

RECOVERY PLAN FOR RAM'S-HEAD LADY SLIPPER (*CYPRIPEDIUM ARIETINUM*) IN NOVA SCOTIA



**A report prepared for the Nova Scotia Department of Lands and
Forestry**

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PREFACE

This Recovery Plan was prepared by Alain Belliveau, Acadia University, in consultation with the members of the Nova Scotia Plants Recovery Team, and the responsible jurisdiction, the Nova Scotia Department of Lands and Forestry. The recovery plan defines the recovery goals, objectives, and actions that are deemed necessary to protect, conserve, and recover Ram's-head lady slipper in Nova Scotia. The implementation of the recovery plan is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations. Therefore, some aspects of this recovery plan may not be implemented immediately, concurrently, or in their entirety.

Ram's-head lady slipper was designated as Endangered in Nova Scotia in 2007. This is the first provincial Recovery Plan prepared for this species.

Recovery plans are not designed to provide a comprehensive summary of the biology and status of Ram's-head lady slipper in Nova Scotia. For more information regarding Ram's-head lady slipper, consult the Nova Scotia Provincial Status Report on Ram's-head lady slipper (*Cypripedium arietinum* R. Br.).

Under the *Nova Scotia Endangered Species Act (2007)*, a Recovery Plan must be developed for species listed as Endangered or Threatened under the Act and include the following:

- Identification of the needs and threats to the species;
- The viable status needed for recovery;
- The options for recovery as well as the costs and benefits of those options;
- The recommended course of action or combination of actions to achieve recovery of the species;
- A schedule for implementation of the recovery plan including a prioritized list of recommended actions;
- Identification of habitat; and
- Identification of areas to be considered for designation as core habitat.

The goals, objectives, and actions identified in this Recovery Plan are based upon the best available information on the species and are subject to modifications and/or revisions as new information becomes available. Recovery of species at risk is a shared responsibility and the collaborative approach emphasized in this document is reflective of that.

ACKNOWLEDGEMENTS

This Recovery Plan was prepared by Alain Belliveau, Acadia University, in consultation with members of the Nova Scotia Plants Recovery Team and the Nova Scotia Department of Lands and Forestry. Additional input was provided by the following individuals and groups:

- Acadia University
- Atlantic Canada Conservation Data Centre
- E.C. Smith Herbarium
- Fundy Gypsum Company
- Harlow Institute
- Nova Scotia Museum of Natural History
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The Department would like to thank these individuals and/or organizations for their contributions to the recovery of species at risk in Nova Scotia.

EXECUTIVE SUMMARY

Ram's-head lady slipper is a small perennial orchid found in temperate eastern North America. In Nova Scotia, it typically grows in upland, calcareous, moderately open forest. The Nova Scotia population is known to have declined significantly in the past, and the species' most recent status assessment reported continued declines that are not sustainable in the long term and possibly in the short term. Its current population estimate is 3144 stems, based on over 90% survey coverage of known locations in 2019. Higher impact threats include gypsum mining, climate change and forestry, followed by agricultural activities and invasive species. Additional threats include residential and commercial development, road building, disturbance by all-terrain vehicle traffic, plant collecting, and possibly pollution. Our collective knowledge, even across its entire range, is still lacking. Based on most recent stem counts and estimated declines, a cautious short-term population recovery goal for Ram's-head lady slipper in Nova Scotia is to maintain current levels of stem counts at all known locations (i.e., no loss of stems or locations) over five years. A long-term goal that reflects the best achievable scenario given the recommendations in this report is a minimum of 5000 stems within 20 years. A number of recommended actions are provided in this report, and revolve largely around efforts to protect core habitat, mitigate threats, increase stakeholder awareness, and conduct more research to address knowledge gaps. Performance measures are provided for assessing progress in the future.

RECOVERY FEASIBILITY SUMMARY

The recovery of Ram's-head lady slipper in Nova Scotia is considered technically and biologically feasible if the following four criteria can be met:

1. Individuals of the wildlife species that are capable of reproduction are available now or in the foreseeable future to sustain the population or improve its abundance.

Yes. Ram's-head lady slipper is capable of asexual reproduction and is likely capable of sexual reproduction although the latter is not well understood in Nova Scotia. Viable seeds are produced by wild-growing specimens elsewhere in North America.

2. Sufficient suitable habitat is available to support the species or could be made available through habitat management or restoration.

Yes. However, gypsum mining and other types of habitat loss have undoubtedly reduced the amount of available suitable habitat, and there is uncertainty surrounding the restoration potential for these areas of lost habitat.

3. The primary threats to the species or its habitat (including threats outside Canada) can be avoided or mitigated.

Yes. All of the primary threats that are currently known, with the exception of climate change, could be avoided or mitigated.

4. Recovery techniques exist to achieve the population and distribution objectives or can be expected to be developed within a reasonable timeframe.

Yes. Some recovery techniques have been developed in other jurisdictions across Ram's-head lady slipper's distribution range.

The Recovery Team concludes that the recovery of Ram's-head lady slipper in Nova Scotia is technically and biologically feasible based on the criteria discussed above.

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1. NSSARWG ASSESSMENT SUMMARY*

Date of Assessment: August 2007

Common Name: Ram's-head lady slipper

Scientific Name: *Cypripedium arietinum* R. Br.

Status: Endangered

Reason for Designation: Ram's-head lady slipper has experienced an estimated 59% decline in Nova Scotia over approximately three generations, and likely other undocumented losses beyond this estimation, due largely to the impacts of gypsum mining. Recent habitat loss and decline in habitat quality has occurred at sites such as Poplar Grove, with further losses anticipated due to gypsum mine expansion. Actual and imminent primary threats include gypsum mine expansion, climate change and clear-cut forestry. Lesser threats include agricultural activities, invasive species, housing or other development, road building and other human intrusions and disturbance (e.g., trampling, collecting, all-terrain vehicle traffic). There is little potential for rescue effect from the nearest occurrences in Maine, which are situated over 300 km away. Only 1344+ "individuals" are known from Nova Scotia, with nearly all occurring in relatively specialized habitat conditions (i.e., gypsum karst) that are limited in the province.

Nova Scotia Occurrence: Cumberland County, Hants County.

Status History: Designated Endangered under NSESA in 2007 when first status report was written. Re-assessment by NSSARWG anticipated in 2020/2021.

* The following definitions are applicable in this section and elsewhere: NSSARWG (Nova Scotia Species at Risk Working Group); COSEWIC (Committee on the Status of Endangered Wildlife in Canada); NSESA (Nova Scotia Endangered Species Act); SARA (Species at Risk Act).

2. SPECIES STATUS INFORMATION

Ram's-head lady slipper is considered globally vulnerable (G3), vulnerable in the U.S. (N3) and vulnerable to apparently secure in Canada (N3/N4) (Table 1); it is not listed under Canada's Species At Risk Act (SARA) or by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Across its distribution in Canada it is designated as Vulnerable in Ontario and Quebec (S3), Vulnerable to Imperiled in Manitoba (S2/S3), Imperiled in Saskatchewan (S2) and Imperiled to Critically Imperiled in Nova Scotia (S1/S2) (NatureServe 2019).

Table 1. NatureServe conservation status ranks for Ram's-head lady slipper in Canada (NatureServe 2019)*.

Global (G) Rank ^a	National (N) Rank ^b	Subnational (S) Rank ^c
G3	N3N4	S2S3 – Manitoba S1S2 – Nova Scotia S3 – Ontario S3 – Québec S2 - Saskatchewan

^a G-Rank – Global Conservation Status Rank, G1 = Critically Imperiled; G2 = Imperiled; G3 = Vulnerable; G4 = Apparently Secure; G5 = Secure

^b N-Rank –National Conservation Status Rank, N1 = Critically Imperiled; N2 = Imperiled; N3 = Vulnerable; N4 = Apparently Secure; N5 = Secure

^c S-Rank – Sub-national (provincial or territorial) ranks, S1 = Critically Imperiled; S2 = Imperiled; S3 = Vulnerable; S4 = Apparently Secure; and S5 = Secure. B = breeding; and U = Unrankable.

*A full list of definitions can be found in Definitions of NatureServe Conservation Status Rankings at http://help.natureserve.org/biotics/Content/Record_Management/Element_Files/Element_Tracking/ETRACK_Definitions_of_Heritage_Conservation_Status_Ranks.htm

3. SPECIES INFORMATION

3.1 Species Description

Ram's-head lady slipper is a small, herbaceous, perennial orchid, producing short rhizomes with long, fibrous root systems. The above-ground parts of this species consist of solitary or clustered erect stems varying in height from 15 to 30 cm for floriferous plants and 5 to 15 cm for vegetative plants and bearing three to four (rarely five) narrowly ovate leaves. Flowers are solitary (rarely 2) and relatively small for the genus, with the sac-like lip petal of the flower white above and reticulated with purple to crimson (sometimes also with green) below. Flowers give off a slight fragrance reminiscent of vanilla. See the Nova Scotia Provincial Update Status Report (Nova Scotia Department of Lands and Forestry 2020a) for a more detailed description and references.

Although overall size of plants and all parts can vary considerably according to habitat, with those of wet soils usually much larger, the species is easily identifiable when in flower. Viewed from the side, the lip petal somewhat resembles the head of a ram, hence the species' scientific and common names. Vegetative plants can be confused with a number of species growing in similar habitats, particularly Yellow lady slipper (*Cypripedium parviflorum*) and Eastern helleborine (*Epipactis helleborine*), a species of Eurasian origin introduced in Nova Scotia. Although both of these species are uncommon to rare overall in Nova Scotia, both commonly co-occur with Nova Scotia populations of Ram's-head lady slipper. Both *Cypripedium* species flower in late May and June while Eastern helleborine flowers in July.

3.2 Population and Distribution

3.2.1 Global Range

Ram's-head lady slipper is native to east-central North America, where it is concentrated in the Great Lakes-Saint Lawrence region. Its range extends from Nova Scotia, Maine and southern Quebec to central Saskatchewan, south to New England, New York, Michigan, Wisconsin and Minnesota (Figure 1). The species reaches its southern limit near the Great Lakes from Wisconsin to Connecticut (approximate latitude 42°) and its northernmost limit in Saskatchewan and Manitoba (approximate latitude 53°). Occurrences are most concentrated in the areas surrounding Lake Huron and Lake Michigan. Many reported occurrences are historic or extirpated and the species is considered extirpated from the state of Connecticut (Dowhan 1979).

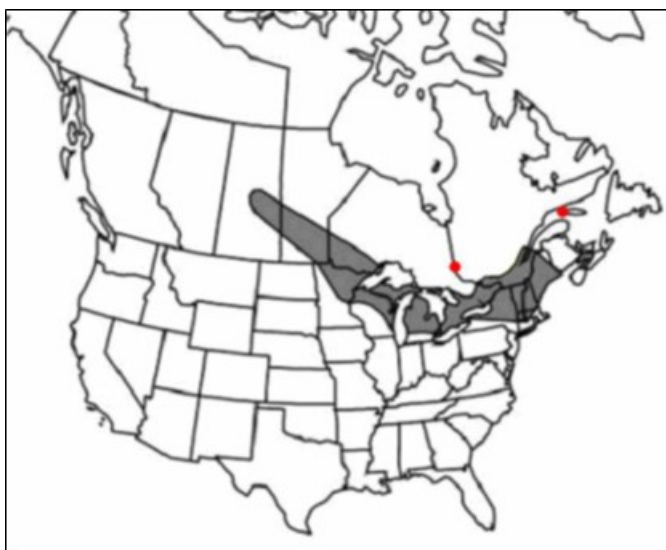


Figure 1. Global distribution of Ram's-head lady slipper, with small disjunct subpopulations represented by red circles (Sheviak 2003; modified in Blaney and Mazerolle 2007).

3.2.2 Canadian Range

In Canada, Ram's-head lady slipper occurs in east-central Saskatchewan, southern Manitoba, northwestern and southern Ontario, southern Quebec, north to the Clay Belt region adjacent along the border with northeastern Ontario and to Anticosti Island, and in central Nova Scotia (Figure 1). The great majority of Canadian occurrences are concentrated between southern Lake Huron and the St. Lawrence River in southern Ontario and southwestern Quebec. It has not been found in New Brunswick, although it occurs in Maine and Nova Scotia relatively close to New Brunswick's borders and it may yet be found.

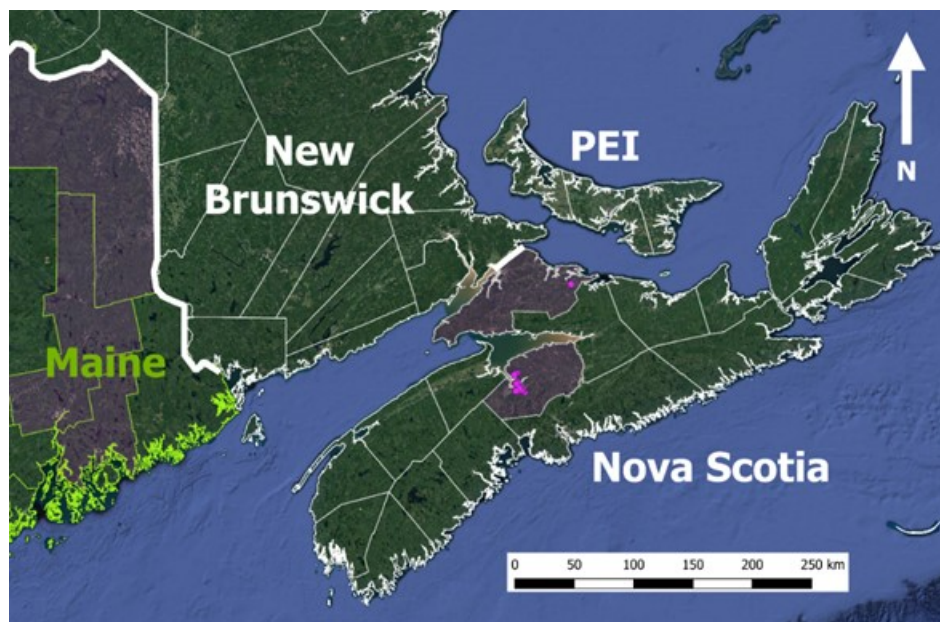


Figure 2. Distribution of Ram's-head lady slipper in Nova Scotia and Maine, showing Maritime province counties (white outlines), Maine counties (green outlines), counties with Ram's-head lady slipper occurrences (shaded pink), and occurrences in Nova Scotia (pink dots) (Nova Scotia Department of Lands and Forestry 2020a).

3.2.3 Nova Scotian Range

Ram's-head lady slipper is represented by eight subpopulations¹ in Nova Scotia, subdivided into 30 specific locations² (Figure 2; Table 2). All subpopulations have been observed since 2019 except the Gypsum Mines location which was last surveyed in 2008. Most of the province's occurrences are located in the Municipality of West Hants (Figure 2). The one current exception is the Angevine Lake population in northeastern Cumberland County. More information on the Nova Scotia population and sites are found in the Update Status Report (Nova Scotia Department of Lands and Forestry 2020a).

3.2.4 Population Size and Trends

Table 2 lists location data for Nova Scotia by subpopulation, with stem estimates for 2019 and net and percentage fluctuation indicating where plants have increased or declined. The 30 locations were delineated based on groups of occurrences that likely exchange genetic material within three generations, and on the geographic and possibly

¹ 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). Subpopulation size is measured as numbers of mature individuals only" (COSEWIC 2019).

² Locations are defined as "geographically or ecologically distinct area[s] in which a single threatening event can rapidly affect all individuals of the taxon present. The size of the location depends on the area covered by the threatening event and may include part of one or many subpopulations" (COSEWIC 2019).

temporal extant of the most serious plausible threats which in this case are gypsum mining and forestry (see Section 4, below).

Counts are of stems (flowering and infertile) rather than genetic individuals, clumps, or flowering stems. Given that mature plants do not flower annually (Bender 1989) and that individuals or clumps could likely only be determined accurately by disturbing plants significantly (i.e., exposing their roots), stem counts are a more accurate and suitable method of estimating number of mature individuals. The total confirmed population in Nova Scotia is a minimum of about 3,144 stems. This likely underestimates the actual numbers to some degree. In nearly all known subpopulations, plants are relatively widespread and very likely occur outside the areas thus far sampled and documented. Occurrences and locations can and will fluctuate (e.g., two locations merging into one, or one occurrence splitting into two or more) through time.

Table 2. Ram's-head lady slipper subpopulations and locations in Nova Scotia, showing 2019 stem estimates and population fluctuations between baseline data (2002-2012) and 2019. See Update Status Report for more detail (Nova Scotia Department of Lands and Forestry 2020a). Red cells represent a decrease in stems, and green an increase.

Subpopulation	Location	2019 Stems*	Fluctuation since previous count		Comment
			Net	%	
Angevine Lake (AL)	AL1-01	191	+57	+42%	Likely a legitimate increase.
Cogmagun River 1 (CR1)	CR1-01	90	increase	N/A	Increase due to new occurrences found.
	CR1-02	0	≤-75	-100%	May be due to occurrence record inaccuracy.
Cogmagun River 2 (CR2)	CR2-01	946	unknown	N/A	Stem counts before 2007 too vague for analysis.
	CR2-02	26	≤-24	≤-48%	Likely a legitimate decrease.
Gypsum Mines (GM1)	GM1-01	7	increase	N/A	Increase due to new occurrences found.
Meadow Pond (MP1)	MP1-01	595	+75 to -23	N/A	Spread of occurrences within location a challenge for determining newly discovered occurrences, and results in a challenging analysis.
Poplar Grove (PG1)	PG1-01	0	≤-40	-100%	Likely a legitimate decrease.
	PG1-02	6	-67	-92%	Likely a legitimate decrease.
	PG1-03	99	-36	-27%	Likely a legitimate decrease.
	PG1-04	104	increase	N/A	Increase due to new occurrences found.
	PG1-05	131	+24	+22%	Likely a legitimate increase.
	PG1-06	0	-26	-100%	Likely a legitimate decrease.
	PG1-07	?	unknown	N/A	No stem counts exist, difficult in locating occurrence due to location uncertainty distance.
	PG1-08	1	unknown	N/A	Only one stem count on record.
	PG1-09	22	+17	+440%	Likely a legitimate increase.
St. Croix River 1 (SC1)	SC1-01	0	≤-19	-100%	Likely a legitimate decrease.
	SC1-02	0	-40	-100%	Likely a legitimate decrease.
	SC1-03	0	-2	-100%	Likely a legitimate decrease.
	SC1-04	3	none	N/A	Two new stems estimated to be a new occurrence.

Subpopulation	Location	2019 Stems*	Fluctuation since previous count		Comment
			Net	%	
	SC1-05	48	-534	-92%	Likely a legitimate decrease.
	SC1-06	254	-127	-33%	Likely a legitimate decrease.
	SC1-07	0	-17	-100%	Likely a legitimate decrease.
	SC1-08	7	-2	-22%	Likely a legitimate decrease.
	SC1-09	47	-127	-73%	Likely a legitimate decrease.
	SC1-10	7	unknown	N/A	Only one stem count on record.
	SC1-11	?	unknown	N/A	No stem counts exist, difficult in locating occurrence due to location uncertainty distance.
	SC1-12	25	-103	-80%	Likely a legitimate decrease.
St. Croix River 2 (SC2)	SC2-01	535	-42	-7%	Likely a legitimate decrease.
	SC2-02	0	-79	-100%	Likely a legitimate decrease.
TOTAL		3144			

*For stem counts where 2019 data was available, it was primarily used. For the few locations where 2019 surveys did not occur, the most recent available older data was used.

Across the Nova Scotia population, stem numbers appear to be decreasing, with recent impacts on occupied habitats (see Section 4: *Threats*) appearing to have had effects on some locations while other locations have decreased for reasons that are less clear. Overall, 17 of the 30 known locations have decreased in number of stems and three locations have increased, while the remaining seven locations were neutral or lacked sufficient data for year-to-year comparison. Although stems will vary from year to year, this analysis used different years of data for the baseline stem counts which spanned the years 2002-2012. Because many different baseline years are used, the likelihood of 2019 simply being a year of increased dormancy – compared to the baseline year – becomes fairly low; therefore, there is a high likelihood that stem numbers have experienced a general decrease across this 8-18 year span.

When assessing the fluctuation of the 20 locations with measurable changes in stems, the overall negative trend becomes clear (Figure 3). Only three locations produced increases in stems, accounting for an apparent increase of 98 stems, while the 17 locations with stem decreases resulted in a possible loss of 1,357 stems.

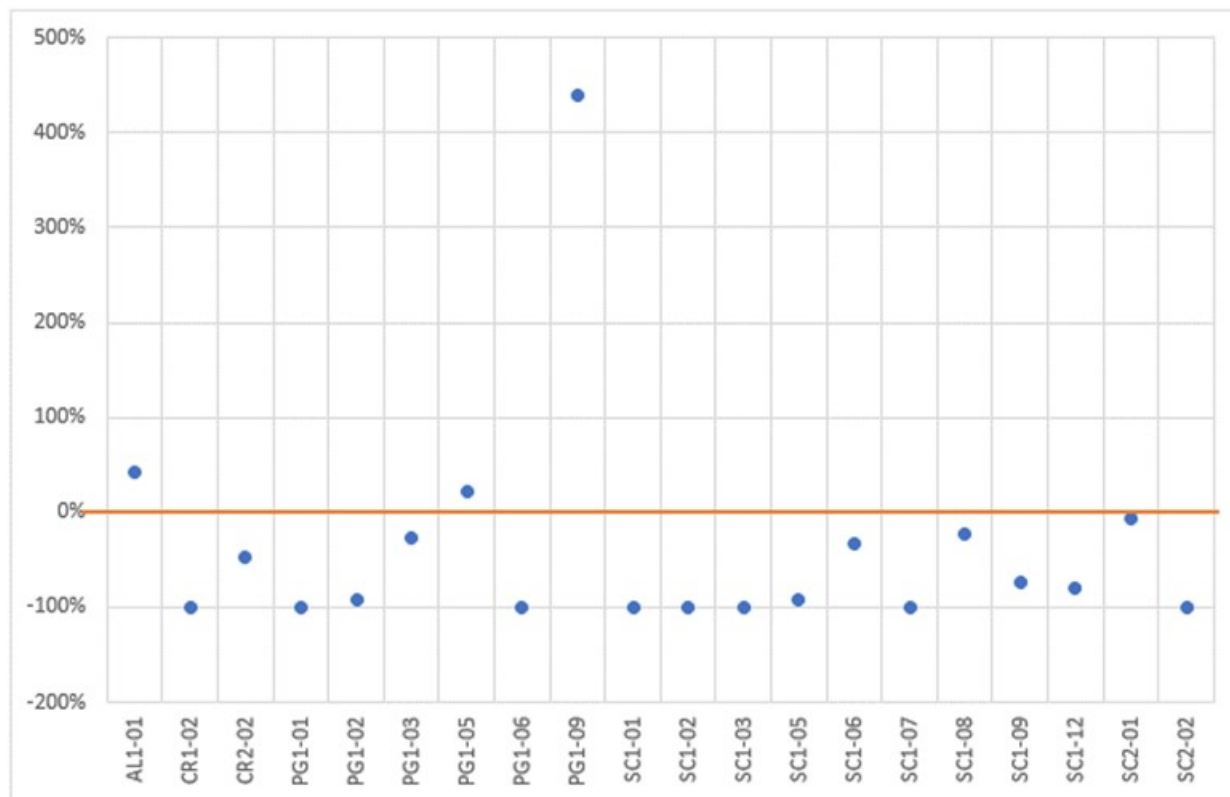


Figure 3. Approximate percentage of increase or decrease for Ram's-head lady slipper locations in Nova Scotia with at least two survey years.

3.3 Species Needs

3.3.1 Habitat Needs

Ram's-head lady slipper is generally found in areas possessing cool, sub-acid or neutral soils (Brackley 1985; Case 1987; Cribb 1997). Cool soils seem to play an important part in defining its range, as it is found in cold bogs or cool, north-facing bluffs in the southern part of its range (Penskar and Higman 1999; Brzeskiewicz 2000). Habitat preference varies considerably across Ram's-head lady slipper range, as do the species found in association. Three general habitat types have been identified:

- 1) Cool, dense cedar - balsam fir - spruce - tamarack swamps or more open fens with the same tree species (Case 1987; Brackley 1985; Sabourin et al. 1999; Brzeskiewicz 2000);
- 2) Nearly pure sand over limestone beach cobble or bedrock, mulched with the needles of coniferous trees such as pine, cedar or juniper (Case 1987; Brzeskiewicz 2000); and
- 3) Mesic soil of sandy loam, or clay under the partial shade of mixed hardwood/conifer forest (Brower 1977; Sabourin et al. 1999; Brzeskiewicz 2000), sometimes in thin soils

over limestone or gypsum bedrock (Whiting and Catling 1986; Roland and Smith 1969). This third type is the only habitat type where the species has been found in Nova Scotia.

A brief description of key habitat variables is provided below. More detail is available in the Update Status Report (Nova Scotia Department of Lands and Forestry 2020a).

Site

In Nova Scotia, this species is strongly associated with gypsum bedrock, and is found growing in moderately open, mesic woods on outcrops, shaded tops of cliffs, terraces, moderate to steep wooded slopes and in sinkholes (Erskine 1954; Pronych and Wilson 1993; AC CDC 2019). Many occurrences are along or near water bodies or open wetlands; however, it is not clear whether this is a direct habitat preference, or whether the species' preferred gypsum karst habitat simply occurs more frequently near water bodies and open wetlands given its propensity to erode quicker than other, adjacent bedrock types. It is also possible that proximity to open wet areas simply increases the likelihood of wind disturbances and more open forest cover habitat.

Soils

In Nova Scotia, occurrences of Ram's-head lady slipper are usually found in fine, moist mineral soil of a pH between 5.41 to 6.12, except for the Angevine Lake site which has coarser soils and a pH of 4.14 to 4.26. Two separate observations of Ram's-head lady slipper on previously bulldozed ground appear to demonstrate this species' ability to recolonize heavily disturbed soil given appropriate conditions otherwise.

Associated Vegetation

In Nova Scotia, Hemlock is the most frequent canopy-dominant tree species found at Ram's-head lady slipper sites, followed by Largetooth aspen, then by Red maple, Trembling aspen, and Balsam fir. Other tree species present, in order of observation frequency (most to least), include White spruce, White birch, White pine, Red oak, Sugar maple, Black spruce, White ash, and Beech. Openings in the forest canopy are important and appear to range in size from single-tree crown openings to openings spanning many tree crowns (Belliveau, pers. obs.). Forest age at these sites, based on estimated tree height, was classified as 40 to 109 years in 2019 (Nova Scotia Lands and Forestry 2019) and estimated shrub cover varied from 1% to 60%, with an average of 14.4%.

Disturbance

Forest cover composed of a mix of shade-tolerant and shade-intolerant tree species, the presence of moist fine soil, and more exposed sites in or near sinkholes, outcrops, and open areas, are all factors that suggest that wind disturbances may be enough to

sustain appropriate forest cover for Ram's-head lady slipper across the landscape and in the long term. Given the frequent presence of long-lived, shade-tolerant and fire-intolerant tree species in Ram's-head lady slipper sites, fire is less likely to play an important role in the persistence of this species, especially intense fires that may damage plant rhizomes. However, the effects of low intensity (non-stand replacing) burns that may not damage plant rhizomes are unknown.

3.3.2 Biological Needs and Ecological Role

Symbiosis

Ram's-head lady slipper inherently needs suitable mycorrhizal associates to grow, and in turn needs suitable soil and habitat conditions that promote the growth of those mycorrhizal associates. This is largely due to the very small size of seeds, which lack the food reserves (endosperm or embryo) needed to germinate independently. Worldwide, phylogenetic studies have revealed that while the majority of lady slipper orchids grow in association with mycorrhizal fungi within the fungal family Tulasnellaceae, they may also associate with Sebacinaceae, Ceratobasidiaceae, and the ascomycetous genus, *Phialophora* (Shefferson et al. 2005; Yuan et al. 2010); however, the specificity and ecology of Ram's-head lady slipper's fungal associations remain largely unknown and may be even more specific in disjunct sites like those in Nova Scotia.

Pollination

Ram's-head lady slipper flowers from late May to mid or late June and, according to research elsewhere in its distribution range, is likely pollinated by bees in the genera *Dialictus* (= *Lasioglossum*, family Halictidae) (Stoutamire 1967) and *Megachile* (family Megachilidae) (Van der Pijl and Dodson 1966; Keddy et al. 1983; Brackley 1985). Nine species of *Megachile* bees and 15 species of *Lasioglossum* subgenus *Dialictus* bees are known from Nova Scotia, with 18 genera that are active in early June and thus are potential pollinators (Sheffield et al. 2003).

3.3.3 Limiting Factors

Generation Time

Ram's-head lady slipper has an estimated 15-25 year generation time, with an estimated age of first reproduction of 10-16 years. Many other herbaceous vascular plant species – including many of those that share a similar habitat type with Ram's-head lady slipper – sexually reproduce within just a few years. The span of time for which a disturbance can curtail an occurrence's regeneration is relatively wide, meaning that Ram's-head lady slipper is relatively more sensitive to interruptions to its reproductive cycle compared to many other species.

Seed Dispersal and Vegetative Spread

Ram's-head lady slipper produces seeds in summer and dispersal begins in the fall, mostly starting in October and continuing through to spring and summer of the following year (Sabourin et al. 1999). Depending on snow depth, the seed capsules can remain exposed through much of the winter and early spring. Size, weight and ability to float for extended periods of time could allow for long-distance dispersal by wind or water. Animal-assisted dispersal is also a possibility (Sabourin et al. 1999). However, Brower (1977) and a study by Jersáková & Malinová (2007), suggest that orchid seeds are probably only dispersed in relative proximity to parent plants (less than 10 m) since the species usually occurs in densely vegetated habitats. It is unknown to what extent seed reproduction is occurring in Nova Scotia and seed viability and dispersal could be a limiting factor for the species. Vegetative spread is also not well understood but is strongly suspected of occurring where habitat conditions allow, suggesting that the species likely needs suitable habitat beyond its current location footprint.

Rescue Effect

Nova Scotia populations are peripheral and disjunct from the species' main range. The closest extant populations are in Maine over 330 km to the west. Considering what is presently known of Ram's-head lady slipper's dispersal potential, the possibility of interaction between Nova Scotia occurrences and out-of-province occurrences is very low. Furthermore, due to differences between preferred habitat types, it is unclear whether plants introduced from Maine populations would survive in Nova Scotia.

Climate

Ram's-head lady slipper's climatic tolerance is relatively narrow and most of Nova Scotia's subpopulations are closer to the species' overall southern limit. Average temperatures during the growing season in Nova Scotia appear to be well within other regional norms within the species' range, as are winter conditions. Sustained cold temperatures and other factors such as snow cover may be critical to the maintenance and reproduction of Ram's-head lady slipper. Within the species' overall range, the Nova Scotia climate is most similar to that of Connecticut, Ann Arbor, and Milwaukee, in the United States. Compared to the average of those locations, Nova Scotia's average January high and low are only 0.8 degrees Celsius and 1.3 degrees Celsius colder, respectively. The overall average high and low for January and February in those U.S. locations is 0.5 degrees Celsius and -8.3 degrees Celsius, respectively (compared to -0.9 and -10 in Nova Scotia) and could be considered the benchmark to monitor in the face of climate change.

4. THREATS

4.1 Threat Assessment

The Ram's-head lady slipper threat assessment (Table 3) is based on the IUCN-CMP (World Conservation Union–Conservation Measures Partnership) unified threats classification system (IUCN 2012) and supporting guidance for completing the threats classification and assessment calculator (British Columbia Ministry of Environment 2015). Threats are defined as the proximate activities or processes that have caused, are causing, or may cause in the future the destruction, degradation, and/or impairment of the entity being assessed (population, species, community, or ecosystem) in the area of interest (in this case, the province of Nova Scotia). Limiting factors are not considered during this assessment process. For purposes of the threat assessment, only present and future threats are considered. Historical threats, indirect or cumulative effects of the threats, or any other relevant information that would help understand the nature of the threats are presented in Section 4.2 *Description of Threats*.

Table 3. Threat calculator assessment.

Threat #	Threat description	Impact^a	Scope^b	Severity^c	Timing^d	Comments
1	Residential & commercial development	Low	Small	Serious	High	
1.1	Housing & urban areas	Low	Small	Serious	High	Significant increase in home building permits, but a low portion of suitable habitat is affected annually. Severity is serious because this threat likely affects tree cover and soil integrity, both of which are likely to negatively impact or destroy Ram's-head lady slipper.
1.2	Commercial & industrial areas	Negligible	Negligible	Serious	High	Golf course construction or expansion is unlikely, but its severity would be similar to 1.1.
1.3	Tourism & recreation areas					Not applicable.
2	Agriculture & aquaculture	High	Large	Serious	High	
2.1	Annual & perennial non-timber crops	Medium	Large	Moderate	High	High level of uncertainty in regards to actual impact on Ram's-head lady slipper pollination. Almost all locations within 1 km of agricultural lands where pesticide use may occur.
2.2	Wood & pulp plantations					Not applicable.
2.3	Livestock farming & ranching	Low	Small	Serious	Moderate	Horse grazing/trampling likely eliminated two occurrences of a total of 54 stems since 2008, although this event was unusual (feral horses) and unlikely to occur again. As such, severity is based more on typical horse or cattle grazing/trampling disturbances. Several locations may still be susceptible to grazing/trampling.
2.4	Marine & freshwater aquaculture					Not applicable.
3	Energy production & mining	Very High	Pervasive	Extreme	High	
3.1	Oil & gas drilling					Not applicable.
3.2	Mining & quarrying	Very High	Pervasive	Extreme	High	Dependent on market prices for gypsum; most occurrences underlain by exploitable gypsum that could become marketable in the next 10 years
3.3	Renewable energy					Not applicable.
4	Transportation & service corridors	Low	Small	Extreme	High	

Threat #	Threat description	Impact^a	Scope^b	Severity^c	Timing^d	Comments
4.1	Roads & railroads	Low	Small	Extreme	High	Highway twinning, and private land road building occurring and may continue to occur. At least one occurrence has likely been destroyed due to road building. Two occurrences are known to grow along the banks of very old roads/trails; however these have likely taken many decades to reach this habitat and at best represent a negligible amount of benefit.
4.2	Utility & service lines					Not applicable.
4.3	Shipping lanes					Not applicable.
4.4	Flight paths					Not applicable.
5	Biological resource use	High	Pervasive	Serious	High	
5.1	Hunting & collecting terrestrial animals					Not applicable.
5.2	Gathering terrestrial plants	Negligible	Negligible	Slight-Moderate	High	One instance of picking noted in 2019; occasionally reported elsewhere across North America.
5.3	Logging & wood harvesting	High	Pervasive	Serious	High	Clear-cutting most common cutting practice in area; most occurrences in areas with commercially viable upland forest. Clear-cutting reported as having negative impacts elsewhere across North America, with some evidence supporting this in Nova Scotia.
5.4	Fishing & harvesting aquatic resources					Not applicable.
6	Human intrusions & disturbance	Low	Restricted	Slight	High	
6.1	Recreational activities	Low	Restricted	Slight	High	Planned hiking and mountain biking trails for Meadow Pond site.
6.2	War, civil unrest, & military exercises					Not applicable.
6.3	Work & other activities					Not applicable.
7	Natural system modifications					
7.1	Fire & fire suppression					Not applicable.
7.2	Dams & water management/use					Not applicable.
7.3	Other ecosystem modifications					Not applicable.
8	Invasive & other problematic species & genes	Medium	Large	Moderate	High	

Threat #	Threat description	Impact ^a	Scope ^b	Severity ^c	Timing ^d	Comments
8.1	Invasive non-native/alien species	Medium	Large	Moderate	High	In 2019, 31.8% of RHLS locations had invasive non-native species present, averaging 8.8% percent cover per location. Blue sedge, perhaps the most threatening invasive species, known from Nova Scotia since 1946 therefore spread may be relatively slow and more prominent in anthropogenically disturbed sites. The latter sites' main threat may be more appropriately assigned to large disturbances such as mining, forestry, road building, etc. Therefore, severity for 8.1 is moderate and may act more as a compounding threat in some cases.
8.2	Problematic native species					Not applicable.
8.3	Introduced genetic material					Not applicable.
9	Pollution	Unknown	Pervasive	Unknown	High	
9.1	Household sewage & urban wastewater					Not applicable.
9.2	Industrial & military effluents					Not applicable.
9.3	Agricultural & forestry effluents					Not applicable.
9.4	Garbage & solid waste					Not applicable.
9.5	Air-borne pollutants	Unknown	Pervasive	Unknown	High	High level of uncertainty. Although research for many other species at risk (e.g., lichens, salmon) describes profound impacts from air-borne pollutants, knowledge on impacts to Ram's-head lady slipper or other lady slippers not well known.
9.6	Excess energy					Not applicable.
10	Geological events					
10.1	Volcanoes					Not applicable.
10.2	Earthquakes/tsunamis					Not applicable.
10.3	Avalanches/landslides					Not applicable.
11	Climate change & severe weather	Very High	Pervasive	Extreme	High	
11.1	Habitat shifting & alteration	Very High	Pervasive	Extreme	High	Based on current trend towards irreversibility. Climate of Nova Scotia

Threat #	Threat description	Impact ^a	Scope ^b	Severity ^c	Timing ^d	Comments
						population near or above average minimum temperature for January/February of southernmost sites in the U.S.
11.2	Droughts					Not applicable.
11.3	Temperature extremes					Not applicable.
11.4	Storms & flooding					Not applicable.
12	Other Threats					

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

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

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

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

4.2 Description of Threats

The most significant threats to Ram's-head lady slipper in Nova Scotia include gypsum mining, climate change, and forestry, followed by agricultural activities and invasive species. Other threats include residential and commercial development, road building, disturbance by all-terrain vehicle traffic, plant collecting, and possibly pollution. The overall threat impact for the species is Very High. The overall threat impact considers the cumulative impacts of multiple threats. A description of each threat is provided below, in order of decreasing level of concern.

Energy Production & Mining – Mining & Quarrying (Very High)

Gypsum mining typically removes all topsoil and vascular plants from a site and results in the disappearance of most or all vascular plant species, followed by a very slow re-establishment of only the most ruderal species (Belliveau, pers. obs. 2014-2019).

In Nova Scotia, gypsum mining is a major threat for which a reasonable estimate of impacts on Ram's-head lady slipper can be made. Because of both the proximity of known sites to gypsum mines and the similarity of presently occupied habitat to habitats that would have been removed by gypsum mining, it is reasonable to assume that Ram's-head lady slipper plants have been lost to gypsum mining within the 45-75 year time frame relevant for this trend assessment. The Meadow Pond occurrence is immediately adjacent to the large, active gypsum quarry at Wentworth Creek and to a former quarry that became Meadow Pond (Blaney and Mazerolle 2007). The Poplar Grove site occurs within 800 m of the Millers Creek gypsum quarry, and within an area containing several smaller, inactive quarries. These sites are largely (Poplar Grove) or entirely (Meadow Pond) owned by gypsum mining companies. Losses of Ram's-head lady slipper at these quarries are unknown because early population data is lacking, but we can estimate losses based on density of plants occurring at each adjacent site in 2007 (15.41 stems / ha at the Meadow Pond site and 1.55 stems / ha at the Poplar Grove site) extrapolated over current quarry areas (351 ha at Wentworth Creek and 392 ha at Millers Creek) (Blaney and Mazerolle 2007). If we assume that 30% and 50% of quarry land was formerly suitable forested habitat at Wentworth Creek and Millers Creek respectively (based on forest cover in the surrounding area), this translates to an estimated loss of 1623 stems at Wentworth Creek and 304 stems at Poplar Grove and would represent a loss of 59% of the provincial population assuming stable populations at all other sites. Another gypsum quarry at MacKay Section, begun in 1943 (Adams 1993) and closed in 1997, could have also eliminated some plants, although plants were never known from the immediate area.

Fundy Gypsum Company, the largest and most recently active gypsum extracting company in the area, was permanently closed in November 2011 (CBC News 2011), due to challenging market conditions (Thompson 2011). However, its Chicago-based parent company, United States Gypsum Corporation (USG), maintains that it is holding

on to their properties in hopes of an upturn in the market for gypsum and wallboard (Thompson 2012). The gypsum product manufacturing price index has been steadily increasing since USG closed in 2011 (Federal Reserve Bank of St. Louis 2019). Because of the inherent economic complexity and market unpredictability, gypsum mining justifiably remains a significant threat.

Climate Change & Severe Weather – Habitat Shifting & Alteration (Very High)

Changes in average climate conditions can affect plant germination, growth, viable seed production, physical soil attributes (e.g., frost heaving, ice scouring), biological soil attributes (e.g., composition and extent of microbial and fungal activity), various stages of insect (pollinator) development, timing of senescence, forest disturbance regimes, and the abundance and composition of associated species. Current climate models predict a minimum of 0.6° C increase on a global scale over this century, plus further warming from additional greenhouse emissions from 2017 onwards (Hayhoe et al. 2017). In Nova Scotia, temperatures are expected to rise, and severe weather events are expected to become more frequent (DeRomilly and deRomilly Ltd. et al. 2005; Lemmen et al. 2008).

The impacts of climate change are contextual and depend considerably on the sensitivity of Ram's-head lady slipper (Hayhoe et al. 2017; Cowles et al. 2018). Due to the complexity of biological systems and a lack of more accurate information for Ram's-head lady slipper's specific needs as they relate to climate, the specific impact or future impact of climate change are largely unknown at present but likely to be generally negative.

Biological Resource Use – Logging & Wood Harvesting (High)

Effects of forestry on abundance and distribution of Ram's-head lady slipper vary with harvesting techniques and intensity. Non-intensive selective harvesting could be beneficial for Ram's-head lady slipper or at least neutral in the longer term given that some Nova Scotia occurrences are in very young forest and occurrences are wide ranging and frequently occur in moderately open-canopy forests. However, modern-clear cutting using heavy equipment has been widely identified elsewhere as a threat to Ram's-head lady slipper habitat and populations (Ostlie 1990; Sabourin et al. 1999; Brzeskiewicz 2000; Fleming 2000). Element occurrence records across the species' range indicate a requirement for at least partial canopy cover (Brzeskiewicz 2000) and the removal of forest cover can subject populations to intolerable conditions such as light intensity and increased competition, modified soil moisture, and temperature fluctuations. Soil disturbance from heavy machinery may destroy or hinder the growth of Ram's-head lady slipper. In addition, the removal of significant amount of current and future deadwood may negatively affect soil dynamics essential to Ram's-head lady slipper germination and growth cycles.

Ram's-head lady slipper habitat is sometimes somewhat protected from modern clear-cutting because the abundance of sinkholes and other karst topography features limits heavy equipment access. Since 1984, forest cutting has, however, occurred at all sites (between or within 200 m of known occurrences) except for Meadow Pond and Gypsum Mines (Gorelick et al. 2017). Most of this forestry activity was by means of clear-cutting. Although this cutting did not impact known Ram's-head lady slipper populations, given that no pre-harvest Ram's-head lady slipper surveys occurred, it could have reduced or eliminated unrecorded populations. Forests not cut since 1984 are often young, suggesting that pre-1984 cutting was frequent (Nova Scotia Department of Natural Resources 2016). This level of cutting suggests that any Ram's-head lady slipper plants on private land are reasonably likely to be subjected to some level of forestry activity over the short to medium term. In 2019, habitat notes suggested that Ram's-head lady slipper does not grow in open conditions similar to those produced by clear-cutting, and several occurrences were not detected where clear-cutting had recently occurred.

Agriculture & Aquaculture – Annual & perennial non-timber crops (Medium)

Worldwide, insect biodiversity including pollinators have and continue to decline (Sánchez-Bayo and Wyckhuys 2019). Although the main driver is habitat loss, agro-chemical pollutants also play an important role (Sánchez-Bayo and Wyckhuys 2019). A study near Ram's-head lady slipper populations in Wisconsin (within 250 km at least) found that sweat bees (*Lasioglossum* spp.) and bumble bees (*Bombus* spp.) were less abundant in orchards that had high toxicity scores due to pesticide use (Mallinger et al. 2015). The effect of pesticide use on potential Ram's-head lady slipper pollinator species suggests agro-chemicals may be a threat; however, more information is needed on pollinator species and their ecology, as well as pesticide use in or near Ram's-head lady slipper sites in Nova Scotia. All locations are within 1 km of agricultural lands, except for the Angevine Lake site which is almost 1.5 km from the nearest agricultural lands.

Invasive & Other Problematic Species, Genes & Diseases – Invasive Non-Native/Alien Species/Diseases (Medium)

The exotic Blue Sedge, *Carex flacca*, is extremely abundant in some forested areas supporting Ram's-head lady slipper at the Meadow Pond and St. Croix IBP sites (Belliveau, pers. obs.) and locally at the Poplar Grove site (Ruth Newell, pers. comm. 2019). Blue Sedge is native to the Mediterranean region and is known to occur primarily in calcareous habitat in its native range (Missouri Botanical Garden 2019). Although sparse in North America, it appears to be "increasing" (Ball et al. 2003) and is also recognized as forming "solid, dense monocultures of tangled roots that displace native plants" (University of Georgia – Center for Invasive Species and Ecosystem Health 2019). This species was observed in 28 of 80 Ram's-head lady slipper locations and ranged from 1% to 50% cover, with an average cover of 8.8% (see Update Status Report; Nova Scotia Department of Lands and Forestry 2020a). Given its extent and

dense cover in some locations, this species is most likely competing with and possibly outcompeting Ram's-head lady slipper. Blue Sedge's growing season matches that of Ram's-head lady slipper, and although its leaves turn straw-coloured during and after the growing season, they remain wide and continue to cover adjacent plants. An exotic *Lonicera* sp., *Tussilago farfara*, and *Poa nemoralis* were also observed, each at one location and not representing more than 5% cover. Other known invasive alien plant species, including *Frangula alnus*, *Ramnus cathartica*, and *Hieracium lachenalii*, occur in several of the sites, but have not been recorded within close proximity to Ram's-head lady slipper.

A field report from the Massachusetts National Heritage Program (1999) also indicates that slug predation had inhibited flowering and seed production in certain individuals. The most common slugs at many sites in the northeast are exotic species (i.e. Ferguson 2004, Davis 1990), meaning levels of slug herbivory may now be beyond historic levels. Slug populations seem extremely high in some humid forests near the Bay of Fundy, to the point of defoliating a significant portion of forest plants in the lily family (i.e. Cape Split, Sean Blaney, pers. comm. 2019). There is some potential that slug predation could be a limiting factor in Nova Scotia.

Field observations indicate that Ram's-head lady slipper plants that are subjected to herbivory by insects or mammals frequently do not appear above ground the following year (Bender 1989). Browsing could be significant in areas with high white-tailed deer numbers, as has been noted for numerous other rare forest plants (reviewed in Russell et al. 2001). White-tailed deer are considered invasive for the purpose of this plan because this species has only been present in Nova Scotia since the early 20th century. All subpopulations of Ram's-head lady slipper are in deer management zones which allow deer hunting. Field observations of deer, tracks, scat piles, and browsed vegetation appeared to suggest high numbers in the Municipality of West Hants subpopulations (Belliveau, pers. obs.).

Residential & Commercial Development – Housing & Urban Areas (Low)

Approximately 48% of all property parcels with Ram's-head lady slipper are residential or woodlot, and potentially available for development. However, most sites in western Hants County are either too far from existing roads, isolated by gypsum cliffs, laden with sinkholes, or owned by gypsum mining companies. The Angevine Lake site is on provincial crown land along the lake and is unavailable for cottage development. However, rural housing development in western Hants County could affect unknown populations. New residential building permits in rural Hants County continue to be issued at increasing rates and the Halifax Regional Municipality continues to grow rapidly and expand into adjacent counties. Because none of the currently known Ram's-head lady slipper sites are likely to be developed for residential housing due to the relative inaccessibility of locations, therefore this threat is deemed low.

Agriculture & Aquaculture – Livestock Farming & Ranching (Low)

Cattle and horse grazing and trampling have impacted the extent of the species' occurrence at the St. Croix IBP site. Cattle graze in the vicinity of the Poplar Grove site but appear to remain on trails in the area (Ruth Newell, pers. comm. 2019). Cattle grazing does not appear to be a current threat at any of the other known sites. Horse grazing and/or trampling appears to have impacted two previously known occurrences (54 stems, representing ~1.8% of total provincial population as of 2019), which could not be detected in 2019. Between 2014 and 2019, approximately five hectares of forested habitat adjacent to existing fields have been cleared (Gorelick et al. 2017) and, based on satellite imagery, some of this recently cleared area now appears to be pasture.

Transportation & Service Corridors – Roads & Railroads (Low)

Road-building can destroy or alter habitat, change water-flow patterns, increase pollution, introduce exotic species, modify site temperature and humidity, increase human access and lead to further indirect negative impacts such as an increase in natural resource harvesting (Forman et al. 2003). Ram's-head lady slipper's need for some forest cover, soils with some organic matter, and the fact that no Ram's-head lady slipper occurrence in Nova Scotia is located on or along a road, all suggest that new roads effectively destroy suitable habitat and possibly as-of-yet undiscovered locations for the species. Since 1984, three sites have experienced habitat loss due to road-building projects. Notably, Highway 101 was twinned through an area with active sinkholes (Belliveau pers. obs.) along the Meadow Pond site in the late 2000s (Gorelick et al. 2017) and further west but still within 1 km of Ram's-head lady slipper during the writing of this report. Also, the St. Croix River IBP Site has a total of approximately 3 km of new or expanded road surface since 2007 (Gorelick et al. 2017). At least one segment of the latter road network was constructed in an area with exposed gypsum and somewhat pronounced sinkholes (Belliveau pers. obs.).

Human Intrusions & Disturbance – Recreational Activities (Low)

People regularly hike next to at least one Ram's-head lady slipper occurrence (Meadow Pond); however, no trampling has been recorded to date (Belliveau pers. obs.). Recreational trails for both hiking and mountain biking are planned for the 50 hectares of Meadow Pond, now partly owned by the Municipality of the District of West Hants. The municipality and contracted trail developers have been working with Ram's-head lady slipper experts to avoid damage or risk of damage to Ram's-head lady slipper and its habitat. ATV trails are present in some subpopulations, but there have been no reports of damage to Ram's-head lady slipper.

Residential & Commercial Development – Commercial & industrial areas (Negligible)

Other large developments near known sites, such as the construction of the Coyote Hill golf course at Newport Corner have not affected known populations but could have affected undiscovered populations.

Biological Resource Use – Gathering Terrestrial Plants (Negligible)

Picking orchids deprives them of their ability to photosynthesize, produce and store energy, and may force plants into dormancy for a growing season or longer. It also eliminates a source of seeds and genetics. Collection of individuals for transplanting can completely remove individuals (including roots and rhizomes) from their habitat, effectively eliminating them from that occurrence or location. Transplants are usually unsuccessful. Other jurisdictions have noted “over-collection by orchid enthusiasts and poachers” as a potential threat (Penskar and Higman 1999). The propagation of Ram's-head lady slipper is now feasible (The Ridges Sanctuary 2015), and this may increase the likelihood of plant or seed collection based on horticultural interest. One occurrence of Ram's-head lady slipper picking in Nova Scotia was noted by the author in 2019.

Pollution – Air-Borne Pollutants (Unknown)

Acid rain can alter nutrient availability, change microbial biogeochemical activity in the soil (Bååth et al. 1979; Pennanen et al. 1998; Killham et al. 2018) and produce beneficial or adverse effects depending on site and soil attributes (Johnson et al. 1982). Sites with neutral soils may benefit from increased nitrogen availability, although the subsequent promotion of vegetation growth and increased vegetation cover may still produce negative consequences considering Ram's-head lady slipper's preference for moderately open sites. pH levels in studies of Ram's-head lady slipper elsewhere and in Nova Scotia average at or near 6.0 to 6.8 (Cribb 1997; Sabourin et al. 1999; Nova Scotia Department of Lands and Forestry 2020a), though it is difficult to determine possible impacts on plant health, germination, vegetative reproduction success, mycorrhizal fungal health, and other factors. Based on changes in plant communities (Belliveau pers. obs.), soils become more acidic further away from core gypsum-influenced soils (i.e., typically where gypsum is exposed) and a transition from near-neutral to moderately acidic soil occurs at all sites in Nova Scotia. As a result of acid rain and the potential shrinking of peripheral areas with marginally suitable soil conditions, it is possible that soils with suitable conditions for Ram's-head lady slipper are less abundant today than in the past.

4.3 Knowledge Gaps

Current Extent and Population Trends

Given Ram's-head lady slipper's ability to remain dormant for a year or longer, its inherently fluctuating population numbers require many years of consistent data collection to properly assess population trends. Before the writing of the Update Status

Report (Nova Scotia Department of Lands and Forestry 2020a), only one somewhat thorough census (Blaney and Mazerolle 2007), and single occurrence monitoring by a local naturalist (Bernard Forsythe, pers. comm. 2019) had occurred. Further, more occurrences continue to be found (AC CDC 2019; Belliveau pers. obs.) suggesting that additional occurrences have yet to be documented.

Seed Viability and Propagation

The maintenance of Nova Scotia's Ram's-head lady slipper population depends on its ability to produce viable seeds and propagate vegetatively. Although vegetative spread of specimens has been documented in Nova Scotia, seed viability and dispersal are not well understood. Further research, coupled with genetic studies, will enlighten core habitat mapping, and likely allow researchers to bank seeds and plant material, and develop the capacity to propagate this species *ex situ* in case of *in situ* population collapse. *Ex situ* conservation efforts are especially important for species populations that are small and isolated (IUCN/SSC 2014). Given reports of lost sites in other jurisdictions, and the threats outlined in this recovery plan, Ram's-head lady slipper appears to be a suitable species for *ex situ* conservation efforts.

Population Genetics

Nova Scotia populations of Ram's-head lady slipper are unique in representing the eastern limit of the species' range and are over 330 km disjunct from the closest occurrence in Maine. Isolation by natural or anthropogenic fragmentation can have significant structural, ecological and genetic impacts on populations. Through local adaptation, the effects of isolation, genetic drift and natural selection can produce genetic and morphological divergence in peripheral populations (Lesica and Allendorf 1995; Garcia-Ramos and Kirkpatrick 1997). Acting as repositories for intraspecific diversity, these populations can have evolutionary and ecological significance that is disproportionately large relative to their numbers or proportion of overall range (Mayr 1982; Lesica and Allendorf 1995; Fraser 2000). The genetic distinctness of Nova Scotia Ram's-head lady slipper populations or intrapopulation occurrences is unknown but should be investigated. From a monitoring point of view, boundary conditions and marginal populations can be more informative in determining species declines (Guo et al. 2005).

Mycorrhizal Associations

Ram's-head lady slipper requires suitable mycorrhizal associates to grow, and in turn needs suitable soil and habitat conditions that promote the growth of mycorrhizal associates. Little is known about the fungal species responsible for promoting the growth of Ram's-head lady slipper across its range, and to date no research has occurred in Nova Scotia. Understanding the species, their ecology, their relationship

with Ram's-head lady slipper and other species on-site, will shed light on the specific conditions needed for the persistence and recovery of Ram's-head Lady slipper.

Pollination

Based on studies elsewhere, Ram's-head lady slipper pollination is likely accomplished by smaller bees, but few details are known including specific species, their ecology, their abundance and population trends, and factors limiting their ability to pollinate Ram's-head lady slipper.

Habitat Modeling

Mapping current and potential habitat for Ram's-head lady slipper leads to improved management, recovery, and botanical surveys. Geospatial analysis using Geographic Information Systems (GIS) provides a framework for projecting and analyzing Ram's-head lady slipper occurrences and habitat. Although some spatial layers already assist in defining preferred and potential habitat, further analysis and modeling using LiDAR and research data from recovery plan actions will provide much greater insight.

Soil Metrics and Suitability

Although studies of Ram's-head lady slipper elsewhere have suggested a preference for specific soil conditions (Cribb 1997; Sabourin et al. 1999), without data specific to Nova Scotia sites, it is difficult to determine possible impacts on plant health, germination, vegetative reproduction success, mycorrhizal fungal health, and other factors. The study of metrics like pH and nutrient availability from pure gypsum (or other bedrock types for Angevine Lake), from habitat where Ram's-head lady slipper grows, and from transitional soils between the preferred habitat and more acidic soils, will elucidate habitat preferences and shed light on suitable recovery actions, potential habitat outside of known sites, and compliment other research topics such as mycorrhizal associations.

Invasive Alien Species and Problematic Native Species Impact

Limited information is available to determine whether the presence of invasive alien species impacts the Ram's-head lady slipper, but the density of some of the exotic sedge patches is such that impacts are possible. Other shrub and herbaceous species, plant-browsing species like White-tailed Deer and slugs, also pose a threat that is not well understood. Given the weedy nature of some subpopulation sites, the cumulative impact of competition and herbivory from introduced taxa may be locally significant. Further study is required to properly assess this threat and produce useful information for species recovery and management.

Impacts of Low-impact Forestry

Element occurrence records across the species' range indicate a requirement for at least partial canopy cover (Brzeskiewicz 2000) and removal of forest cover can subject populations to intolerable conditions as light intensity and competition increase, soil moisture is modified and temperature fluctuations become more pronounced. However, at least one forest thinning study suggests that low-impact forestry activities may not result in negative impacts to populations (Bender 1989). Light selective harvesting could sometimes be beneficial or at least neutral in the longer term given that some Nova Scotia occurrences are in young forest and occurrences range-wide are frequently in relatively open-canopy forests. More research is required.

5. POPULATION AND DISTRIBUTION OBJECTIVES

5.1 Viable Status for Recovery

Recognizing that in Atlantic Canada this species is only located in Nova Scotia, and recognizing the significant loss of occupied habitat that has likely occurred in this province, and the on-going threats still impacting this species, the long-term recovery goal (>20 years) for Ram's-head lady slipper in Nova Scotia is to maintain and promote conditions that allow for self-sustaining and ecologically functioning populations within the province. A population and distribution objective that reflects the best achievable scenario (e.g., reversing the negative trend by taking all possible actions and using the best available information including current and future research) is a minimum of 5000 stems within 20 years.

5.2 Short-term population and distribution objective

The short-term population and distribution objective for Ram's-head lady slipper is to maintain current levels of stem counts at all known locations (i.e., no loss of stems or locations) over five years.

5.3 Rationale

Population and distribution objectives assist with the identification of activities needed for recovery, and for Ram's-head lady slipper are based on the best information in this document as well as the most recent Update Status Report (Nova Scotia Department of Lands and Forestry 2020a). In 2019, over 90% of Nova Scotia locations were surveyed by the author and colleagues, and combined with previous surveys for the remaining locations, offer the most accurate population assessment to date of 3144 stems. Occurrences or locations can fluctuate by as much as 440% or -100% across 8 to 18 years; however, an average decline of at least 1.55% per year since 2002 across all subpopulations warrants the establishment of a targeted minimum population size threshold.

The short-term population and distribution objective of maintaining current stem count levels at all known locations (i.e., no loss of stems or locations) over five years is a composite approach that considers both changes in number of individuals and changes in distribution as possible elements of decline, and allows room for some landscape-wide natural fluctuation. An additional and more specific goal is to ensure that not more than 50% of monitored locations experience a reduction of 50% or more of stems between any two years of monitoring. Given the current rate of decline, two consecutive years of recording fewer stems should prompt investigation and implementation of actions from and beyond the scope of this document. These goals are based on available information on population size and trends (see Section 3.2.4 *Population Size and Trends*) as well as historic and recent habitat trends.

The long-term goal of increasing the population to a minimum of 5,000 stems within 20 years, and maintaining and promoting conditions that allow for self-sustaining and ecologically functioning populations within the province, may require *ex situ* conservation efforts (e.g., outplanting) and restoration of currently unsuitable habitat. However, significant research is required to address knowledge gaps in these areas, before the best course of action can be determined for the species. A number of recommended actions to address this are included Table 4, and Section 6.3.5 *Research to Address Knowledge Gaps*.

6. BROAD STRATEGIES AND GENERAL APPROACHES TO RECOVERY

6.1 Actions Completed or Underway

- Ram's-head lady slipper is of substantial interest to the small community of botanists in Nova Scotia, and there have been many botanists' outings to known sites, as well as some informal effort to find additional sites.
- Targeted fieldwork for Ram's-head lady slipper has been conducted as follows:
 - 2 days by the AC CDC in the Oxford area in 2004.
 - 6 days on behalf of Fundy Gypsum around the Meadow Pond, Poplar Grove and St. Croix River sites in 2006.
 - 3 days surveying calcium-rich-dependent species within close range of Ram's-head lady slipper sites by the AC CDC in 2014 and 2015.
 - 11 days by the author and a team of naturalist students and volunteers in 2019 for the provincial Update Status Report.

- Monitoring data indicating potential population fluctuation or decline has been recorded at one portion of the Meadow Pond site (north of Highway 14) in four different years between 1998 and 2003, and in 2019.
- A provincial Status Report was prepared for Ram's-head lady slipper in 2007, and an Update Status Report was prepared in 2019 (currently under review).
- Ram's-head lady slipper was assessed by the Nova Scotia Species at Risk Working Group and listed as Endangered under Nova Scotia's *Endangered Species Act* in 2007.
- An 8.5-hectare portion of one privately owned parcel at the St. Croix River site received a conservation easement from the Nova Scotia Nature Trust in 2007 and is referred to as the Myrta Stewart Conservation Lands (Nova Scotia Nature Trust 2019).
- Test drilling sites on Fundy Gypsum lands at Poplar Grove were pre-screened for above-ground presence of Ram's-head lady slipper prior to 2007.
- The Nature Conservancy of Canada (NCC) developed a Conservation Plan in 2011 which prioritized sites in three key areas for land securement, including Ram's-head lady slipper habitat at Angevine Lake near Wallace River; see *Conservation Planning for Species at Risk and their Habitats in Nova Scotia* (NCC 2012).
- The NCC is also developing a Central Nova Natural Areas Conservation Plan (near completion) which prioritizes several properties for land securement in the calcareous gypsum region of the Avon River, including some sites which have Ram's-head lady slipper occurrences or potential habitat.
- A 52-hectare portion of the Meadow Pond site was purchased by the Municipality of the District of West Hants (2019) from a private owner (U.S.G. Canadian Mining Limited) in 2017. The acquisition was primarily made to protect the pond as a public fishing hole; however, the municipality has also expressed interest in protecting conservation values such as Ram's-head lady slipper.
- In 2012, 2014 and 2015, the Atlantic Canada Conservation Data Centre conducted extensive biodiversity surveys in Nova Scotia's gypsum- and limestone-associated habitats. Mainly funded through the Nova Scotia Crown Share Land Legacy Trust, these fieldwork efforts collectively involved the detailed survey of over 90 karst sites throughout the geographic range of Nova Scotia's gypsum occurrences, from western Hants County to northern Cape Breton. Although these surveys covered vast amounts of potential Ram's-head lady slipper habitat, only two new occurrences were uncovered.

6.2 Options for Recovery

The following table (Table 4) summarizes recovery actions and specific steps recommended to address threats and achieve successful recovery of Ram's-head lady slipper in Nova Scotia, along with their priority and approximate costs.

Table 4. Recovery options planning table.

Broad Strategy / Approach	Threats Addressed*	Specific Actions	Priority**	Cost***
Habitat Protection, Management and Stewardship				
Protect Ram's-head lady slipper habitat, especially land with or near known occurrences.	All	<ul style="list-style-type: none"> Support the development of a collaborative land protection strategy. Prioritize land protection according to proximity to occurrences, parcel size, presence of suitable habitat and other factors. Define and designate core habitat under the <i>Nova Scotia Endangered Species Act</i>. Incentivize the protection of private land. 	High	\$\$\$\$
Develop the capacity to preserve local genetic material for Ram's-head lady slipper and to propagate this species successfully.	All	<ul style="list-style-type: none"> Collect and preserve Ram's-head lady slipper seeds and material in order to achieve long-term viability. Consider experimental outplanting of specimens or manual dispersal of seeds in areas of population decline. 	High	\$
Identify, mitigate and prevent the illegal collection of Ram's-head lady slipper and trampling of habitat.	5.2	<ul style="list-style-type: none"> Ensure regulations prohibiting the collection of this species and destruction of its habitat are posted and easily accessible. Promote awareness of the regulations through the media, social media and online. Identify and map or list locations where recreational values and Ram's-head lady slipper overlap. Develop mitigation options (e.g., diversion of trails), propose changes to landowners, and assist with mitigation efforts in high-conflict areas. Consider the prohibition of new trails in the core habitat area. 	Medium	\$

Surveys and Monitoring				
Conduct ongoing monitoring of known Ram's-head lady slipper occurrences.	1.1, 3.2, 4.1, 5.2	<ul style="list-style-type: none"> Develop a monitoring plan with standardized survey approaches and timelines. Conduct ongoing monitoring of known occurrences of Ram's-head lady slipper and gather baseline data to assess population dynamics. Record and monitor changes in site and habitat parameters and the impacts of threats. Analyze results to model habitat suitability and refine core habitat polygons. 	High	\$
Conduct surveys of potential sites to identify possible new occurrences.	1.1, 3.2, 4.1, 5.2	<ul style="list-style-type: none"> Conduct botanical surveys of high-potential sites where Ram's-head lady slipper may occur but has not been documented. 	Medium	\$
Communication, Outreach and Education				
Provide information to stakeholders about the presence and status of Ram's-head lady slipper on public and private land.	1.1, 2.3, 3.2, 4.1, 5.3	<ul style="list-style-type: none"> Develop factsheets / handouts summarizing information about Ram's-head lady slipper, the impacts of various threats on lady slipper populations, and impact mitigation options. Distribute handouts to stakeholders in relevant sectors including real estate and residential property owners, agriculture, mining, road construction and forestry. Attach informative statement and relevant contact information to transactional processes such as property deeds and permit applications. 	High	\$
Communicate the risks of developing over gypsum bedrock with real estate firms, developers, and provincial and municipal governments.		<ul style="list-style-type: none"> Provide a list of gypsum-related incidents of loss of or injury to human life or damage to property and infrastructure to stakeholders. Consider restrictions on development in these areas. 	Medium	\$
Enhance communication and collaboration among relevant government and non-government organizations.		<ul style="list-style-type: none"> Define responsibilities and communication pathways between provincial, municipal, and non-governmental organizations responsible for the management of land on which core habitat occurs. 	Medium	\$
Encourage all citizens, organizations and governments to use less, reduce their environmental footprint and support efforts to combat climate change.	All	<ul style="list-style-type: none"> Communicate the importance to Ram's-head lady slipper and other Species at Risk of using less, reducing one's environmental footprint and fighting climate change, through educational material, guided walks, media articles, etc. 	Low	\$

		<ul style="list-style-type: none"> Encourage citizens, non-governmental organizations and governments at all levels to support increased efforts to combat climate change. 		
Law, Policy and Enforcement				
Incorporate Ram's-head lady slipper in road construction planning within the core habitat area.	4.1	<ul style="list-style-type: none"> Ensure that government processes related to roadbuilding include a mechanism to flag the presence of this species and before road building occurs. 	High	\$
Establish a mandatory pre-harvest survey protocol within core habitat area and in suitable habitat in vicinity of core habitat area.	5.3	<ul style="list-style-type: none"> Request all landowners within core habitat areas notify the Department of Lands and Forestry prior to any harvesting activities. Implement permitting scheme that triggers a site survey for Ram's-head lady slipper. Use GIS layers / predictive modelling and expert advice to locate and identify high potential sites outside of core habitat. 	High	\$\$
Support the development and implementation of strategies to prevent and manage introductions of invasive alien species.	8.1	<ul style="list-style-type: none"> Communicate the importance to Ram's-head lady slipper and other Species at Risk of preventing, responding to, and managing invasive species. Support the development and implementation of regulatory programs aimed at preventing and managing invasive species. Report invasive alien species data and findings from Ram's-head lady slipper sites to government departments responsible for the management of these species. 	Medium	\$
Support the implementation of legislative measures (e.g., Clean Air Act) that mitigate the amount of air-borne pollutants in Nova Scotia.	9.5	<ul style="list-style-type: none"> Communicate the importance to Ram's-head lady slipper and other Species at Risk of legislative measures that mitigate the amount of air-borne pollutants with government departments implicated in air pollution decision-making processes. 	Low	\$
Research to Address Knowledge Gaps				
Conduct research on Ram's-head lady slipper biology and ecology.	All	<ul style="list-style-type: none"> Conduct research on Ram's-head lady slipper population and reproductive biology including pollinator surveys. Determine genetic relationships between subpopulations. Provide support for experimental germination and/or tissue culture trials in order to refine techniques for 	Medium	\$\$

		<p>the propagation of this species from Nova Scotia material.</p> <ul style="list-style-type: none"> Conduct novel and complimentary research on associated species and their ecology as it relates to the recovery of Ram's-head lady slipper. 		
Conduct research on Ram's-head lady slipper habitat parameters.	1, 1.1	<ul style="list-style-type: none"> Conduct detailed studies on Ram's-head lady slipper site and site changes including soil properties within the core habitat area, and the impacts of acid rain. 	Medium	\$\$
Investigate the impacts of invasive alien species on Ram's-head lady slipper in core habitat areas.	8.1	<ul style="list-style-type: none"> Conduct detailed multi-year surveys on the distribution and abundance of invasive alien species to assess their threat more accurately. Based on the findings of detailed surveys and on expert advice, develop an invasive alien species management strategy for Ram's-head lady slipper. 	Medium	\$\$
Conduct research on the potential for restoration and outplanting on currently unoccupied lands.		<ul style="list-style-type: none"> Search for and consult with landowners interested in restoring lands that could support Ram's-head lady slipper. Conduct experimental outplantings based on the best available knowledge of Ram's-head lady slipper biology and ecology. 	Low	\$\$
Compile forest management experimentation data to assess management options for Ram's-head lady slipper in Nova Scotia.	5.3	<ul style="list-style-type: none"> Gather and assess information about forest management options that may benefit this species and its core habitat in Nova Scotia. Consider implementing appropriate forest management if, when and where deemed necessary (link to Habitat Protection, Management and Stewardship, above). 	Low	\$

*Threat or Limitation should refer to the IUCN Threat Classification Table Rankings. Either the first level or second level threat ranking can be used depending on how the Broad Strategy affects the threat. Multiple threats can be addressed under a single Broad Strategy.

**Priority should be classified as High, Medium, or Low. "Priority" is a qualitative measure of the relative degree to which an approach will have a positive impact on the recovery objective. High priority conservation approaches are considered those most likely to have an immediate and/or direct influence on reaching the management objective for the species. Medium priority conservation approaches may have a less immediate or less direct influence on reaching the management objective but are still considered important measures to implement. Low priority conservation approaches will likely have an indirect or gradual influence on reaching the management objective and are more tied to increasing knowledge or public perception/education.

***Cost categories: \$ = < 10 000; \$\$ = 10 000-50 000; \$\$\$ = 50 000-100 000; \$\$\$\$=>100 000

6.3 Narrative to Support the Recovery Options Planning Table

6.3.1 Habitat Protection, Management and Stewardship

Protection of habitat is a key element in the recovery of Ram's-head lady slipper populations and the most effective way to mitigate the impacts of multiple threats, particularly those associated with land use and industry. There is a need to prioritize land protection for Ram's-head lady slipper and incentivize protection on private land. Although habitat protection can be costly (e.g., cost of land acquisition; lost revenue from limiting land use and resource-based activities), some level of protection is necessary to meet the population and distribution objectives above. Recommended activities include the development of a land protection strategy to help identify priority areas for protection based on conservation goals, and designation of core habitat under the NSESA on both public and private lands. Incentivization of private land protection where possible would also benefit the species and help achieve recovery objectives.

Conservation and management of genetic material is another important component of the recovery plan for Ram's-head lady slipper. The maintenance of Nova Scotia's population depends on its ability to produce viable seeds and propagate vegetatively. Although vegetative spread of specimens has been documented in Nova Scotia, seed viability and seed dispersal are not well understood. Coupled with further research (see below), it will be important to preserve genetic material and develop the capacity to propagate this species *ex situ* in case of *in situ* population collapse. Recommended activities include support for the collection and storage of seeds, viability studies and consideration of outplanting under specific circumstances.

Targeted stewardship activities will complement land protection and genetic conservation as described above. While regulations already exist to prohibit the collection of Ram's-head lady slipper and destruction of its habitat under the NSESA, there is a lack of awareness and enforcement. Education and stewardship activities to discourage collecting and minimize human disturbance in high-conflict areas would mitigate this risk to the species. Recommended activities include clarifying and raising awareness of existing regulations that prohibit collection of the species and destruction of habitat, identification of high-risk areas where recreational values and Ram's-head lady slipper co-occur, development of mitigation options (e.g., trail diversion, prohibition of new trails in core habitat).

6.3.2 Surveys and Monitoring

It is critical to continue monitoring and inventorying populations and habitat of Ram's-head lady slipper. Its ability to remain dormant for a year or longer and its inherently fluctuating population numbers require many years of consistent data collection to properly assess population trends. In addition to ongoing monitoring of known occurrences, it will be important to gather optimum baseline data in order to assess population dynamics and the impacts of threats. Recommended activities include

development of a standardized monitoring plan for ongoing monitoring of known occurrences including population dynamics, habitat parameters and threats. Data should be analyzed and reviewed periodically to model habitat suitability and continue to refine our understanding of core habitat over time.

In addition to monitoring known populations, it is important to continue to survey for new occurrences. Although the level of search effort for Ram's-head lady slipper has been sufficient to determine that it's very rare in the province, there are many areas of potentially suitable habitat that have not been comprehensively surveyed for the species. In addition, its cryptic nature and preference for forested areas can make it difficult to find. It is recommended that botanical surveys of new potential sites be conducted based on GIS analysis and botanical expert input.

6.3.3 Communication, Outreach and Education

Communication, outreach and education are essential to the recovery of Ram's-head lady slipper in Nova Scotia, and complementary to other broad recovery strategies. Only by raising awareness among landowners, users and managers will it be possible to implement management practices that will benefit the species. Approximately 92% of known occurrences are currently on private land, split roughly evenly between industrial (gypsum mining) and non-industrial uses, with the remaining 8% on public land. Communication with the general public, with industry and among government departments are therefore all important and interconnected. Communication with landowners and managers may also result in new information about occurrences, current and past land uses, threats, and population changes. Recommended actions include the development and distribution of information and factsheets to relevant sectors (e.g., real estate agriculture, mining, road construction, and forestry) and stakeholders (e.g., private property owners, industry associations, municipal and provincial governments), informing developers and other stakeholders about the risks of developing over gypsum bedrock, improving communication and coordination among responsible government departments, and promoting awareness with the general public about the impacts of habitat destruction and climate change.

6.3.4 Law, Policy and Enforcement

Habitat loss is a significant concern for Ram's-head lady slipper and its small populations and restricted distribution make it particularly vulnerable to the impacts of disturbances. While land protection and stewardship, along with improved communication and outreach will all contribute to the species' recovery there are opportunities to develop complementary regulatory processes and policies that will enhance the species' protection. Recommended actions include consideration of mandatory surveys and data reporting prior to road building and forestry activities, inclusion of Ram's-head lady slipper in permitting schemes, and modelling to identify high potential sites outside of core habitat. In addition, it is recommended that the

Department and Recovery Team support the development and implementation of legislative measures and regulatory programs aimed at managing invasive species and mitigating the effects of airborne pollution.

6.3.5 Research to Address Knowledge Gaps

Research is an important tool for developing a better understanding of Ram's-head lady slipper biology and ecology, as well as habitat changes and the impacts of various threats. The species is at the eastern limit of its range in Nova Scotia and not much is known about its life history, genetics, population dynamics or relation to fungal associations and various pollinators. Another area of uncertainty centers around habitat preferences including site parameters and soil types, nutrient profiles, possible adaptation to gaps in the canopy and its affinity for areas of sinkholes and gypsum, as well as the potential for habitat restoration. Research in a number of areas will be necessary to inform recovery of the species and prioritize the most effective approaches over time. Recommended actions involve supporting research on Ram's-head lady slipper biology, ecology, genetics, propagation techniques and habitat parameters, as well as associated species (e.g., fungal associates, pollinators), the impacts of invasive species and different forest management regimes, and the potential for restoration of potentially suitable habitat in previously degraded areas.

7. RECOMMENDED COURSE OF ACTION(S) FOR RECOVERY

All actions identified above are considered to be priority items, however the Nova Scotia Plants Recovery Team has identified a number of high priorities for the recovery of Ram's-head lady slipper over the next 5 years, including:

- Protection of core habitat on both public and private land, along with conservation planning, exploring the potential for land acquisition and incentivizing protection of private land;
- Regular monitoring and surveys to improve our knowledge of the species' distribution and population dynamics;
- Communication and outreach activities to raise awareness among landowners and the general public;
- Coordination of internal government programs and policies to support increased protection; and
- Support of relevant research to address priority knowledge gaps.

Specific recovery actions along with an implementation schedule are provided in Table 5. Note that recovery of species at risk is a shared responsibility and not all the actions in the table below will be carried out by the Department. Implementation will depend to a large degree on opportunities for collaboration with other individuals and organizations, and will be subject to budget constraints, appropriations, and changing priorities.

Table 5. Recovery actions and implementation schedule.

Broad Strategy: Habitat Protection, Management and Stewardship		Implementation Schedule
Approach 1.1: Protect Ram's-head lady slipper habitat, especially land with or near known occurrences.		
Action 1.1.1	Support the development of a collaborative land protection strategy with private land trusts, local naturalist organizations, provincial and municipal governments, industrial landowners, and small private landowners.	2020-2022 (already underway)
Action 1.1.2	Prioritize land protection based on known occurrences, parcel size, presence of suitable but unoccupied habitat, ownership type, and other factors typically employed in conservation strategy efforts.	2020-2022
Action 1.1.3	Define and designate core habitat under the <i>Nova Scotia Endangered Species Act</i> .	2020-2021
Action 1.1.4	Investigate options for incentivizing the protection of private land with tax breaks, the allocation of total-amount or matching funds for land purchases for conservation purposes, and other means that encourage the protection of land.	2021-2025
Approach 1.2: Develop the capacity to preserve local genetic material for Ram's-head lady slipper and to propagate this species successfully.		
Action 1.2.1	Provide support for the Acadia Seed Bank for the collection and storage of Ram's-head lady slipper seeds and genetic material in order to achieve long-term viability.	2020-2025
Action 1.2.2	Consider experimental outplanting of specimens or manual dispersal of seeds in areas where Ram's-head lady slipper is no longer present, or where an occurrence is experiencing dramatic declines, or other suitable sites and circumstances.	2021-2025
Approach 1.3: Identify, mitigate and prevent the illegal collection of Ram's-head lady slipper and trampling of habitat.		
Action 1.3.1	Ensure regulations prohibiting the collection of this species and destruction of its habitat are posted and easily accessible on the provincial Department of Lands and Forestry website non-governmental Species at Risk websites.	2020-2021
Action 1.3.2	Promote awareness of the regulations through the media, social media and online, and encourage this information to become a top-ranking result for commonly used search engines.	2021-2025
Action 1.3.3	Identify and map or list locations where recreational values and Ram's-head lady slipper occurrences overlap and where interactions between people and Ram's-head lady slipper have occurred or can be expected to occur.	2021-2023
Action 1.3.4	Develop mitigation options (e.g., diversion of trails), propose changes to landowners, and assist with mitigation efforts in high-conflict areas.	2023-2025
Action 1.3.5	Consider the prohibition of new trails in the core habitat area.	2023-2025
Broad Strategy: Surveys and Monitoring		Implementation Schedule
Approach 2.1: Conduct ongoing monitoring of known Ram's-head lady slipper occurrences.		
Action 2.1.1	Develop a monitoring plan with standardized survey approaches and timelines.	2020 (already underway)
Action 2.1.2	Conduct detailed ongoing monitoring of known occurrences of Ram's-head lady slipper and gather baseline data to assess population dynamics.	2020-2025
Action 2.1.3	Record and monitor changes in site and habitat parameters and the impacts of threats, including land use and invasive species.	2020-2025

Action 2.1.4	Analyze results in GIS using LiDAR, bedrock geology, surficial geology, forest composition, Ram's-head lady slipper monitoring data, and other datasets to model habitat suitability and refine core habitat polygons.	2023-2025
Approach 2.2 Conduct surveys of potential sites to identify possible new occurrences.		
Action 2.2.1	Conduct botanical surveys of high-potential sites where the species may occur but has not been documented, based on GIS analysis (as above) and botanical expert input.	2023-2025
Broad Strategy: Communication, Outreach and Education		Implementation Schedule
Approach 3.1 Provide information to stakeholders about the presence and status of Ram's-head lady slipper on public and private land.		
Action 3.1.1	Develop factsheets / handouts summarizing information about Ram's-head lady slipper, the impacts of various threats on populations, and mitigation options; include sector-specific information such as known and potential impacts of pesticide use on agricultural lands, the impacts of roads, and the importance of avoiding clear-cut forestry, as well as impact mitigation options.	2020-2021
Action 3.1.2	Distribute handouts to stakeholders in relevant sectors including: <ul style="list-style-type: none"> Real estate: developers, residential property owners, municipal governments. Agriculture: landowners and users, industry organizations, provincial Department of Agriculture. Mining: mining companies (active or inactive), industry organizations. Road construction: provincial Department of Transportation and Infrastructure Renewal, landowners, and other organizations that assist with road building projects (e.g., provincial departments, Forest Nova Scotia, etc.). Forestry: private woodlot owners, forestry companies, industry organizations, provincial Department of Lands and Forestry. 	2021-2023
Action 3.1.3	Attach informative statement and relevant contact information to transactional processes such as: <ul style="list-style-type: none"> property deeds property queries or other land documents available online municipal building permit application process permitting schemes for all habitat-altering activities assessed by the provincial government (e.g., mining, road building, forestry) 	2023-2025
Approach 3.2: Communicate the risks of developing over gypsum bedrock with real estate firms, developers, and provincial and municipal governments.		
Action 3.2.1	Provide a list of gypsum-related incidents in Nova Scotia to stakeholders, including loss of or injury to human life or damage to property and infrastructure, e.g., Falmouth in 2017 (CTV Atlantic 2018), Oxford in 2018 (Cole 2018).	2021-2022
Action 3.2.2	Consider implementing restrictions on development in higher-risk areas such as gypsum bedrock.	2023-2025
Approach 3.3: Enhance communication and collaboration among relevant government and non-government organizations.		
Action 3.3.1	Define responsibilities and communication pathways between provincial, municipal, and non-governmental organizations responsible for the management of land on which Ram's-head lady slipper core habitat occurs.	2021-2023
Broad Strategy: Law, Policy and Enforcement		Implementation Schedule
Approach 4.1: Incorporate Ram's-head lady slipper in road construction planning within the core habitat area.		

Action 4.1.1	Ensure that government processes related to road construction include a mechanism to flag the presence of this species and prompt further investigation (e.g., survey for presence of species, potential impact of road construction, etc.) before road building occurs.	2021-2023
Approach 4.2: Establish mandatory pre-harvest survey protocol within core habitat area and in suitable habitat in vicinity of core habitat area.		
Action 4.2.1	Request all landowners within core habitat areas notify the Department of Lands and Forestry prior to any harvesting activities.	2021-2023
Action 4.2.2	Implement permitting scheme that triggers a site survey for Ram's-head lady slipper (related to core habitat designation).	2021-2023
Action 4.2.3	Use GIS layers / predictive modelling and expert advice to locate and identify high potential sites outside of core habitat.	2023-2025
Approach 4.3: Support the development and implementation of strategies to prevent and manage introductions of new invasive alien species.		
Action 4.3.1	Communicate the importance to Ram's-head lady slipper and other Species at Risk of preventing, responding to, and managing invasive species.	2021-2023
Action 4.3.2	Support the development and implementation of regulatory programs aimed at preventing and managing invasive species.	2020-2025
Action 4.3.3	Report invasive species data and findings from Ram's-head lady slipper sites to government departments responsible for the management of these species.	2020-2025
Broad Strategy: Research to Address Knowledge Gaps		Implementation Schedule
Approach 5.1: Conduct research on Ram's-head lady slipper biology and ecology.		
Action 5.1.1	Support research on Ram's-head lady slipper biology (e.g., life history, recruitment, population dynamics).	2020-2025
Action 5.1.2	Support research on Ram's-head lady slipper genetics (e.g., relationships to other populations, and among subpopulations in Nova Scotia).	2020-2025
Action 5.1.3	Support research on experimental germination and/or tissue culture trials in order to refine techniques for the propagation of this species from Nova Scotia material.	2020-2025
Action 5.1.4	Support complimentary research on associated species, including but not limited to fungal associates and pollinators, and their ecology as it relates to the recovery of Ram's-head lady slipper.	2020-2025
Approach 5.2: Conduct research on Ram's-head lady slipper habitat parameters.		
Action 5.2.1	Investigate site parameters and site changes including soil properties within the core area and impacts of acid rain.	2023-2025
Approach 5.3: Investigate the impacts of invasive alien species on Ram's-head lady slipper in core habitat areas.		
Action 5.3.1	Conduct detailed multi-year surveys on the distribution and abundance of invasive species to assess their threat more accurately.	2020-2025
Action 5.3.2	Based on the findings of detailed surveys and on expert advice, develop an invasive species management strategy complete with a budget, action items, a timeline, monitoring schedule, and follow-up reporting to suggest next steps.	2022-2025
Action 5.4: Conduct research on the potential for restoration and outplanting on currently unoccupied lands.		
Action 5.4.1	Search for and consult with landowners interested in restoring lands that could support of Ram's-head lady slipper.	2021-2023
Action 5.4.2	Conduct experimental outplantings based on the best available knowledge of Ram's-head lady slipper biology and ecology.	2023-2025
Approach 5.5: Compile forest management experimentation data to assess management options for Ram's-head lady slipper in Nova Scotia.		
Action 5.5.1	Work collaboratively with organizations throughout Ram's-head lady slipper's distribution range (e.g., The Ridges Sanctuary, WI) to gather and	2020-2025

	assess data on management options that may benefit Ram's-head lady slipper and its core habitat in Nova Scotia.	
Action 5.5.2	Consider implementing appropriate forest management if, when and where deemed necessary (link to Habitat Protection, Management and Stewardship, above).	2020-2025

8. IDENTIFICATION OF CORE HABITAT

8.1 Core Habitat Definition and Attributes

The Nova Scotia Endangered Species Act defines core habitat as “specific areas of habitat essential for the long-term survival and recovery of endangered or threatened species”. A definition for Ram's-head lady slipper core habitat is included here using the best available information at the time of writing; however, given the knowledge gaps and anticipated increases in our collective knowledge of this species' needs in Nova Scotia, this definition should be updated as soon as new information is available.

Based on known and inferred needs, core habitat for Ram's-head lady slipper is defined as all known occurrences with a locational uncertainty of 50 m or less, as of the Nova Scotia Provincial Update Status Report (Nova Scotia Department of Lands and Forestry 2020a), along with a buffer of forested areas (as determined by LNDCLASS=99 in the NSLDF Forest Inventory (Nova Scotia Department of Lands and Forestry 2020b) within 1500 m of each occurrence. The 1500 m buffer is included to account for undocumented occurrences of Ram's-head lady slipper and to provide transitory allowance for plant movement beyond the current distribution of known occurrences. The size of the buffer was determined based on more recent newly discovered occurrences and their distance relative to the nearest known occurrence at that time (see Table 6). From a pragmatic standpoint, suitable habitat (i.e., forested areas) are used to delineate core habitat within the buffer areas and should be the focus for most direct recovery efforts; however, currently unsuitable habitat (i.e., non-forested) should still be considered for outreach efforts, habitat restoration initiatives, and other peripheral or long-term activities. It should also be noted that the delineation of core habitat on the ground should be considered dynamic rather than static; as factors such as location of known occurrences can be expected to change over time, mapping will need to be updated accordingly. Information critical to revising and updating core habitat may include complete LiDAR coverage for Nova Scotia, long term population and site monitoring data, and efforts to discover undocumented occurrences. Core habitat may be amended if new populations are discovered.

Table 6. List of more recent newly discovered occurrences of Ram's-head Lady Slipper in Nova Scotia, and their distance from the nearest occurrence known at that the time of discovery.

Location	Year Found	Distance to Nearest Occurrence at the Time (m)
PG1-8	2008	1200
SC2-1	2008	1000
SC1-12	2009	1500

CR1-1	2014	1500
SC1-10	2015	1000

In summary, core habitat for Ram's-head lady slipper can be identified based on the following criteria (maps included in Appendix 1):

- Known occurrences (i.e., all known occurrences with locational uncertainty of 50 m or less, as of the Nova Scotia Provincial Update Status Report; Nova Scotia Department of Lands and Forestry 2020a)
- 1500 m buffer around each occurrence point
- Buffer overlaid with forest cover layer from the NSLDF Forest Inventory (Nova Scotia Department of Lands and Forestry 2020b) (i.e., buffer included only where forest cover occurs)

Although Ram's-head lady slipper is strongly associated with Windsor group geology in Nova Scotia, it was decided not to include this in the current core habitat criteria as available mapping layers may not be as accurate as needed to inform on-the-ground decisions. The Windsor group geology information is an essential piece in identifying potential Ram's-head lady slipper occurrences, but it is only part of the larger, complex landscape of the species.

8.2 Activities Likely to Result in the Destruction of Core Habitat

Destruction of Ram's-head lady slipper core habitat would result if part of the habitat was degraded, either permanently or temporarily, such that it would not serve its function when needed by the species. Destruction may result from single or multiple activities at one point in time or from the cumulative effects of one or more activities over time and must be determined on a case by case basis.

Activities likely to result in destruction might occur within the core habitat but might also occur outside of the core habitat. Activities that are likely to result in the destruction of Ram's-head lady slipper core habitat include but are not limited to:

- Mining and quarry activities that remove or disturb soil and/or reduce forest cover;
- Forestry activities such as logging and wood harvesting that disturb soil, reduce forest cover, and/or alter tree, shrub and ground strata composition and structure, especially if involving heavy equipment, and if conducted on unfrozen ground;
- Conversion of habitat to agricultural cultivation;
- Conversion of habitat to residential, commercial or institutional infrastructure;
- Road construction and expansion;
- Introduction of invasive non-native / alien species that outcompete Ram's-head lady slipper or reduce habitat availability or quality;
- Use of fertilizers and pesticides that reduce habitat quality (e.g., by altering tree, shrub and ground strata composition and structure); and

- Any other activities that destroy plants or affect soil through compression, covering, inversion, or excavation/extraction (e.g., recreational activities, plant collecting, etc.).

8.3 Habitat Protection / Ownership

The approximate area of parcels that have or likely have Ram's-head lady slipper in Nova Scotia is 1547 hectares. Of that, 130 hectares (8.4%) are publicly-owned and the remaining 1417 hectares (91.6%) are privately-owned (Figure 4). Of the publicly-owned parcels, 79 hectares are owned by the provincial Department of Lands and Forestry, 50 hectares are owned by the Municipality of the District of West Hants (2019), and one hectare is an old road or right of way likely owned by the provincial Department of Transportation and Infrastructure Renewal. For privately-owned land, 749 hectares are non-industrial (including but not limited to residential and woodlot properties) while 668 hectares are owned by gypsum mining companies.

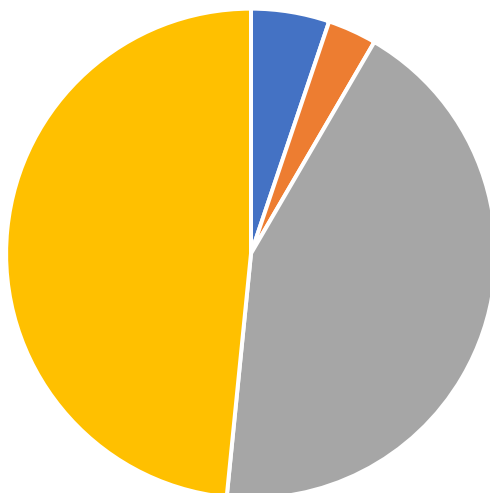


Figure 4. Pie chart showing proportions of privately-owned non-industry land (orange), privately-owned industry land (gray), provincially-owned land (blue), and municipally-owned land (red), for property parcels with or likely with Ram's-head lady slipper in Nova Scotia as of February 2019.

Existing protected areas include an 8.5-hectare portion of one privately-owned parcel called the Myrta Stewart Conservation Lands that received a conservation easement from the Nova Scotia Nature Trust in 2007 (Nova Scotia Nature Trust 2019) and 50 hectares of the Meadow Pond site acquired by the Municipality of the District of West Hants in 2017 that is used as a public park with a focus on the pond's sport fishery (Municipality of the District of West Hants 2019). The Myrta Stewart Conservation Lands are located within the St. Croix River 1 subpopulation and include approximately 25 individual plants as of 2019, while the municipal park includes at least half of the Meadow Pond subpopulation's 595 individual plants as of 2006 when the last survey occurred.

9. MEASURING PROGRESS

9.1 Performance Indicators

The performance indicators identified below are a means by which progress towards population and distribution objectives for Ram's-head lady slipper can be measured.

Table 7. Performance measures used to determine whether Ram's-head lady slipper recovery objectives are being met.

Performance Measure	Check-In
Planning:	
Number of Recovery Team meetings to discuss recovery activities and assess performance to date (minimum one per year)	Annually
Number of initiatives and groups involved in delivering conservation messaging	Annually
Number of individuals or teams assigned to, or supported to implement, recovery-related projects such as land protection efforts, GIS mapping, the production of educational material, research on seed viability and propagation, forest management experiments, etc.	Annually
Conservation:	
Number and type of communication products produced and distributed that target general public, miners, foresters, government and others identified in the recovery actions table	Annually
Improved coordination and implementation of governmental permitting or approval processes that can address a threat to this species and effective communication with appropriate staff	Annually
Increased percentage of core habitat protected	Every five years
Known occurrences and population of Ram's-head lady slipper maintained	Every five years
Number of new Ram's-head lady slipper records or documented effort to survey for new occurrences	Every five years
Increased percentage of knowledge gaps addressed by published research	Every five years
Successful <i>ex situ</i> propagation of Ram's-head lady slipper from Nova Scotia material	Every five years

9.2 Monitoring

The Ram's-head lady slipper monitoring plan is aimed at providing consistent data over time to assess population dynamics, habitat parameters and threats in Nova Scotia. Known locations will be monitoring annually, with the remainder of known locations being monitored every 3-5 years on a rotating basis. Success of this monitoring plan will

be reviewed and adjusted as needed and as management actions change. Refer to Appendix 2 for more information.

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Appendix 1: Maps of proposed core habitat for Ram's-head lady slipper in Nova Scotia



Figure 5. Map showing location of core habitat areas in Nova Scotia.

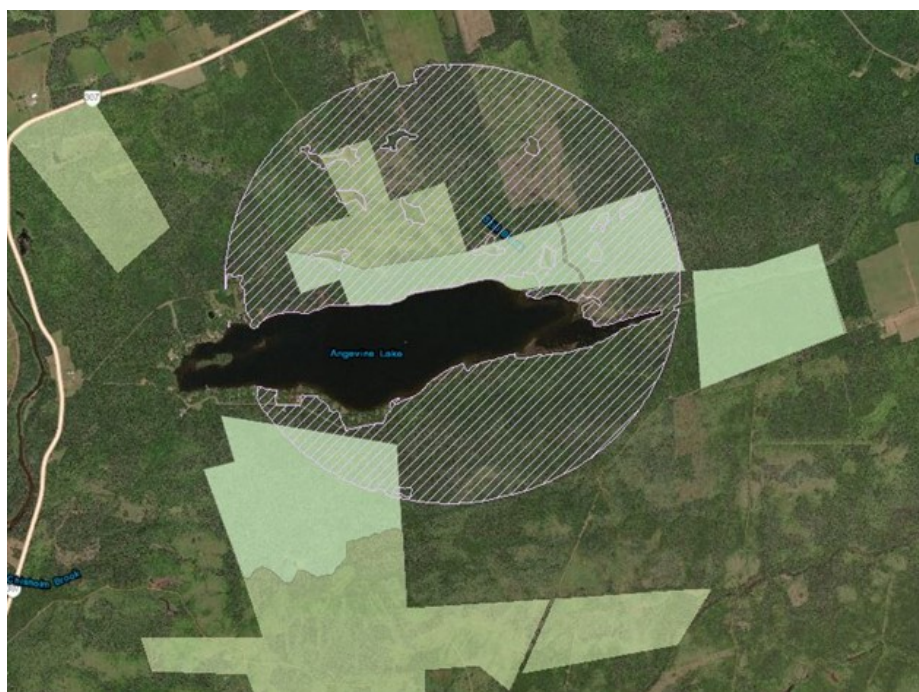


Figure 6. Map showing proposed core habitat at Angevine Lake, Cumberland County. Green rectangles indicate public land or protected areas.



Figure 7. Map showing proposed core habitat in the Municipality of West Hants, Nova Scotia.



Figure 8. Map showing close-up of proposed core habitat in the Municipality of West Hants, Nova Scotia (northern section).



Figure 9. Map showing close-up of proposed core habitat in the Municipality of West Hants, Nova Scotia (central section).



Figure 10. Map showing close-up of proposed core habitat in the Municipality of West Hants, Nova Scotia (southern section).

Appendix 2: Monitoring plan for Ram's-head lady slipper in Nova Scotia

This monitoring plan is aimed at providing consistent data over time to assess Ram's-head lady slipper population dynamics, habitat parameters and threats in Nova Scotia on an ongoing basis. The overall strategy involves selecting a subset of known locations for monitoring annually, with the remainder of known locations being monitored every 3-5 years on a rotating basis.

Selection of locations to monitor annually is based on the following:

- Capturing at least 50% of stems based on 2020 data
- At least one location from each subpopulation
- Representative of range of habitat and extent (e.g., Angevine Lake)
- At least one, and preferably two, past surveys completed
- More than 10 stems present in 2019 survey
- Areas that can be monitored (flagged/staked) for plant movement
- Presence of invasive alien species for monitoring
- Potential collaboration with partners

Recommended locations to be included in yearly monitoring survey (estimated to require ~4 days of monitoring):

- AL1-1 (outlier for range of habitat and extent)
- CR2-1 (400+ stems)
- GM1-1
- MP-1-North of Highway 236
- PG1-3
- PG1-5
- SC1-5
- SC1-6
- SC1-12
- SC2-1 (500+ stems)

Data to be collected:

- The following data should be collected every year during flowering (late May to mid or late June) for the subset of locations identified above and every 3-5 years for all other known locations surveyed in 2019:
 - Stem counts
 - General threats observations
 - Invasive species observations (see further detail below)
 - Staked occurrences for monitoring movement (at key sites)

Invasive species:

- The following data should be collected every year for the subset of locations identified above and every 3-5 years for all other known locations surveyed in 2019:
 - For each location, record all exotic species and their estimated percent cover within 10 m of Ram's-head lady slipper.
 - For each location, record whether Blue Sedge occurs within 10 m, 50 m, and 100 m of Ram's-head lady slipper. Record estimated percent cover of Blue Sedge outside a 10 m buffer around Ram's-head lady slipper but within 50 m and 100 m of Ram's-head lady slipper, respectively.
 - Where Blue Sedge is not within 10 m of RHLS, record shortest distance between Blue Sedge and Ram's-head lady slipper.
 - Where both Ram's-head lady slipper and Blue Sedge are present within a 10 m x 10 m square, establish a 10 m x 10 m permanent plot to monitor relative distribution and abundance. Once permanent plots are set up, they can be monitored in subsequent years.

A more detailed methodology along with data sheets and other materials for field collection will be developed at a later date.