disturbance level and site quality should be recorded. Some guidelines for determining overall site condition are provided below. Additional considerations may be incorporated into the rank as needed on a site-by-site basis. Notes on disturbances at each site should be taken.

5.2.8.1. Developing Size Considerations for Southern Ontario Fens

The NHIC Plant Community Ranking Methodology for Alvars, Dunes and Prairies (Henson and Bakowsky 2014) contained size considerations for prairie and savannah communities; however, no documentation could be found to provide size considerations for southern Ontario fens. Following the methodology outlined by Henson and Bakowsky (2014) and through personal communication with one of the authors (W. Bakowsky pers. comm 2020), a size consideration was developed.

This exercise was completed using ESRI ArcGIS and the Ontario wetlands shapefile from Land Information Ontario (LIO)[9]. The shapefile was queried for fen polygons which were then clipped to the boundaries of Ecoregions 6E and 7E). For the purposes of this exercise, fens located within 1 km of each other were considered connected. In order to achieve this in GIS, fen polygons were buffered by 1 km and were grouped if they occurred within the 1km buffer. Fens that did not occur within the buffer were considered separate, even if complexed in the LIO shapefile. Fens were also considered separate (even if they were within 1 km) if:

[9] Land Information Ontario: https://geohub.lio.gov.on.ca/

- There was agriculture or urban development between two fens;
- There were open areas between them over 120 m wide (e.g., large transmission corridors) without a clear path of connection; or
- There was imagery separation or the fen was obscured by cloud cover.

Rivers and waterways under 150 meters were not considered as a separation as they are part of the wetland complex. Roads were not considered to break up patches as they are a small separation. This methodology resulted in a dataset of 646 fens. Geometical intervals are included in (**Table 8**).

The authors acknowledge that this methodology may be improved based on the following:

- A more thorough review of fen boundaries to improve accuracy of the values calculated using this methodology (feature boundaries in the Ontario wetlands shapefile do not always accurately reflect actual wetland boundaries on the landscape).
- Selecting only alkaline fens (e.g., by using a soils or bedrock dataset), which are the preferred habitat of Small White Lady's-slipper.

5.2.8.2. Community Ranking Methodology

The text below within this section (Section 5.2.8) was adapted from page 3-5 of the NHIC Plant Community Ranking Methodology for Alvars, Dunes and Prairies (Henson and Bakowsky 2014).

Ranks developed by NatureServe for occurrences include:

- A excellent predicted viability
- B good predicted viability
- C fair predicted viability
- D poor estimated viability
- Other ranks that can be assigned in certain cases include:
- E verified to be extent (not enough information to rank properly)
- H historical (lack of recent field information to verify continued existence)
- F failed to find (purposeful search at site and element was not found)
- X extirpated (documented destruction or pervasive evidence of eradication)

Factors used to estimate viability of the occurrence are size (area of occupancy), condition (development/ maturity, ecological processed, abiotic physical/chemical factors) and landscape context (landscape structure and extent and condition of surrounding landscape).

Henson and Bakowsky (2014) support the use of size, community condition and landscape context for determining a site condition rank. Size ratings for prairie and savannah communities based on patch sized and geometrical interval from Hensen and Bakowsky (2014) have been included in **Table 8**. Criteria to consider for evaluation community condition include but are not limited to:

- Are there old growth conditions present?

- Is the overstory and understory structure intact?
- Is the native species composition intact?
- Are there co-flowering species to attract pollinators?
- What is the extent of introduced species in the community?
- Are ecological processes integral to the community occurring? e.g. fire
- What is the extent of human-induced disturbance? Are the disturbances historic or occurring?
- Are hydrological regimes still natural?

Landscape context must consider landscape structure, extent and the condition of the surrounding area. Ratings and criteria for landscape context are provided in **Table 9**.

Table 8. Size Considerations for Prairie/ Savannah and Fen communities.

Type	Rating	Patch Size Description	Geometrical Interval (Ha)
Prairies and Savannahs	**A**	Very large	>26.5
	B	Large	4.1-26.0
	C	Medium	0.565-4.09
	D	Small	0-0.56
Fens	**A**	Very large	>47.9
	B	Large	4.59 - 47.99
	C	Medium	0.40 - 4.59
	D	Small	0.0 - 0.40

**geometrical interval analysis excluded the Pinery tallgrass woodland for range determination.

Table 9. Ratings for Landscape Context.

Rating	Description
A	highly connected, surrounding area is largely intact natural vegetation, with species interactions and natural processes occurring across communities
B	moderately connected, surrounding area is moderately intact natural vegetation; landscape includes partially disturbed or semi-natural communities
C	moderately fragmented, surrounding area is combination of cultural and natural vegetation, with barriers to species interactions and natural processes
D	highly fragmented, almost entirely surrounded by agricultural or urban land use

To determine a rank, first determine the size/landscape context rating by comparing the size against the landscape context according to **Table 10**.

Table 10. Determining size/landscape context rating.

		Landscape Context			
		A	**B**	**C**	**D**
Size	**A**	A	A	B	B
	B	B	B	B	C
	C	B	C	C	C
	D	C	C	D	D

Very High; High; Medium; Low

To determine the overall rank of the occurrence compare the size/landscape rating with the condition rating using **Table 11**.

Table 11. Determine occurrence rank based on size/landscape rating and condition rank.

		Size/Landscape Context Rating			
		A	**B**	**C**	**D**
Condition	**A**	A	A	B	C
	B	A	B	B	C
	C	B	C	C	D
	D	C	D	D	D

Very High; High; Medium; Low

5.2.9. Additional Data to Monitor

Summarizing weather (precipitation and temperature) during the period of bud growth (early spring), initiation (late spring) and development (summer) during the collection of baseline data (three initial consecutive years of study) and for the years in which long-term monitoring data (collected every five years) are collected will assist in interpreting trends in population demographics. The minimum, maximum and average daily temperature and amount of daily rainfall can be found on Environment Canada's website[10]. Any occurrences of frost will be particularly useful, although the microclimate of the actual site will need to be accounted for.

Measuring water table fluctuations and water quality may be the only sure way to quantifiably assess the threat of changing hydrology; however, this is potential expensive and intrusive and it may not be feasible to undertake. If surface and/or groundwater monitoring is deemed essential to monitoring a specific subpopulation the methodology should be decided on a site to site basis (if needed). The Ecological Land Classification for Southern Ontario (Lee et al. 1998) provides a method for determining soil moisture regime that could be used to assess changes long-term; however, it is uncertain how quickly changes would become apparent using this methodology. If there is standing water at the time of survey the soil moisture regime should be recorded as flooded and the water depth should be recorded. A water quality meter (or other devices) may be used to record pH, temperature, conductivity and turbidity. The method used to record such data should be noted. If water quality appears to be of concern due to adjacent land-use a water sample could be sent out for analysis. However, as there is limited information of the water quality parameters that are important for Small White lady's-slipper and the range of values which are important for it to persist, this may be of limited value. Such testing may be useful to determine if there are potentially harmful chemicals

[10] Historical Weather Data, Environment Canada: https://climate.weather.gc.ca/historical_data/search_historic_data_e.html

present in the water. If there is no standing water, soil moisture level should be described as saturated, wet, moist, semi-moist or dry based on subjective observation.

Incidental data on the presence/abundance of pollinators would be valuable to include but was not recommended as a requirement in the survey protocol since it would further constrain sampling to certain weather conditions. Insect sampling methods may require extensive monitoring that would lead to increased damage to the habitat and techniques that involve the collection of insect specimens. If pollinator surveys are completed it would be beneficial to collect data on co-flowering species and relate this to pollinator abundance (if possible). Abundance (1 = 1-2 plants, 2 = 3-5, 3 = 6-20, 4 = 21-50, 5 = 51-100, 6 = 100+) and distribution (L=localized, O=occasional, P=scattered patches, W=widespread) of co-flowering species could be recorded so that changes in the co-flowering community (within the area of occurrence) can be documented.

There have been no studies on fruit set in Ontario populations and a study of this nature (over a range of habitats and population sizes) may be worth considering in order to fill the gap in knowledge (A. Worley pers. comm. 2020). Hybrids have been noted to have higher fruiting success in Manitoba. In order to more accurately assess hybridization potential and the threat of hybridization more knowledge on pollination and fruiting success between the species and its hybrids in Ontario is needed (A. Worley pers. comm. 2020).

Due to the low seed set rates typical of this species, assessing seed set was not included in this methodology. If surveys on fruit set or seed production are to be completed the timing of surveys should be determined by what data is desired:

- If information on presence/ absence of fruit is to be collected, initial surveys of swollen capsules could take place 3-5 weeks after flowering.
- If information on seed number and filling were desired, the fruit would have to be collected in August once they had matured (but before the capsule dehisce in September).

Surveys on fruiting success should repeat the methodology as outlined above for small or large populations but with the presence/ absence of fruit recorded for each individual instead of flowering. In the event an individual has multiple capsules this should also be noted.

5.2.10. Future Considerations

Although the use of Unmanned Aerial Vehicles (UAV: also called drones or RePAS (Remotely Piloted Aerial System) is not recommended as a standard monitoring methodology due to their cost and unproven success in detection of the orchids, the use of UAV for evaluating threats such as woody succession should be further explored. Since the species occurs in open habitats, UAV may be able to capture high quality images of the habitat in order to evaluate changes over time. The ability for UAV to complete counts is currently unlikely due to the small size of the plant and flower, its inconspicuous colour and identification issues with respect to hybrids. However, as UAV technology is further

developed, and the cost of UAVs declines, high-end UAV may potentially be used to complete counts of flowering stems. This option for surveys should be first explored further by relating the survey results of fieldwork to a survey using UAV to assess their accuracy.

Currently, UAV are used in a variety of studies (Meinen and Robinson 2019; 2020) and can achieve a 0.6 cm spatial resolution when flying at a height of 40 m (D. Robinson pers. comm. 2020). This was achieved with a high-end military grade UAV (FLIR Systems R60 Skyranger UAV) that can cost up to $120,000; however, cheaper UAV (approximately $500) can achieve similar resolution by flying lower and slower (D. Robinson pers. comm 2020). Structure for motion software is needed to stich images together so that they can be analyzed (D. Robinson pers. comm. 2020). It is expected that if the location of a population is known, UAV may be used to monitor woody succession within the habitat over time.

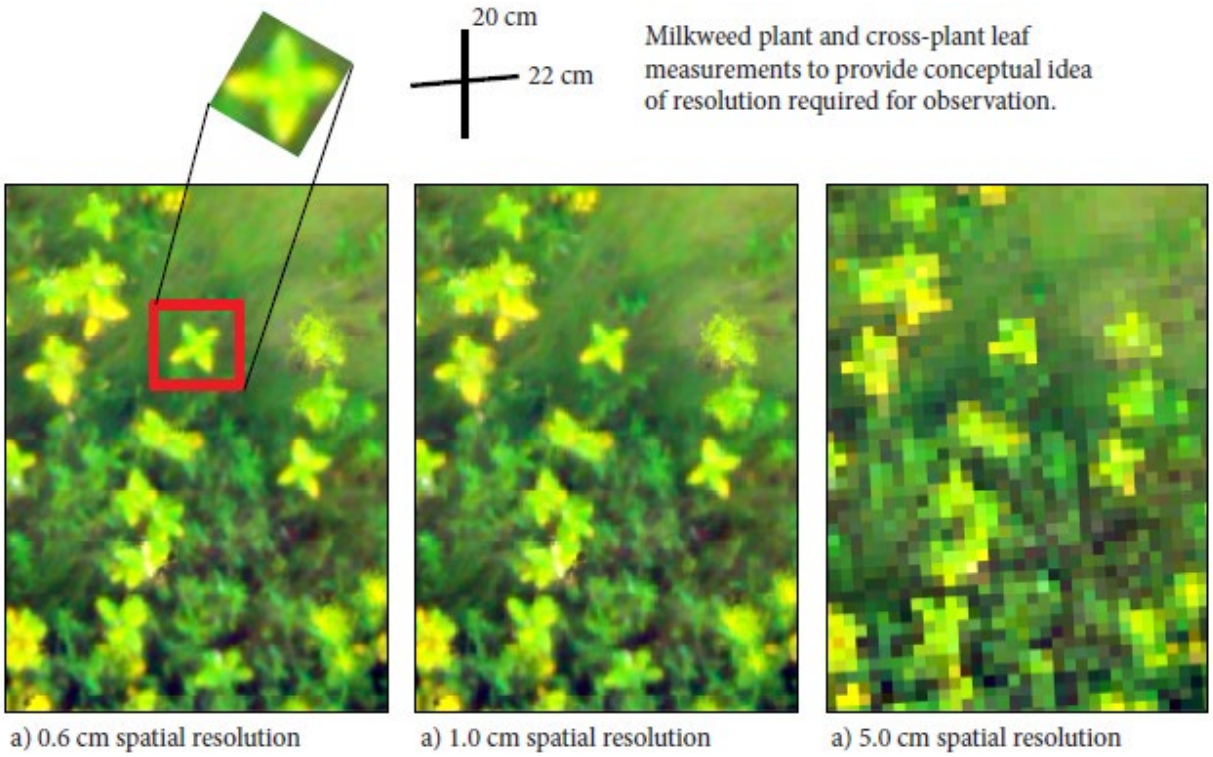

Figure 9. Images of milkweed plants captured by a UAV (FLIR Systems R60 Skyranger UAV) demonstrating the various spatial resolutions. Photo Credit: Derick Robinson.

5.3. Documentation and Reporting

5.3.1. Documentation

Developing a standard datasheet or utilizing a program or mobile app to collect data can ensure completeness, consistency and accuracy. An example datasheet that can be adapted has been included in **Appendix 3**. The following should be documented for each survey (regardless of whether or not Small White Lady's-slippers were located):

- names of all contributors and their roles in the survey;
- survey date(s);
- survey location(s);
- survey effort (person hours in the field);
- photographs of the habitat;
- a map that delineates survey locations; and
- result (observed or not observed).

The following should be recorded and reported for each occurrence of Small White Lady's-slipper:

- time and date of observation;
- name and contact information of observer(s);
- location description and directions;
- area of occurrence polygon and/or coordinates of centroid;
- map of distribution of plants within area of occurrence;
- photo record for each occurrence;
- count of flowering genets;
- average genet size (ramets per genet) across 20 random genets;
- percent cover of each vegetation layer and description of the community;
- list of dominant associated species in each vegetation layer;
- comparison of the proportion of flowering Small White Lady's-slipper, Yellow Lady's-slipper and hybrids;
- description and locations of nearby invasive species; and
- percent cover of non-native species.

The following should be recorded and reported for each subpopulation (small subpopulations of 50 or less individuals will include data on all individuals whereas larger subpopulations will provide data collected along a 25 m transect):

- whether the full count or sampling method (transects) was used;
- if transects were used, their location and length;
- locations (GPS or transect references) and tag numbers of all marked plants;
- number of emergent and non-emergent genets;

- numbers of flowering, mature non-flowering and immature genets of Small White Lady's-slipper and hybrid individuals; and
- an assessment of threats and site condition.

This protocol is science -based and has been used to survey this species in other locations; however, it is untested in Ontario. As noted in **Section 5.1.2**, it is highly recommended that any issues with the survey method be recorded and reported so the protocol can be improved and adapted in the future.

5.3.2. Reporting

SAR data should be reported to the Natural Heritage Information Centre (NHIC) at the Ontario Ministry of Natural Resources and Forestry (MNRF).[11] NHIC is Ontario's conservation data centre and maintains the record of Ontario's SAR occurrences. Negative survey results should also be submitted to the NHIC. Data should be submitted in digital format (spreadsheet or shape files with associated tabular data) as per the instructions on the NHIC website.[12] Incidental observations of other SAR or other provincially tracked species encountered during surveys of Small White Lady's-slipper should also be reported to the NHIC, either in digital format or iNaturalist (by joining the NHIC Rare species of Ontario project).

If survey work is completed within a provincial park or conservation reserve reporting requirements will be defined in the authorization to conduct the work.

Reporting requirements or expectations for work completed on First Nations land should be established in consultation with the band council and any protocols for data transfer and use of data are to be followed. Distribution of data collected from First Nations lands is at the discretion of the band.

[11] www.ontario.ca/nhic
[12] https://www.ontario.ca/page/report-rare-species-animals-and-plants

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APPENDIX 1 | Personal Communications

Appendix 1. List of experts contacted including those who participated in consultation and review of the document.

Contact Name	Organization	Department / Division or Location	Title	Contacted (Yes/No)	Provided input (Yes/ No)	Reviewed Document (Yes/ No)
Anne Worley	University of Manitoba	Biological Sciences	Professor	Yes	Yes	Yes
Audrey Heagy	St. Williams Conservation Reserve	Community Council	Project Coordinator	Yes	Yes	Yes
Bruce Ford	University of Manitoba	Biological Sciences	Professor	Yes	Yes	No
Cary Hamel	Manitoba Conservation Data Centre	Wildlife and Ecosystem Protection Branch, Manitoba Conservation, Winnipeg, Manitoba	Biologist	Yes	No	No
Chris Friesen	Manitoba Conservation Data Centre	Wildlife and Ecosystem Protection Branch, Manitoba Conservation, Winnipeg, Manitoba	Biologist	Yes	No	No
Christie Borkowsky	Nature Conservancy of Canada	Manitoba Tallgrass Prairie Preserve	Biologist	Yes	No	No
Clint Jacobs	Walpole Island First Nations	Walpole Island First Nations Heritage Centre		Yes	No	No
Colin Murray	Manitoba Conservation	Conservation Data Centre		Yes	Yes	Yes
Corina Brdar	Ontario Parks	Ontario Parks	Senior Ecologist – Protected Areas Section	Yes	Yes	Yes
Derek Robinson	University of Waterloo	Department of Geography and Environmental Management	Associate Professor	Yes	Yes	No
Eric Snyder	Ministry of the Environment, Conservation and Parks	Species at Risk Branch	Plant Species at Risk Specialist	Yes	Yes	Yes
Erika Barkley	Ministry of the Environment, Conservation and Parks	Southeast Zone – Ontario Parks	A/ Zone Ecologist	Yes	Yes	No
Garry Allen	Parks Canada			Yes	No	No
Mary Gartshore	Nature Conservancy of Canada	Ontario	Senior Biologist	Yes	Yes	No
Mike Oldham	Ministry of Natural Resources and Forestry	Ontario Natural Heritage Information Centre	Provincial Botanist	Yes	Yes	No
Mirek Sharp (co-author)	North -South Environmental Inc.	Ontario	Senior Ecologist	Yes	Yes	Yes
Paul Catling	Agri Food Canada / DAO Herbarium	Ottawa	Research Scientist	Yes	Yes	Yes
Sam Brinker	Ministry of Natural Resources and Forestry	Ontario Natural Heritage Information Centre	Project Botanist	Yes	No	Yes
Steven Anderson	Nature Conservancy of Canada	Manitoba	Assistant Conservation Biologist	Yes	Yes	Yes
Vivian Brownell	Ministry of Natural Resources and Forestry	Species at Risk Branch	Senior Biologist	Yes	Yes	Yes
Wasyl Bakowsky	Ministry of Natural Resources and Forestry	Ontario Natural Heritage Information Centre	Community Ecologist	Yes	Yes	Yes

APPENDIX 2 | List of Associated Plants

Table 1

Plants Associated with Cypripedium candidum in a Mesic Prairie in Lambton County, Ontario

Compiled by V.R. Brownell in 1979

Equisetum laevigatum A.Br.
Poa compressa L.
Agrostis stolonifera L.
Spartina pectinata Link.
Panicum virgatum L.
Panicum lanuginosum var. implicatum (Scribn.) Fern.
Panicum praecocius Hitch. & Chase
Andropogon scoparius Michx.
Andropogon gerardi Vitm.
Carex crawei Dewey
Carex lasiocarpa Ehrh.
Carex aquatilis Wahl.
Carex buxbaumii Wahl.
* Scleria triglomerata Michx.
* Tradescantia ohioensis Raf.
Lilium philadelphicum L.
* Aletris farinosa L.
Smilacina stellata (L.) Desf.
* Hypoxis hirsuta (L.) Cor.
Sisyrinchium mucronatum Michx.
Spiranthes cernua (L.) Rich.
Comandra richardsoniana Fern.
Anemone canadensis L.
Parnassia glauca Raf.
Fragaria virginiana Duchesne
Lespedeza capitata Michx.
Lathyrus palustris L.
* Polygala incarnata L.
Polygala sanguinea L.
Viola affinis LeConte
* Viola sagittata Ait.
Zizia aurea (L.) Koch.
Lysimachia quadrifolia L.
Lithospermum canescens (Michx.) Lehm.
Lycopus americanus Muhl.
Prunella vulgaris L.
Pycnanthemum virginianum (L.) Durand & Jackson
* Veronicastrum virginicum (L.) Farw.
Pedicularis canadensis L.
Lobelia spicata Lam.
Solidago juncea Ait.
* Solidago rigida L.
* Solidago ohioensis Riddell
Aster ericoides L.
Aster laevis L.
Antennaria neglecta Greene
* Liatris spicata (L.) Willd.
* Veronia altissima Nutt.
Cirsium muticum Michx.
Hieracium florentinum All.
Rudbeckia hirta L.
Helenium autumnale L.
* Krigia biflora (Walt.) Blake

* Listed as rare in Ontario by Argus and White (1977)

Table 2

Plants Associated with Cypripedium candidum in a Marl Fen in Hastings County, Ontario

Compiled by P.M. Catling, K.M. Lindsay, S.M. McKay, and J.L. Riley in 1976

Equisetum arvense L.
E. scirpoides Michx.
E. variegatum Schleich.
Osmunda cinnamomea L.
O. regalis L.
Oteridium aquilinim (L.) Kuhn var. latiusculum (Desv.) Underw.
Dryopteris thelypteris (L.) Gray
Larix laricina (DuRoi) K.Koch
Picea mariana (Milla) BSP.
Abies balsamea (L.) Mill.
Thuja occidentalis L.
Triglochlin maritimum L.
Phragmites communis Trin.
Muhlenbergia glomerata (Willd.) Trin.
Schizachne purpurascens (Torr.) Swallen
Eriophorum viridi-carinatum (Engelm.) Fern.
Scirpus acutus Bigelow
S. hudsonianus (Michx.) Fern.
Carex diandra Schrank.
C. disperma Dewey
C. eburnea Boott.
C. flava L.
C. hystericina Willd.
C. interior Bailey
C. lasiocarpa Ehrh. var. americana Fern.
C. leptalea Wahl.
C. limosa L.
C. prairea Dewey
C. sterilis Willd.
C. stricta Lam.
Tofieldia glutinosa (Michx.) Pers.
Clintonia borealis (L.) Desf.
Smilacina stellata (L.) Desf.
S. trifolia (L.) Desf.
Maianthemum canadense Desf.
Cypripedium arietinum RBR.
C. calceolus L. var. pubescens (Willd.) Correll
C. candidum Willd.
C. reginae Walter
Arethusa bulbosa L.
Salix candida Fluegge
Coptis trifolia (L.) Salisb.
Sarracenia purpurea L.
Mitella nuda L.
Aronia prunifolia (Marsh.) Rehder
Rubus pubescens Raf.
Potentilla fruticosa L.
Rhamnus alnifolium l'Her.
Viola nephrophylla Greene
V. renifolia Gray var. brainerdii (Greene) Fern.
Aralia nudicaulis L.
Cornus canadenis L.
Pyrola sp.
Ledum groenlandicum Oeder.
Kalmia angustifolia L.
Andromeda glaucophylla Link.
Chamaedaphne calyculata (L.) Moench
Gaultheria procumbens L.
Gaylussacia baccata (Wang.) K. Koch.
Vaccinium myrtilloides Michx.
V. oxycoccus L.
Trientalis borealis Raf.
Utricularia intermedia Hayne
U. vulgaris L.
Mitchella repens L.
Galium labradoricum Wieg.
Linnaea borealis L.
Lonicera oblongifolia (Goldie) Hooker
Valeriana uliginosa (T.&.G.) Rydb.
Senecio pauperculus Michx.

APPENDIX 3 | Datasheets

Note: These datasheets provide a template for capturing all the information collected in this survey protocol and may be used as is or adapted by surveyors to suit personal preferences, site-specific needs or to the use of iPads/ tablets for data collection, as long as data collection remains consistent.

FIELD DATA SHEET SITE: _____ SURVEYOR(S): _____

SMALL WHITE LADY'S-SLIPPER SURVEY EFFORT(HRS) _____

COMMENTS: DATE (DD/MM/YY): _____ WEATHER: TEMP (°C): _____

TIME START: _____

TIME END: _____ WIND (BEAUFORT): _____

OCCURRENCE: Y / N LOCATION(S): _____

MANAGEMENT ACTIVITIES: Y / N LOCATION(S): _____

SOIL MOISTURE LEVEL: FLOODED (WATER DEPTH= _____) **OR** SATURATED WET MOIST SEMI-MOIST DRY

OCURRENCE DATA

OCCURRENCE AREA: <5m^2 / >5m^2 **PHOTO RECORD:** Y / N LOCATION: _____

CENTROID: _____ **WAYPOINTS OF POLYGON:** _____

NUMBER OF FLOWERING GENETS: _____

HABITAT DATA

% COVER NON-NATIVES: _____

VEGETATION COMMUNITY: HT CODES: 1 = >25M 2 = 10-25M 3 = 2-10M 4 = 1-2M 5 = 0.5-1M 6 = 0.2-0.5M 7 = <0.2M

CVR CODES: 0 = NONE 1 = 1-10% 2 = 10-25% 3 = 25-60% 4 = >60%

LAYER	HT	CVR	SPECIES IN ORDER OF DECREASING DOMINANCE (>> MUCH GREATER THAN; > GREATER THAN; = ABOUT EQUAL TO)
CANOPY			
SUB-CANOPY			
UNDERSTORY			
GROUND			

PERCENT COVER ESTIMATES: THATCH: _____ LEAF LITTER: _____ BARE EARTH: _____ ROCK: _____

NOTES:

ABUNDANCE OF FLOWERING LADY'S-SLIPPERS:

Abundance of flowering Lady's-slippers is noted in relation to total flowering Lady's-slippers following the codes: R=Rare, O=Occasional, A=Abundant, D=Dominant.

SMALL WHITE LADY'S-SLIPPER: _____ HYBRIDS: _____ YELLOW LADY'S-SLIPPER: _____

NOTES:

POPULATION DEMOGRAPHICS STUDY DATA SUMMARY

METHOD USED: ALL PLANTS SURVEYED TRANSECT

AVERAGE NUMBER OF RAMETS/GENET: _____

NUMBER OF TRANSECTS: _____

TRANSECT START: _____ TRANSECT END: _____

GENET COUNTS TOTALED (SEEDLINGS HAVE 1-2 LEAVES AND ARE <12 CM IN HEIGHT, MATURE PLANTS ARE COUNTED AS FLOWERING OR NON-FLOWERING):

SPECIES	EMERGENT			NON-EMERGENT
	FLOWERING	NON-FLOWERING	SEEDLING	
Cypripedium candidum				
hybrid				
Cypripedium sp.				

NOTES:

THREATS AND DISTURBANCES

INVASIVE SPECIES:

SPECIES	ABUN,	DIST.	SPECIES	ABUN,	DIST.

POPULATION SIZE CODES: 1 = 1-2, 2 = 3-5, 3 = 6-20, 4 = 21-50, 5 = 51-100, 6 = 100+

DISTRIBUTION CODE: L = LOCALIZED, P = SCATTERED PATCHES, W = WIDESPREAD

NOTES:

DESCRIPTION OF THREATS AND DISTURBANCES:

Threat	Scope	Severity	Impact	Timing
Introduced species				
Woody Encroachment				
Trampling				

NOTES:

SITE QUALITY

HABITAT TYPE: FEN PRAIRIE / SAVANNAH

SITE SIZE: SMALL MEDIUM LARGE VERY LARGE

SITE SIZE RATING (A-D): _____

LANDSCAPE CONTEXT RATING (A-D): _____

SIZE/LANDSCAPE CONTEXT RATING (A-D): _____

SITE CONDITION RATING (A-D): _____

OVERALL SITE QUALITY RATING (A-D): _____

ADJACENT LAND USE:

NOTES:

ADDITIONAL OBSERVATIONS

POPULATION DEMOGRAPHICS STUDY (MARKED GENETS):

TAG #	SPECIES	1ST YEAR NOTED	LOCATION (UTM OR FROM TRANSECT)	EMERGENT OR NOT	FLOWERING, MATURE (NON-FLOWERING) OR SEEDLING

APPENDIX 4 | Definitions and Abbreviations

Area of Occurrence: The area of a polygon around a group of individuals located within 30 m of each other.

Competition: The negative effects one organism has upon another, usually in the context of consuming limited resources, such as food or water.

COSEWIC: Committee on the Status of Endangered Wildlife in Canada.

Disturbance: An event that causes measurable change in an ecological community.

ELC: Ecological Land Classification

Endangered: A wildlife species facing imminent extirpation or extinction.

Extirpated: A wildlife species no longer existing in that area, but still occurring elsewhere.

Genet: An individual plant comprised of multiple ramets (stems) connected by an underground rhizome. All ramets within the genet arise from the same seedling through vegetative reproduction and are genetically identical. For the purposes of this report ramets separated by 20 cm or more should be considered separate genets to provide an estimate of number of individuals.

NHIC: Natural Heritage Information Centre

Occurrence: An occurrence is an area where a species is, or was, present. For the purposes of this report, an occurrence is a group of individual plants located within 30 m of each other. Small occurrences occupy less than 5 m^2 and larger occurrences occupy more than 5 m^2. Note this does NOT equal an Element Occurrence as defined by NatureServe.

Population: Population is here defined as the total number of individuals of the taxon in a geographical area. Based on the context of the sentence it may refer to the Canadian or Ontario populations.

Population Demographics: the study of size and age composition of populations, subpopulations or occurrences over time.

Protocorm: the name for the orchids stage between germination until the seeding develops a shoot tip with leaves.

Ramet: A unit of clonal growth. The leafy stem of the orchid that appears physiologically distinct but is attached to other stems of the genet vias underground rhizomes. Ramets are produced vegetatively

from buds that develop each year at the growing end of the rhizome. Ramets within a genet are genetically identical.

Rhizome: An underground organ of plants, not a root but an underground horizontal stem with a shooting end that allows clonal growth.

SAR: Species at Risk

Succession: A sequence of changes in vegetation that occurs over time after a disturbance. In the context of this report it is most frequently described as woody succession, which is the change of an open vegetation community from being dominated by herbaceous species to having an increased cover/ abundance of woody species. Woody succession may cause declines in Small White Lady'-slipper due to competition or increased shading.

Subpopulation: Subpopulations are defined as geographically or otherwise distinct groups in the population between which there is little demographic or genetic exchange (typically one successful migrant individual or gamete per year or less).

Threat: Any factor (natural or anthropogenic) that may cause declines in the abundance of the species.

Threatened A wildlife species likely to become endangered if limiting factors are not reversed.