



Goldenseal

(Hydrastis canadensis) in Ontario

Ontario Recovery Strategy Series

Recovery strategy prepared under the
Endangered Species Act, 2007

2016

Natural. Valued. Protected.

About the Ontario Recovery Strategy Series

This series presents the collection of recovery strategies that are prepared or adopted as advice to the Province of Ontario on the recommended approach to recover species at risk. The Province ensures the preparation of recovery strategies to meet its commitments to recover species at risk under the *Endangered Species Act, 2007* (ESA) and the Accord for the Protection of Species at Risk in Canada.

What is recovery?

Recovery of species at risk is the process by which the decline of an endangered, threatened, or extirpated species is arrested or reversed, and threats are removed or reduced to improve the likelihood of a species' persistence in the wild.

What is a recovery strategy?

Under the ESA a recovery strategy provides the best available scientific knowledge on what is required to achieve recovery of a species. A recovery strategy outlines the habitat needs and the threats to the survival and recovery of the species. It also makes recommendations on the objectives for protection and recovery, the approaches to achieve those objectives, and the area that should be considered in the development of a habitat regulation. Sections 11 to 15 of the ESA outline the required content and timelines for developing recovery strategies published in this series.

Recovery strategies are required to be prepared for endangered and threatened species within one or two years respectively of the species being added to the Species at Risk in Ontario list. Recovery strategies are required to be prepared for extirpated species only if reintroduction is considered feasible.

What's next?

Nine months after the completion of a recovery strategy a government response statement will be published which summarizes the actions that the Government of Ontario intends to take in response to the strategy. The implementation of recovery strategies depends on the continued cooperation and actions of government agencies, individuals, communities, land users, and conservationists.

For more information

To learn more about species at risk recovery in Ontario, please visit the Ministry of Natural Resources and Forestry Species at Risk webpage at:

www.ontario.ca/speciesatrisk

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DECLARATION

The recovery strategy for the Goldenseal was developed in accordance with the requirements of the *Endangered Species Act, 2007* (ESA). This recovery strategy has been prepared as advice to the Government of Ontario, other responsible jurisdictions and the many different constituencies that may be involved in recovering the species.

The recovery strategy does not necessarily represent the views of all of the individuals who provided advice or contributed to its preparation, or the official positions of the organizations with which the individuals are associated.

The goals, objectives and recovery approaches identified in the strategy are based on the best available knowledge and are subject to revision as new information becomes available. Implementation of this strategy is subject to appropriations, priorities and budgetary constraints of the participating jurisdictions and organizations.

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this strategy.

RESPONSIBLE JURISDICTIONS

Ontario Ministry of Natural Resources and Forestry
Environment and Climate Change Canada – Canadian Wildlife Service, Ontario
Parks Canada Agency

EXECUTIVE SUMMARY

Goldenseal (*Hydrastis canadensis*) is a long-lived perennial herb that grows in moist deciduous woodlands in Ontario. It is currently listed as threatened in Ontario under the provincial *Endangered Species Act, 2007* (ESA). The Natural Heritage Information Centre (NHIC) has designated the plant with a conservation status rank of S2, indicating that it is imperiled in Ontario.

In Ontario, Goldenseal has remained relatively stable over the past four decades with approximately 24 distinct extant natural populations (defined as at least one km apart) scattered among seven counties and regional municipalities. Historically it had a wider distribution, possibly reaching as far as eastern Ontario. Current Ontario populations are primarily restricted to the deciduous forest region (ecoregion 7E) of southwestern Ontario, with the majority of populations confined to the western half of the region around Lake Huron. One non-native population exists within the Great Lakes-St. Lawrence forest region (ecoregion 6E).

The main threats to Ontario's populations are alteration of the natural disturbance regime, deforestation, habitat destruction or fragmentation, changes in hydrology and drainage, harvesting, invasive species and trampling of plants. The recovery goal for Goldenseal in Ontario is to maintain the existing populations at sustainable levels. Research on the natural disturbance regime favoured by Goldenseal should inform conservation management approaches. The following protection and recovery objectives are recommended to accomplish the recovery goal.

1. Survey and monitor all extant populations of Goldenseal and its habitat across its native range in southern Ontario.
2. Address knowledge gaps relating to the species' habitat needs.
3. Manage and protect habitat at all extant sites in Ontario.
4. Develop and deliver education and stewardship programs for private landowners.
5. Address knowledge gaps relating to the species' biology and conservation, including potential propagation and reintroduction.

It is recommended that the area to be prescribed as habitat in a regulation for Goldenseal includes the extent of the area of occupancy within which the species is found, the Ecological Land Classification (ELC) ecosite polygon plus an additional 50 metres of natural vegetation. For plants which are within 50 m of the edge of their polygon, a minimum distance of 50 m from the outer limit of the population and around each plant is recommended for regulation. It is recommended that cultivated (i.e., plants grown commercially for the purpose of propagation or medicinal uses) Goldenseal should be excluded from a habitat regulation.

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1.0 BACKGROUND INFORMATION

1.1 Species Assessment and Classification

COMMON NAME: Goldenseal

SCIENTIFIC NAME: *Hydrastis canadensis*

SARO List Classification: Threatened

SARO List History: Threatened (2008), Threatened – Not Regulated (2004)

COSEWIC Assessment History: Threatened (2000, 1991)

SARA Schedule 1: Threatened (2003)

CONSERVATION STATUS RANKINGS:

GRANK: G3G4

NRANK: N2

SRANK: S2

The glossary provides definitions for technical terms, including the abbreviations above.

1.2 Species Description and Biology

Species Description

Goldenseal (*Hydrastis canadensis*), also known by the local vernacular names of Orangeroot and Yellow-puccoon, is a perennial long-lived herb measuring 20 to 50 cm in height. The bottom, middle and upper leaves of the Goldenseal plant are palmately¹ shaped with one to nine lobes radiating from the central part of the leaf (NatureServe 2014). Superficially, these leaves resemble maple (*Acer* spp.) leaves. Leaves are generally doubly toothed, or coarsely serrated around the edges and are usually attached to the main plant stem in sub-opposite or alternate leaf arrangement (Jolly 2015). The number of leaves present is a function of age, with younger plants possessing one leaf and older, more reproductively mature plants having two to three leaves. Plants producing a flower are one-leaved plants at least two or three years old. Two-leaved plants are four to six years old, and three-leaved plants are greater than six years old (Jolly 2015).

The leaves of Goldenseal plants may be mistaken for other Ontario plants, particularly during early growth stages. The first or second year Goldenseal seedling is identified by a stem, which may be hairy, approximately five cm tall, reddish towards the base and attached to a bright yellow root (Riley 2009). The first pair of leaves from older plants that emerge from the ground in the early spring are called cotyledon leaves

¹ Palmate means radiating from a common point, as in leaflets or veins in a leaf (Voss 1985).

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(NatureServe 2014). The general structure of a Goldenseal plant emerging with cotyledon leaves may be visually mistaken in the field with palmately-shaped leaves from other plants emerging in the early spring. Some of these other plants include Wild Geranium (*Geranium maculatum*) and Maryland Black-snakeroot (*Sanicula marilandica*). Later in the season, after leaves are completely unfolded and expanded, Goldenseal leaves may resemble the maple leaf shape of other plants, such as Mayapple (*Podophyllum peltatum*) and Sweet Coltsfoot (*Petasites frigidus* var. *palmatus*) (Cherniawsky and Bayer 1998).

The root is a bright yellow or orange rhizome measuring 4 to 7 cm long by 0.5 to 2 cm wide when fresh (Sinclair and Catling 2000b) and covered with fine yellow rootlets. Annual growth rings on the rhizome have been observed (Jolly 2016) and may be used to measure age.

The solitary flower (Figure 1), located at the base of the uppermost leaf is distinctive in that it lacks showy petals or sepals (Gleason and Cronquist 1991, Jolly 2015). The flower has multiple conspicuous, showy white stamens (i.e., the male part of the flower), which may number as many as 50. The flower diameter averages 1.4 cm (EARTHQUEST 2014). Fertilized flowers develop into fruit, maturing in June or July, with 10 to 30 dark shiny seeds (Sinclair 2002, USDA Forest Service 2003, NatureServe 2014, Jolly 2015). The fruit somewhat resembles raspberries, with each “berry” the product of a collection of fertilized pistils or carpels (i.e., the female part of the flower) (Sinclair and Catling 2000b). This collection of fertilized pistils or carpels (i.e., by insect pollinators), may contain 1 or 2 achenes for each pistil or carpel.

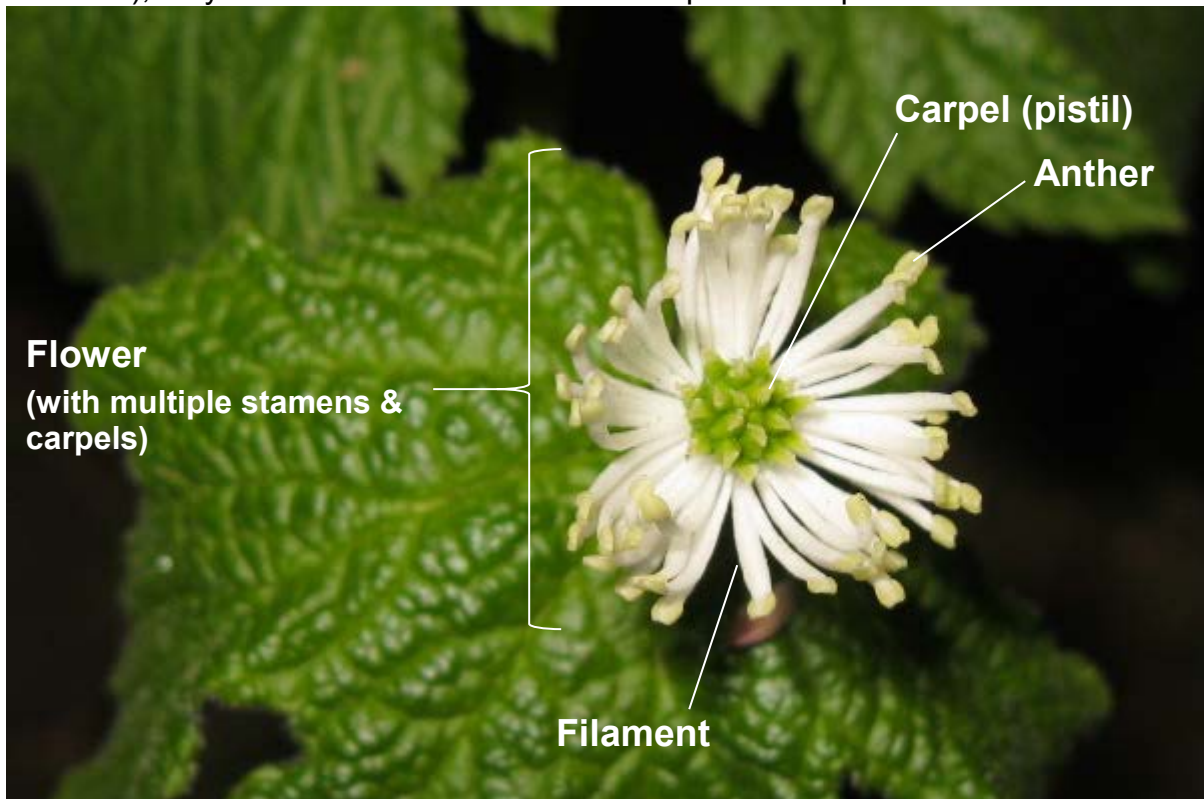


Figure 1. Structure of Goldenseal flower. Photo by Dave Jolly.

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Species Biology

Goldenseal plants in Ontario have been observed to emerge as seedlings or cotyledon leaves between April 28 and May 10 before the overhead canopy has fully closed (EARTHQUEST 2014). Flowering may occur within several days of emergence. They have been observed to flower until May 30 in Ontario (EARTHQUEST 2014). At the first frost (mid to late October), most plants die (Sinclair and Catling, in press), although some plants may persist until December (D. Jolly, pers. obs. 2014). Goldenseal overwinters as either seeds or rhizomes. Little published information is available on what length of time is required for wild plants to grow from seed to sexually maturity with viable fruits.

Goldenseal can reproduce both asexually (new shoots from rhizomes) and sexually (seeds produced from self-fertilization or cross-fertilization). Self-fertilization is common in most flowering plants with both male and female reproductive organs and has been documented for Goldenseal by some researchers (Sanders 2004). Asexual reproduction is accomplished through the production of vegetative ramets from rhizomes between October 27 and November 8 (Jolly 2015, Jolly 2016, Sinclair and Catling in press). Each rhizome may have a single, or as many as eight stems arising from it, which complicates estimations of how many individuals live in a population. Sexual reproduction through cross-fertilization is likely accomplished through the action of pollinating insects. Plants do not flower until they are two to three years old with at least one leaf. The oldest age noted for first flowering is five years old (NatureServe 2014). The few insects documented as visiting Goldenseal flowers in Ontario include sweat bees (*Lasioglossum* spp.), bumble bees (*Bombus* spp.) (Sinclair et al. 2000, Sinclair 2002), and flies in the family Syrphidae (Environment Canada 2011). Pollination does not appear to limit population growth and spread of Goldenseal in Ontario (Environment Canada 2011).

Seed dispersal is believed to be facilitated by animals eating ripe fruits (Tait 2006, Lonner 2007, D. Jolly, pers. obs. 2014). Sinclair et al. (2000) found that Red-winged Blackbirds (*Agelaius phoeniceus*) may serve as effective dispersal organisms, but may not disperse seeds to appropriate germination sites (Environment Canada 2011). It has been inferred by Tait (2006) that birds may be carrying the bright red fruits containing seeds larger distances than other dispersers. Some researchers suggest that these other dispersers may be ants, but do not specify which species of ants (Albrecht and McCarthy 2011).

Goldenseal tends to occur in clumps as a result of their vegetative growth and presumed limited seed dispersal (Eichenberger and Parker 1976, Sinclair and Catling 2000a). In a study of Goldenseal in Ohio, Eichenberger and Parker (1976) found that clumps in interior forests had more individuals than clumps at forest edges. Plants that originate from asexual reproduction (shoots from rhizomes) exhibit slower growth rates than plants grown from seeds (Lonner 2007). Sanders (2004) found that how Goldenseal reproduces (vegetatively versus sexually) appears unlikely to be a major factor limiting the distribution or abundance of Goldenseal. A study of three Ohio populations of Goldenseal suggested 87.5 percent of new seedlings originated from

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asexual and 12.5 percent from sexual reproduction (Christensen and Gorchoff 2010). Sinclair and Catling (in press) noted that on average 24 percent of Ontario's populations produce healthy, viable flowers during a given year. In their 2015 field surveys, however, Sinclair and Bickerton found that 31 percent of 14 populations were in bloom (COSEWIC 2016). Flowering plants usually produce fruit in Ontario (Sinclair et al. 2005).

Since Goldenseal rhizomes are sometimes harvested illegally (see Threats section), responses to rhizome cutting is a key aspect of this species' biology for conservation management. It is not known what rate of recovery can be expected under various levels of harvest, given natural levels of mortality. Limited laboratory and field-based results suggest Goldenseal can grow new stems from the root fragments remaining after harvest, but these stems are generally shorter, fewer in number, and less frequently have flowers than stems from intact roots (Van der voort et al. 2003). This is supported by observations of Tait (2006) for Ohio populations of Goldenseal.

1.3 Distribution, Abundance and Population Trends

The global distribution of Goldenseal is restricted to eastern North America, with most of its range occurring in the United States. In the United States, Goldenseal occurs on rich and moist soils of deciduous forests. The distribution extends from New England in the east, to southern Minnesota and northeastern Kansas in the west, and from Mississippi, Alabama and Georgia in the south, to Wisconsin in the north. Goldenseal is currently ranked rare (S3) in Indiana and most of the other states of the USA except Illinois, Kentucky, Ohio, Pennsylvania, West Virginia and Wisconsin (BONAP 2013, NatureServe 2014).

In Canada, Goldenseal is largely confined to the deciduous forest region (ecoregion 7E) of southwestern Ontario between the north shore of Lake Erie and the southern ends of Lake Huron from Windsor to Goderich (COSEWIC 2000). The most northern occurrence of the species in Ontario is in Grey County, but this population was planted and spread into the surrounding woodland (White 1990, J. Penner, pers. comm. 2014).

Overall, the abundance of Goldenseal in Ontario appears to be increasing, with some colonies declining in abundance (Sites C, E, L, and O, Table 1) and others increasing (Sinclair and Catling in press). It is not known how many Goldenseal colonies (i.e., groups of Goldenseal separated by a distance of 500 m) existed in Ontario prior to 1957, but they were likely more extensive than they are today. Most studies of Ontario colonies occurred between 1989 and 2001 (A. Sinclair, pers. comm. 2014), with approximately 14,500 stems being surveyed in 1998 (Sinclair and Catling 2002). Although considered native, the origin of the newly-discovered population in Wellington County (Site P, Table 1) is uncertain (COSEWIC 2016). Nevertheless, added with 13 known populations resurveyed (COSEWIC 2016) in 2015 the total number of native, wild extant Goldenseal in Ontario is estimated to be approximately 76,053 stems from 24 populations (Figure 2; Table 1). The increase in some populations between 1998 and 2015 may be attributable to disturbances in the forest canopy such as from

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Emerald Ash Borer (*Agrilus planipennis*) (Site M, Table 1) and Hickory die-off (Site H, Table 1) (COSEWIC 2016). Past survey results have been complicated by inconsistent application of survey protocols, such as some surveys assuming that each stem represents a distinct plant when, in fact, several stems may share the same root. Sites are defined as a group of Goldenseal within 1.5 km of each other. Populations are considered by the author to be distinct if they are separated by at least one km, consistent with the approach employed by COSEWIC, NatureServe, and Ontario's Natural Heritage Information Centre (NHIC). Groups of plants within 500 m of each other are considered sub-populations of a single population, and are referred to in this report as colonies. There is often more than one colony in a population of Goldenseal. Subsequently, there are approximately 79 distinct colonies ranging from several individuals to several hundred ramets (i.e., vegetative stems emerging from one parental plant) currently occurring in Goldenseal populations in the province of Ontario (Sinclair and Catling 2000b, Mulligan and Gorchov 2004, Sanders and McGraw 2005). Projection matrix models suggest that flowering stems is the most important factor that contributes to Goldenseal population growth in Ontario (Sinclair et al. 2005).

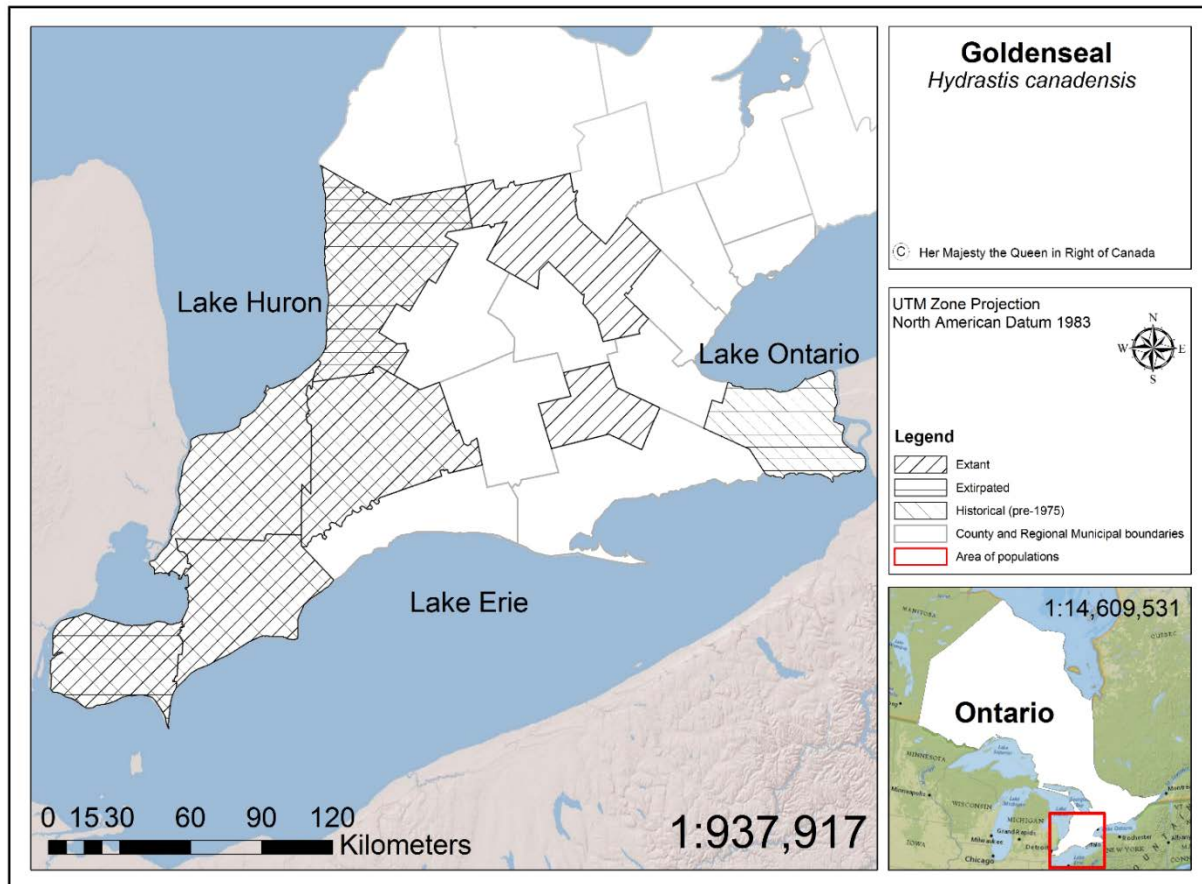


Figure 2. Population distribution by county of extant, extirpated and historical range of Goldenseal in Ontario (NHIC 2014b). Excludes populations considered to be planted.

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Table 1. Summary of known extant populations of Goldenseal in Ontario documented between 1957 and 2015 (Botham 1981, White 1990, Morningstar 2005, Environment Canada 2011, NHIC 2014b, Sinclair and Catling in press, EARTHQUEST 2014, C. Cecile, pers. comm. 2014).

County/ Region	Site Name	Status	Number of Known Colonies/ Populations	Year of Last Survey/ Observation	Approximate Number of Stems	Surveyor(s)
Brant County	A	Extant	1 colony; 1 population	2014	26,122	Dave Jolly, Nata Mateev, Kathryn Markham, Lindsay Campbell (2014), Derek Morningstar (2005)
Chatham- Kent	B	Historical	1 colony; 1 population	1986	70	Ian Macdonald
	C	Extant	4 colonies; 1 population	2015	397	Adrienne Sinclair & Holly Bickerton (2015), Adrienne Sinclair & Paul Catling (1998), David White (1989), Mike Oldham & Gary Allen (1986), R. Zavitz (1964), James Soper & M. Landon (1957)
	D	Extant	2 colonies; 1 population	2014	100*	Melody Cairns (2014), Dave Jolly (2009), Allen Woodliffe (2006), Ramsay Hart et al. (2002)
Essex County	E	Extant	6 colonies; 1 population	2015	2,179	Adrienne Sinclair & Holly Bickerton (2015), Adrienne Sinclair & Paul Catling (1998)
	F	Extant	27 colonies; 4 populations	2015	21,384	Adrienne Sinclair & Holly Bickerton (2015), Adrienne Sinclair & Paul Catling (1998), David White (1989), Mike Oldham & Gary Allen (1986), William Botham (1973)
	G	Extant	22 colonies; 7 populations	1998	1,607	Adrienne Sinclair & Paul Catling (1998), Gary Allen & Allen Woodliffe (1985 - 1989)

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Huron County	H	Extant	5 colonies; 1 population	2015	8,308	Adrienne Sinclair & Holly Bickerton (2015), Dave Jolly (2014; 1 colony), Julia Riley (2009), K. Vlasman (2005), Adrienne Sinclair (1998), Mike Oldham (1995)
Lambton County	I	Extant	1 colony; 1 population	2008	6 (106 in 1998)	Tim Payne (St. Clair Region Conservation Authority, 2008), Adrienne Sinclair & Paul Catling (1998, 2000, 2001)
	J	Historical	1 colony; 1 population	1958	Unknown	H. Lawrence
	K	Extant	2 colonies; 1 population	2015	6,832	Adrienne Sinclair & Holly Bickerton (2015), Adrienne Sinclair & Paul Catling (1998), David White (1991)
	L	Extant	2 colonies; 1 population	2015	149	Adrienne Sinclair & Holly Bickerton (2015), Adrienne Sinclair & Paul Catling, Larry Lamb (1980)
	M	Extant	4 colonies; 2 populations	2015	3,116	Confidential (2015, 2008)
Middlesex County	N	Extant	1 colony; 1 population	2010	430* +	Melody Cairns (2014), Sandy Dobbyn (2007)
	O	Extant	1 colonies; 1 population	2015	335	Adrienne Sinclair & Holly Bickerton (2015), Ausable River Conservation Authority (2008) Adrienne Sinclair & Paul Catling (1998)
Wellington County	P	Extant	1 colony; 1 population	2015	5,088	Adrienne Sinclair, Holly Bickerton, Charles Cecile (2015)
Populations considered to be non-native in origin						
Grey County	Q	Extant	1 colony; 1 population	1998	50,544	Adrienne Sinclair (1998)
Stormont County	R	Extirpated	1 colony; 1 population	1998	Unknown	Cited in Sinclair and Catling (in press)
Populations not assigned an Element Occurrence (EO) by the NHIC						
Niagara Region	S	Extirpated	1 colony; 1 population	1894	Unknown	R. Cameron cited in Plants of the Niagara Parks System of Ontario (1943)

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Lambton County	T	Extirpated	1 colony; 1 population	Late 1970s	30 - 40	Environment Canada (2011)
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* Exact number of Goldenseal not provided by surveyor(s)

1.4 Habitat Needs

Goldenseal tends to live in, or at the edge of, nutrient-rich, deciduous forests with fairly neutral soils (Sinclair and Catling 2000a). The amount of overhead forest canopy cover can vary from semi-open to closed, with 47 to 80 percent shade being considered optimal for Ontario populations (Sinclair and Catling 2001). Goldenseal is often associated with disturbed forest areas and edges of forests, suggesting they may benefit from some disturbance (Sinclair and Catling 2000b). Soil pH of Ontario populations can range from slightly acidic (5.4) to slightly basic (7.8) (Sinclair and Catling in press), with the type of soil including clay, sandy loam, or loam (Riley 2009). Moisture levels can range from dry mesic to mesic (Sinclair and Catling in press).

Transplantation experiments have been successful in Ontario. Germination rates were low (9%) in growth chamber experiments using wild Goldenseal seeds, with shaded conditions only benefiting germination under dry conditions (Environment Canada 2011). Ontario field transplantation experiments revealed that Goldenseal plants produced more flowers, fruits and seeds when their soil was disturbed than when it was not (Sinclair and Catling 2004). It was successfully demonstrated that transplanting should be considered an effective tool for restoration efforts of Goldenseal and transplant success can be increased with soil turnover (Sinclair and Catling 2004).

Many plants can co-exist with Goldenseal in Ontario because Goldenseal can occur in lush, diverse groundcover communities in several habitats (Sinclair and Catling 2000b). The sparse shrub understory can consist of Red Maple (*Acer rubrum*) and Swamp White Oak (*Quercus bicolor*), among other species (Sinclair and Catling in press). Lists of plants associated with Ontario populations of Goldenseal have been summarized in White (1990), Sinclair and Catling (2000b, 2001), and NHIC (2014b). Some of the plant associates noted in the Wellington County population discovered in 2013 are new and include Zigzag Goldenrod (*Solidago flexicaulis*), Smooth Goldenrod (*Solidago gigantea*), Early Meadow-rue (*Thalictrum dioicum*), Yellow Trout-lily (*Erythronium americanum*), several sedge species (*Carex* spp.), Red Baneberry (*Actaea rubra*), White Trillium (*Trillium grandiflorum*), False Solomon's-seal (*Maianthemum racemosum*) and Large-flowered Bellwort (*Uvularia grandiflora*) (Cecile 2014).

Ecological Land Classification (ELC) data for Goldenseal has been updated by COSEWIC (2016) and Jolly (2016). To date, the author and other surveyors have classified 12 communities from 11 Goldenseal sites:

- Dry-Fresh Basswood Deciduous Forest Type (FODM4-9);
- Fresh-Moist Sugar Maple Deciduous Forest Ecosite (FODM5);
- Dry-Fresh Sugar Maple Deciduous Forest Type (FODM5-1);

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- Fresh-Moist Sugar Maple-Beech Deciduous Forest Type (FODM5-2);
- Fresh-Moist Oak-Sugar Maple Deciduous Forest Type (FODM7-5);
- Fresh-Moist Poplar Deciduous Forest Type (FODM8-1);
- Fresh-Moist Oak-Sugar Maple Deciduous Forest Type (FODM9-1);
- Fresh-Moist Shagbark Hickory Deciduous Forest Type (FODM9-4);
- Fresh-Moist Bitternut Hickory Forest Type (FODM9-5);
- on a drier micro-habitat within Fresh-Moist Sugar Maple/Beech-Spicebush Carolinian Deciduous Forest Type (FODM10-1a);
- Fresh-Moist Deciduous Woodland Ecosite (dominated by Black Walnut) (WODM5); and
- Fresh-Moist Elm Deciduous Woodland Type (WODM5-2).

1.5 Threats to Survival and Recovery

Five out of 24 populations (21%) of Goldenseal are found on public lands within conservation areas, provincial parks, and provincial nature reserves, which are relatively secure. Two populations (8%) are on First Nations land, while the remaining 17 populations (71%) are located on private property. A few populations may be under environmental pressure from human-induced influences due to trampling of plants found along trails, removal of forest canopy, non-selective cutting, changes in hydrology including drainage, and harvesting. However, Sinclair and Catling (2000a, 2003, 2004) suggest that trampling of plants, removal of forest canopy and non-selective cutting may be beneficial since they simulate natural disturbance processes that have been lost through the settlement of southern Ontario landscapes. The main threats facing populations of Goldenseal in Ontario include alteration to natural disturbance regime, logging, changes in hydrology and drainage, harvesting, flooding and invasive species.

Alteration to Natural Disturbance Regime

Goldenseal may benefit from woodland disturbances, such as floods and fires, which were more common prior to European settlement (COSEWIC 2000). Perhaps these disturbances facilitated Goldenseal dispersal or colonization (Sinclair and Catling 2004), and the recent rarity of these disturbances may be a reason why many Ontario populations are ageing without spreading (Sinclair and Catling 2002, Sinclair et al. 2005). A reduction in these forest disturbances may affect soil moisture, nutrient levels, and result in over-shading of undergrowth, all of which may hinder Goldenseal colonization. Ontario populations of Goldenseal are often associated with disturbed forest areas, such as forest paths and forest edges, suggesting a benefit of disturbance (Sinclair and Catling 2000a). Furthermore, Goldenseal tends to have relatively larger populations in smaller habitat patches in Ontario, suggesting a benefit of habitat fragmentation for this species (Sinclair and Catling 2000a). This was verified with field surveys of one of the largest native stands in Ontario in Brant County (Site A) (Jolly 2016) and Site H in Huron County (COSEWIC 2016). Goldenseal may have also benefited from now-extinct animals, such as massive flocks of Passenger Pigeon (*Ectopistes migratorius*) or large pleistocene mammals, which may have not only

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contributed to disturbance but also facilitated seed dispersal (Sinclair and Catling 2000b).

Deforestation

Selective cutting has occurred at nine populations, mostly on private properties or adjacent to an Area of Natural and Scientific Interest (ANSI), and is contributing to Goldenseal disappearance or decline at three locations (Environment Canada 2011). If standard forestry Best Management Practices (BMPs) are not implemented during selective cutting activities, the changed micro-habitat may not be suitable to support healthy Goldenseal populations. Mulligan's (2003) observations from her study on the impact of logging practices on Goldenseal also apply here, whereby too much selective cutting would allow excess sunlight to penetrate the forest floor. Logging and commercial deforestation practices have been implicated in the decline of Goldenseal populations in the United States, particularly in Ohio. At one site in Ohio, which had been logged a few weeks prior to a site visit, Mulligan (2003) observed plants aging prematurely as a result of full exposure to direct sunlight since the canopy had been almost entirely removed. The disturbance caused by not clearing woody debris away from Goldenseal colonies, or the increased soil compaction caused by commercial machinery, may also restrict soil drainage. However, there is considerable evidence that Goldenseal plants in Ontario and their immediate habitat are frequently damaged by logging (Environment Canada 2011).

Habitat destruction or fragmentation

Development, such as the construction of housing, can cause habitat destruction or fragmentation. This threat has been documented and is believed to have caused local extirpation in one population located primarily on First Nations land (A. Sinclair, pers. comm. 2014). With the clearing of woodlands some of the prime Goldenseal habitat may have been converted to residential housing for development. Two additional populations on private property have had the forest canopy altered or removed through clearing of lots for constructing houses. This activity may detrimentally affect the survival and growth rate of Goldenseal by increasing exposure to direct sunlight.

Changes in hydrology and drainage

Plants are negatively affected by prolonged dry conditions; seeds are susceptible to drying out, and fruit and seed production are reduced (Sinclair and Catling 2001). Alteration of the water regime (e.g., dams), agricultural drainage and changes in local climate may restrict the growth and spread of Goldenseal (Sinclair and Catling 2001). The rivers along which Goldenseal occurs do not appear to flood to the extent that they did in the past (Environment Canada 2011). One population occurs in close proximity to a major highway corridor (Site L, Table 1) which may have affected the soil hydrology and drainage patterns (Environment Canada 2011, NHIC 2014b). Since Goldenseal is associated with riparian forests adjacent to water courses in Ontario, changes to soil hydrology and drainage resulting from land uses adjacent to riparian areas (such as from agriculture, grading, ditching, sand pits or quarries) may also be a significant threat affecting habitat quality and suitability.

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Harvesting

The root of wild Goldenseal is valuable to harvesters for medicinal purposes in Ontario (NHIC 2014a) and in the United States (Gagnon 1999, Mulligan 2003, Lonner 2007, NatureServe 2014, Sinclair and Catling in press). It is known as a popular herb that soothes and heals the mucous membranes of the respiratory, digestive and genitourinary tracts when affected by allergy or infection (Lenarduzzi 2000). Tinctures of the root are believed to provide some relief for stomach pains (Sinclair 2002) and serve as an agent that helps to constrict blood vessels, relieving inflammation (Lenarduzzi 2000, Plants for a Future 2009).

An observed 10 percent rate of decline of the North American Goldenseal population as a result of harvesting wild populations may contribute to extinction over time (Mulligan and Gorchoy 2004). The threat posed by harvest and international trade prompted listing of the plant in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) on June 8, 1998 (Sinclair and Catling in press). The threat of harvest is considered medium in Ontario (Sinclair and Catling in press). Although this threat is not as clearly evident in Ontario, it may be a greater threat for some of the smaller populations located close to trails. These populations are primarily on land under public ownership and, to a lesser extent, on private property. Sinclair and Catling (in press) noted that since public access to private lands is more restricted, plants on private lands may be more protected from wild harvest. One population could be in danger of harvest if the location becomes public knowledge (C. Cecile, pers. comm. 2014). Over a period of four years (1998 – 2001) Sinclair and Catling (2000b) found that only two of 20 populations showed signs of harvesting, where holes in the ground were discovered with the vegetative portions of approximately 90 plants left and rhizomes missing. However, evidence of harvest was not observed during field visits to 11 sites in 2003, 10 sites in 2004 (Environment Canada 2011) and 13 sites in 2015 (COSEWIC 2016). Three populations in Ontario that are in danger of potential harvesting due to their close proximity to recreational trails are located on public lands owned and managed by conservation authorities or provincial parks (NHIC 2014b). People harvesting Wild Leek (*Allium tricoccum*) were observed on public land within close proximity to the Brant County site (Site A in Table 1) in 2010 (Jolly 2016).

Invasive species

Disturbances to Goldenseal habitat from natural or human-induced factors promote the expansion of invasive alien species, such as Garlic Mustard (*Alliaria petiolata*). Three populations have substantial amounts of Garlic Mustard that may be out-competing native Goldenseal. While the effects of Garlic Mustard and the severity of this threat on Goldenseal are not known, Garlic Mustard is known to inhibit germination and growth of several other native plants by interfering with their root growth (Roberts and Anderson 2001) and is recognized as a threat to native biodiversity in Canada (Catling et al. 2015). Additionally, three Goldenseal sites, Site F in Essex region, Site H in Huron County and Site M in Lambton County, have invasive woody shrub species such as Poison Ivy (*Toxicodendron radicans*) and numerous non-native woody plants including Tatarian Honeysuckle (*Lonicera tatarica*), Common Barberry (*Berberis vulgaris*),

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Japanese Barberry (*Berberis thunbergii*), Japanese Honeysuckle (*Lonicera japonica*), European Privet (*Ligustrum vulgare*), Multiflora Rose (*Rosa multiflora*) and Raspberries (*Rubus* spp.). Another invasive species observed at the Brant and Wellington County populations was European Buckthorn (*Rhamnus cathartica*) (D. Jolly, pers. obs. 2014, C. Cecile, pers. comm. 2014).

Trampling of plants

Thirteen Ontario populations are located within close proximity or adjacent to well used hiking or recreational trails. Proximity to trails may lead to trampling of Goldenseal plants. At least three sites, Site A in Brant County, Site F in Essex region and Site H in Huron County (Table 1), exhibit impacts from trampling (Riley 2009, D. Jolly, pers. obs. 2014, COSEWC 2016) and are located on public land or within a conservation area. Indeed, Riley (2009) stated that the most noticeable threats to Goldenseal in her survey were proximity to a hiking trail and die-off of Bitternut Hickory (*Carya cordiformis*) causing large openings in the canopy. Catling and Kostuik (2011) noted that hiking trails are beneficial, rather than a hindrance, to populations of wild orchids found in close proximity. This supports the contention by Sinclair (Environment Canada 2011) that hiking trails may also be beneficial to Goldenseal. Site C in Chatham-Kent, Sites E and F in Essex region, Site L in Lambton County and Site O in Middlesex County (Table 1) may be in jeopardy of damage from the unauthorized or authorized use of all-terrain vehicles (ATVs) which wander off trails, inadvertently crushing vegetation. However, this may be a short term threat that may be remedied in the long term by soil disturbance and crushing of competing plants.

1.6 Knowledge Gaps

A number of knowledge gaps exist that may hinder Goldenseal recovery efforts in Ontario. These include our understanding of Goldenseal habitat quality, the species' pollinators and animal dispersers, pathogens and diseases, as well as the factors influencing growth and reproduction. Specific knowledge gaps and research questions are listed below.

- What is the size and extent of potential suitable habitat such as mesic, deciduous woods and wooded floodplains with closed or semi-closed canopies occupied by Goldenseal?
- How much, and what type of, forest disturbance benefits Goldenseal? The precise extent of habitat at extant sites is needed to determine the species-specific boundaries for potential habitat protection (e.g., habitat quality and condition at disturbed forested riparian areas that are prone to periodic flooding versus less disturbed mature forest sites with closed canopies).
- What influences rates of seed germination and seedling establishment? Are populations with young one-leaved and two-leaved plants less successful than those with older three-leaved plants?

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- What factors lead to Goldenseal reproducing sexually or asexually? Is there a mechanism which turns plants reproducing asexually into sexual reproducers?
- What soil pathogens and diseases may affect Goldenseal survival rates? Some information is available for cultivated Goldenseal in the U.S.A., but we know little about the pathogens and diseases of wild populations in Ontario.
- What species are pollinators of Goldenseal in Ontario?
- What animals disperse Goldenseal seeds in Ontario and how far are they dispersed?

1.7 Recovery Actions Completed or Underway

To date, recovery actions for Goldenseal that are completed or currently underway are limited to population surveys, landowner engagement, monitoring, mapping and educational initiatives. There is no official survey protocol methodology available for Goldenseal. Such a protocol would aid in undertaking standardized survey, mapping, inventory and monitoring initiatives. EARTHQUEST is currently writing a best management practices survey methodology for Ontario species at risk plants which may be available to professionals and practitioners by late 2016. When released this may provide a good foundation for establishing monitoring programs. Current recovery actions include the following.

- **Management via *in situ*² augmentation and *ex situ*³ conservation:** Field trials of Goldenseal transplantation in Ontario have been successful, with high rates of survival, flowering, fruiting, and seed production (Sinclair 2002, Sinclair and Catling 2003, 2004). The influence of soil disturbance and fertilization on transplantation success has been evaluated (Sinclair and Catling 2004), which may inform any future transplantation projects.

The Canadian Clonal Gene Bank is maintaining Goldenseal plants and seeds from sites across Ontario. These plants and seeds may facilitate research (e.g., studies of genetic variation) and stewardship (e.g., population augmentation).

- **Population surveys:** Surveys and monitoring of Ontario's Goldenseal colonies have occurred, with survey effort peaking in the late 1990s and early 2000s with Adrienne Sinclair's Ph.D. research on Goldenseal in Ontario. The most recent survey provided new information on nine sites in Ontario (COSEWIC 2016).
- **Walpole Island First Nation:** Goldenseal populations occurring at Walpole Island First Nation (WIFN) have been surveyed and mapped as part of the draft Walpole Island Ecosystem Recovery Strategy (Bowles 2005). The WIFN

² A Latin term meaning on site.

³ A Latin term meaning off site.

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conducts various conservation activities, including education about Goldenseal and other species at risk at the Walpole Island Heritage Centre.

- **Public education:** EARTHQUEST (Canada) for the Environment received funding from TD/Canada Trust's Friends of the Environment Foundation in 2010 to produce a book on species at risk trees, shrubs and wildflowers of Ontario. A revised copy that includes Goldenseal has been prepared for distribution to conservation authorities, habitat stewardship councils, naturalist clubs, provincial and national parks. A webpage has also been constructed featuring Goldenseal, with conformity to NHIC data sensitivity policies, available on the EARTHQUEST website⁴.

The Huron Habitat Stewardship Council has conducted some education and stewardship programs for Goldenseal.

Adrienne Sinclair produced a pamphlet "Woodlot Management Recommendations" and a document "Suggestions for Various Ways of Monitoring Populations" with guidance on habitat management and monitoring protocols for Goldenseal in Ontario (A. Sinclair, pers. comm. 2014).

⁴ Supplemental information on Goldenseal can be found at the following link:
<http://www.earthquestcanada.ca/Goldenseal.htm>

2.0 RECOVERY

2.1 Recovery Goal

The recovery goal for Goldenseal in Ontario is to maintain the existing populations at sustainable levels.

2.2 Protection and Recovery Objectives

Table 2. Protection and recovery objectives.

No.	Protection or Recovery Objective
1	Survey and monitor all populations of Goldenseal and its habitat across its native range in southern Ontario.
2	Address knowledge gaps relating to the species' habitat needs.
3	Manage and protect habitat at all extant sites in Ontario.
4	Develop and deliver education and stewardship programs for private landowners.
5	Address knowledge gaps relating to the species' biology and conservation, including potential propagation and reintroduction.

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2.3 Approaches to Recovery

Table 3. Approaches to recovery of the Goldenseal in Ontario.

Relative Priority	Relative Timeframe	Recovery Theme	Approach to Recovery	Threats or Knowledge Gaps Addressed
1. Survey and monitor all populations of Goldenseal and its habitat across its native range in southern Ontario.				
Critical	Ongoing	Inventory, Monitoring and Assessment	1.1 Establish and regulate monitoring programs for all populations. <ul style="list-style-type: none"> - Ensure that data are collected in a systematic and consistent manner implementing standardized survey methodology and a protocol developed specifically for Goldenseal in consultation with Dr. Adrienne Sinclair's survey techniques (Sinclair 2002). 	Knowledge gaps: <ul style="list-style-type: none"> • habitat suitability
Critical	Ongoing	Inventory, Monitoring and Assessment	1.2 Inventory all occupied and historical areas of known sites. <ul style="list-style-type: none"> - Monitor Goldenseal populations at occupied sites. - Monitor habitat at currently and historically occupied sites, including habitats exhibiting disturbance regime. - Conduct demographic studies to further quantify demographic parameters (e.g., growth, seed production, mortality) to estimate population growth rates. 	Knowledge gaps: <ul style="list-style-type: none"> • habitat suitability • seed germination and establishment • mode of reproduction
Necessary	Short term	Research	1.3 Identify and survey additional sites with suitable habitat that may be downstream from Site H in Huron County, the Ausable River population in Middlesex County and the surrounding woodland for Site P in Wellington County. <ul style="list-style-type: none"> - Ensure that habitat regulation includes any newly-discovered populations 	Knowledge gaps: <ul style="list-style-type: none"> • habitat suitability

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Relative Priority	Relative Timeframe	Recovery Theme	Approach to Recovery	Threats or Knowledge Gaps Addressed
2. Address knowledge gaps relating to the species' habitat needs.				
Critical	Long term	Research	<p>2.1 Encourage research on topics related to Goldenseal biology and habitat.</p> <ul style="list-style-type: none"> - Research potential negative impacts of Garlic Mustard and other non-native plants. - Research natural disturbance regime favoured by Goldenseal. - Determine the precise extent of habitat at extant sites in order to inform habitat protection decisions. - Investigate seed productivity, dispersal, fertility and vitality. - Conduct forest interior habitat studies and compare with edge habitat studies. - Conduct field and demographic studies at the largest native Ontario populations to understand growth success compared to other populations. - Investigate habitat suitability modeling for optimal Goldenseal seed germination sites. - Determine which pollinators are visiting Goldenseal flowers, which animals are dispersing seeds, how far seeds are dispersed. - Examine which soil pathogens and what diseases affect Goldenseal populations. 	<p>Threats:</p> <ul style="list-style-type: none"> • alteration to natural disturbance regime • invasive species <p>Knowledge gaps:</p> <ul style="list-style-type: none"> • habitat suitability • size and type of forest that benefits Goldenseal • seed germination and establishment • mode of reproduction • seed dispersal • pollinators • pathogens and diseases
Beneficial	Short term	Research	<p>2.2 Research health, vitality and age-structure.</p> <ul style="list-style-type: none"> - Collect data on health and vitality of populations found at all sites. - Determine if seedlings require different habitats from already established plants. 	<p>Knowledge gaps:</p> <ul style="list-style-type: none"> • habitat suitability • seed germination and establishment • mode of reproduction
3. Manage and protect habitat at all extant sites in Ontario.				
Critical	Short term	Management	<p>3.1 Establish formal management agreements between private landowners to develop Best Management Practices (BMPs) for property management plans.</p>	<p>Threats:</p> <ul style="list-style-type: none"> • all

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Relative Priority	Relative Timeframe	Recovery Theme	Approach to Recovery	Threats or Knowledge Gaps Addressed
Critical	Long term	Management	<p>3.2 Actively seek partnerships with landowners, municipalities, Conservation Authorities, MNR and First Nations groups.</p> <ul style="list-style-type: none"> - Work with groups to remove invasive plants from Goldenseal sites to improve seed establishment areas. - Monitor and evaluate potential illegal harvesting. - Promote and encourage canopy thinning to promote the growth and enhancement of populations that are declining due to over-shading. 	<p>Threats:</p> <ul style="list-style-type: none"> • alteration to natural disturbance regime • invasive species • harvesting
Critical	Long term	Management	<p>3.3 Delineate suitable ecosite and vegetation types as prescribed habitat within a habitat regulation. Add other ecosite and vegetation types as more ELC is completed.</p>	<p>Knowledge gaps:</p> <ul style="list-style-type: none"> • habitat suitability
Critical	Short term	Stewardship	<p>3.4 Provide recommendations and BMPs to municipalities, Conservation Authorities, MNR, Ontario Ministry of Agriculture, Food and Rural Affairs, adjacent landowners, private land owners and members of First Nations groups.</p> <ul style="list-style-type: none"> - Concentrate habitat stewardship agreement on the natural areas occupied by Goldenseal on privately owned land. 	<p>Threats:</p> <ul style="list-style-type: none"> • all
4. Develop and deliver education and stewardship programs for private landowners.				
Critical	Short term	Protection, Stewardship	<p>4.1 Implement and maintain a Goldenseal educated network of landowners.</p> <ul style="list-style-type: none"> - Protect habitat on public lands by updating Forest Management Plans. - Protect habitat on private lands through land acquisitions and landowner agreements. 	<p>Threats:</p> <ul style="list-style-type: none"> • all
Critical	Ongoing	Education and Outreach	<p>4.2 Develop outreach materials that highlight the significance, vulnerability and threats to Goldenseal, emphasizing the threat of illegal collecting and trampling.</p>	<p>Threats:</p> <ul style="list-style-type: none"> • all

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Relative Priority	Relative Timeframe	Recovery Theme	Approach to Recovery	Threats or Knowledge Gaps Addressed
Necessary	Short term	Stewardship	<p>4.3 Based on knowledge obtained from researchers and members of First Nations groups, provide resources and fact sheets on:</p> <ul style="list-style-type: none"> - species ecology; - mechanisms for seed dispersal; - how to manage plants to encourage seed establishment; - optimal habitat conditions; and - disturbance factors, etc. 	<p>Threats:</p> <ul style="list-style-type: none"> • all
Necessary	Short term	Education, Outreach, Communication	<p>4.4 Disseminate educational materials to target audiences (landowners and First Nations).</p> <ul style="list-style-type: none"> - Continue communication with Walpole Island First Nation to find ways to meet community needs while still protecting the species. 	<p>Threats:</p> <ul style="list-style-type: none"> • all
<p>5. Address knowledge gaps relating to the species' biology and conservation, including potential propagation and reintroduction.</p>				
Necessary	Long term	Research	<p>5.1 Evaluate feasibility of reintroduction and restoration efforts.</p> <ul style="list-style-type: none"> - Evaluate feasibility of restoring historical populations based on ELC data and results of research on population ecology. - If deemed necessary and feasible, establish additional populations in suitable habitat to enhance population expansion. - Employ population augmentation at locations where Goldenseal populations are stationary or declining. - Perform additional work on seed germination models and methodology. 	<p>Knowledge gaps:</p> <ul style="list-style-type: none"> • seed germination and establishment
Necessary	Short term	Research	<p>5.2 Management of habitat.</p> <ul style="list-style-type: none"> - Encourage studies that link habitat quality (i.e., amount of canopy closure, soil hydrology, etc.) with threats facing Goldenseal populations (e.g., alteration of disturbance regime) and knowledge gaps. 	<p>Threats:</p> <ul style="list-style-type: none"> • all <p>Knowledge gaps:</p> <ul style="list-style-type: none"> • habitat suitability

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Relative Priority	Relative Timeframe	Recovery Theme	Approach to Recovery	Threats or Knowledge Gaps Addressed
Necessary	Ongoing	Management, Research	5.3 Complete germination and vitality studies. <ul style="list-style-type: none"> - Investigate germination rates and identify optimal germination conditions. 	Knowledge gaps: <ul style="list-style-type: none"> • seed germination and establishment

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Narrative to Support Approaches to Recovery

Table 3 provides the recovery approaches needed to address knowledge gaps, reduce the threats to Goldenseal populations in Ontario and implement actions for the recovery of the species. Of these, some of the critical actions linking most recovery approaches emphasized are monitoring, surveying, protecting and reintroduction or restoration. An extension of reintroduction and restoration efforts would be to conduct germination studies to investigate germination rates, seed establishment and vitality and identify optimal germination conditions. It has been demonstrated that transplanting rhizomes is a successful way to reintroduce Goldenseal. Once germination rates are understood, transplant and reintroduction programs could be supplemented by seed germination programs. Such reintroduction and restoration efforts are needed to propagate Goldenseal at low quality habitat sites, altered disturbance regime areas, or areas where Goldenseal occurred historically. Concurrently, ongoing assessments and evaluations of habitat condition and quality are recommended coinciding with research efforts in order to prioritize recovery activities. Best Management Practices for the management of Goldenseal should be developed to facilitate forest management plans and watershed report cards for Conservation Authorities. Recovery actions should be coordinated with efforts being undertaken by the Carolinian Canada Coalition's Conservation Action Plans (CAPs) and the Carolinian Woodland Recovery Strategy. The purpose of the Carolinian Woodland Recovery Strategy is to improve the integrity of those portions of the Carolinian woodland landscape in which species at risk occur (Jalava and Ambrose 2012). Many of the recovery steps recommended in this strategy could be incorporated into planning, policy, habitat stewardship and restoration activities associated with these CAPs and likely benefit the species in the long term.

Regular surveying (i.e., once every three years) of extant colonies to develop a consistent population growth rate estimate, after Sinclair and Catling's (in press) benchmark comparison between historical and extant populations, is critical and would greatly aid in recovery, management and protection efforts. Regular sampling could also include searching for any new patches that may arise and monitoring for illegal harvest. Sampling should occur at various time periods, depending on project goals. For example, studies seeking demographic structural analysis should time sampling to occur in mid to late May, when Goldenseal are in full bloom and July when most plants have produced fruits. This time period would enable researchers to readily differentiate plants from confusing look-a-likes and ensure that plants may be separated by age. It is also suggested that invasive species, such as Garlic Mustard, should be removed from within and around Goldenseal colonies to prevent any adverse competition that may occur and encourage the spread of Goldenseal and their native plant associates. Thinning of the canopy may enhance the survival and expansion of populations that have declined due to extensive shading.

2.4 Performance Measures

Performance measures can best be addressed and gauged for implementation once more information is gathered on Goldenseal population ecology from monitoring efforts and research. Performance measures should be based on the extent to which goals and objectives can be met within measurable target ranges and dates. Measurements to gauge recovery should include long term trends and patterns in population size and ecology, habitat quality and success in mitigating threats. As with other species at risk in Ontario such as Drooping Trillium (*Trillium flexipes*), site quality could be measured through habitat suitability modelling, or an index constructed based on habitat need parameters. In the absence of standardized survey protocol methodology, habitat suitability modelling has been utilized by the Nature Conservancy of Canada (NCC) for identifying suitable high quality habitats for the threatened Massasauga (*Sistrurus catenatus*)⁵.

Once data from regular population counts and monitoring are collected, a scoring system should be developed to allow for quantitative comparisons between Goldenseal populations and factors affecting the quality and extent of its suitable habitat. For example, scoring the level and type of threat such as the distance to recreational trails and volume of trail usage. Specific recommended performance measures are outlined in Table 4 below.

Table 4. Performance measures for the recovery of Goldenseal.

Objective	Performance Measure
1. Survey and monitor all populations of Goldenseal and its habitat across its native range in southern Ontario.	<ul style="list-style-type: none"> • Monitoring protocol is established in a consistent and repeatable fashion. • Accessible database of habitat characteristics and plant survey results is established and maintained. • Several field seasons required to complete updated monitoring by 2025.
2. Address knowledge gaps relating to the species' habitat needs.	<ul style="list-style-type: none"> • Devise habitat suitability models. • Score habitat based on quality in order to derive an index. • Several field seasons required; all habitats scored by 2025. • Conduct seed germination, vitality and establishment experiments by 2020. • Allow research community to be aware of research needs. • Review information gathered to consider when developing a habitat regulation. • Research on population health, vitality and age-structure should be completed by 2020. • Other research (e.g., demographic studies to further quantify demographic parameters) to be completed by 2024. • Municipalities and affected landowners become aware of Goldenseal habitat.

⁵ Additional information on NCC habitat suitability modeling for Massasauga can be found at the following link: <http://massasauga.ca/html/stewardship/section5.pdf>

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<p>3. Manage and protect habitat at all extant sites in Ontario.</p>	<ul style="list-style-type: none"> • Develop habitat and stewardship Best Management Practices (BMPs) and tools for public and private landowners by 2018. • Coordinate Garlic Mustard invasive species management plan and implement by 2020. • Implement habitat stewardship agreements with landowners by 2020.
<p>4. Develop and deliver education and stewardship programs for private landowners.</p>	<ul style="list-style-type: none"> • Maintain a Goldenseal educated network of landowners and integrate with habitat stewardship agreement by 2020. • Develop outreach materials that highlight the significance, vulnerability and threats to Goldenseal by 2018. • Disseminate educational materials to target audiences (landowners and First Nations) by 2020. • Outreach material developed and delivered by 2020. • Ensure reconnection with or keep landowners, property managers, and stakeholders current with knowledge about Goldenseal.
<p>5. Address knowledge gaps relating to the species' biology and conservation, including potential propagation and reintroduction.</p>	<ul style="list-style-type: none"> • Nurseries and restoration ecologists provided with information on Goldenseal reintroduction and restoration efforts continue communication with clonal⁶ gene bank in Harrow, Ontario, that maintains Goldenseal <i>ex situ</i> from a sample plant taken from various sites in 1998. • Revisit reintroduction plots established in 1999 to measure plants and evaluate longer term success. • Develop seed germination and successful seedling establishment protocols.

⁶ Clonal plants are derived from genetically identical individuals by asexual reproduction, in this case by vegetative growth (modified from Allaby 1992)

2.5 Area for Consideration in Developing a Habitat Regulation

Under the ESA, a recovery strategy must include a recommendation to the Minister of Natural Resources and Forestry on the area that should be considered in developing a habitat regulation. A habitat regulation is a legal instrument that prescribes an area that will be protected as the habitat of the species. The recommendation provided below by the author will be one of many sources considered by the Minister when developing the habitat regulation for this species.

It is recommended that the area prescribed as habitat in a regulation for Goldenseal should include the following three area types:

1. The full extent of the ELC ecosite polygon within which a population occurs.
2. A 50 metre area around each Goldenseal plant when located within 50 metres of the outer edge of the ELC ecosite polygon to protect the microhabitat.
3. If naturally vegetated, a minimum distance of 50 metres from the outer limit of the ecosite occupied by the Goldenseal population to protect the terrestrial integrity and hydrological function of the population.

The ELC ecosite within which a population occurs is recommended for protection to provide suitable habitat conditions (e.g., mesic, deciduous woods and wooded floodplains with closed or semi-closed canopies) to carry out essential life processes for the species. This includes seed germination sites, the surface water features that influence disturbance regimes and thereby promote recruitment areas, and areas required for seed dispersal and pollination to encourage sexual reproduction.

Specific habitat information for some Ontario Goldenseal populations has been updated for consideration when developing a habitat regulation with the aid of ELC data. The 12 ELC vegetation communities within which Goldenseal has been observed may be regarded as a starting point to consider in developing a habitat regulation area. However, since not all ELC vegetation types are known for all populations, it is recommended that the full extent of the ELC ecosite polygon within which the population occurs be considered when developing a habitat regulation. This approach takes into account that Goldenseal is found in a variety of different deciduous forest ecosites. Moreover, it is not possible to delineate all the suitable habitat on a finer scale using remote survey techniques such as aerial photo interpretation.

A 50 m radius around native/wild Goldenseal plants is recommended for plants located within the ELC ecosite polygon but near its edge (i.e., within 50 m of its edge). A distance of 50 m is important to protect Goldenseal microhabitat.

The 50 m distance of natural vegetation from the outer limit of the ecosite is recommended as the distance to protect the habitat for Goldenseal. A buffer distance of 50 to 120 m is required to minimize the negative impacts of water draw down caused

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by human-induced activities such as changes in hydrology from elevating water levels (Brown et al. 1990). Moreover, it has been demonstrated that buffers at least 30 m wide are needed to protect the biological, chemical and physical integrity of small streams (Sweeney and Newbold 2014). A minimum buffer of an 80 m radius was recommended for wetlands smaller than 2 ha by Brown et al. (1990). In the case of Goldenseal, a forest understory species that depends on soil and canopy disturbances and primarily propagates vegetatively by rhizomes (Gagnon 1999, COSEWIC 2000, Environment Canada 2011), the suggested buffer of a 50 m radius may help maintain local drainage requirements needed for propagation. Prescribing 50 m of habitat beyond the ecosite boundary also allows expansion of Goldenseal colonies via vegetative or sexual mechanisms into areas influenced by the natural disturbance regime (e.g., floodplains). This includes potential seed germination sites, the surface water features that influence disturbance regimes and thereby promote recruitment areas, as well as the areas required for seed dispersal and pollination to encourage sexual reproduction. The 50 m of natural vegetation around Goldenseal-inhabited ecosites may also reduce the potential for incursion of invasive plants into the forest ecosite from its edge.

The Grey County population is thought to be of non-native stock and planted. Given the size of this population, it may be valuable for restoration purposes should the wild Ontario population experience notable declines. At this time, however, it is not recommended that a habitat regulation for Goldenseal include this population or other potential future planted populations.

GLOSSARY

Abiotic: A process that is not associated with living organisms.

Achene: The seed of flowering plants, which is usually encased by a hard outer capsule or coat.

Anther: The portion of the stamen that bears and produces pollen, usually found at the end of the filament.

Areas of Natural and Scientific Interest (ANSI): Areas of land and water that represent significant geological (earth science) and biological (life science) features.

Basal leaf: The lowest, or lower leaf on the main plant stem.

Colony: For the purposes of this recovery strategy, a group of Goldenseal plants within 500 m of each other. There may be several colonies within a population.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC): The committee established under section 14 of the Species at Risk Act that is responsible for assessing and classifying species at risk in Canada.

Committee on the Status of Species at Risk in Ontario (COSSARO): The committee established under section 3 of the *Endangered Species Act, 2007* that is responsible for assessing and classifying species at risk in Ontario.

Conservation status rank: A rank assigned to a species or ecological community that primarily conveys the degree of rarity of the species or community at the global (G), national (N) or subnational (S) level. These ranks, termed G-rank, N-rank and S-rank, are not legal designations. Ranks are determined by NatureServe and, in the case of Ontario's S-rank, by Ontario's Natural Heritage Information Centre. The conservation status of a species or ecosystem is designated by a number from 1 to 5, preceded by the letter G, N or S reflecting the appropriate geographic scale of the assessment. The numbers mean the following:

1 = critically imperilled

2 = imperilled

3 = vulnerable

4 = apparently secure

5 = secure

NR = not yet ranked

Cotyledon leaves: Flowering plants whose seed typically has two embryonic leaves or cotyledons that emerge after the seedling sprouts.

***Endangered Species Act, 2007* (ESA):** The provincial legislation that provides protection to species at risk in Ontario.

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Filament: The anther-bearing stalk of the stamen.

Pistil: The female organ of the flower usually made up of the ovary, style and stigma.

Mesic: A habitat that has a well-balanced supply of moisture, making it more moist than dry habitats.

Population: For the purposes of this recovery strategy, a group of Goldenseal plants within one km of each other. There may be several colonies within a population, and several populations within a site.

Ramets: New vegetative growth that occurs on the plant, generally on the rhizome or roots, that is formed asexually.

Rhizome: The portion of a plant stem that is below ground from which roots and shoots grow.

Site: For the purpose of this recovery strategy, a group of Goldenseal plants within 1.5 km of each other. There may be several colonies within a population, and several populations within a site.

Species at Risk Act (SARA): The federal legislation that provides protection to species at risk in Canada. This act establishes Schedule 1 as the legal list of wildlife species at risk. Schedules 2 and 3 contain lists of species that at the time the Act came into force needed to be reassessed. After species on Schedule 2 and 3 are reassessed and found to be at risk, they undergo the SARA listing process to be included in Schedule 1.

Species at Risk in Ontario (SARO) List: The regulation made under section 7 of the *Endangered Species Act, 2007* that provides the official status classification of species at risk in Ontario. This list was first published in 2004 as a policy and became a regulation in 2008.

Stamen: The pollen-producing male organ of the flower containing an anther and filament.

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